Understanding Drawing:
a cognitive account of observational process

....

Michelle Fava

Doctoral Thesis submitted in partial fulfillment of the requirements for the award of

Doctor of Philosophy

of Loughborough University

29.04.2014

Neither this thesis nor the original work contained therein has been submitted to this or any other institution for a degree.

"We know more than we can say,

but we cannot say anything without listening to what we cannot say"

(Polanyi 1966: 4)

Acknowledgements

I would like to thank Loughborough University School of the Arts for making this Ph.D. possible, and Phil Sawdon for seeing the potential in my proposal at the very beginning. I would also like to express my very great appreciation to Russ Marshall for his unwavering support over four years, and for diligently reading countless (and sometimes unintelligible) drafts with level-headed and constructive criticism. Thank you Russ, I could not have done this without you. Many thanks also to Alastair Adams for his encouragement and analogies. Advice given by Eddie Norman has been a great help, his enthusiasm and genuine commitment to design education is an inspiration. I am particularly grateful to Simon Downs for always having time to talk, even when he doesn't. Thanks to Marion Arnold for nurturing us all throughout the PhD programme and to Emma Nadin for doing so much paperwork on our behalf, while still smiling.

I wish to acknowledge the time and effort contributed by the artists involved in this study, Amanda Roberts, Angela Brew, Anthony Connolly and David Cobley. Thank you for being such willing, patient and interesting subjects.

Special thanks is due to Angie Brew and Andrea Kantrowitz. Without these women, this would have been a whole lot less fun. Only by coming together did we realise we were not alone. Also, to Barbara Tversky, Stephen Farthing and Simon Betts for believing in the value of our endeavours, and somehow finding the time to champion the *Thinking though Drawing* project. Their contribution has been hugely valuable in our efforts to connect innovative people who have genuine concern and enthusiasm for drawing in education.

Finally, Sophie Coleman, it's a very special thing to be brought unexpected cups of tea while working late at night. You were a ray of sunshine when things were difficult.

Mum, this is for you.

Contents

List of Figures

Tables & Boxes

Figures

Abstract

This thesis contributes to theorising observational drawing from a cognitive perspective. Our current understanding of drawing is developing rapidly through artistic and scientific enquiry. However, It remains fragmented because the frames of reference of those modes of enquiry do not coincide. Therefore, the foundations for a truly interdisciplinary understanding of observational drawing are still inceptive. This thesis seeks to add to those foundations by bridging artistic and scientific perspectives on observational process and the cognitive aptitudes underpinning it.

The project is based on four case studies of experienced artists' drawing processes, with quantitative and qualitative data gathered: timing of eye and hand movements, and artists' verbal reports. The data sets are analysed with a generative approach, using behavioural and protocol analysis methods to yield comparative models that describe cognitive strategies for drawing. This forms a grounded framework that elucidates the cognitive activities and competences observational process entails. Cognitive psychological theory is consulted to explain the observed behaviours, and the combined evidence is applied to understanding apparent discrepancies in existing accounts of drawing. In addition, the use of verbal reporting methods in drawing studies is evaluated.

The study observes how drawing process involves a segregation of activities that enables efficient use of limited and parametrically constrained cognitive resources. Differing drawing strategies are shown to share common key characteristics; including a staged use of selective visual attention, and the capacity to temporarily postpone critical judgement in order to engage fully in periods of direct perception and action. The autonomy and regularity of those activities, demonstrated by the artists studied, indicate that drawing ability entails tacit self-knowledge concerning the cognitive and perceptual capacities described in this thesis.

This thesis presents drawing as a skill that involves strategic use of visual deconstruction, comparison, analogical transfer and repetitive cycles of construction, evaluation and revision. I argue that drawing skill acquisition and transfer can be facilitated by the elucidation of these processes. As such, this framework for describing and understanding drawing is offered to those who seek to understand, learn or teach observational practice, and to those who are taking a renewed interest in drawing as a tool for thought.

Introduction: ***what does expertise in observational drawing involve, and how can we describe it?***

This research investigates the cognitive basis of observational drawing skill. The project was motivated by the idea that recent developments in psychology – regarding our understanding of visual cognition – could offer insights into the cognitive basis of drawing process, and that such insights would be well placed to inform teaching practices, and debates around the cognitive value of drawing ability. In particular, to scrutinise claims that observational skill entails aptitudes that 'transfer' or extend beyond the ability to make a representation. In order to consider such claims, it is necessary to first understand what cognitive processes drawing skill actually involves. So, in this research, I look directly at drawing process, aiming to interpret the cognitive strategies employed by experienced artists, and to explain them in the context of contemporary understandings of perception and cognition.

Rationale

Educators and practitioners widely describe drawing as entailing a set of cognitive and perceptual aptitudes. Deanna Petherbridge describes the correlation between the act of drawing and 'training the eye' as "one of the few notions about drawing generally regarded today as 'irrefutable'" (2008: 30). Ruskin famously described observational drawing as a means of learning 'to see' (1991 [1857]). Historically, others have gone further, claiming that drawing enhances other related faculties, such as attention, memory, analysis, visualisation, creativity, lateral thinking, problem solving and motor skills. 19th Century French painter Montabert described a "heightened consciousness through the discipline of drawing" (quoted in Picon 2003: 132). The architect Eugene-Emmanuel Viollet-le-duc maintained "Drawing, properly taught, is the best way of developing intelligence and forming judgement" (quoted in Petherbridge, 2008: 30).

More recently, Stephen Farthing (2010) describes how his own drawing practice helps him to "see more clearly". David Haley maintains "that drawing is integral to perception and cognitive understanding" (2010). Howard Riley speaks of "an intelligence of seeing developed through the practice of drawing” (2008: 162). Eduardo Corte-Real tells us it ‘develops the intellectual capacity for learning and creativity’ (2009). The IDEAL Project (a European gallery education initiative) work under the stated premise that:

> The practice of drawing encourages acceptance of change, promotes creativity and develops problem solving. Though an undervalued means of ‘learning to learn’, it is readily transferable to wider social, economic and personal fields. (2009)

A review by Jane Tormey demonstrated that these views are widely held among educators. Tormey cited many foundation course tutors echoing these sentiments, describing drawing as: “the means of visual thinking and analytical learning, the means to invent and experiment, to improve perceptions, visual awareness and manual skills” […] “the ‘ultimate transferable skill’; it ‘encourages the ability to adapt’; it ‘provides the progression from research, through analysis and speculation to solution’; it ‘progresses visual thinking’” (1997).

While there is a high degree of consensus here, exactly what these statements refer to remains open to interpretation. They are pointing to a set of phenomena, but it remains to fully describe or explain them. It is safe to assume that this is because much of the practice of drawing is held tacitly. There is a sense of knowing that exceeds our ability to explain. As Deanna Petherbridge notes: “Tacit knowledge is something very familiar to artists, and a lot of untheorised teaching in art and design schools resides in the passing on of tacit knowledge between tutor and pupils (2008: 34).

Petherbridge argues that this ‘tacit’ nature is why drawing has, for a time, been “happily disregarded as an academic subject under the delusory rubric that *in itself* it is an aspect of tacit knowledge” (2008: 34). However, as Riley points out, “more than ever before, a burgeoning research culture demands of drawing tutors a much higher degree of articulacy on theoretical issues” (2008: 154).

At the same time, the way drawing is taught in schools and universities appears to be changing. While there is no comprehensive review of this, there is extensive anecdotal evidence. My own personal discussions with art and design educators over recent years have indicated a decline in observational drawing tuition in the UK: it's "not really part of many/most curricula across the UK anymore" (Leo Duff 2010, personal communication). Many note a decline in drawing 'ability' (Alsop 2002; Rose, Jolley & Burkitt 2006; Jolley 2009). My own prior research (Fava 2011; Brew, Fava & Kantrowitz 2011) has indicated that there is not only a change, but also a growing concern amongst UK art educators over a perceived decline in school leavers' drawing ability and educational investment in the practice. Simon Betts (dean of Wimbledon College of Arts), notes that:

> in recent years, any conversation with colleagues in the UK teaching in pre-undergraduate art & design foundation courses would inevitably have focused on increasing anecdotal evidence of students' drawing weaknesses and their low confidence in their drawing ability. From 2005, all six University of the Arts foundation course directors were noticing in their course selection process an increasingly worrying trend in the applicants' portfolios. These concerns amounted to decreasing amounts of any kind of drawing in the portfolios, a limited range of subject matter and uses of drawing, and little speculative drawing for ideas development or research. Certainly, there would often be no observational drawing where a student had learnt how to look, analyze, scrutinize, and record visual information. (Betts 2011: 28)

This account, and many others like it, indicate a general decline in drawing tuition at secondary level. Such trends are not driven by arguments *against* the need for drawing tuition, rather, there is a complex set of reasons behind them, which require further documentation and analysis.

Accurate hand rendering is no longer entirely necessary to art or design practices, and some are advocates of the 'paperless studio model' – Ashraf Salama and Nicholas Wilkinson, design pedagogy researchers (2007: 41) note that many architects hold this opinion – but this trend is coming under increasing scrutiny (Norman, 2001). As well as changing drawing practices, there appears to be a number of additional reasons why other aspects of the curriculum are prioritised ahead of drawing, including institutional, economic and policy factors (also discussed in Fava 2010).

In this light, observational drawing presents itself as a timely object of study. Clearly, debates around observational drawing's cognitive benefits (and its enduring educational relevance) would benefit from a more scientifically grounded understanding of the process, and theoretical tools for describing and explaining it. It is in this context that I aim to elucidate and theorise tacit aspects of observational process.

The research question

For debates around the cognitive benefits of observational drawing practice (and the potential for instruction to capitalise on them) to be consequential, it is critical to understand what cognitive skills and capacities are involved in observational drawing. Therefore, this investigation asks:

> *What does expertise in observational drawing involve, and how can we describe it*?

Of course, any attempt to describe the act of drawing linguistically will necessarily be limited, as it is a primarily visual activity, and so the second part of this question is considered separately. While this project aims to elucidate tacit aspects of drawing it also seeks to evaluate the usefulness of verbal methods of eliciting and describing knowledge about drawing.

As George Whale outlines, in his Ph.D. thesis, there is scope for further research about drawing process, and this includes "a clear need for complementary research about methods, especially methods of collection/elicitation (verbal or otherwise) and methods of data analysis" (2006: 224). Specifically, he poses this question: "What, if any, are the relationships between the character of artists' working processes and the reportability of those processes" (2006: 224). This is adopted as a secondary research topic here. It serves to scrutinise the validity and limitations of the verbal data, as well as to consider the role of the verbal faculty in drawing more generally.

In order to address these questions, I first examine existing cognitive accounts of drawing from the arts and the sciences. I then observe and analyse a variety of artists' drawing processes, and consider those in relation to existing psychological understandings of visual cognition. In doing so, I aim to understand apparent discrepancies in existing cognitive accounts, and encompass them within a more overarching cognitive theory of observational drawing ability and the range of competences it involves.

The research applies methods and theories, established in the cognitive sciences, to the analysis of artists' process of observational portrait drawing and, in doing so, offers both theoretical and methodological insights. The contribution of this research is threefold:

1. it proposes a model of how attentional resources are applied and distributed during observational drawing process, and an account of four artists' patterns of activity;
2. it offers a framework that consolidates existing cognitive accounts and theories of observational drawing process, resolving apparent contradictions;
3. it evaluates the use of verbal reporting methods in the study of drawing.

Each of these contributions casts light on some aspect of drawing process. The study itself does not venture as far as applying its findings in an educational context, but the potential ramifications of its conclusions are considered and areas for further research are outlined, particularly discussion around what – if anything – is transferable in observational drawing skill.

Overview

The thesis begins by reviewing existing literature around drawing and cognition, in order to outline established perspectives and identify discrepancies between them. Chapter 1 describes popular accounts given by John Ruskin, Ernest Gombrich and Betty Edwards, noting contentions between them, regarding the roles of language, attention, memory and schematic knowledge. These accounts are reviewed alongside the findings of contemporary psychologists who study drawing process, and are returned to in chapter 5, where I address the contentions raised. The limitations of cognitive investigations into drawing activity are also discussed and used to support the methodology this research, described in Chapter 2. The review also partly informs the scope of a further literature review, presented in chapter 4, in which I survey relevant themes and concepts in cognitive psychology.

While the project aims to understand the roles of language, attention and memory in drawing process, it did not set out, initially, to prove any specific hypotheses. I had no 'hunch' about what I would find, and did not seek to construct one in the manner of the psychological studies reviewed in chapter 1. Instead, I use a 'grounded theory' approach to allow initial insights and working hypotheses to emerge from observed behaviour patterns, which are then analysed in more depth in relation to secondary literature. Grounded theory is favoured for this research as it supports an investigation where there is no prior hypothesis and where emergent insights from the research are desirable. This approach is detailed in Chapter 2, which describes the primary methods and their relationship to the secondary theoretical analysis.

Chapter 3 presents the primary studies. It begins by observing each artist's process and describing their drawing strategies. The grounded approach allows patterns to emerge from data – collected in the form of video, eye-tracking data and artists' verbal reports, which provide both quantitative and qualitative evidence of cognitive activity. The video data is interrogated in terms of the timing of looking and drawing activities (their speed and coincidence), and this is complemented by the artists' own subjective reports of the process, both concurrently and retrospectively. Further studies looked in more detail at two of the artists' eye movements, in order to more closely observe patterns of activity identified in the video analysis. In addition to this, verbalised and non-verbalised trials are compared in order to gauge the effects of the reporting task on the drawing.

Together the combined approaches aim to provide evidence of cognitive activity, to be further interpreted by theoretical analysis. The verbal accounts provide insights into each artists' differing strategy for drawing, while the data regarding their timing allows a more focused analysis of the cognitive processes involved, i.e., how particular strategies were manifested in complex rhythms of movement and eye-hand coordination. The combined data is analysed in a generative fashion. Categories are identified, in both qualitative and quantitative data sets, and used as schemes for further analysis and comparison. Observed similarities in approach and timing are distilled into propositions about the artists' cognitive processes. The outcome of the analysis in chapter 3 is a diagrammatic model that provides a framework for describing and comparing drawing strategies in terms of the range of possible cognitive states involved.

While chapter 3 describes drawing strategies and provides a comparative model, it does not *explain* why those strategies occur in the way they do. Questions remain unanswered regarding the roles of language, attention, memory, and further questions are raised regarding the unconscious or 'tacit' element. While artists' accounts allude to these notions, and the case studies provide examples, it is within the strict language of cognitive psychology that we may describe with more precision what occurs and why. In order to inform further discussion of these questions, Chapter 4 reviews further literature from cognitive sciences. This thesis, therefore, contains two literature reviews: the first (chapter 1) surveys existing cognitive accounts of drawing and identifies apparent discrepancies between them; the second (chapter 4) departs from studies specifically concerned with drawing in order to delve further into current understandings and theories of perception, visual attention and cognition.

Given that this dissertation is aimed primarily at art educators, chapter 4 provides an overview of relevant current perspectives in psychology, offering clarification of key terms and concepts used in theoretical discussions. Despite the lack of consensus among the psychological community regarding many of these concepts, it is still possible to present a pragmatic overview of relevant areas, sufficient for the purposes of this thesis.

Chapter 5 returns to the issues outlined in the literature review (chapter 1), aiming to resolve apparent discrepancies between popular cognitive accounts of drawing process by applying the '2D model' (of potential cognitive states, proposed in chapter 3) as a comparative tool. It also draws on the body of literature reviewed in chapter 4 to resolve ambiguities in those accounts' usage of cognitive terminology.

Chapter 6 addresses the roles of attention and memory in drawing. Here I aim to further explain the patterns of activity observed in the case studies and further interpret the cognitive skills involved in observational drawing, with reference to the literature presented in chapter 4. In doing so, I revise the '2D model' of potential cognitive states, extending it to three dimensions by taking account of working memory and its various capacity limitations. I offer the '3D model' to illustrate how artists' drawing strategies make efficient use of cognitive resources that are parametrically constrained, and argue that such strategies are evidence of a high level of tacit self-knowledge and control regarding the application of visual attention and working memory.

Chapter 7 addresses issues around drawing and verbalisation raised in previous chapters. My aims here were firstly to question the usefulness of verbal methods in studies of drawing and secondly, by extension, to consider the cognitive role of the verbal modality in drawing process. This chapter draws from both literature reviews and the case study analysis, to offer an understanding of how the verbal methods used can be considered to reflect drawing process, and what the reports may omit. I discuss the applicability and limitations of these methods in the present study. The chapter goes on to apply that understanding to an evaluation of verbal reporting methods in the study of drawing, and briefly considers the potential for further research and development in drawing methodology and pedagogy regarding the use of verbal methods.

Chapter 8 returns to the question of the transferability of drawing skill. The various components drawing ability, identified in the case studies, are presented as potentially transferable to many domains including analogical thinking and creative strategies, even to one's ability to manage one's own learning. I draw from recent studies of analogical transfer to argue that we cannot, however, assume that transfer between domains will occur: rather, there is *potential* for transfer, and this can be facilitated by elucidating the underlying structure of knowledge and thought processes.

The sum of this thesis is a description and explanation of cognitive strategies for observational drawing, grounded in the observation of four experienced artists. I offer explanatory models in order to compare a range of possibilities, and discuss the relevance of the understanding offered to existing theoretical positions and practical considerations.

In addition to the picture of drawing ability I offer in chapters 3, 5 and 6, the final chapters arrive at two complementary conclusions: first, the account of drawing process offered here and the verbal methods used to elicit it, have the potential to aid instruction, performance, independent learning and transfer; second, it is important to consider *when* this type of elucidation is appropriate, and to acknowledge that, at certain times, it is not possible and could even be detrimental to performance and learning. Therefore, I identify two avenues of further development in drawing instruction: one which seeks to enhance learning by drawing from this study and others like it to make explicit the thought processes underlying drawing activity; another which acknowledges the limits of possibility regarding such explications, and explores instead non-verbal and intuitive aspects of drawing.

Chapter 1.

Cognitive accounts of representational drawing

Drawing, like so many other skills, is a matter of being able to think of several things at once. Since the conscious mind seems to be able to think about only one thing at a time, the subconscious mind must take care of a good deal when we draw. So the process of learning to draw demands that we acquaint the subconscious mind with a certain amount of material, so that the subconscious can largely take over the control of our hand.
(Robert Hale, 1989: 13)

To situate the present investigation into the cognitive basis of observational drawing skill, this literature review covers accounts of representational drawing that make claims about the cognitive processes involved. First, I outline influential popular accounts from the arts and humanities, with ambiguities and discrepancies between them noted. After this, I survey more recent cognitive studies that investigate drawing process using empirical methods. Mapping this literature by way of its themes, this chapter covers two disciplinary approaches with complementary strengths and weaknesses: studies made by psychologists tend to be fragmentary, explaining only isolated elements of drawing process; while those from the humanities use cognitive terms more loosely and tend to make broad generalisations based on experience, rather than empirical evidence. By comparing these perspectives, this review provides a rationale for the methodology, which relies on both empirical evidence and the subjective reports of artists themselves. It identifies key terms and concepts to be applied in later analysis, and also recognises issues and discrepancies within the literature, which will be addressed in chapter 5 in light of the outcomes of the case study analysis in chapter 3.

Points of contention are highlighted; for example, regarding the role of schematic knowledge, which is said in different accounts both to aid and interfere with drawing process. Neither the specific roles of attention nor memory (in its various forms) are currently fully understood, and questions surrounding the use of mental imagery or visualisation remain unresolved.

Overall, this review outlines the context of the present study outlining unresolved matters, and providing a rationale for the methodological approach by describing the two fields of study it aims to bridge.

1.1 Schemata and the 'innocent eye'

Ernst Gombrich used the concept of the schema[1] to explain representational drawing and painting, as well as creativity more generally. (Although, as Aaron Kozbelt (2008) notes, Gombrich's thinking lacked influence on later theories of creativity, his writing on perception and representation have been very influential.) In *Art and Illusion* (1960), Gombrich explains artists' use of schemata as part of a process of 'trial and error', towards representation: 'making precedes matching'. He explains that artists develop 'vocabularies' which induce the desired visual effects, based on schemata for what things look like and how best to represent them. For Gombrich, perception is not given but learned, involving an active construction of the world. He went so far as to claim that 'cultures determine what is possible', in terms of pictorial representation (1960: 86).

Gombrich positioned his schematic theory in opposition to John Ruskin's notion of the 'innocent eye' (see also Verstegen 2004). Ruskin had described the skill of observation as relying on the ability to see in a particular way:

> what might be called the innocence of the eye; that is to say, of a sort of childish perception of these flat stains of colour, merely as such, without consciousness of what they signify — as a blind man would see them if suddenly gifted with sight. (Ruskin 1991 [1857]: 3)

Roger Fry similarly argued that artists were able to 'see past' higher cognition, to the 'structure of appearances' (1981[1919]). (Kozbelt & Seeley 2007, refer to this as the 'Fry-Ruskin model'.) This is perhaps also similar to Constable's dictum, which defines the goal of painting as "the pure apprehension of natural fact" (Steinberg 1972 [1953]: 292).

While Gombrich acknowledged the influence of the 'doctrine' of the innocent eye – in as far as it "prepared the ground for impressionism" (1979: 42) – he also refuted it as a "myth"

---

1 The concept of the schema can be traced back to Head (1920) and Piaget (1926). The Oxford Dictionary of Psychology defines a schema as "a plan, diagram or outline, especially a mental representation of some aspect of experience, based on prior experience and memory, structured in such a way as to facilitate (and sometimes distort) perception, cognition, the drawing of inferences, or the interpretation of new information in terms of existing knowledge" (Colman 2012: 674).

(1960: 298) on the premise that it is futile to fight against preconceived notions of what we see, because perception relies so heavily on previously acquired knowledge. For Gombrich, there is no return to innocence (see also Hodgson 2004, for a review of Gombrich's attitude to Ruskin).

Gombrich's ideas reflected contemporaneous notions of perception. At the time, the idea that much of human perception relies on prior knowledge was gaining credence. We can now observe, as Richard Gregory (1990) notes, that around 90% of neural activity associated with perception (in adults) is top-down, indicating that what we 'perceive' is largely determined by what we know and expect to see. This is demonstrated by many optical illusions, including the bi-stable duck-rabbit image, which Gombrich used to illustrate the phenomena (see figure 1). To follow Gombrich's logic, to see neither duck nor rabbit would be impossible (unless, of course, we knew neither animal), our prior knowledge having permanently influenced our perception. Likewise, it is difficult to un-see the Dalmatian in figure 2 once it has been recognised. The Fry-Ruskin model holds that it is possible to return to a more naïve reading of the images.

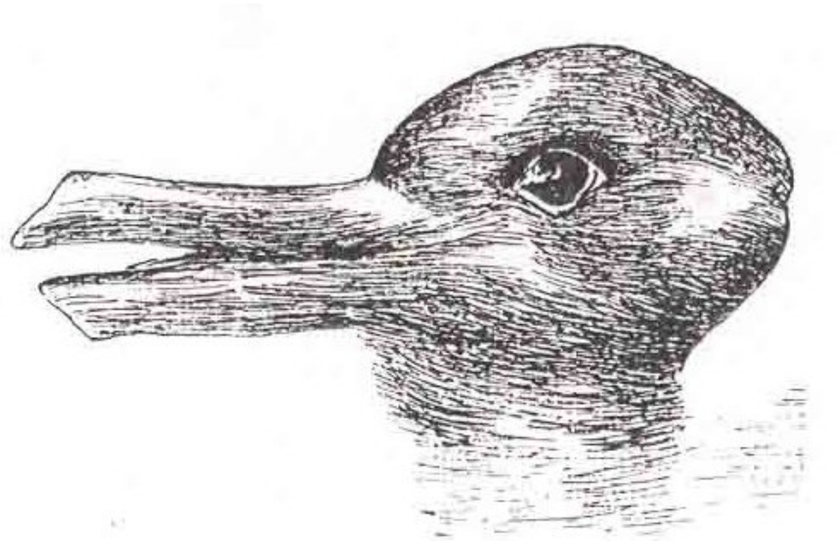


Figure 1. Bistable Duck/Rabbit drawing (from Scheidemann 1939: 67, as cited by Gombrich 1960: 4).

Figure 2. Dalmatian dog (from Gregory 2005: 1238).

While, on one level, it seems impossible to override object recognition, i.e., to 'un-see' the Dalmatian, there are many established drawing exercises that aim to do just this, facilitating a more direct perception. Kimon Nicolaides, for example, suggests:

> Imagine that your pencil point is touching the model instead of the paper. Without taking your eyes off the model, *wait* until you are *convinced* that the pencil is touching that point on the model upon which your eyes are fastened. (2008[1941]: 9)

Similarly, Bridget Riley, although not referring specifically to observed drawing, describes:

> It is as though there is an eye at the end of my pencil, which tries, independently of my personal general-purpose eye, to penetrate a kind of obscuring veil or thickness (2009: 20).

Both these descriptions suggest an 'objectless' perception, similar to that described by Ruskin. Surely, Ruskin was describing the way he believed he drew, and so this begs the question of what kind of perceptual skills or processes he was referring to, if not those described by Gombrich. Indeed, Gombrich was not really referring to perceptual *skills*, as such, rather he was describing the *knowledge* associated with representational ability.

It may be fair to note that Gombrich's perspective was that of a historian rather than a practitioner and, as such, his perspective may have been partial. It seems that while Gombrich's schematic account is apt for drawings made from memory or imagination, *observed* drawing likely entails both schematic knowledge and perceptual skills (enabling the fragmentation of details), as discussed in later chapters.

1.2 Drawing development and education

The distinction between direct perception and schematic understanding is also present in developmental accounts of drawing. Georges-Henri Luquet described children's drawing development as progressing from an 'intellectual realism' to a 'visual realism' (1927), i.e., from a schematic to a perceptual emphasis. (The questions of whether this shift is innate or culturally conditioned or, indeed, whether it is a desirable direction for children's drawings to take, are matters of some contention.) Luquet's thinking influenced Jean Piaget and Bärbel Inhelder's (1967) schematic account of child development in relation to drawing and spatial cognition. As children develop, it seems they are better able to represent the world with less influence from their own subjectivity. This is also demonstrated in Rudolph Arnheim (2004) and John Willat's (1997; 2005) accounts of drawing development. According to them, as children grow older, they are able to make better use of perceived details, and to create more illusionist representations. This indicates a move away from schematic influence towards the use of more directed perception. However, Gombrich would hold that this too indicates the acquisition of more sophisticated schemata, those for representational conventions – prescribing how to go about the drawing process and how to represent things effectively and which features to include.

This distinction is also comparable to differing traditions of academic drawing. The French Atelier system involved an 'analytical' method of drawing, which aimed to build representational skills through knowledge of the visual world. Geometry, perspective and anatomy were important elements of learning, aimed at drawing figurative compositions without a model, and combining observed details with imagined or idealised ones. It was believed that knowledge of the figure and proportion would also enable practice in design and architecture (see Elkins 2001: 10). In contrast, later shifts away from this tradition (while emphasising individual expression and creativity) involved drawing instruction that promoted a more perceptual emphasis. In these, measurement systems intended to pick out particular, rather than idealised or archetypal, features. Ruskin's teaching at the Working Men's College (see Hewison 1996) emphasised this, as did the Euston Road School – established by Claude Rogers and Victor Pasmore with the influence of Henry Tonks – which, although drawing from the French tradition, encouraged drawing directly from the everyday urban environment (see Laughton 1986 for a detailed history). William Coldstream was also a co-founder of the Euston Road School. His measurement system epitomised the perceptual approach, aiming for objectivity through measurement, although Howard Riley (2001) points out that what is intended to be an objective method of drawing, while empirical, is actually subjective; it distorts the image around the central observer even more so than classical perspective systems. In either case, the method still contrasts with the 'analytical' tradition, relying on measurement over knowledge, and the particular over the idealised.

David Bomberg, another student of Tonks, espoused a more affective approach to observation that re-introduced subjective interpretation in another way: "[n]ot the representation of appearance of form, but more the representation of all our feelings about form" (Bomberg 1937: 18). Bomberg wanted a method of drawing which recorded 'the drawer's engagement with the subject' that equated "the movement of the drawing hand with the movement of the eyes as they ranged over the subject, focusing on one part before scanning across to another" (Riley 2001: 46). Coldstream and Bomberg's drawing pedagogies were influential, and can be traced through their students.[2]

Instructional manuals vary in the degree to which they embrace one approach or the other. At one extreme are Ruskin's (1991 [1857]) *The Elements of Drawing* and Betty Edwards' (2008 [1979]) *Drawing on the Right Side of the Brain,* which describe a measured approach

[2] Bomberg's students included Frank Aurbach, Leon Kossoff, Dorothy Mead, Dennis Creffield and Miles Richmond. Coldstream's included Euan Euglow, John Lessore and many others.

to observing and recording. At the other are instructional approaches which favour the analytical method, such as Robert Hale's (1989) *Drawing Lessons from the Great Masters,* which encourages the use of projected geometries and Clint Brown & Cheryl McLean's (2003) *Drawing from Life*, which stresses anatomical knowledge. Various other publications fall between these two extremes. Harold Speed's (2012 [1913]) *Practice and Science of Drawing* encourages a balance between these two positions, advising that the visual alone is not enough: be it analytical or observed, "[f]orm to be expressed must first be appreciated" (Speed 2012 [1913]: 103). Nicolaides (2008 [1941]) acknowledges additional modes of observation alongside the visual and analytical, including tactile and bodily awareness. Nicolaides also advises that memory drawing be practiced separately to observational drawing. While these examples take a stance, the majority of drawing manuals cover both approaches, either separately or as part of a single drawing system (e.g. Stanyer & Rosenberg 1999, Curtis 2001, Micklewright 2005)[3]. Edwards' account, however, polarises the schematic/perceptual distinction most starkly, and deserves further consideration.

1.3 Betty Edwards' split brain model

Betty Edwards presents a polarised model of drawing and cognition, arguing that 'modes' of cognition associated with the right cerebral hemisphere facilitate observational drawing, while cognition located in the left hemisphere is detrimental to drawing. She refers to two cognitive 'modes' as 'R' (right) and 'L' (left) mode. Edwards' notion of 'R-mode' drawing is comparable to Ruskin's notion of the innocent eye, although they are described very differently. Ruskin's account seems to be very specific; concerned primarily with perception, while Edwards seems to be addressing generalised categories of thinking, implying a more fundamental duality in human thought, only one aspect of which is ideally employed in drawing and creativity.

---

[3] A full review of drawing schools and manuals is outside the present scope. Howard Riley's doctoral thesis (2001) offers a more detailed review of 20th century teaching practices, while Rafael Denis presents a comprehensive review of UK drawing manuals between 1825 and 1875 (2008) and Peter Marzio (1976) reviews American drawing manuals of a similar period, 1820-1860, documenting the decline of American traditions of drawing instruction in favour of Ruskin's approach, and influenced by more modern concepts of child development. More extensive surveys of drawing instruction and manuals are lacking.

Edwards' brain-based rationalisation of her instructional technique was based on studies of hemispheric lateralisation, mainly those by Roger Sperry in the 1960s (see Sperry 1967). Sperry located verbal, analytical thought in the left hemisphere, and perceptual, intuitive thought in the right. This dichotomy was popularised and applied to many scenarios. Its popularity may have been due in part to its simplicity, and perhaps even to the "the seductive allure of neuroscience explanations"[4] (as defined by Weisberg et. al. 2008). It may also have been the case that this model provided an appealing rationale for championing visual thinking, intuition and tacit knowledge, at a time when some regarded these as overlooked, particularly in educational arenas.

Edwards' suggestion was that the non-verbal, intuitive, visual mode of reasoning described by Sperry is the preferable cognitive mode for drawing. She also quotes Richard Bergland:

> You have two brains: a left and a right. Modern brain scientists now know that your left brain is your verbal and rational brain; it thinks serially and reduces its thoughts to numbers, letters, and words.... Your right brain is your non-verbal and intuitive brain; it thinks in patterns, or pictures, composed of 'whole things,' and does not comprehend reductions, either numbers, letters, or words. (Bergland, quoted in Edwards 2008 [1979]: xx)

However, this is now regarded as simply a 'useful metaphor', as she acknowledges herself:

> Very likely it is not a simple thing going on when a cognitive shift takes place in the brain. It is not like turning out one light and turning on another. But never mind. It's still a useful metaphor for what experience tells you is actually happening. (Edwards, quoted in Schwartz 1989: 48)

While perhaps a 'useful metaphor', the dichotomy between creative and analytical thinking espoused by early split-brain models is an oversimplification and, as such, can be misleading. Edwards' definition of 'two ways of knowing' conflates various dichotomies. Her 'L' and 'R-modes' at times refer to logic and intuition, at other times to verbal and visuo-spatial modalities, to global and local perception, to lower and higher orders of perception (feature

[4] "Even irrelevant neuroscience information in an explanation of a psychological phenomenon may interfere with people's abilities to critically consider the underlying logic of this explanation" (Weisberg et. al. 2008: 470)

detection and object recognition) and sometimes to serial and parallel processes. She defines her two modes as follows:

> L-mode. A mental state of information processing characterized as linear, verbal, analytic, and logical. […]
> R-mode. A state of information processing characterized as simultaneous, global, spatial, and relational. (2002: xi)

She also describes R-mode as "specialized for perceiving how parts fit together" (2002: 17), explaining her method of drawing as a "*conscious volition* to the visual, perceptual mode of thinking" (2008 [1979]: 4, emphasis in original).

Edwards' 'R-mode' is comparable to the 'innocent eye, but her dualistic account seems to include more elements, and relegates many others to the 'L mode'. While the enduring popularity of her methods and publications cannot be attributed to the scientific validity of her explanations, they certainly describe something rooted in her own experience of drawing, and are authentic in this sense.

Gombrich was neither an artist, nor a psychologist. His method was to apply cognitive principles to an art history analysis of the role of schemata in drawing. That we normally perceive the world in a particular (highly interpretive) way does not preclude other modes of perception as Gombrich implies. Indeed, many task-specific perceptual abilities have become objects of study, including artists' representational skills. The roles of knowledge and perception come into question in more recent cognitive accounts. These rely on empirical methods of observing drawing process in artists and novices, and are usually carried out by non-artists (with the exception of Kozbelt who does practice drawing himself, although this is not mentioned in his publications).

1.4. Psychologists' accounts

Psychological studies of drawing consider a number of factors: proceduralised drawing techniques and strategies, schematic knowledge, and the roles of attention, memory and mental imagery. These studies use empirical methods to measure timing, movement, accuracy and cognitive activity and often make expert-novice comparisons.

Psychologists Dale Cohen and Holly Jones support the Fry-Ruskin hypothesis. They describe how the "ability to overcome constructive perception[5] processes that transform the retinal image into the final percept […] is necessary for the accurate rendering of objects" (2008: 8). Other cognitive studies show schemata to be a potential cause of inaccuracy[6]. For example, Peter Mitchell et al. (2005) demonstrated that the inclusion of table legs on a parallelogram caused participants to copy the image less accurately, demonstrating the interference of top-down object recognition processes on shape constancy. Barbara Tversky and Paul Lee (1989) showed similar results in children, while Pia Broderick and Judith Laszlo (1989) also show cultural influences on copying[7]. (Drawing tutors Edwards 2008 [1979] and Hoffman 1989, among others, suggest that inverting an image can improve copying accuracy for this reason.)

Kozbelt, however, describes the *constructive* role of schematic knowledge in image production, supporting Gombrich's position: "An artist's goal plan, akin to Gombrich's (1960) notion of schemata, mediates which visual qualities the artist selectively attends to and incorporates into what is drawn" (2001: 718). Here Kozbelt is referring not only to image schema, but to schema for representational conventions and drawing methods.

---

5 Cohen & Jones' use of the term 'constructive perception' is different from Suwa & Tversky's (2002) definition of the term, which refers to a creative strategy. Here, Cohen and Jones are referring to something akin to Gombrich's concept of schematic recognition.

6 Cohen rejected this, based on the results of his (2005) study of non-artists' drawings. However, Kozbelt et al's (2010) study of visual selection in drawers contradicts Cohen's (2005) findings. They showed that only drawings of faces *made by novices* showed significant improvement when the stimulus was inverted, at least when experienced artists were judging the accuracy. They also pointed out that Cohen's study had used tracing, rather than observational drawing, and non-artists as judges of accuracy.

7 Cohen lists other documentation of "the influence of stimulus interpretation on the drawing process" (2005: 997; see also Blakemore 1973; Blakemore, Carpenter, & Georgeson 1970; Deregowski 1973; Freeman 1980; 1987; Gregory 1990; Van Sommers 1984).

Tversky and Lee argued that, due to their schematic nature, drawings (and observation of drawing *process*) can reveal insights into individuals' conceptual knowledge and understanding. Drawings "reveal people's conceptions of things, not their perceptions of things" (1999: 95) and, as such, they "can provide insights into conceptualisations, not just imaginings" (1999: 96). "The segments that make up the sketch vocabulary give insight into the conceptual components of that domain. [… Similarly,] the order of drawing, then, reflects order of mental transformations" (1999: 96-7) and therefore reveals the underlying conceptual structure. "The structure captured by sketches is not the structure of the environment, but rather, the conceptual structure of the information" (Tversky 2002: 1, see also Tversky 1995; 2001). Although Tversky is not referring specifically to observed drawings, her insight acknowledges the role of schemata, and further implicates drawings, and drawing process, as objects of study that can *reveal* the structure of schemata.

We can conclude that schematic knowledge can function *both* to inform and to interfere with drawn representations. In this light, observational skill must involve strategies both to make use of and to inhibit schematic knowledge. Schemata provide cues about selection and rendering (which features to draw and how) while they can be overridden to avoid undesired interference. The polarisation between Gombrich's schematic account of representation and Ruskin's notion of the 'innocent eye' may be a moot point, as we can appreciate each position as describing complementary modes of visual cognition, of importance to different approaches to drawing. This issue will be discussed further in chapter 5.

1.4.1 Models of drawing ability and process

Psychological studies of drawing consider drawing process in relation to a number of factors: proceduralised drawing techniques and strategies, schematic knowledge, and the roles of attention, memory and mental imagery. These studies use empirical methods to measure timing, movement, accuracy and cognitive activity.

Van Sommers (1989) proposed a 'global cognitive model' of drawing abilities, describing two hierarchical systems. One is 'visual perception', based on David Marr's three stage model (Marr's model is described in section 4.2). The other is 'graphic production', to which he gives four stages: depiction decisions, production strategy, contingent planning and economic constraints. Van Sommers' depiction process is congruent with Gombrich's (1960) schematic account, and also with Kozbelt's more recent account, which distinguishes between schematic knowledge of the visual world, and the proceduralisation of production techniques (2007: 80).

Van Sommers' model was reviewed by Guérin, Ska and Belleville (1999), who question his argument that drawing recruits a 'depiction process' rather than mental imagery**.** They favour Stephen Kosslyn and Oliver Koenig's (1992) model of perception over David Marr's (1982), as it is more detailed and specific. Kosslyn and Koenig propose two pathways of visual perception. Both can be involved in drawing: a bottom-up "spatiotopic mapping component from the dorsal system" whose role is "to locate objects in space and place their coordinates inside a unique reference frame" (Guérin, Ska & Belleville 1999: 469), and a 'top down hypothesis testing' processing system which verifies hypotheses about objects. This distinction is variously referred to as 'bottom-up and 'top down' or 'exogenous' and 'endogenous', although this also alludes to the dorsal-ventral distinction (reviewed in section 4.1). They also formulate an 'attentional shifting sub-system' which "adjusts the position of the eyes, head and body as well as the location and size of the attentional window on different parts of an object" (1999: 469). To this, Guérin, Ska and Belleville also add Alan Baddeley & Graham Hitch's (1974; 1994) 'visuo spatial sketchpad', which they consider to be "involved in planning and executing spatial tasks" (1999: 471).

In addition to the size and location of the 'attentional window', Pamela Sutton and David Rose (1998) describe its duration as another key factor. Sutton and Rose were among the first psychologists to consider the role of attentional process in drawing development. Their studies suggest that "intellectual and visual realism are not distinct developmental stages, but may instead reflect the use of different *attentional strategies* by children" (1998: 87 emphasis added). They measured the proportion of time children spent looking at the model and the paper while drawing, showing that while gross levels of attention did not differ, children (aged 8) producing visually realistic drawings "adopted the attentional strategy of continuously referencing the model while drawing" (1998: 98).

More recently, Dale Cohen (2005) studied the effects of 'gaze frequency' on drawing accuracy in adult artists. Cohen explained that faster gaze frequency allowed artists to hold less information in their working memory, reducing memory distortion and other context affects through 'inattentional blindness'. This came after an earlier study with Susan Bennett, which identified "the artists' misperception of the object as the major source of drawing errors" (Cohen & Bennet 1997: 609). They refer to schematic knowledge as a source of delusions, which occur when the artist "relies on information that he or she possesses about the appearance of an object or similar objects" (1997: 610) and describe faster gaze frequency as a strategy for minimising this.

Tchalenko also recognises this in his analysis of segmentation and accuracy. He claims that the 'process of segmentation' of a line, with each segment 'immediately executed', renders "the use of working memory […] minimized or even completely avoided" (2009b: 799) by "using the original itself as a sort of memory scratchpad" (2009a: 434; See also Tchalenko & Miall 2009: 376) through a 'just in time' strategy' (Hayhoe & Ballard 2005; Land 2006).

Cohen and Jones go on to suggest instructional applications of these findings:

> one way in which teachers may help train students to quickly alternate their gazes is to have students perform a task similar to the shape constancy task while instructing them to alternate their gaze at a variety of frequencies […] future experiments should address whether this and other similar exercises facilitate drawing accuracy and reduce shape constancy errors. (2008: 18)

The implication here is that the duration of the 'attentional window' may be shortened in order to reduce the influence of memory. However, simply instructing students to adjust their timing may be fruitless if they do not know what they are looking *for*. That is to say, the 'attentional window' has been shown to operate within many variables (as will be discussed in chapter 4) which also require selective control, so duration is only one parameter in a complex set of attentional processes that need to be accounted for in an attentional strategy.

Kozbelt and William Seeley offer a more detailed consideration, describing "attentional strategies that enhance the encoding of expected features in the visual field" enabling them to "focus attention on stimulus features relevant for adequate depiction" (2007: 80). They suggest that the 'perceptual advantages' they observed in artists who draw can be attributed to such abilities (2007). Kozbelt and Seeley also acknowledge the role of schematic knowledge, describing how it informs both the “structure of appearances” and “motor priming achieved through the proceduralisation and practice of productive techniques in artistic media” (2007: 80).

So far, we see that – in contrast to accounts of drawing from the humanities, which seek generalisations and ask broader questions – more recent psychological studies focus on isolated aspects, aiming to describe them in the language of cognitive psychology, and within the framework of existing understandings of perception and cognition. In doing so, they rely on understandings derived from studies of more fundamental visual processes (which will be reviewed in chapter 4). One particular area of contention is the role of visual memory or internal imagery, discussed further in the following section.

1.4.2 The role of visual memory

Guérin, Ska and Belleville’s account is extensive. They infer the use of ’top-down processing systems’ in drawing, describing their role in ‘hypothesis testing’ (which implies the reviewing, rather than the production, of the image), but the extent to which this involves internal mental imagery remains unclear. The extent to which internal visualisation is used may be an important question, but it can likely not be answered straight-forwardly as it may be subject to individual differences in both visualisation ability and drawing strategy, as well as more universal factors. Models such as Guérin, Ska and Belleville’s tend to assume a single ‘expert’ approach to drawing but, as Keogh & Pearson (2011) note, some people are ‘poor visualisers’ and devise alternative strategies for completing visual tasks. We can therefore expect to observe a range of strategies, in which artists may rely on visual imagery (and therefore visual *memory)* to differing degrees.

Chris Miall and John Tchalenko (2001) consider this, observing looking behaviours on a finer scale. Beyond ‘gaze frequency’, they defined ‘dwell cycles ‘ in order to compare durational patterns. They recognised a rhythm to what they term the ‘conventional mode’ of observational drawing[8], identifying units of action in order to make meaningful comparisons. Miall and Tchalenko’s method for defining dwell cycles involves coding drawing behaviour by segmenting the process into periods in which the drawer is looking at the paper or the

[8] Tchalenko (2009) distinguishes between a ‘conventional’ and a ‘direct’ mode. The conventional mode involves drawing while shifting attention back and forth. The direct mode involves maintaining attention on the model during mark making.

original, and periods of drawing and not drawing. These are grouped into ‘cycles’ bound by the return of the eyes to the ‘original’ (i.e., the subject, not the paper). Drawing may take place while the artist’s eyes are directed to the paper or to the original (from hereon these will be referred to as ‘blind’ and ‘sighted’ drawing). These two processes can take place separately or can both occur within a single drawing. That is, the drawer might be employing both at different times in the drawing process, or during each dwell cycle, for example, if they “continued drawing during periods of reference back to the original” (2009: 434).

This distinction between blind and sighted drawing enables differentiation between periods within the dwell cycle, facilitating further analysis. The division of drawing into blind and sighed activity, as in Tchalenko’s studies, will also be applied to the case study analysis in chapter 3, in which those phases will be timed and analysed for four case studies. Collectively, Tchalenko’s collaborations represent the most empirically grounded research into drawing process, relying on both behavioural evidence (timing) and fMRI data. These studies offer some interpretation of the cognitive processes involved in blind and sighted drawing, in terms of the role of visual memory, although Tchalenko’s later studies offer a different interpretation.

Miall & Tchalenko hypothesise two distinct cognitive activities during blind and sighted drawing. They interpret ‘blind’ drawing to be “a process of visual information being perceived by the eye and simultaneously implemented by the hand, i.e., a direct visuomotor process not requiring encoding to, and recalling from memory” (2012: 12). They had previously described how “perception of the original and drawing of the copy were taking place simultaneously and that *the action was lead by the eye*” (Tchalenko & Miall 2009: 372, emphasis added). They describe sighted drawing as “a process of encoding to working memory. It is only when the eye shifts to the picture that the hand starts drawing, and it does so presumably, by referring to the retrieved memory image” (Miall & Tchalenko 2012: 12).

Miall & Tchalenko’s experimental evidence supports these descriptions. However, their observation that ‘it is only when the eye shifts to the paper that the hand starts drawing’ is based mainly on their observations of one artist, Humphrey Ocean (discussed in the following section), so we cannot extrapolate that this represents ‘expert behaviour’. Neither does it necessarily follow that a ‘retrieved memory image’ is relied on. That the action is 'lead by the eye' means that there is certainly a slight delay which working memory must mediate, but this does not necessarily indicate a pictorial 'memory image'. Other forms of memory might be used.

The role of visual memory in sighted observational drawing may seem straightforward (as described above) but, as Tchalenko notes, certain assumptions are held:

> when the painter is not seeing the model, it is commonly assumed that drawing proceeds from a visual working memory of the model or, more precisely, of a detail of the model. Alberto Giacometti held that "working from life is working from memory: the artist can only put down what remains in his head after looking", and cognitive psychologists Phillips, Hobbs and Pratt wrote: "Since normal drawing involves looking away from the object being drawn any information acquired during perception must be remembered while actually drawing". Having put down on the paper the remembered bit of information, the artist's hand will pause while the eyes refer back to the model for the next bit, imposing in this way a rhythmic pattern to the drawing action. (2009a: 433)

Tchalenko refers to this assumption as the 'conventional interpretation':

> This conventional interpretation posits the following sequence: the original, or part thereof, is first encoded to visual memory during fixation on the original, after which the subject turns to the paper and drawing proceeds from the stored mental image. As the image fades there comes a point where the subject needs to return to the original. Much of the eye tracker data obtained with Humphrey Ocean supported such an interpretation, but instances when this behaviour did not hold were also noted. (2009a: 369)

Guérin, Ska and Belleville (1999) also suggest that drawing likely requires 'multipart images' "formed by allocating attention during the inspection or by activating visual memories" (1999: 472). They describe this process as directing "the attentional window to the image parts maintained in the visual buffer in order to copy or draw it from memory" (1999: 472). While it is reasonable to assume that artists rely on mental imagery to varying extents, its role in observed drawing is questionable. Jennifer McMahon (2002) argues that it is impossible to draw directly from mental imagery because this would require simultaneously perceiving the drawing and the mental image (although this argument assumes the artist must see the drawing while making it). She explains that memory drawing relies instead on recalled ’denotative’ descriptions of objects rather than structural or visual descriptions, the memory is therefore propositional in nature, rather than visual. Guérin, Ska and Belleville (1999) instead positing that memory drawing may require only the ‘spatial form’ of a mental image, using Kosslyn & Koenig’s (1992) distinction between spatial and physical properties; although the ‘visual buffer’ is still implicated here, it is the *location* of key features that is of importance to the drawing action, rather than their appearance. It is possible that different artists do not make use of their memory faculties in the same way, as these explanations seem to assume. Either way, they indicate that form the memory takes may not necessarily be visual, it could instead be propositional or spatial.

Whether or not it is possible to draw from mental imagery, to do so would require the interpretation of that memory into visual primitives to be drawn, and then to spatial cues for movement. The drawer would therefore be no closer to completing their task than if they were looking directly at the object itself. They would even be further from it, as their mind would already be occupied with retrieving the image, as McMahon suggests. However, as Tchalenko’s later studies demonstrate, drawing also occurs *while not looking the drawing* (blind drawing), so the artist need not perceive the drawing while making it. The problem is not with the allocation of gaze, per se, but with visual cognitive resources. True memory drawing must be a more complex task than observed drawing, having this additional load.

Guérin, Ska and Belleville propose that ‘unfamiliar ‘nonroutine’ memory drawing and copying both involve a ‘mental image’, either generated internally or maintained, while familiar ‘routine’ memory drawing can bypass this:

> On the one hand, a nonvisual imagery pathway, which processes familiar and routine drawing from memory, goes directly from the associative memory to the procedural memory. On the other hand, the visual imagery pathway, which processes unfamiliar drawing tasks, goes through associative memory to the visual buffer and includes two parallel processing systems. […] When drawing from memory, these two processing systems are activated by the generation processes that elicit representations in *associative and visual memories* and subsequently send

> feedback to the visual buffer. Drawing from memory and copying tasks involve two other processes that *maintain and inspect the mental image* in the visual buffer or the working memory. These processes explore and retain the image as long as the drawing is being organized and produced. (1999: 472 emphasis added)

Any cognitive description of drawing must account for the distinctions raised here. However, the notion of both ‘maintaining and inspecting’ the image in the visual buffer while ‘copying’ seems inefficient, at least for observational drawing (as this account conflates ‘memory and copying tasks’). This implies *two* viewings, the first to form the image, the second to ‘inspect’ it internally in order to translate it into movement. It seems more plausible that this translation could be done with reference to the original, at least during ‘blind’ drawing.

Tchalenko’s later papers argue just this. While his earlier descriptions seem to assume the role of visual memory – “[t]he eye frequently returned to the same location on the model, at a rate that would indicate visual memory was refreshed about every 5 seconds” (Miall & Tchalenko 2001: 37) – he later challenges this interpretation by offering a ‘motor memory’ hypothesis: artists may encode the information to be drawn in refined motor or spatial (rather than visual) signals. He goes on to apply the hypothesis to his (2009a) study of archival footage of Matisse drawing.

Miall, Gowen & Tchalenko’s (2009) fMRI study of non-artists drawing offers further evidence for the ‘motor hypothesis’:

> we found no overt face-specific activation of occipital areas during the memory retention interval. This suggests that the visual information is not retained as continued activation within these visual face-processing areas, but is instead converted into more refined visuo-motor or spatial signals in order to guide the subsequent drawing actions. (2009: 402)

This study offers evidence that, when drawing from short-term memory, ‘facial information’ was ‘stored’ as planned actions rather than visually. They found that activation patterns were “consistent with visuomotor mapping during the encoding phase, and no evidence for retention and recall of a mental visual image was found” (Miall & Tchalenko 2009: 376), and suggest that the “the premotor cortex is a possible site of retention as a motor plan” (405).

They also found that, in the absence of other visual stimuli, the participants' "eyes sometimes moved in sequence to locations that approximately matched the drawn lines" (Miall, Gowen & Tchalenko 2009: 405), indicating the involvement of visual areas in the mark making phase, although they infer that this is likely involved in "planning and self-monitoring of the ongoing drawing process, because the pencil and paper cannot be seen" (403). Blind drawing also includes motor encoding, but is still a "strongly visually guided action, dependent on visual input, with powerful activation of the extrastriate visual cortex, parietal and premotor cortices and of the cerebellum (2009: 402).

Collectively, these studies indicate that there are many aspects of working memory to be accounted for, beyond the visual. Tchalenko's 'motor memory' hypothesis helps address issues about use of mental imagery. However, the fMRI study used a highly simplified and contrived task with non-artists, and his most detailed work has focused on a single artist. Others may have developed differing ways of using their memory abilities, relative to individual aptitudes and objectives and so it is important to consider a wider sample before drawing any conclusions.

1.4.2.1 Two processing systems

Guérin, Ska & Belleville's account mentioned 'two parallel processing systems' as part of the pathway that 'processes unfamiliar drawing tasks':

> The first one, which allows the formation of a single-part image, goes through associative memory, long-term visual memory, encoding of coordinate and categorical spatial relations, and spatiotopic mapping, and ends in the visual buffer. The second system, which allows the addition of parts to the global image, goes through long-term visual memory, associative memory and the subsystems of top–down hypothesis testing. The latter is also needed to inspect the mental image formed in the visual buffer. (Guérin, Ska & Belleville 1999: 472)

Again, this account implies the use of visual memory and the 'visual buffer' (the visual component of working memory, described in more detail in chapter 4). It also proposes parallel processing of the 'single-part image' and the 'addition of parts to the global image'. This explanation of the cognitive architecture behind drawing process appears to be the most detailed to date, but both the notions cited here (that the ‘visual buffer’ is used, and that there are two parallel systems dealing with parts and the whole) will be questioned later in this thesis.

1.4.3 Eye-hand interactions

The division of the dwell cycle into ‘blind’ and ‘sighted’ phases allowed the more detailed analysis of drawing process that resulted in Tchalenko’s motor memory hypothesis. Eye-tracking studies allow us to look even closer into the process by considering individual eye-movements.   Studies have shown observational drawing to consist of generalisable expert-novice differences in areas such as the duration of ‘dwell cycles’ (Cohen 2005) , the distribution of drawing activity within those cycles (Tchalenko & Miall 2009; 2012), and the relationship between eye and hand movements (Tchalenko 2009). Tchalenko’s analysis of the portrait painter Humphrey Ocean was among the first eye tracking studies of drawing. Later studies used larger sets of participants, usually 10 to 20, and aimed to make expert-novice comparisons. Tchalenko also observes eye-hand interactions, such as the monitoring of drawn lines.

The studies of Ocean demonstrated a regular fixation pattern, with roughly 20 fixations on the model per minute during brief sketches. Tchalenko infers that Ocean was ‘capturing about 1.5cm of detail per fixation’ (2001: 37). Some variations were observed, including “long fixations on the model at the start, during the first minute” (2001: 37), and ‘practice strokes’ in which ‘[t]he pencil would move several times just above the paper’s surface” (2001: 37).

The pencil tip was said to have been “followed precisely by Ocean’s eyes, in a smooth movement” (2001: 37). That the eye would follow the pencil seems counter-intuitive; one might expect the eye to anticipate the journey of the pencil, being slightly ahead, rather than observe the resulting mark, or by following the pencil tip as if someone else were moving it. It is possible that eye tracking technology at this time was not precise enough to gauge whether the eyes were in fact following or anticipating the pencil tip, especially considering the small scale of these actions. A later study with a wider sample (20 drawers of varying experience) reports a similar behaviour: “‘close pursuit’ fixations closely follow the pencil with a sequence of small saccades” (Tchalenko 2007: 1152). This seems to contradict the study of Ocean, in which drawing actions were said to be 'lead by the eye', but the 2007 study involved drawers of mixed ability completing a highly simplified task, and therefore this result deserves further scrutiny in relation to more complex expert behaviour.

In the same (2007) study, Tchalenko contrasts 'close pursuit' to 'target locking', in which "a stable fixation was made on the end point of the line throughout the entire drawing action" (2007: 1152). All the subjects were observed to use a combination of close pursuit and target locking when monitoring a drawn line. In addition to these patterns of looking, a review of Ocean's data revealed another behaviour in which "during the later stages of the portrait when most of the longer lines were being created. Here *the eye would depart altogether from the line being drawn* and refer to previously drawn elements as the hand continued drawing" (2007: 1152). In addition to this Gowen and Miall report another possible eye-hand relationship: "participants frequently moved their eyes far ahead, to the end point of the shape (where vision was important) or even *fixated a central location while the hand moved around the eye position*" (2006: 582, emphasis added), implying that an area of the visual field was attended for a period without the need for separate fixations.

Similarly, Tchalenko and Miall's subsequent study of 10 'beginner' art students differentiates "four very different eye–hand interaction strategies which provide evidence for the eye's dual role in the copying process: acquiring visual information in order to activate the visuomotor transformation and guiding the hand on the paper" (2009: 368). These four strategies do not correspond exactly to the four described above, there is no mention of 'close pursuit' of the pencil during drawing, although 'target locking' is noted in the blind copying strategy.

The four strategies are summarised as:

1. 'Direct copying': "the hand draws the copy line in one continuous movement while the eye alternates rhythmically between the pencil and the corresponding segment of the original" (2009: 375).

2. 'Direct Blind copying': "the unseen hand draws the copy line in one continuous movement while the eye moves along the original line. The eye leads the drawing movement in target locking mode" (2009: 375).

3. 'Memory copying': During encoding, the eye covers the original in one or several rapid passes with fixations located only approximately on the line. During execution the hand draws the copy line in consecutive segments. The hand leads the drawing movement in close pursuit mode. Fixation patterns for encoding and execution are similar" (2009: 375).

4. 'Non-specific Memory copying': "fixations are concentrated in a central region away from the original line. During execution, the hand draws the components individually, with the eye only very loosely connected to the hand's position" (2009: 375).

While these four strategies seem a plausible range, it should be noted that they were derived from an experiment in which there were four specific tasks. It is possible that there are more than four, and that the drawers studied may use entirely different strategies in their typical drawing practice.

The roles of attention and memory are likely to be different in such differing patterns of activity, but present models of drawing and cognition are not able to account for these. The 'motor memory' hypothesis represents a significant step, but the extent to which this, and other types of memory, are used in various strategies remains unclear.

1.5 Summary and 'gaps in knowledge'

The review highlights a number of useful concepts defined by existing cognitive studies: 'gaze frequency', 'segmentation', 'eye-hand strategy', 'sighted' and 'blind drawing', 'proceduralisation' and 'routine' – these concepts will become useful as tools for interrogating the data presented in chapter 3.

Overall, this literature provides a picture of drawing in which knowledge and perceptual processes both play a part. Schematic knowledge provides cues about what to draw and how, and this is carried out through perceptual processes involving the direction of attention to visual details which are encoded to drawing actions through spatial and motor processing.

Observed patterns of drawing behaviour, such as those described above, can be interpreted to infer cognitive strategies. Observation of drawing process seems to be a fruitful avenue of enquiry, and the literature reviewed here offers some (limited) interpretation regarding the roles of attention and memory in drawing process:

- Frequent 'dwell cycles' are part of artists' 'attentional strategies', possibly functioning to minimise schematic interference.

- Visual memory is likely not involved in blind drawing, in the way assumed by the 'conventional interpretation'. Rather, propositional, spatial and motor forms of memory are implicated.

- Various types of eye-hand interaction can be labelled, and these possibly relate to different drawing approaches – for example, 'direct' and 'conventional' approaches are defined by Tchalenko.

This literature represents a significant advance in understanding over recent decades, but there is much still to be understood. Kozbelt et al. note that "understanding the psychological nature of representational drawing remains a major research challenge, and we suspect that investigations to date have only scratched the surface" (2010: 101).

Returning to the question posed in the introduction, we can now say that observational drawing skill involves cognitive strategies for allocating and using attention and memory. However, what those strategies actually consist of requires further scrutiny. The timing of drawing routines and eye-hand strategies have been observed in a handful of case-studies, but the cognitive basis of these strategies stands to be better explained. To consider *why* eye-hand strategies are timed with such regularity, this study aggregates recent insights about the nature of vision, attention and memory, to update and expand on existing accounts of drawing, in order to help explain a range of observed behaviours.

To this day, the exact roles of visual attention and memory are not fully understood. In particular, the extent to which artists ‘visualise’ or rely on ‘internal imagery’ is questioned in this literature, but not fully addressed; although a relationship with other modalities is noted. The nature, and even the existence, of internal imagery or internal ‘representations’ more generally (beyond drawing) is still a matter of some dispute. Chapter 4 reviews these debates, enabling further analysis of this matter in chapter 6: how does the artist ‘hold in mind’ visual information, and how is this balanced with perceiving external events and informing movement?

Similarly, although alluded to by artists, the role of ‘subconscious’ or ‘unconscious’ cognition in drawing is poorly explained, and a closer consideration of this requires clarity regarding those terms. Recent debates concerning the boundaries between conscious and unconscious cognitive processes are called on in chapter 4, and these contribute to further analysis (in chapters 5-7) of how the conscious mind guides the process, what elements occur below the conscious radar and the plasticity of that boundary.

This chapter surveyed prior cognitive studies of observational drawing process which focus mainly on strategies for constructing the drawing – for transcribing what is seen – but the creative control of the drawing (towards a desired outcome) must also find a space in the ‘cycle’ of hand-eye interaction. To scrutinise this, silent observation and timing of drawing activity is not enough: we can tell what the eye is focused on and for how long, but we cannot tell specifically what *about it* the artists is concerned with, or *how they are treating the information*. In order to ascertain that, this study asks the artists themselves to talk through their process.

Although verbalisation methods raise many issues (discussed in section 2.4), regarding the extent to which such reports can be considered valid or neutral and the extent to which they may interfere with the drawing, those issues are also of relevance to understanding the drawing process. That is, a skewed picture of drawing process may still be valuable if we are able to understand *the way in which* it is skewed and what might be omitted. In fact, the skewing of the reports is as interesting as the strategies they point to. What factors influence the filtering of verbal reports? How does it interfere with drawing? Is it always possible to verbalise drawing process? What is the relationship between visual and verbal modalities? Artist reports can offer some insight, as can secondary literature around verbalisation methods, and so these questions are is discussed in chapters 3 and 7 (with regard to the case studies and literature reviewed in chapter 4).

This literature review reveals scope for better explaining drawing process through theoretical analysis, but there is also much still to be observed. Single case-studies and expert-novice comparisons infer generalisations about expert behaviours (often correctly, e.g. faster and more regular dwell cycles) but such studies assume similarity between expert artists. This is perhaps an oversight on the part of psychologists; artists would know that expert strategies are likely to differ. In seeking a thorough explanation, it is important to differentiate idiosyncratic elements of drawing process from more universal ones. This study therefore proposes to identify individual strategies, thus enabling a comparison *between* artists to precede and inform a theoretical analysis. In this way, I seek to describe and explain a range of processes and behaviours, rather than a specific set or example.

It is on this basis that the current study proposes to observe and time drawing process in four experienced artists who, although all practice figurative drawing, differ in their approach and purpose. I will analyse their own accounts of their process and strategy and consider their behaviour patterns, first alone, then in light of recent cognitive literature. The preliminary analysis asks questions directly regarding the observed drawing processes: how are they timed, what categories of activity can be defined, what do artists say about their own process and strategies? This enables a preliminary comparison of drawing strategies, establishing differences and common characteristics. A further stage of analysis will then allow a second order of questions regarding the roles of attention and memory, questions left unanswered by the present literature review: how is visual attention focused and directed, what occurs deliberately (consciously), how are different modalities employed, what are the roles of long-term (schematic) memory and working memory?

In asking these questions, I seek to contribute to a more grounded understanding of drawing, necessary to several areas of research, including debates about the 'transferable' cognitive benefits of drawing alluded to by artists and art educators. In learning to draw, what specific skills are developed or gained? What set of cognitive abilities does drawing mobilise or refine, and how might they be transferable?

1.6 Bridging two approaches to studying drawing

While this literature constitutes an advance in our understanding of the mental apparatus employed in drawing, there remain disparities and gaps that necessitate resolution, if we are to develop the debates in pedagogically fruitful ways.

The literature reviewed here represents two perspectives. Artists and art historians give accounts of drawing process, which, while perhaps employing cognitive concepts such as attention and schema, are based on personal experience and historical analysis. They 'know' how to draw, but their cognitive explanations are limited by self-knowledge and vocabulary. On the other hand, there is more empirical research in which artists are taken as subjects to be studied, using methods such as video analysis, eye-tracking, and drawing tasks devised to address specific hypotheses. These offer complementary perspectives that potentially contribute to discourses around what drawing is, and to its present educational relevance. However, it is difficult to marry these perspectives. Psychologists' accounts offer concrete evidence of measurable phenomena. Although these tend to use limited variables, they are concerned with very specific details and tend to generalise about 'expert behaviours'. Artists' accounts lack empiricism, objectivity, reproducibility and precise terminology, but point to rich and holistic understandings of drawing practice and its real value, based on authentic experiences. The latter lack the certainty required to make a cogent argument for continued investment in drawing education, while the former are devised more dispassionately, not intended for this end (arts curricula are not the concern of cognitive psychologists).

It is in this context that the present study proposes to bridge these two camps. It uses quantitative and empirical methods, and theoretical frameworks and terminology borrowed from cognitive sciences, while also tapping into artists' self-knowledge of their own drawing process, recognising the potential contribution of subjective reports. As such, the 'gaps in knowledge' this study proposes to fill are not actually 'unknown'. Artists 'know' how to draw, and on some level this entails self-knowledge of the strategies and cognitive processes employed, albeit *tacit* knowledge. The contribution of this thesis is not to create such knowledge, but to reveal it. The following chapter details the tools and methods used for collecting and analysing evidence to this end.

Chapter 2.
Research design

"Like a camera with many lenses, first you view a broad sweep of the landscape. Subsequently you change your lens several times to bring scenes closer and closer into view." (Charmaz 2006: 14)

Chapter 1 surveyed cognitive studies and accounts of drawing, identified key terms and concepts, and reviewed contributions to understanding observational process. It also outlined scope for further inquiry into how attention, memory and knowledge are used in cognitive strategies for drawing. In this methodology, these questions are positioned so as to enable a more informed discussion of the potential transferability of the cognitive skills involved in observational drawing.

In devising this methodology I recognised that, while the cognitive study of drawing is a relatively recent endeavour, artists themselves already 'know' a great deal regarding drawing process demonstrated by their drawing ability and sometimes alluded to in their accounts of it. In this sense, the aim of this study is not so much to *create* knowledge about drawing process, as to *reveal* knowledge that already exists, albeit tacitly . The set of methods described in this chapter aims to understand the artists' strategies for drawing, to uncover their own self-knowledge of those strategies, and to interpret them in light of contemporary understandings of cognitive function. The extent to which it is possible to elucidate tacit knowledge about drawing will also come under question: what is it possible to document and talk about, and where is the limit?

In order to elucidate tacit knowledge involved in cognitive strategies that experienced artists use for observational drawing, this research project employs a hermeneutic approach; it seeks to "elucidate and make explicit our practical understanding of human actions by providing interpretations of them" (Packer 1985: 1088). The research relies on both quantitative and qualitative methods, comparing objective measures of observable drawing process (timing of movement) with subjective verbal reports. Theoretical resources from cognitive sciences are also mobilised in an analysis of the observed behaviours and reported strategies.

In this chapter I explain the scope and structure of the project, and discuss and justify the approach. Section 2.1 covers the questions used to interrogate the primary evidence, and the way in which the methods employed then proceed through two analytical phases (a case study analysis consisting of a behavioural analysis, and a 'protocol analysis' of the verbal reports). This is followed by a secondary theoretical analysis that interrogates the outcomes of the first, in relation to relevant cognitive theory.

Section 2.2 gives a summary overview of the project structure and 2.3 presents the preliminary questions in relation to the primary evidence, listing which forms of evidence will be scrutinised in relation to which questions.

In section 2.4 I begin to discuss the validity of the methods, raising issues concerning the verbal reports (pursued further, with hindsight, in chapter 7). Few studies of drawing have applied concurrent verbalisation techniques (I mention several of them in section 2.7.1). The use of that method here was experimental, in the sense that I was also interested in evaluating its usefulness in drawing studies and, in doing so, considering the effect of speaking on one's ability to draw (not only for methodological reasons, but also because talking is an important element of drawing instruction).

Section 2.5, explains the grounded theory approach and how it is applied to this research. I briefly cover the epistemological assumptions embedded in this methodology in 2.6. Section 2.7 covers how the specific data and data collection methods were arrived at, and why the selected artists were appropriate candidates. The final two sections (2.8 and 2.9) detail the particulars of the data collection procedures and methods for analysing the resulting evidence. There I describe how the project progresses through levels of analysis, from an initial consideration of directly observable phenomena, to a theoretical analysis that considers existing knowledge about cognitive function, through to a consideration of the insights about drawing skill emerging from this study in a broader educational context.

2.1 Approaching the research questions

What does observational drawing skill consist of, and how can we describe it? As noted in the previous chapter, we can expect that different artists possess different aptitudes and have different goals, and therefore employ different drawing strategies. Comparison of their drawing processes may reveal such differences, while similarities will point to more universal characteristics of drawing skill; characteristics that are a result of human cognitive capacities and limitations. This project seeks both to describe artists' divergent strategies and to identify more universal aspects of observational drawing skill. In doing so, it aims to enable a more considered treatment of questions around the broader value of these skills.

In order to describe and compare elements of a particular skill, what should we suppose 'skills' to consist of, and how does this study propose to treat them? A behavioural analysis would treat the person as a 'black box', considering only the concrete, observable aspects of phenomena, while a theoretical analysis could aim to "identify the underlying mechanisms responsible for observable phenomena" (Reif 2008: 19). As Frederic Reif notes, "theoretical concepts are useful because they allow much better predictions and explanations of observable phenomena than analyses focused solely on the phenomena themselves" (2008: 19). This study involves both approaches in two stages: a primary observational approach, concerned with the similarities and differences between artists' behaviours (and what they say about those); and a secondary theoretical approach, in which those observations are scrutinised in the context of a wider body of cognitive theory, in order to consider the 'underlying mechanisms'. This order avoids creating hypotheses based on prior theory, instead it generates theory that is 'grounded' in observation.

Reif (2008) stresses that, in a theoretical analysis that considers the educational relevance of cognitive perspectives, it is important to distinguish between 'knowledge' and 'thought processes'. Artists' 'attentional strategies' are the objects of investigation in this study (as opposed to specific *knowledge* associated with the appearance of things, representational conventions, or methods of image production). Artists' self-knowledge of their own thought processes will also come under scrutiny, as will the methods used to elicit this knowledge. In this respect, the main research question can be framed as: what cognitive strategies for drawing do experienced artists employ?

The inclusion of verbal reporting methods in the study raises further questions about the cognitive role of language in drawing process (which I discuss further in chapter 7). In this regard, the accuracy and comprehensiveness of the verbal reports is questionable. The extent to which spoken reports reflect 'thinking' is relevant to both the methodology and the research questions (i.e., what role does language play in drawing process?). therefore, as well as applying verbal methods, this study seeks to evaluate them: to assess their usefulness and validity to the study of observational drawing. Verbalisation is of interest as talking and writing are – other than drawing – the main activities in drawing tuition. A better understanding of the relationship between these activities may be of value, therefore. The questions outlined in the literature review can thus be listed and extended, as below.

- **What cognitive strategies for drawing do experienced artists employ?**
    - How do they differ from artist to artist?
    - What characteristics are common to such strategies?
- **How is attention used within cognitive strategies for drawing?**
    - In what ways is visual attention focused and directed?
    - What occurs deliberately (consciously) and automatically (unconsciously)?
- **What is the role of memory in observational drawing?**
    - How are different modalities (e.g. visual, motor) used?
    - What is the role of long-term (schematic) memory?
    - How is working memory allocated and used?
- **What is the role of language in observational drawing?**
    - Does propositional/verbal thinking accompany drawing activity?
    - Can talking interfere with drawing processes?

The reports also invite a consideration of the artists' self-knowledge *about* their skill**.** This distinction is significant as our skills are separable from our knowledge of them. It is possible to be able to do something without being able to say how, just as it is possible to nominally know how something should be done without the ability to do it. In this light, interpreting verbalisation presents itself as rather more complex than it first appears. Much of drawing skill is likely to be tacit, perhaps even ineffable.

'Tacit' is commonly defined as that which is "understood or implied without being stated" (OED 2012). This being the case, how might we come to discuss tacit elements of drawing, and how might a methodology elicit knowledge of this kind? Surely any spoken description would represent elements of the skill that are *not* tacit; by definition, the act of talking renders the knowledge explicit. However, we may still consider what is said, what is *not* said, and when. We can also compare the coincidence of talking and drawing activity. In doing so, the 'tacit dimension' of drawing process will come under scrutiny, in terms of what it involves and the extent to which it is possible to elicit a verbal report of it.

Thought processes are the object of study here, but in verbal reports they are mediated through the subject's knowledge of them, the ability to reflect on them, and the choices about how to describe them. This study triangulates several additional methods, accounting for different perspectives. While artists' accounts will be a rich source, these will be complemented by quantitative analysis of the timing of their looking behaviour and drawing activities, derived from video and eye tracking data. These methods are used in an inductive, grounded theory framework, summarised below.

2.2 A brief overview of the methodology

The choice of methods for data collection was driven by the research questions and the initial literature review, and the procedure for using those methods was devised through pilot studies. In turn, the analytical framework (codes and categories for data analysis) is derived from the primary evidence. The ongoing literature review informs a further stage of theoretical analysis that takes place after an initial interpretation of the primary data. In this manner, the research unfolds step-by-step, following a grounded theory approach, allowing findings to 'emerge'. Figure 3 illustrates this progression. By adopting such a methodology, the intention is to remain as transparent as possible, proposing testable and generalisable outcomes that are less ambiguous than those usually associated with artistic enquiry, but which do not confine themselves to pre-conceived, limited hypotheses.

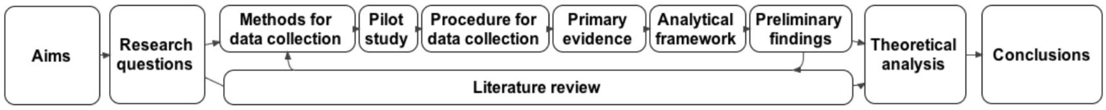


Figure 3. Summary overview of the project structure.

The procedures are developed iteratively - involving participants in determining how the verbal reports are given and which trials are used, by giving feedback on which reports they feel best reflect their thinking and how to proceed with further verbalisations. Similarly, eye-tracking trials are devised in response to emerging patterns in the video data. Both the researcher and the participants review the primary data many times, allowing initial interpretations to be entertained and discussed.

Transcription of the verbal reports is the next stage. This is key, as it allows ‘immersion in the data, and thereby a more detailed understanding of it’ (Bloor & Wood 2006: 167). The transcripts are parsed and coded, but the coding scheme is not predetermined. Rather, categories emerge in response to the content initial ones being treated tentatively and reviewed many times. Quantitative primary data is treated similarly, although the coding scheme is much simpler.

In this way the analytical framework is developed iteratively, in a process of coding and re-coding in response to primary evidence until a ‘saturation point’ has been reached (until all data can be accounted for by the coding scheme, and no new categories are necessary). The process involves “constructing analytic codes and categories from data, not from pre-conceived logically deduced hypotheses” (Glaser & Strauss, cited in Charmaz 2006: 6). Devising the coding scheme in this way allows a more neutral treatment of the data than would a pre-determined scheme structured around specific questions or hypotheses. The resulting scheme becomes a comparative tool that is tailored to the specific data.

With this method, the emergent scheme can then be treated as a theoretical construct, open to further scrutiny from theoretical perspectives. As such, the 'coding scheme' is a product of the analysis, rather than a tool constructed for the purposes of analysis. It is summarised (as a '2D' model) and then serves several purposes:

1. to describe and compare the case studies (in chapter 3);
2. as a framework to compare existing accounts of drawing and cognition 9in chapter 5);
3. to form the basis of a theoretical analysis aiming to verify, refine and explain the observed phenomena (chapter 6).

The theoretical analysis scrutinises the consistency of the model against existing theory, elaborating and further clarifying it.

In this way, the methodology first derives theories from primary evidence, and then re-appraises these in light of recent debates and findings in cognitive sciences. It refines and substantiates claims to knowledge by comparing observed phenomena and their interpretations, with what might be expected based on the most recent understandings of perception and cognition. In doing so, no paradigm has been favoured. Rather than try to 'prove' or consolidate theoretical perspectives, they are treated as 'lenses' through which to interpret the evidence. Existing theory is therefore not intended to 'dress the data' but to contribute to an understanding of its emergent characteristics.

The final model is grounded in primary evidence (observed behaviour and verbal reports) but also accounts for a broader theoretical context. This model is intended to both explain and predict drawing process, and ultimately to inform broader discussions around the value of the cognitive skills described.

2.3 Primary evidence and preliminary questions

The project involves four case studies, combining methods for data collection and analysis from a variety of disciplines (behavioural studies, cognitive psychology and social sciences). Protocol Analysis methods are used to elicit verbal reports of drawing process, both concurrently and retrospectively. Quantitative data about timing is also used as a complementary data set, in order to compare artists' activity with their reports of it.

Video footage of each artist drawing is made (as described in section 2.8) and analysed using behavioural analysis software (*Observer 10*) to allow close scrutiny of the timing of looking, drawing and talking activities, their durations, distribution and co-occurrence (see section 2.9.2). This requires the definition of codes and categories, deconstructing the drawing activity into distinct and identifiable 'behaviours'. These can be considered 'point events' (occurring instantaneously and periodically, with intervals) or 'state events' (continuous, durational and mutually exclusive within each category). Figure 4 shows the Observer interface.

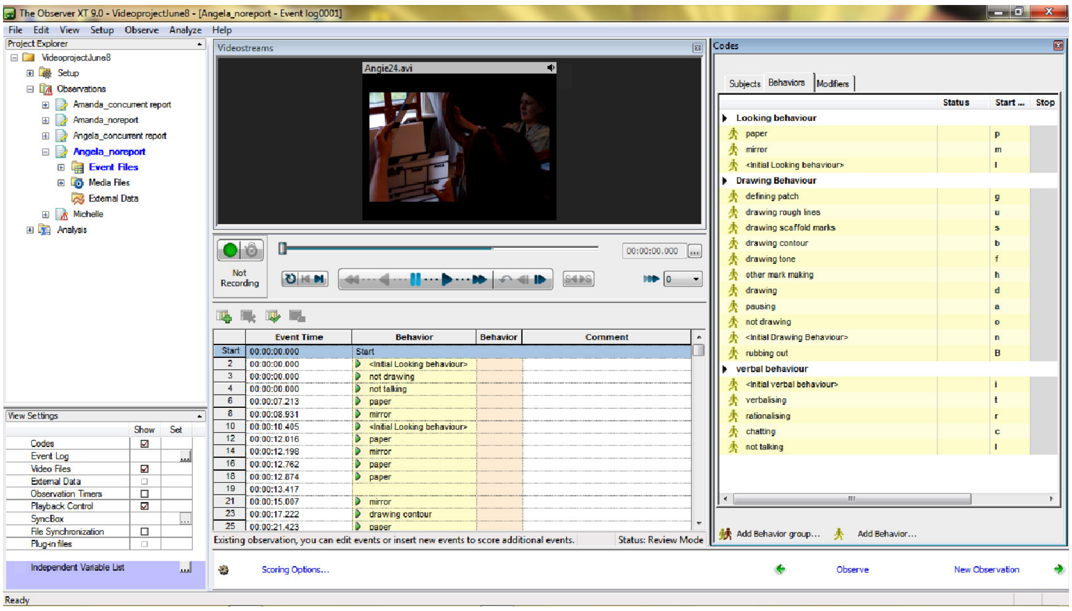


Figure 4. Screen grab from Observer X. The software allows footage to be reviewed frame by frame, while coding takes place. Here three behaviour groups have been defined with state events. Section 2.9 details the categories used in the final coding scheme.

This video data is complemented by eye-tracking studies, which allow a more detailed and accurate observation of scanpaths and patterns of looking. Video footage is complemented by further eye-tracking data from two of the four artists, which allows more detailed documentation of scanpaths (eye movements).

The verbal reports are transcribed and the concurrent reports are parsed and coded, as described in section 2.9.1 (see appendix A for coded transcripts). The specific categories for timing behaviours and comparing verbal reports are devised in response to the footage, as part of the data analysis procedure, described in section 2.9.

Both forms of evidence address the primary questions, shown in table 1. By first addressing these questions in relation to the primary evidence, this stage of the research aims to describe a range of drawing strategies, informing further theoretical analysis.

Primary research questions	Evidence	
	Verbal reports	Video & eye tracking
What cognitive strategies for drawing do experienced artists employ?		
How do they differ?	Comparison of reported goals and visual descriptions	Comparison of timing and eye-hand strategies (co-incidence of drawing and looking activities)
What characteristics are common to such strategies?	Comparison of reports	Comparison of pattern and distribution of activity
How is attention used within these?		
In what ways is visual attention focused and directed?	Types of visual details reported at different times during the process.	Scanpaths & gaze frequency, variation of glance duration
What occurs deliberately (consciously) and automatically (unconsciously)?	What is reported and omitted	Timing of looking activities
What is the role of memory?		
How are different modalities (e.g. visual, motor) used?	What types of features are referred to and when	Eye-hand strategies
What is the role of long-term (schematic) memory?	References to anatomy/perspectival systems/projected geometries	
How is working memory allocated and used?		Timing and eye-hand strategies
What is the role of language?		
Does propositional/verbal thinking accompany drawing activity?	Possibility of verbal reports; Ability to draw as usual while giving report	Coincidence of drawing activities and verbalisation
Can talking interfere with drawing processes?	Difficulties giving reports; Difficulties drawing while giving reports	Coincidence of drawing and talking activities; Effects of verbalisation on timing

Table 1. Research questions and evidence.

The verbal reports describe or indicate strategies by way of visual descriptions and mentioning of goals, while the video and eye tracking allow close observation and comparison of the timing and overlapping of behaviours.

Several comparisons can be made here: between concurrent and retrospective reports; between reported and observed behaviour (what they say and what they do); and between observed behaviour in verbalised and non-verbalised conditions.

The questions listed here cannot be fully answered using only the case studies, but the outcome of this primary analysis will result in a description and comparison of a range of artists' cognitive strategies, enabling these questions to be further considered in the theoretical analysis.

2.4 Issues surrounding verbal reports and observational data

While this thesis aims to remain grounded in observed phenomena, methods for observing are never entirely transparent. Tools for recording data, such as the eye-tracker, are 'inscription devices' (as defined by Bruno Latour and Steve Woolgar 1979) which themselves were devised relying on many working assumptions about the nature of the phenomena to be observed. As such they run the risk of colouring or skewing the data or at least omitting aspects of it. Verbal reporting methods are also of this nature, perhaps even more so.

There is an analogy to be made here with observed drawing. The history of the drawer (e.g. their skills, their knowledge about the subject matter and the nature of their interest in it, their awareness of the values of their community of practice) influences which features they choose to draw and how. No observed drawing is regarded as truly objective. Given Latour and Woolgar's caution, it might even be argued that no representation is ever entirely impartial. Even the eye itself is the result of evolutionary processes and gives us only a very limited view of the world, however full and rich it may seem. In the same way, there are many spaces in which the phenomena observed in this study may be partially treated.

Given this, it seems appropriate to consider the validity of the data before proceeding with the analysis. Quantitative data (gained from video and eye tracking) can be easily verified. Where a participant is looking at any given time, what they are doing and for how long, can be timed precisely. Although, arguably, the parameters and categories for segmenting activities could have been devised differently, they are reasonably straight forward (drawing/not drawing, looking/not looking), and timed precisely. (Scrutiny of eye-tracking methods is perhaps an area for sociology of science to deal with and outside the present scope.) Verbal reports, on the other hand, are a more questionable source of evidence. There are many more opportunities for such data to become skewed. The following section argues that they cannot be treated as a full or objective narrative of thought processes, only as a reflection of what participants themselves believe to be their thought process, and what they deem relevant enough to verbalise. The reports are possibly subject to biasing factors, such as the perceived purpose of the report (possibly based on the experimental context) and possible misconceptions or post-rationalisations on the artists' part, about the nature of their own thinking (inferential bias). There will also be idiosyncrasies in vocabulary, requiring some construal on the researcher's part. The following section, therefore, discusses issues surrounding verbal reports and their interpretation. (This discussion is continued in chapter 7 with reference to the actual results).

2.4.1 Contentions about concurrent reports

Karl Ericsson and Herbert Simon define concurrent and immediate retrospective verbal reports as "powerful means for gaining information" about specific cognitive processes (1993: 30). However, Ericsson observes that there has been "considerable controversy over the extent to which experts are capable of explaining the nature and structure of their exceptional performance" (2006: 223). Self-reports were more or less abandoned in the mid-20th Century as valid sources of data, in favour of behaviourist approaches, on the basis of several contentions:

- accounts often proved to be inconsistent between experts (Binet 1983/1966, cited in Ericsson 2006)
- discrepancies were often found between reported strategies and observed behaviours (Watson 1913, cited in Ericsson 2006)
- self-observation during performance could change the content of ongoing thought processes

Although extensive evidence has been presented against the third point (reviewed by Ericsson (2006: 223-227), such evidence is mainly derived from tasks more easily verbalised than drawing. as they are more propositional in nature, and include pauses for considering the next action (for example, mental arithmetic, chess or puzzles). Those studies indicate that the 'underlying structure of thought processes' (including the order) is not changed by concurrent verbalisation, although it may be slowed down. However, perhaps more significantly in relation to the present research, further evidence has been presented that indicates concurrent verbal reports often actually *enhance* performance. For example, Robert Gagné and Ernest Smith (1962) observed that participants solved the 'Tower of Hanoi' task with fewer moves when required to verbalise their reasons for each move[1]. This evidence suggests that, while concurrent reports cannot be considered a transparent reflection of thought processes, they are nevertheless a rich source, even interesting on more levels, due to the factors described above.

Performance effects associated with concurrent reports are accounted for in the present study by comparison of trials in verbalised and non-verbalised conditions. Besides the descriptive content of artists' accounts, it will be interesting to observe what types of descriptions artists are *able to* give, and the relationship to the drawing activity taking place. What is *not* reported will therefore also be of interest. This is discussed further in chapter 8, which identifies patterns in observed behaviours and verbalisations, proposing a model for understanding what kinds of drawing and talking activity are possible concurrently, inferring ways in which artists are utilising different facets of working memory.

A further issue is whether drawing process can be considered propositional in nature. That is, whether drawing process is verbalisable at all, or at least the extent to which any verbal description of drawing process can truly reflect the cognitive mechanisms at play (this is also discussed further in chapter 8). It is unlikely that experienced artists narrate to themselves all details of the process they are using to draw, at least not in a way that can be directly vocalised. They will be using a range of modalities including visual and tactile senses, requiring some translation before verbalisation.

[1] They also indicated that this improved 'transfer' to more complex problems (discussed further in chapter 8).

Ericsson and Simon (1993) differentiate between two 'levels' of concurrent vocalisation on this basis. Problem solving tasks, such as those mentioned earlier (chess, puzzles, etc.) can usually be considered 'level one' (talk-aloud) vocalisations, while drawing would be considered 'level two' (think-aloud) because the 'information heeded' is not vocalised directly, but one or more mediating processes occur before speaking. Figure 5 illustrates how the 'think-aloud' protocol requires an additional level of encoding, in which words do not come automatically, but must be chosen or formulated to describe cognitive activity.

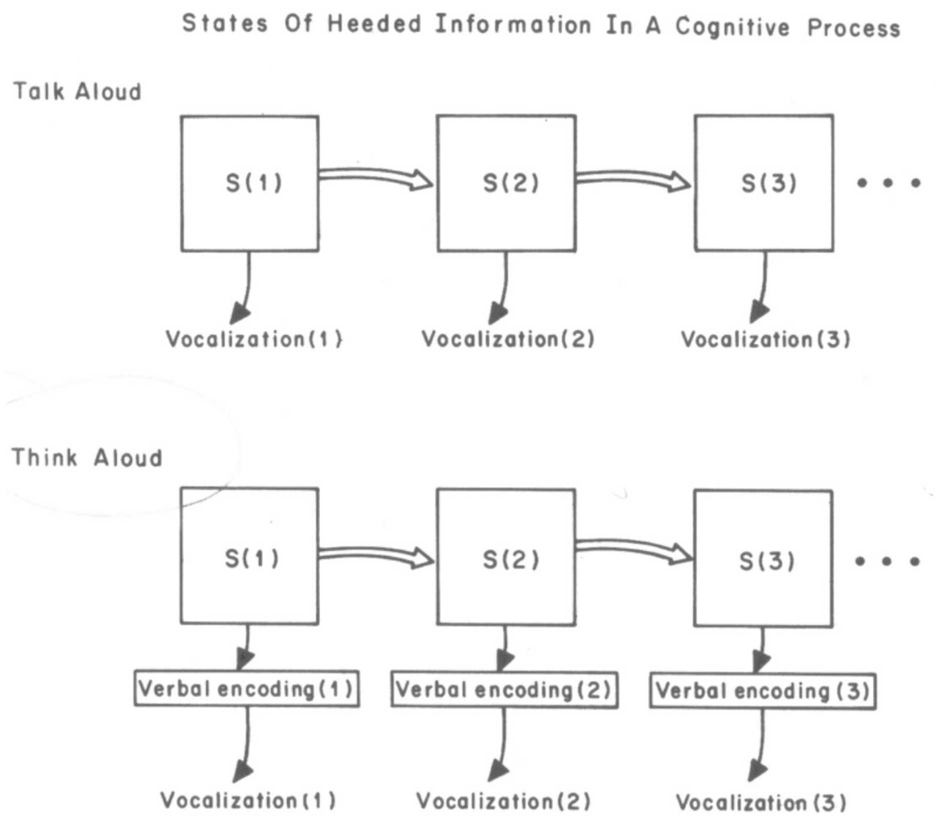


Figure 5. Two types of vocalisation (from Ericsson & Simon 1993: 17).

The protocol used in this study can therefore be described as ‘think-aloud’. The resulting data is less reliable than that from ‘talk-aloud’ protocols due to variability associated with this additional stage of processing. It is more likely to slow down the cognitive processes it is concerned with, and involves a selection process (about what to report) as well as a translation process, as discussed further in chapter 7).

Ericsson describes Protocol Analysis (PA) as “a tool that allows researchers to identify information that pass through expert performers’ attention while they generate their behavior without the need to embrace any controversial theoretical assumptions” (2006: 237). However, implicit in this model is the assumption that cognition is a serial process. This assumption is convenient to PA methods, as a verbalised stream of thoughts is by nature serial – we can only utter one word at a time. Verbal reports are then well suited to exploring hypotheses that also assume seriality. This thesis does not make that assumption, rather it questions the temporal nature of the cognitive processes involved in drawing and acknowledges parallel processing.

Given this, the analysis is concerned not only with the *content* of the verbal reports, but with the artists’ ability to report while drawing, and any practice effects. The content of the reports are also considered in relation to the quantitative data, enabling a comparison between what the artists describe they are doing, and what they are actually doing.

2.4.2 Issues with retrospective reports

Retrospective reports can complement concurrent reports, revealing aspects of the process not included previously through multiple reviews. However, they come with their own set of validity issues.

With retrospective reports, timing is crucial. Usually, short tasks (5-10 seconds) with short response latencies are used (with responses given immediately after completion), as the validity of this type of report is considered to be high – the participant being able to recall a manageable amount from STM. For longer tasks recall becomes more difficult, hence the importance of conducting retrospective reports immediately, and the use of video as a prompt.

However, even with video to aid memory, the risk of '**inferential bias'** is increased in longer tasks, as the participant is more likely to be tempted to infer what they were probably thinking:

> Because participants can access only the end-products of their cognitive processes during perception and memory *retrieval*, and they cannot report why only one of several logically possible thoughts entered their attention, they must make inferences or confabulate answers to such questions. (Ericsson 2006: 230)

Inferential bias in retrospective reports has been demonstrated, particularly in response to 'why' questions (e.g. Nisbett & Wilson 1977). Explanations should therefore be treated tentatively. Certain factors may also encourage or otherwise affect the reports:

- gaps between the activity and the report
- perceived pressure to speak
- discomfort or distractions (away from the film)
- perceived purpose of the report/study

The following measures will be taken to minimise this:

- retrospective reports must be conducted immediately
- making clear that periods of silence are acceptable
- ensuring the comfort of the participants (both physical and psychological)
- a description of the aims of the project that is clear enough to satisfy curiosity, but not mentioning specific hypotheses before the trial
- chosen participants must not have a vested interest in the outcomes of the research

Another factor to take into account is the way questions are posed. In order to minimise the influence of the researcher, the interview starts with very general, open-ended questions and works towards more specific questions which respond to previous statements, for clarification and explanation. In addition to this, the artists are encouraged to draw, as necessary, to supplement their retrospective reports when describing their process. These sketches are also filmed and this enhances the interpretation of the retrospective reports.

Similar problems are associated with interviews of experts who often show difficulties in fully describing their methods (see Hoffman 1992). For this reason, PA studies increasingly use eye-tracking to study the processes mediating perception and memory, in addition to verbal reports. For example Merim Bilalić, Peter McLeod, and Fernand Gobet's (2008) study of chess players was able to show that experts reported seeking a better solution to a problem (i.e. the next move), while their eye movements revealed they were still attending to features of the solution previously devised. Using both verbal reports and behavioural analysis in tandem seems to provide a good solution for accounting for inferential bias and omitted details.

However, eye movements involved with drawing are very complex and difficult to interpret. The present study introduces a shorter, simplified task in order to gain eye-tracking data pertaining to specific drawing activities. The results represent a finer level of detail than data from the video analysis alone. Earlier eye tracking studies also used simplified tasks, for example, Tchalenko (2009) asked participants to copy a simple line, instructing them where to begin and end, in order to minimise their decisions about how to represent the object with line, and focus on characteristic eye movements. However, this type of simplification also minimises individual differences in strategy, which we are interested in here. The present study focuses mainly on more natural drawing tasks using the instruction 'draw as you usually would', and only uses simplified tasks to isolate certain actions (using simple lines generated by the artist, rather than standardised ones).

Despite the risk of inferential bias, retrospective reports remain a useful tool in this study, when used in combination with other tools; eye tracking and video analysis. While the verbal reports can be seen as neither exhaustive nor neutral, and their use may actually affect the process they aim to describe, it is these problematic aspects of verbal reports that offer the most food for thought, in attempting to understand the relationship between drawing, thinking, speaking and learning.

While there are issues around potential bias from both the participants and the researcher (through the research design and interpretation of data), it is possible to seek to minimise the risks. While grounded theory was originally developed as a research framework for the social sciences, it includes many relevant strategies for neutralising potential researcher bias through open ended methods for data collection and analysis, as described below.

2.5 Grounded theory

Grounded theory approaches acknowledge data from a variety of sources, initially comparing data to data, then comparing data to emerging theory (Glaser 1998) and to secondary sources. In this model, concepts are developed "by studying the data and examining our ideas through successive levels of analysis" (Charmaz 2006: 17).

> Theoretical categories must be developed from analysis of the collected data and must fit them: these categories must explain the data they subsume. Thus grounded theorists cannot shop their disciplinary stores for preconceived concepts and dress their data in them. (Charmaz 2000: 251)

As such, it seeks to 'ground' theories in observable phenomena in a bottom-up approach.

Klaus Krippendorff (2004) criticises this approach for assuming sources to 'contain' meaning; "there is nothing inherent in a text; the meanings of a text are always brought to it by someone" (2004: 22). The same must be true of drawing and verbal accounts. 'Allowing' codes and categories to 'emerge' from data (rather than pre-defining them) is likely still influenced on some level (however unconscious) by the researcher's preconceived notions, cultural conditioning or knowledge of the situation. However, Krippendorff assumes this to be undesirable. It is worth noting here that I (the researcher) also have an active drawing practice, and am therefore perhaps better placed to interpret artists' accounts than an 'objective' third party. That is, any meaning 'contained' in the artists' reports might be more readily recognised by someone who draws, for the very same reasons Krippendorff mentions.

Brian Haig (1995), Steven Miller and Marcel Fredericks (1999) argue that the grounded theory model of induction can, in practice, be 'abduction', in that 'discoveries' may in fact be constructed or inferred. Similarly, Gary Thomas and David James (2006) question the 'epistemic security' promised by grounded theory. In their view, grounded theories can resemble 'invention' more than 'discovery' due to interpretive methods.

Charmaz, however, proposes a 'constructivist' model of grounded theory that claims to "bridge traditional positivistic methods with interpretative methods' (Charmaz 1995: 30), acknowledging the interpretive role of the researcher. The grounded approach includes the researcher as an active contributor who generates meaning from data, and must be personally 'immersed' in it. The approach seeks to avoid not the personal view of the researcher, but the biasing influence of specific hypotheses during the early stages of the research. Indeed, hypotheses can be the outcomes of such an approach, rather than the starting point. It has been argued that traditional modes of enquiry that position themselves as 'objective' 'hide assumptions' (Datson & Galison 2007; Datson 2004), in that they do not account for situated knowledge. Grounded theory is a more careful approach, as it brings into the project the unquestioned assumptions that 'objective' methodologies hide.

Ian Dey (1999) notes that verification is 'a puzzle' and the role of prior theory is unclear in early grounded theory models, suggesting that there is room for development in formulations of the approach. While Thomas and James (2006) criticise 'continual reinventions' of grounded theory, whose approaches can be far from those proposed by Glaser and Strauss, it is clear that grounded theory is necessarily flexible and is itself open to interpretation depending on the research context and aims.

This study proposes to use Charmaz's formulation, deriving initial tentative theory from primary data only, without pre-determined hypotheses. Only after this can subsequent stage of analysis account for prior theory.

In Charmaz's model, primary data is first analysed through an initial coding process. Conceptual categories begin to emerge from this, allowing comparisons to be made between data, which can influence subsequent sampling if appropriate (new data is then compared to emerging theory, and it is refined). This project follows these steps, with a secondary level of analysis that compares the 'emerging theory' to prior theory (contemporary cognitive perspectives). In this way, grounded theory provides a framework within which behavioural data can be analysed and interpreted emergently, without 'dressing the data'. Such an approach is consistent with the epistemic perspective taken in this research.

2.6 Epistemological standpoint

This project considers knowledge to be not simply 'discovered' but built from an accumulation of working assumptions, within networks of research practices. The theoretical framework is subtended by this approach. The knowledge generated, i.e., the theory developed using this methodology, should be seen as 'constructed' in this sense. The model arrived at is therefore not presented as a definitive or superior way to consider drawing skill, but simply as one possible framework offering potentially useful insights. A framework open to scrutiny, and that can act as a source of hypotheses for further deductive testing.

The data gathered is multifaceted. Artists' cognitive and drawing processes vary considerably. While their behaviour is observed, cognitive processes are not observed directly, but funnelled through the artists' own knowledge/awareness through verbal reports. In this sense, the skill itself is obscured on a number of levels: by limitations in the artist's self-knowledge; by limitations in their ability to access and report this knowledge within a given time; by limitations of language (although this is balanced with quantitative methods). While these factors render the data very complex, the complexities and disparities between individuals become interesting. To access and analyse this subjective and 'tacit' knowledge, and account for disparities, requires multiple perspectives and multiple methods.

2.6.1 The role of tacit knowledge in research

> The declared aim of science is to establish a strictly detached, objective knowledge. Any falling short of this ideal is accepted only as a temporary imperfection, which we must aim at eliminating. But suppose that tacit thought forms an indispensable part of all knowledge, then the ideal of eliminating all personal elements of knowledge would, in effect, aim at the destruction of all knowledge. The ideal of exact science would turn out to be fundamentally misleading and possibly a source of devastating fallacies. (Polanyi 1966: 20)

"Pierre Bourdieu argues that tacit knowledge and the alternative logic of practice underpins all discovery; and yet the operation of this logic is often overlooked because it is subsumed into the rational logic of discursive accounts of artistic production" (cited in Barrett & Bolt 2007: 4). This is significant in considering the object of study: an enquiry into the tacit must tread carefully among established paradigms in order not to overlook that which is sought, in pursuit of 'objective' knowledge. Also in considering the role of the researcher, this perspective positions the artist-as-researcher as an active participant in the study, rather than an external or transparent conduit. If we are to accept that the "subjective is already implicit in the objective" (Varela & Shear 1999: 1), both the participants' and the researcher's knowledge are to be viewed not as objective, but as embodied and situated, and comprising tacit, yet valid, elements.

Donna Haraway voices a case for the weight of embodied, situated knowledge. She talks of a 'partial perspective', and "would like to insist on the embodied nature of all vision and so reclaim the sensory system that has been used to signify a leap out of the marked body and into a conquering gaze from nowhere" (1991: 188). John Law, in turn, identifies "a need to rethink our ideas about clarity and rigour, and find ways of knowing the indistinct and the slippery without trying to grasp and hold them tight", proposing a 'situated inquiry' which takes into account "our relations with whatever it is we know, and ask how far the process of knowing also brings it into being" (2004: 3).

In the light of the above, how should objectivity be practiced in the study of an experience as subjective as drawing, when the subjective is routinely rendered invisible by established epistemes? The position of this thesis is that a 'situated enquiry' into drawing must not only account for the subjective, it may draw on it as a resource, the subjective aspect of the drawing process being reflected by subjective accounts.

2.7 Seeking appropriate data

The forms of evidence used include verbal reports, video and eye-tracking data. These have been used in previous studies of drawing, outlined below.

2.7.1 Existing studies of drawing using eye tracking and verbal reports

Verbalisation and self-reports have been used in a number of drawing studies to date. Notably, Van Sommers' (1995) study had artists give concurrent accounts of drawing, arguing that concurrent reports were preferable to retrospective reports as they reduced the risk of memory-related distortions. However, the majority of researchers favour retrospective reports due to the extent concurrent reporting interferes with the drawing situation, compromising the validity of the results. Most use memory cues to improve the validity and specificity of retrospective reports.

Geoffrey Bailey's (1982) phenomenological study of observational drawing used time-lapse photographs of drawing process to prompt responses, but more recent studies have used video for these purposes. George Whale's (2006) study of observational drawing strategy used video to prompt retrospective accounts in semi-structured interviews. Whale, like others, favoured retrospective accounts of drawing, reasoning that concurrent accounts affected the 'ecological validity' of the drawing situation. He used these methods to define features of spatial strategies, used by his sample group of artists for constructing observed images. The presence of the drawing itself was also important to aid memory, and the interviews were conducted with a view through to the drawing studio.

Studies of design and architectural drawing have also used both concurrent and retrospective interview. Again, retrospective reports are favoured, for similar stated reasons, and video is often used to cue memory. A number of Suwa and Tversky's studies have used video to cue retrospective reports of architectural sketching, in order to gain detailed information about what the architect was thinking 'for each stroke of the pencil', e.g.:

> While watching their own videotapes, participants were asked to remember and report what they were thinking as they drew each portion of each sketch. Participants were not interrupted with questions during the report. We recorded the participants' voices as well as videotaped the screen itself on which not only their sketching activity in the design task but also their pointing gestures in the report task were visible. (Suwa & Tversky 1997: 3)

This method was intended to glean information about the way attention was focused during sketching. Filming the retrospective report during video review appears to be an effective method.

These studies represent precedents for the use of concurrent and retrospective reporting in studies of drawing process. These methods were adapted for this project, although they could not be applied directly, and consideration was needed regarding the specific procedure for data collection, as described below.

2.7.2 Developing the procedure for data collection and qualitative analysis

Pilot studies were used to test the applicability of the methods mentioned above, and to develop and refine the procedures for data collection and analysis.

Initial experimentation with verbal reporting took place over several months with three volunteers (PhD students with drawing practices, one of whom Angela Brew - is included in the analysed results). This revealed possibilities, and also limitations. All participants were able to report retrospectively, and this proved most effective immediately after drawing. Reviewing the video successive times seemed to enhance the description as more detail could be added with each review. It became apparent that allowing the participant to pause and slow down the footage also facilitated this process.

Concurrent reporting was more problematic, and at first seemed unfeasible, as it visibly affected the drawing process. There seemed to be two factors in this. First, the essence of the verbal reporting task was difficult to communicate (some attempts at verbalisation revealed misunderstandings about what was required). Second, drawing is less conducive to verbalisation than other tasks usually studied with this method, and the verbalisation task seemed to actually interfere with the making of the drawing in some instances. In the early trials and pilot studies, participants paused in order to talk, which distracted them from the process, or they were not satisfied their drawing was unaffected by it. The initial prompt "report what you are attending to" proved too leading, and led one participant to skew the emphasis of her gaze. Expectably, the process was slower and involved more pauses than usual, but these were mainly directed towards the subject. Overall, the participant spent more additional time looking at the subject while talking, indicating that her response was only partial, and probably lacking elements of her process that took place during glances to the paper.

The problem of communicating the task was solved with the introduction of unrelated practice tasks early in the procedure (described below in the procedure section), which allowed a discussion of the difference between concurrent and retrospective reporting and provided opportunity to query the instruction. The second problem remained unresolved, but it was decided to persevere with this method as its *limitations* were of interest to the research questions, and became themselves objects of study. With a number of trial runs, participants generally found ways of verbalising their process that they felt comfortable with.

The retrospective reporting was less problematic, but it became clear that the results were most valid when the initial prompts were as open ended as possible, in order to avoid potential biasing of statements. Specific or directed questioning belonged only after the participant's first responses to their own footage. These were made in response to previous statements, in keeping with the 'emergent' methodology. Although the method for data collection was still emerging, data from the last of the pilot studies is included as it was key to initial development of the coding schemes and it provided a meaningful point of comparison for the three further studies.

Subsequent studies also showed concurrent reporting to slow down the looking and drawing processes, but the slowing was not skewed towards the paper or the mirror. Assuming that the reports still only reflect a portion of the thought processes, instructions were revised to "please think aloud", which revealed to be more neutral. Its meaning was clarified by the practice task, leaving decisions about *what* to report up to the participant. Studies with more specific hypotheses could have employed more directed questioning (for example the artist could be asked to report only when they are making a decision, only when they are making a measurement, or only when attending to a specific type of detail, and so on) but here an open-ended approach was favoured in order to avoid the influence of directed questions.

Elements of the coding scheme were identified during these early stages but the final scheme was not resolved until much later, during analysis of the main trials. For simplicity's sake, only two versions of the coding scheme are presented in chapter 3 to illustrate the process of devising the scheme. While the instructions remained consistent throughout the three main studies, each artist responded very differently to the task, and devised their own approach to verbalising. This is discussed in chapter 3.

2.7.3 Participants

Artists studied were selected for the main study on the basis of expertise in observational drawing.

A large sample of artists were invited by email to volunteer in the study. The sample was a non-probability sample; there was no randomisation. A small sample was required (four artists participated in the main study) and a range of approaches to observational drawing was sought. The sample was selected by the researcher, on the basis of the artists' practice. The only criteria for 'expertise' was an established and regular practice of drawing that involves observation of human subjects. They included portrait artists (members of the Royal Society for Portrait Painters - RSP), figurative painters with well established practices, and postgraduate students carrying out practice-based research involving observational drawing.

The chosen respondents all spoke English as a first language (in order to avoid potential problems with verbal reports). The sample was balanced in terms of age and gender (as far as possible with such a small sample), although the demographics of the individuals were less important than the characteristics of their drawing practices, as it was not intended to make generalised comparisons based on demographics, but rather to closely compare divergent approaches.

The artists in the pilot study were Ph.D. students making practice-based drawing research, who were willing to participate in extended trials. The four artists selected for the main study included two Ph.D. students and two members of the RSP. These were deemed a suitable sample as their styles and approaches to drawing differed markedly. The artists' practices were selected for diversity on a number of criteria:

- audience (for commissions or as part of a more self driven practice)
- treatment (portraiture or figure)
- reported aims (achieving a good likeness, aesthetics, exploring the drawing process itself)
- usual media (paint, ink, charcoal or watercolour – although all use graphite in the trials)
- style/aesthetic (linear or tonal, gestural or measured, loose or precise)

2.8 Main study

2.8.1 Ethics

Each artist was briefed, indicating what would be asked of them during the trial and that data pertaining to their footage would be kept and may be used in published material. They were given a consent form, and asked if they had any medical conditions that might be exacerbated by the trial. Before proceeding, they were reminded that they were able to opt out of the trial at any time and could revoke permission to use or keep their footage or drawings.

2.8.2 Data collection

Artists were visited in their studios where the equipment would be set up. Each artist was given the same sequence of tasks.

2.8.3 Equipment and set-up

A drawing board and mirror were positioned near each other, and the artist consulted on positioning the set-up (if they were right or left handed, preferred to stand or sit, their preferred scale, and so on), although there were some restrictions on layout (paper and mirror had to be reasonably close together so as to both be captured on camera at once). A digital video camera was mounted on a tripod behind and above the artist's head, to capture both the artist (reflected in the mirror, with eyes visible) and their drawing. The camera also recorded sound. (Later trials used a head mounted eye tracker, rather than a camera – see 5.3.3.) (More than one recording device could have been used, e.g. to film the artist and the drawing separately, but using only one ensured that there was no margin for error in synchronising timing, and the footage could be quickly transferred without editing).

A laptop and data projector were also set up to project the footage back onto the same drawing board for later review. The projection was adjusted to be at a similar size and position to the original, so that the artist could review footage of their progressing drawing and hand movements in-situ. Paper would be placed over the mirror during review if necessary, so that the artists' eye and head movements could also be seen. This entails positioning the projector and camera close to each other, with both as perpendicular to the board as possible, making sure the artist's head is not significantly occluding the mirror or paper. This was not always easy, but solutions were found in each studio. Figure 6 shows stills from the footage for each artist.

Figure 6. Video stills showing studio set up. The camera and projector were mounted on tall tripods above and behind the artists, ensuring that both the drawing and the artists' eyes were visible at all times.

Footage would be transferred to the laptop via memory-card, ready to transition between making and reviewing drawings as quickly as possible. The video camera remained in place during review, and retrospective reports were recorded in the same manner.

The researcher stood behind the artist during drawing to avoid distracting their gaze, while monitoring the video camera and live drawing process during the trials. During review, the researcher would sit or stand nearby to give instructions and further discuss the footage.

2.8.4 Procedure

1. **Initial footage**

   The artist is asked to draw him/herself from a mirror for a short time (5 – 10 minutes) and to go about it “as they usually would”, in a format and size they find familiar, using a pencil or graphite stick.

   A number of drawings are made until the participant feels comfortable with the setup, and would agree that they are drawing in a manner and pace which feels natural to them and typical of their usual process.

2. **Briefing**

   The participant is then briefed about the concurrent and retrospective report using a practice task. They are given the following instructions for concurrent reporting:

   - ‘Think aloud throughout the task, just say what comes to mind naturally’;
   - ‘Do not give explanations, unless you would usually think them through to yourself when alone’;
   - ‘Don’t worry about using full sentences or correct grammar';
   - ‘Try to keep talking’;
   - ‘Report what you can remember about your thinking from the moment I give the task to the moment you think of the answer’.

   They are then given the practice task (taken from Ericsson & Simon 1993 [1980]: 378) in which they count the number of windows in their house while thinking aloud. They are given the instruction:

   - ‘Now tell me what you can remember about your thinking.’

   Once the initial drawing and practice task are completed, the difference between the concurrent and retrospective report is discussed, to ensure the participant understands the distinction, and any issues are addressed. Once their response demonstrates a grasp of what is being asked for in the concurrent and retrospective reports, the next stage can begin.

3. **Concurrent account: think-aloud protocol**. The participant was asked to draw again for 5-10 minutes, as in the initial footage, and given the instruction to 'think aloud' while drawing. The artist is reminded of the instructions above or prompted if necessary.

4. **Immediate response**. Immediately after the drawing, the artist is asked about their experience of giving the verbal reports, if they felt it interfered with their drawing and if they want to repeat the process. Steps 3 and 4 are repeated until both the experimenter and the participant are satisfied with the verbal report.

5. **Retrospective report**. The participant then chooses footage to review, and asked to retrospectively report what they can remember about their thinking, as in the practice task. It is important that the retrospective report be made as soon as possible after the concurrent report. It is mentioned that it is acceptable to be silent if nothing comes to mind, and that the video can be paused and reviewed at will. The footage is reviewed a number of times with varying degrees of prompting:

    a. No prompt
    b. Some prompts based on previous statements or actions in the footage, e.g. 'Why did you pause there?' or 'Can you explain what you meant when you said that?'
    c. Further questions based on actions and statements from other participants.

6. **Evaluation.** The drawing strategy is then discussed and summarised between the artist and the researcher.

2.8.5 Eye-tracking task

The eye-tracking task was devised after the video trials, and two of the four artists re-visited.

2.8.5.1 Equipment and set-up

The eye tracker is a piece of equipment capable of measuring the direction and duration of eye movements. This enabled documentation of eye-movements within glances to the paper and mirror, as well as gross movements between the paper and mirror as in the video studies.

A mobile, head mounted, binocular eye-tracking system was used. (SMI Eye tracking glasses, used together with SMI ETG Laptop and data capture software: SMI I-View 10.2). The glasses include three cameras: one HD camera captures the scene in front of the wearer, the other two capture their eye movements, which are treated as co-ordinates. This allows live viewing of eye movements superimposed onto the scene video in real time. I-View converts the eye videos into data files (.edf). These were exported with video files into BeGaze 3.2, which associates the files and superimposes scanpaths onto the scene footage. Parameters were set to log any fixation above 80 milliseconds. That is, if the eyes rest on the same spot for more than 80ms this is categorised as a single 'fixation', movement between points being 'saccades'. Blinks were also registered. (Some eye-tracking studies use 50ms as a minimum fixation duration; since the majority of fixations captured were well over 150ms, 80ms was an adequate minimum duration parameter).

2.8.5.2 Procedure

1. **Calibrate eye-tracker**. The wearer is asked to look at 5 dots (drawn on the paper) sequentially, so their fixations can be located in order to calibrate the equipment (matching scene views with real-time eye-data).
2. **5 minute self-portrait.** Participants are given the same instruction as before: to draw for five minutes a self-portrait from a mirror, not worrying about 'finishing'.
3. **Profile contour drawing**. Participants were asked to draw someone else (the researcher or, in AC's case, his daughter) in profile view. A simple line describing the

profile was requested. This task is also repeated several times. The eye tracker is active for at least 30 seconds before and after the drawing takes place.

4. **Profile contour copy**. The line drawn is then placed beside a new sheet of paper and participants are instructed to copy the line they drew previously.

2.9. Analysis methodology

2.9.1 Qualitative analysis of verbal reports

Verbal reports were transcribed from the video footage and these were parsed and categorised as separate statements. The grounded theory approach used in this study differs from the usual structure of protocol analysis (the methodology from which the methods for eliciting and analysing verbal reports was borrowed). The process would typically begin by defining the coding scheme prior to data collection (as shown in Figure 7), but a more neutral approach was sought here, as mentioned above.

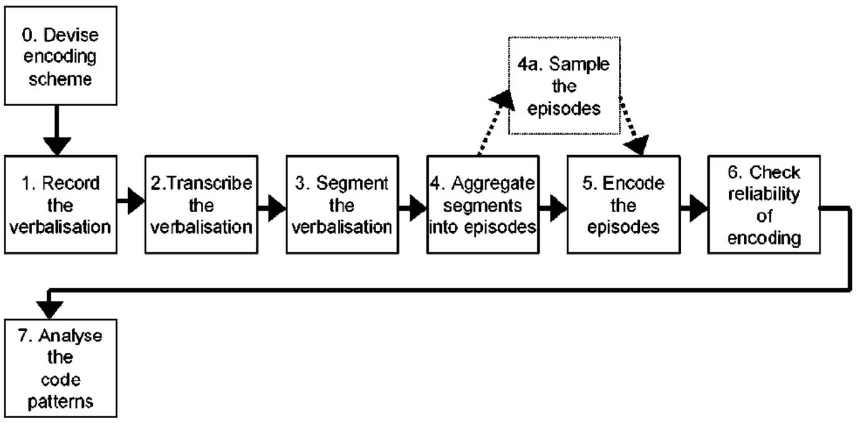


Figure 7. Stages of verbal protocol analysis (from Hughes & Parkes 2003: 128).

Using the grounded theory framework allowed a more open-ended approach. Figure 8 shows the alternative stages used. Here, rather than a strictly sequential process, the data collection continues as the coding scheme is devised and reviewed in successive iterations.

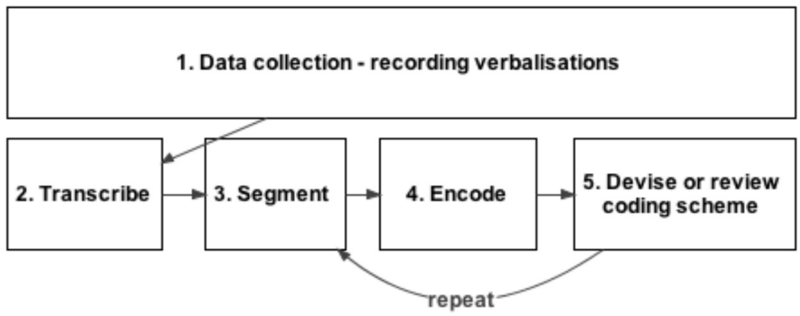


Figure 8. Alternative stages of protocol analysis used in this project.

As new data comes to light, new codes and categories must be added to the scheme, or existing distinctions changed. This process is continued until modifications to the scheme become minimal. This is what Charmaz (2006) describes as the 'saturation point': the point at which new data ceases to require changes to the scheme. All data is then re-coded using the final scheme (see appendix A for the final coding of the concurrent transcripts).

2.9.2 Behavioural analysis

The video footage was also used to analyse patterns in behaviour. Behavioural analysis software (Observer X) was used to extract quantitative data about the timing of activities. This involves reviewing the video frame-by-frame and manually indicating (coding) when defined behaviours begin and end. The Observer software allows coding schemes to include multiple 'behaviour groups' coded in parallel, each of which can have a number of nested behaviours. Behaviours in different groups can occur simultaneously, while behaviours within a group must be mutually exclusive. This allows for comparison and assessment of the co-occurrence of different types of behaviours. Initially, gaze direction was recorded (whether the eyes were directed towards the mirror, the paper or neither) and subsequently drawing and talking activities were also defined as behaviour groups and manually coded, frame-by-frame.

The behavioural coding scheme was developed in the same, iterative manner, requiring new behaviours to be defined with each subject. The coding schemes themselves are described in the results section.

As mentioned earlier, the final schemes are a product of this analysis. They are research outcomes, rather than simply means for interrogating the data. As such, the qualitative analysis informs a model, within which the drawing behaviours are described and compared. The quantitative analysis also results in a (simpler) scheme for comparing behaviours, both within and between subjects.

This analytical method allows the findings of the case-study to identify different drawing strategies, and assess the similarities and differences between those both quantitatively and qualitatively. Common features across diverging strategies are interpreted as constituting more general elements of drawing skill. In this way, the primary methods allow an initial consideration of the research questions, resulting in propositions that provide the basis for subsequent theoretical analysis.

2.9.3 Theoretical analysis

The theoretical analysis aims to understand and explain the preliminary findings. It asks if they are consistent with what might be expected, given the extant body of knowledge about perception and cognition, and infers what the cognitive mechanisms underlying those phenomena might involve. In this way, it seeks to explain the observed phenomena, elaborating and refining the model. In this way, the theoretical analysis allows the observed drawing behaviours and 'skills' to be explained in a cognitive framework.

A brief 'contextual' stage of analysis completes the methodology (in chapter 8), allowing a broader consideration of the implications of the findings. This third stage contains no original 'claims to knowledge', but suggests areas for further research and development.

2.9.4 Positioning theoretical perspectives and levels of analysis

This study aims to address questions about the role of memory and attention in drawing process from a cognitive perspective. The evidence gathered is looked at through a wide array of theoretical sources. While certain paradigms may at first appear contradictory, such as computational and embodied cognitive perspectives, they both afford valuable insights and each offers different (partial but overlapping) frames of reference.
For example, Lakoff and Johnson (embodied cognitive linguists), list three levels of analysis necessary in creating a grounded theory of cognition, describing this as 'the common paradigm':

> Top Level: Cognitive
> Middle level: Neuro-computational
> Bottom Level: Neurobiological (Lakoff & Johnson 1999: 110)

The neuro-computational level therefore bridges the divide between (more observable) neurobiological and cognitive phenomena: "to model the structure of the brain or some aspect of it, while using that model to account for aspects of thought, language, and other cognitive functions" (1999: 110). Lakoff and Johnson remind us that computational models are only ever metaphorical descriptions of thought process. Computational descriptions themselves are inferred, partial, and indirectly derived from observed evidence; not truly reflecting the real nature of the brain or cognition. While this must be remembered, they are nevertheless useful, providing a language with which to describe underlying cognitive structures.

Computational models are useful tools for making reductive models and predicting behaviours (devising hypotheses), while ecological and embodied perspectives are able to *explain* phenomena, accounting for their situated and embodied nature. The embodied paradigm is not a single 'level of analysis' per se, but a holistic perspective that accounts for relational structures *between* levels, including the brain, body and environment: "the entire paradigm, involving all three levels, makes sense only relative to the fact that we are organisms functioning in a physical and social environment and that we have evolved to survive in such an environment" (Lakoff & Johnson 1999: 113). Neurobiological and computational perspectives will inform the theoretical analysis, while embodied perspectives will be relevant to later contextual discussions.

The present study aims for a cognitive account that is relevant to education. As Daniel Willingham (2009) notes, when considering cognition in an educational context, many more levels of analysis are implicated beyond the three mentioned above, including the level of individual learners (and their histories), particular groups, group dynamics and pedagogies. The discussion will address certain broader pedagogic concerns, but only in later chapters, once the findings of the present study have been crystallised. In this way, the theoretical analysis forms one element of a three-part structure (illustrated in figure 9) supporting a cognitive account that is grounded in observed behaviour, so that it may be considered in a wider context.

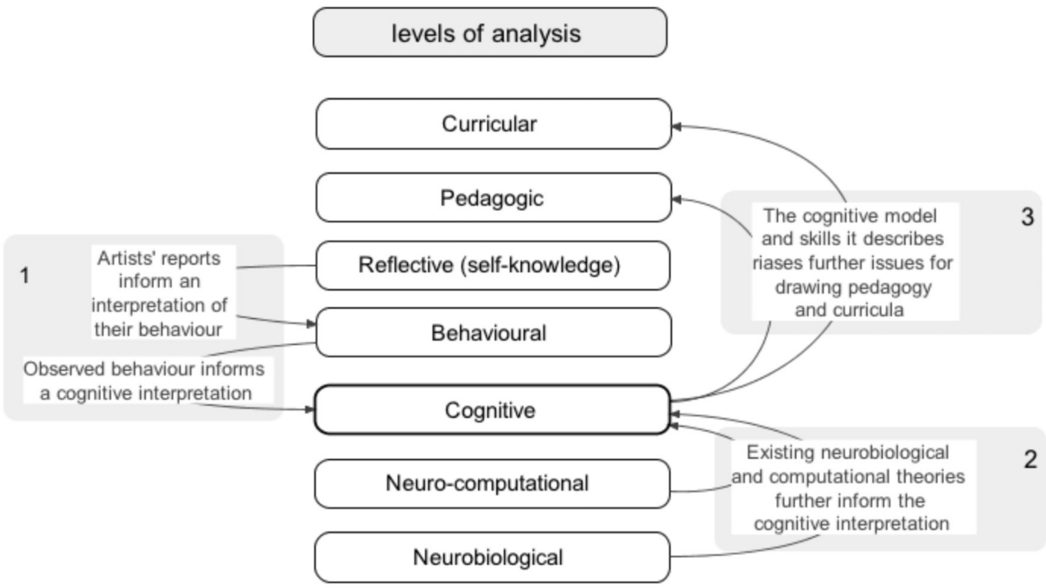


Figure 9. Relationship between levels of analysis in the methodology. The primary analysis is concerned mainly with the case studies, which inform a cognitive interpretation. The secondary (theoretical) analysis is concerned with existing theory, further interpreting and refining the model. The third stage considers the broader relevance of the resulting understanding of drawing skill. The account given is by no means an exhaustive description of the processes involved in drawing on any of these levels, but analysis visits these levels at different stages.

As Willingham (2009) suggests, when the purpose is educational innovation, the appropriate approach is to consider the behavioural level of analysis as a ‘funnel’ through which to pass other levels of analysis. That is, any theory devised must be consistent with, and applicable to, observed behaviours. Similarly, Stephen Grossberg (2010: 6) describes how to ‘insist on understanding the behavioural data’ is a crucial ‘metatheoretical’ constraint in developing theory. He considers observed phenomena (including both behaviour and neural anatomy/activity) to be the foundations of any theoretical model. In this study, an initial interpretation of observed drawing behaviour provides the point of departure for subsequent theoretical analysis.

Grossberg describes a further ‘metatheoretical constraint’, the ‘embedding constraint’:

> one needs to be able to embed the previous model into the new model. Otherwise expressed, the previous model needs to be “unlumpable” as it evolves into an increasingly complex “brain”. This is a type of *correspondence principle* that places a surprisingly severe test on the adequacy of the previously discovered theoretical principles. Many models regularly fail the embedding constraint. (Grossberg 2010: 7-8)

In this sense, the analysis is concerned with understanding not only the observed drawing behaviour, but also existing cognitive accounts of drawing, such as those reviewed in the previous chapter (these are re-visited in chapter 5). More generally, there is a consideration of the consistency of the emerging cognitive interpretation of the case studies with existing theories and models of perception and cognition, and these contribute to further refinement of the model (chapter 6).

Grossberg suggests that a ‘theoretical cycle’ can add to the robustness of a cognitive model:

> one can work both top-down from behaviour and bottom-up from brain to exert a tremendous amount of conceptual pressure with which to better characterize and refine the model […] such a theoretical analysis also discloses the *shape* of the

> theoretical boundary, within the space of data, beyond which the model no longer has explanatory power. (Grossberg 2010: 6-7)[2]

It is in this way that this project proceeds: to consider that which is observed as the only certainty (be it from this study or other experimental studies), and explanatory theories and models as working assumptions under pressure to be consistent with, and to explain, observed phenomena.

This thesis aims to be grounded and robust in the manner described above, and therefore well placed to make propositions about the cognitive elements of drawing skill with some certainty. Such certainty is welcome, perhaps even *necessary*, in debates around the contemporary relevance of drawing skill. However, the resulting account of drawing will still be only a partial one, relating directly only to the case studies.

Future technological and theoretical developments in psychology and neurobiology are expected to lead to more sophisticated and full explanations, better able to account for such complex activities as drawing. The present thesis is presented as a working model, contributing to understanding drawing process by describing and interpreting a range of cognitive strategies used by experienced artists, in light of current understandings of perception and cognition. It does so in a pragmatic way, in that it does not seek a dispassionate understanding that simply details cognitive functions, rather, it is mindful of the potential educational relevance of a more thorough understanding.

The following chapter (3) describes the results of the data collection described in section 2.8, and application of the analytical methods described in sections 2.9.1 and 2.9.2. The outcome of these analyses is then (in chapter 5) applied to the issues raised in the first literature review, and unresolved issues are further considered in chapters 6 and 7 in relation to more comprehensive and recent cognitive theory (presented in chapter 4). Collectively, these chapters fulfil the aim of describing and explaining many aspects of drawing skill, enabling

---

[2] Grossberg also stresses the importance of large samples, but given the purpose of this study – to develop a detailed working model – it seems more appropriate to deal in depth with a few case studies. The sample can be considered large when thought of as a number of instances of looking, drawing and looking again, an event which happens on the order of split-seconds – hundreds of times in each drawing.

the final chapter to consider that explanation in the regard to the question of the potential transferability of cognitive skills associated with drawing.

Chapter 3.
Case studies

This chapter gives an account of four case studies, observing artists' drawing process and their own accounts of it. Here, I describe the artists' drawing strategies and outline observed similarities and differences in their patterns of activity. I also consider the artists reports in terms of both the specific content, and the artists' responses to the concurrent verbalisation task. Together, these elements constitute the first stages of the analysis: the behavioural analysis and protocol analysis. The outcomes of this chapter are taken forward in three ways: they identify further areas for literature review (chapter 4); they are treated as propositions to be compared with existing claims about drawing and cognition (chapter 5); and they form the basis of a secondary, theoretical analysis (chapters 6 and 7) which considers their consistency with existing cognitive theory and, in doing so, validates, refines and develops the propositions into more detailed cognitive models.

Four artists participated in the main study: Angela Brew, a PhD candidate from University of the Arts London; Amanda Roberts, a PhD candidate from Swansea Metropolitan University; David Cobley and Anthony Connolly, members of the Royal Society of Portrait Painters (RSP). All are experienced artists with sustained observational and figurative drawing and painting practices, which differ visibly in approach and style, making them apt candidates for this study.

Here, I present the results of these primary studies, addressing the artists' drawing strategies, their self descriptions and the timing of their looking and drawing activities. (Full transcripts of the verbal reports can be found in Appendix A. Quantitative analysis results are listed in Appendices B and C.)

This chapter compares each case study in the following ways:

3.1 Approaches to drawing

- Overview of the artists' drawing practices (why they are appropriate case studies)
- Initial observations about their drawing process (during these trials)
- Their strategies and aims (as described in their reports)

3.2 Preliminary qualitative analysis

- Analysis of the verbal reports and development of the coding scheme
- Summarising the coding scheme as a '2D model'
- Applying the model to describe and compare drawing strategies

3.3 Quantitative analysis

- The proportion of time taken up by drawing and looking activities
- The micro-timing of specific patterns of glance cycles

3.4 Patterns of looking activity

- Comparing eye-tracking data for Connolly and Brew

3.5 Responses to the verbalisation task

- What happened and how the artists differed in their responses
- How the verbalisation affected their drawing process
- How the verbalisation affected their timing

Collectively, these observations inform a preliminary analysis of the observed behaviours and characteristic patterns of activity, to be carried forward to the theoretical analysis.

3.1 Approaches to drawing

3.1.1 Angela Brew

Brew is a PhD student, fine artist and drawing instructor. Her drawing practice is largely observational, she spends around 5 hours per week drawing from observation. Brew has done so consistently for many years, making her an appropriate case study candidate. She draws a range of subject matter, including portraits. These tend to be quick pencil or charcoal sketches made for her own purposes, rather than for the sitter. Her practice is concerned with quality of line, and the experience of looking closely in a controlled way, rather than with creating an accurate likeness. Brew is a germane case study as she describes a particular way of looking that is involved with her drawing strategy, which seeks a synchronicity between eye and hand.

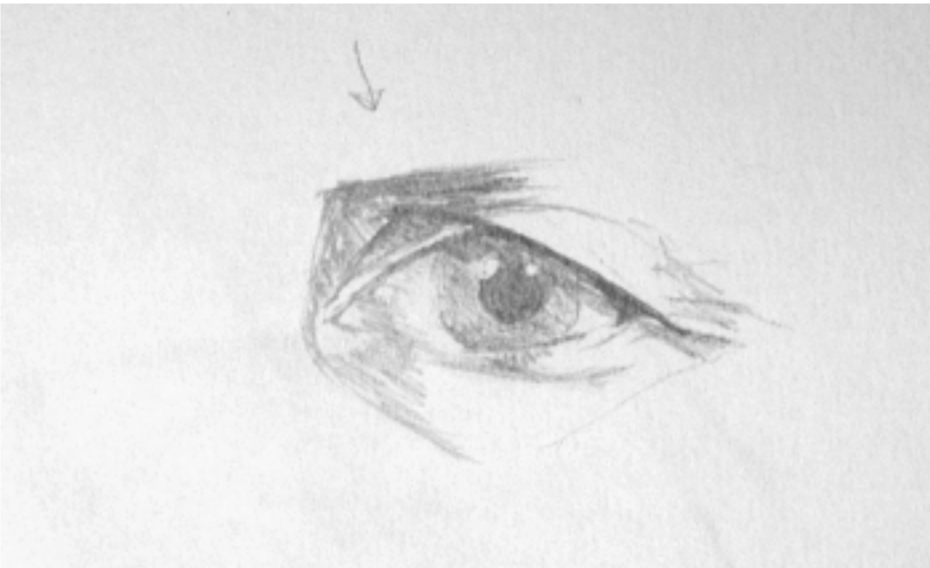


Figure 10. 5m drawing fragment made by Brew.

Her strategy involved accumulating closely measured groups of lines and shapes, relying on the accuracy of drawn marks for the correct placement of following marks. She drew very slowly, and only completed fragments during each five minutes (e.g. figure 10). Line and tone were treated separately, tone often being added to areas bound by lines already drawn. Most lines were drawn once only. Brew occasionally erased areas entirely, to begin measuring afresh. The starting point, here the corner of the eye, became a point of reference for measuring. The emphasis of the drawn lines seemed to be on edges and contrast boundaries. Figure 11 shows the drawing in progress.

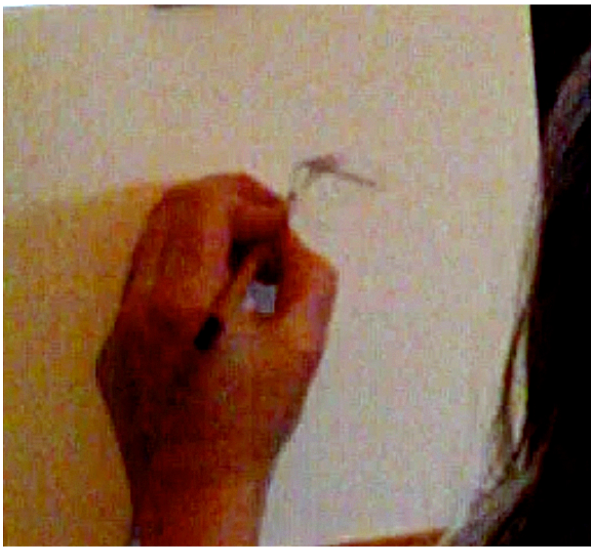


Figure 11. Brew, drawing in progress 4m 10s.

Brew reported attending to line segments separately, and considering their orientation, and the angles between them, as well as abstracted shapes they made, and tonal variations. The concurrent report focused mainly on these types of features:

> "I'm gonna follow the line of the edge of the skin."
> "And then I've got to the little change of angle"
> "and then I'm looking at how that line connects to this other line here,"
> "then I'm drawing the edge of my eyeball and lining it up with the highest point of this line here."
> "I'm shading those. I'm shading these in so that the, only the highlight bits show […] as the lightest bits of the drawing."
> (Brew, concurrent report)

Brew's retrospective report reiterates this occupation with line and direction, and also specific points in the drawing where lines intersect (see figure 12, showing annotations indicating significant points representing separable segments). While drawing she is "responding to movement along line, and topology of the area", aware of the movement of her gaze along the line. She mentions "Consciously trying to sync eye and hand. Trying to sense a match of speed and orientation” (retrospective report). She described an awareness of her eye and hand as separate entities, each requiring attention or, in her words ‘support’, the eye needing more support than the hand.

She also mentions ‘double checking’ (glancing back to the mirror to judge accuracy), and ‘triangulating’ (double checking the position of the pencil/line against additional points). An anchor point is used to check vertical and ‘horizontal alignment’, i.e., double checking whether points such as the end point of a line correspond vertically and horizontally to other measurable points. Brew mentions the importance of a sense of gravity, to judge where a vertical line would fall.

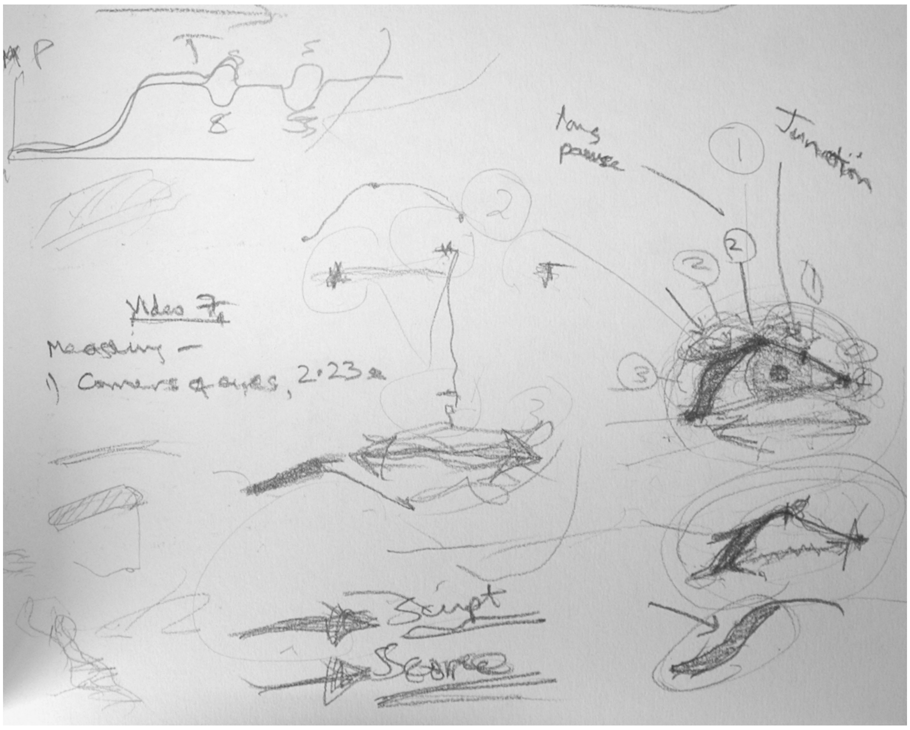


Figure 12. Brew's drawing, annotated during retrospective report

Shape is also said to be measured “not thinking about length of line as much as shape of small section” (retrospective report), although this was not mentioned concurrently.

The retrospective report also includes evaluative statements not mentioned in the concurrent report. She notes that her certainty about positioning is reflected in the weight of line, and that sometimes – if an error is spotted – ‘backtracking’ is necessary. This indicates an ongoing review of the approach. Towards the end of the drawing, Brew mentions feeling ‘satisfied’ with positioning, and ‘moving attention to’ fine details. “I sense by now that I know where I am”. Her statement “like running around in a playground, feeling like I know the space and am safe to experiment” (retrospective report) pre-empted tone and finer detail becoming more of a focus.

Overall, Brew’s description of her drawing strategy is characterised by a treatment of line as a moving point, and a “sense of finding out as I go, […] responding, not pre planned” (retrospective report).

3.1.2 Amanda Roberts

Roberts draws female nudes from life. Her work is concerned with gendered female representations, and includes many large-scale (life-sized) charcoal works. While drawing, she talks with her models. She feels this both allows her a greater affinity with them as subjects and also affords greater spontaneity in her mark-making, which she feels is an important aspect of her process, influencing the quality of line. The works are large scale and gestural, using both line and tone, sometimes including mixed media, and sometimes made over several sheets of paper with shifting perspectives. They are intended for gallery viewing.

Figure 13. Roberts' drawing in progress (5m).

Roberts' approach to drawing was heuristic, beginning generally with progressive revisions and showing clearly differentiated phases, in which different types of features would become the focus. These progressive stages were punctuated by evaluative pauses. Each stage accounted for a greater complexity of visual information with the initial structural emphasis giving way to abstracted shapes, texture and tone, and to a sense of three-dimensionality and features 'sitting correctly'. Figure 13 shows her drawing at the end of the 5 minute period.

The initial marks were faintly drawn, long curved lines, made quickly to indicate the general shape of the head and the 'sort of compositional size that I want the head to fill' (concurrent report). The following marks were of a similar quality, although more refined, and broke the head into component sections by following the most prominent structural features: the edge of the jaw, the foremost ridge of the nose, an oval from under the nose to below the chin, arc of the brow, the position of the right eye. In the retrospective report she describes this process as 'looking all over, it's not like following one part and working your way down, it's just, literally just moving your eye over the whole sort of head area and just trying to map it in' (retrospective report), in order to then iteratively evaluate, re-define and refine. She describes this cyclical process as: 'Drawing, re-assessing, changing. Drawing, re-assessing, changing. Drawing, re-assessing, changing' (retrospective report).

Figure 14. Roberts' drawing after 45s and 2m 38s (video stills).

The reports reflected changes in emphasis between evaluative pauses, referring initially to size, space, angle and measurements; and later to tone, texture and 'feel'. However, the concurrent report was almost entirely concerned with evaluation and decision-making, rather than describing the features to be drawn (as Brew's was) or the drawing actions.

The retrospective report revealed an awareness of this cyclic strategy, and other elements of the process not mentioned concurrently. Roberts described how she would consider the composition before beginning, then progress through various stages, evaluating and changing or refining, with added complexity in later iterations.

> I'm sort of looking all over, it's not like starting in one part and working your way down, just, um, it's literally just sort of moving your eye over the whole sort of head area and just trying to map it in, just to get in the space that you're gonna, that the head is gonna fit on your paper. And doing that in rough and then refining it and refining it, and redefining it where everything's gonna be. (Roberts, retrospective report)

Roberts describes how she sees the head as constructed by shapes during this early stage. She would squint “to try and make the shapes a bit more basic”, “you’re not seeing details, you’re seeing it more as blocks”. She also mentions that squinting “stops that sort of descriptive thing going on” (retrospective report), indicating that she abstracts the shapes. The drawing at this early stage appears angular and structural, see figures 14 & 15. The shapes can be defined by contrast, but they are also described as three dimensional, in that they might be concave or convex, and that affects the lines she uses to describe tone within them. The shapes are also ‘connected’, ”like a three dimensional jigsaw with everything fitting in” (retrospective report).

Lighter, more gestural and structural marks that fill the paper are gradually replaced by smaller, more closely observed marks, with tonal and textural subtleties being introduced later in the process. Again, ‘firmer’ lines indicate more certainty: “only do the dark bit when it’s been mapped up from underneath” (Roberts retrospective report). Similarly to Brew, she also mentions vertical measuring lines, calling them ‘plumb lines’, used to gauge spatial accuracy, usually against one or a few anchor points, of relative certainty.

Figure 15. Roberts’ drawing after 2m 53s (video still).

In discussion, Roberts describes a number of levels on which the drawing operates, in addition to shape and line:

> as well as that, you're thinking how, how strong is it, is it something that's peripheral, is it sitting back in the drawing, is it coming out, Is it coming out in space, is it receding in space, what sort of line do you need to define what that is, um, is this the right size for what's going on over here, is it the right angle? Do you know what I mean? It's just like there's like loads and loads of layers to what's sort of going on in a really short space of time. (Retrospective report)

She acknowledges the increasing complexity of the process:

> The more the drawing develops, the more things come into play. The more complicated the type of lines that you are making become. (Retrospective report)

This approach involves a disregard for full accuracy *during the process of mark-making*, which is compensated for by designated periods of reflection and evaluation: "I'll keep drawing on top of the lines regardless, so once I know, yeah, I've got about three lines in the same place there so I was quite confident that that was, if I'm re-drawing something it's alright isn't it?" If something 'wrong' is identified, the rubber is used to 'take back' part of the drawing, sometimes over half of the entire drawing. Traces of marks are left intentionally still visible, partly for aesthetic reasons, but mainly to reveal the history of the drawing as a point of comparison for further revisions.

This cyclic pattern of drawing and revising can be observed in all four of Roberts's filmed drawings.

3.1.3 Anthony Connolly

Connolly is a portrait artist, and a member of the RSP. Much of his work is commission based. His portraits are as frequently drawn as painted, often taking many hours. The work is precise and detailed, with striking likenesses. The Sunday Telegraph (John McEwen) described his work in the BP Portrait Exhibition as “the most tender and searching of the head portraits” (John McEwen, cited on the artists’ website: Connolly 2010). Figure 16 shows an example of his drawing from the trials.

Figure 16. Connolly’s Drawing in progress (5m).

Like Brew, Connolly's drawing process was additive: beginning from a central point, usually the centre of the left eye, and building outwards in patches. A high level of accuracy and detail were observed from the start (see figure 17).

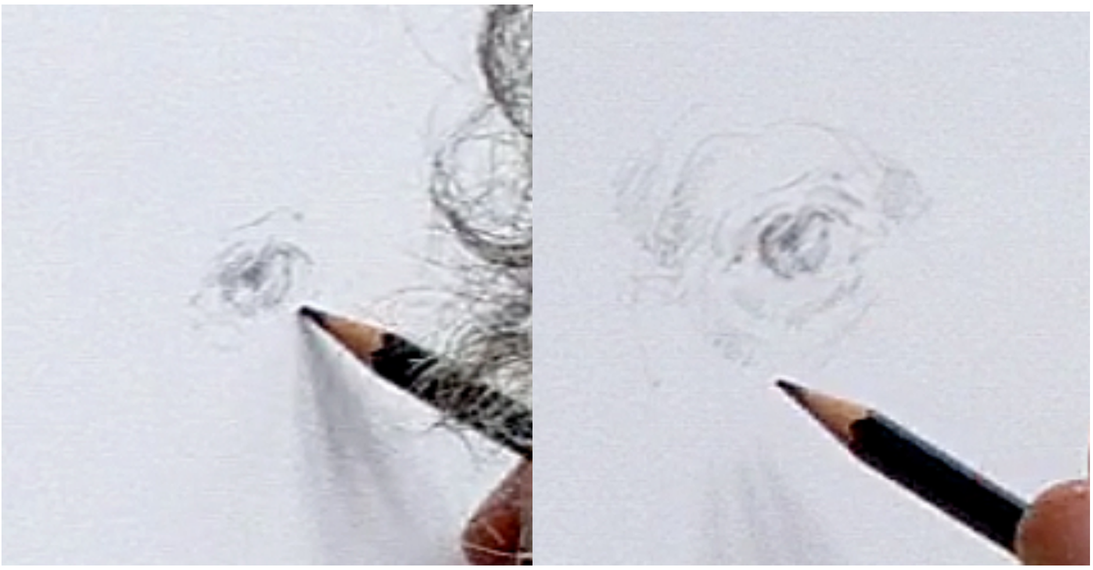


Figure 17. Connolly's drawing after 2m 5s and 4m 20s (video stills).

Connolly would periodically return to the starting point to re-assess relationships before moving on to further areas. Abstracted shapes and tonal values would be measured, but he would also 'drop a line' to assess distances from a vertical axis.

Connolly's concurrent report included statements about both details and judgements, as did Brew and Roberts', but his report differed, in that was concerned mainly with the qualities of anatomical features: The "roundness of the eyeball", the way the 'flesh' of the eyelid 'rests' on the eye. Bone structure was also an important element:

> I'm quite conscious of the skull, the bone beneath the brow. […] Some of these lines that wrap around I feel like they're wrapping themselves round the skull bone. […] the flesh is coming down. Yeah, and it's falling, hanging rather […] And similarly the way this crease comes down here, the flesh folds under it, and then it comes out again to this part to the bottom of the nose. (Connolly concurrent report)

Spatial qualities were also mentioned: "this bit here is, it's just shadow, but you could sort of stick a thumb in there" (concurrent report).

Many statements were concerned with goals: “Just trying to coax it into something that I like.” The rubber was used to ‘take back’ elements that had been ‘overstated’, indicating an ongoing assessment. The retrospective report points to a more emotional aspect to the evaluative process: “and then when I get up there, it might occur to me that actually you look really sort of forlorn or something, and that’s not actually what I’m seeing, so you might go back to the mouth and look at that again”; although evaluations such as this, concerned with likeness or ‘essence’ were reserved for later in the drawing.

The retrospective report also reveals that Connolly – while aware of using prior knowledge (anatomical knowledge, familiarity with his own head) – is wary of doing so to too great an extent: “I’m in a slight danger of kind of drawing, using a template […] because the looking element recedes and the knowing element becomes more dominant”. While using his knowledge to inform the drawing process, he wishes to remain engaged with observed (rather than imagined or remembered) details, and feels this is important to the quality of the drawing. These observed qualities must somehow be ‘held’ in the drawing: “it sort of becomes sufficiently resonant that you actually feel that there is, that you are holding something of that matter, that moment, in the drawing. It might be just the slightest thing. But if it’s there at all, that, for me I value the drawing.”

This comes about through rigorous attention to detail, followed by more reflective, emotional judgements:

> the more reflective kind of looking at the entirety of the thing, I would say, I wonder if that’s just an accumulation of looking at the eyeball, looking at the, you know, the skull underneath, you know, thinking that the skin there is really thin. I wonder if it’s an accumulation of looking at details, which you get enough of them together, then you can start reflecting on whether it has a… whether it holds something *a little bit more than the sum of the parts*. […] In that sense, it’s something that happens two thirds of the way into the drawing, I would guess. And not before that. And certainly not immediately. […], it may not even be a particularly good likeness, it’s just, I just feel something. (Connolly retrospective report)

It is in this way that Connolly describes his process as progressing from 'isolating bits' with careful measuring, to conveying a sort of essence.

> you know when you get putty, and its cold, it's quite hard, you have to warm it in your hands for it to become malleable. I think drawing is a bit like that in that, in a sense, you have to start this looking process, and you kind of warm up the thing you're looking at in the drawing. And then if it gets sufficiently warm it becomes malleable and then it becomes more interesting. (Retrospective report)

3.1.4 David Cobley

Cobley is an award-winning painter and member of the RSP. His work is figurative and includes many large sustained paintings with dynamic spatial compositions. These are made for commission, or as commercial or competition pieces. The paintings often convey a sense of intentionality. Ken Dodd described Cobley's portait of him as "a portrait of a comedian in a vest who's done the performance and is slightly melancholic. He's debating which jokes got the laughs" (quoted in The Times 2005, by Dayla Alberge). Cobley often teaches painting classes, in which he demonstrates his approach. Figure 18 shows one of his drawings after 5 minutes.

Figure 18. Cobley's Drawing in progress (5m).

Cobley's strategy could also be described as heuristic, beginning very generally with progressive revisions. However this process was markedly different to Roberts'; rather than roughly drafting out structural features, 'important' points were carefully located. The outline of the head was sketchily mapped in first. Features were then located within this, including the pupils, nostrils, mouth, ears and chin. These points were measured against each other and the outline. This was reported to be a familiar routine.

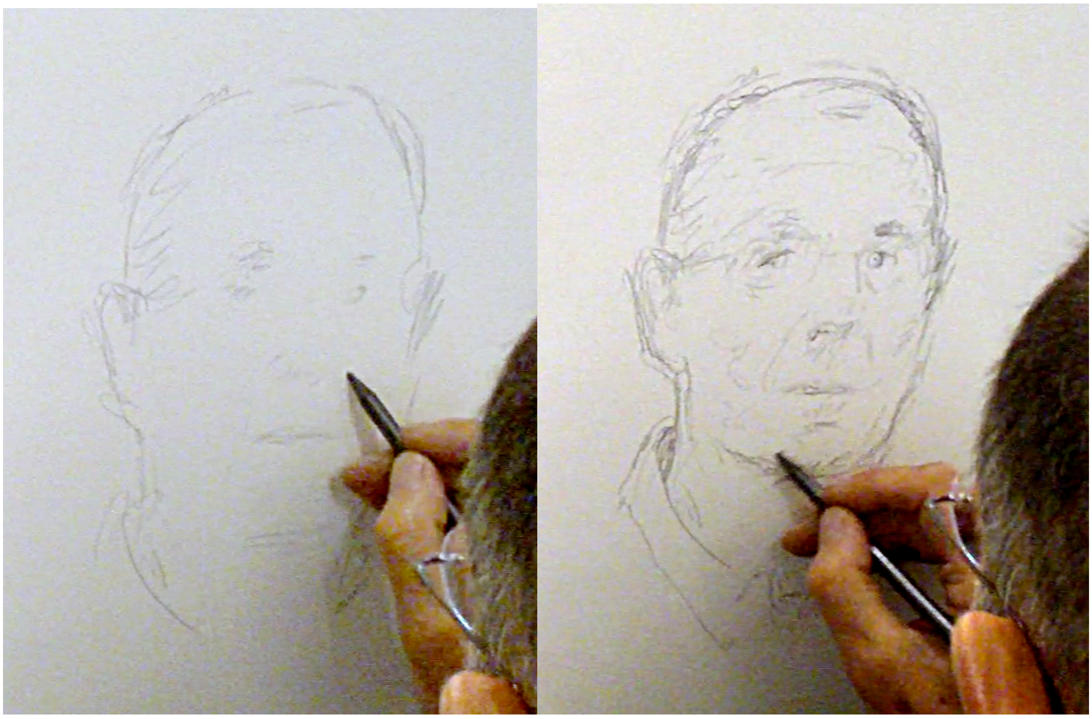


Figure 19. Cobley's drawing at 54s and 3m 34 (video stills).

Unlike the other artists, Cobley positioned features as free-floating points (see figure 19). That is, they did not rely on shapes or planes, only measured distances: "The eyes, the nose, the mouth, thinking about the distances between" (concurrent report). These locations functioned as anchor points, from which to measure (although there were many as opposed to just one, as in the others' drawings). Cobley only moved on to more localised details once these locations were relatively certain, although they were still a 'moveable feast, particularly as his head may not 'settle into position' right away. "I'm just searching it out really, finding out where all these things are" (concurrent report). He also mentioned being aware of the 'skull underneath' and the direction of lighting. Later in the drawing the emphasis changed from distances to relationships, such as 'the relation between the head the neck and the shoulders' (concurrent report).

Cobley seemed to consider the whole composition from the start: “what I’m trying to do initially is to, um, draw the whole head all at the same time” (concurrent report). Facial features would be treated in pairs. In this way, the drawing remained compositionally balanced throughout: “because there is this symmetry, always work in pairs” (retrospective report). Similarly, tone tended to be treated across the entire drawing, rendering many patches of similar tonal value across the drawing at once, rather than neighbouring patches of differing tone.

Each drawing went through distinct phases: composing, locating features, refining measurement, adding tone and adding fine detail. These, like in Roberts’ drawing, were punctuated by evaluative moments. Evaluations were concerned with the whole: “I’m aware of how scribbly the drawing looks“ or with parts in relation to the whole: “I’ve got too much of the top of my head here” (concurrent report). Each evaluation concerned itself with a different aspect of the drawing. Like Connolly and Roberts, later evaluations were concerned with a more emotional or affective reading: “I’m beginning to look like artists often do in their own self-portraits. Rather suspicious of themselves” (concurrent report).

Cobley’s retrospective report revealed a great deal of awareness of his drawing strategy. He described mapping facial features’ locations carefully “because that’s what makes each person different” (retrospective report). This early mapping is again described in terms of ‘distances’ which are judged using vertical and horizontal frames of reference: “Soon as I’ve put my pencil there, I’m aware of distance between there and there, there and there, there and there [pointing…] that goes on throughout. […] I don’t think I think much about diagonals, they kind of take care of themselves”. Like Connolly, Cobley was aware of the difficulties caused by “all these pre-conceived ideas about the way you look” (retrospective report), and used careful measurement to avoid the influence of such pre-conceptions.

“The whole process […] is one of constant re-evaluation and not accepting that the mark you’ve already made is necessarily the, in the right place, or does what you want it to do” (retrospective report). And, like Roberts’ and Connolly’s drawings, the initial concern with purely formal elements such as structure and positioning was gradually replaced by more complex and affective aspects such as likeness: “it will look like me if the marks are in the right place […] Fairly near the end I suppose I was thinking: does it look like me" (retrospective report).

Cobley also mentions in his retrospective report "I very much feel that I'm feeling things with the tip of the implement I'm using". This describes a similar approach to Brew, who aimed to synchronise her eye and hand movements, being aware of a specific point in space at any time. It also indicates a certain tactile awareness of the subject.

3.1.5 Preliminary comparison

The overall strategies can be described as heuristic or additive, beginning generally then refining, or constructing more precisely from a single point. Other variations in process include the measurement system (single point, multiple point, using angles, shapes or distances along vertical and horizontal axes) and the type of mark-making used (i.e. if it focuses on structure, contour, tone, texture etc.).

Both types of strategy seemed to include anchor points, relative to which measurements could be made, often vertically or horizontally. In the additive strategy this tended to be the first point drawn, in the heuristic strategy it was usually defined later on. Evaluative strategies also differed considerably, and will be discussed in more detail below. The following section considers the content of the reports, giving an account of the analytical process and its results.

3.2 Qualitative analysis: developing the coding scheme

The drawing strategies were divergent, and the reports differed in both content and approach. As described in the previous chapter, the aim of the qualitative analysis was to devise a framework for comparing and contrasting the reports. For this purpose, a coding scheme was devised using the grounded theory framework. It is likely that the verbal reports only reflect part of the thinking that underlies the drawing processes described. But, while the results are not the full story, they are nevertheless diverse, and between them represent a wide range of possible cognitive actions or states involved in drawing.

This section gives an account of how the scheme was developed, using a grounded framework as described in the previous chapter. The scheme resulting from this analysis is presented for consideration in addition to the data captured by other methods, but also as a comparative tool for describing and understanding a range of drawing processes.

3.2.1 Development of the coding scheme for verbal reports

Verbal reports were transcribed from video. The process of developing a coding scheme from the concurrent report transcripts involved parsing statements into segments for categorisation. For consistency, rules for parsing were adapted from existing protocol analysis studies (Box 1).

Rules for parsing

1. There should only be one main verb per parse.
2. If there is repetition, follow the rule of one main verb per parse.
3. If the same verb is used twice, but the first use is in a sentence fragment, keep it as one parse.
4. If there is a statement with an implied verb, then parse as though there were a verb.
5. if a statement has a verb, but no object, parse separately but code as 'miscellaneous'.
6. If the statement conveys no real information, code as 'miscellaneous'.
7. if a statement is re-iterated immediately, treat as one parse.

Box 1. Rules for parsing verbal report transcripts (adapted from Fayena-Tawil et al.).

As the statements were parsed, I began to establish categories. Many statements described drawing actions:

> and I'm outlining them (Brew, concurrent report)

> And then dropping, I'm dropping a line from that bit there where the cheek meets the nose (Connolly, concurrent report)

Some clearly reflected decisions:

> I'm gonna go for a slightly more tilted head angle there (Roberts, concurrent report)

Others were relating to goal setting, usually for part of the drawing, rather than the entire composition:

> so just rearrange the angle of that (Roberts, concurrent report)

> and then I'm gonna draw my pupil (Brew, concurrent report)

> Just trying to coax it into something that I like (Connolly, concurrent report)

Evaluative statements could also be categorised according to whether they referred to part of the drawing or to the whole (sometimes in relation to sub-goals):

> just a little bit too defined here. (Roberts, concurrent report)

> I'm happy about the general structure of the head now (Roberts, concurrent report)

> I've got most of it there (Cobley, concurrent report)

Rationalisations were also made:

> or if I start drawing there because it's the thing I see most clearly (Connolly, concurrent report)

> cos each new line effects what I've already got down there (Cobley, concurrent report)

In addition to rationalisations, some other statements were also a step removed from the drawing process. For example, the artists referred to themselves as doing the looking or setting the goals, etc.; or referred more generally to drawings in the abstract, to the difficulty of the task or to statements previously made. These could be considered meta-cognitive, and were categorised as meta-description, meta-plan, meta-goal and meta-evaluation (respectively):

> I'm looking at how much of my, the edge of my eyeball I can see (Connolly, concurrent report)

> I'm just seeing how it looks (Brew, concurrent report)

> Part of what, a large part of what I'm trying to do is describe the form that I'm seeing. (Cobley, concurrent report)

> it's sort of all over the shop (Roberts, concurrent report)

These sorts of categories relating to cognitive and metacognitive activity are unsurprising, and similar to those typically used in protocol analysis studies. However, many statements (and groups of statements) were purely descriptive, only demonstrating evidence of observing, for example:

> and there's no light reflecting in that (Brew, concurrent report)

> The glasses. There's the bridge over the nose. The two side pieces that are more obvious than the glass, they help also describe the angle of the head. (Cobley, concurrent report)

> Um, there's quite a soft line between the lid and the eyeball (Connolly, concurrent report)

These kinds of statement did not fit with the previous categories, seeming distinct from more propositional or strategic thinking that was concerned with planning, monitoring and decision-making.

After several iterations, all the transcripts had been coded and parsed with this scheme and no statements remained uncategorised other than occasional digressions, which were categorised as 'misc'. Collectively the categories used in the final were grouped, as in box 2 which also shows the working definitions used.

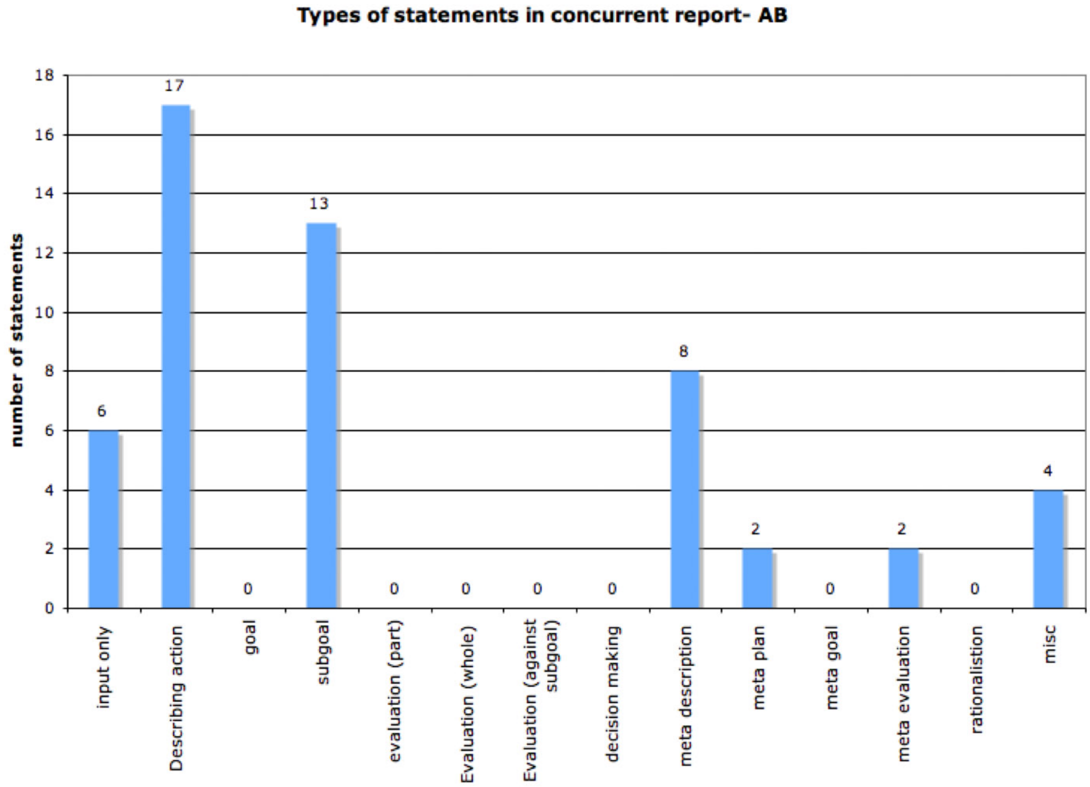
Categories and terminology in the initial coding scheme

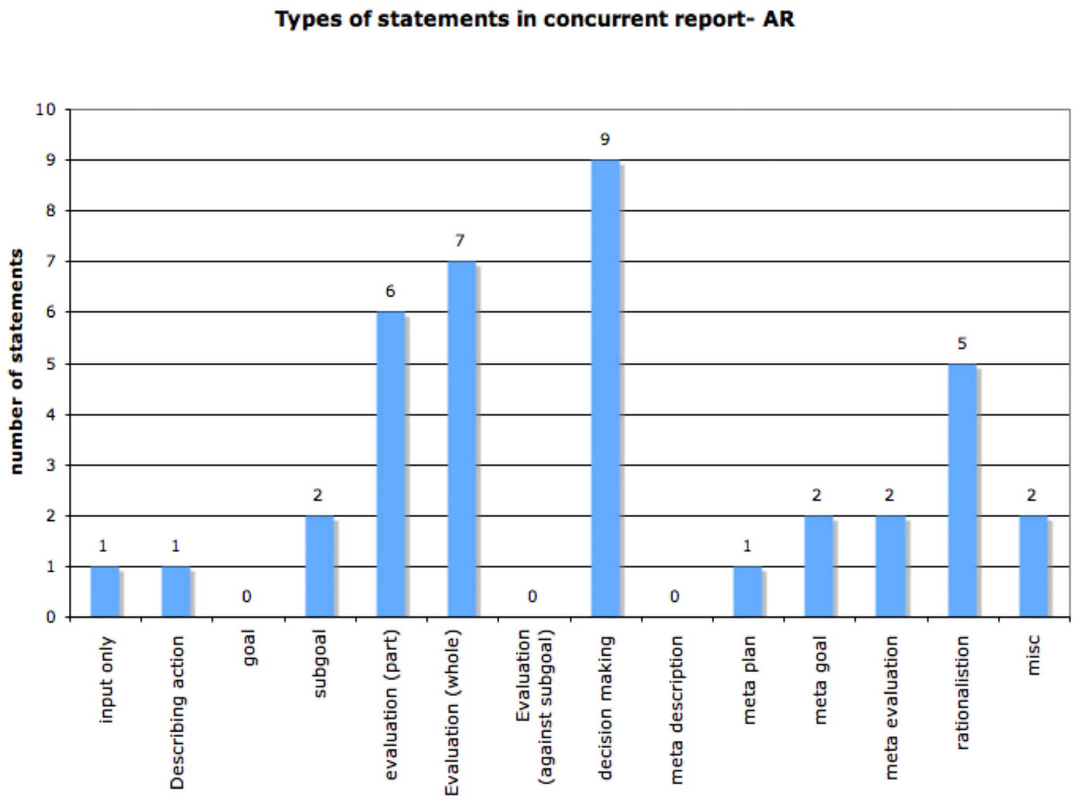
Category	Term	Definition
Cognition	Input only	Only describing apprehended features
	Describing action	Describing drawing activities (following, rubbing out, shading)
	Goal	Setting a goal for the entire drawing
	Subgoal	Setting a goal for part of the drawing
	Evaluation against subgoal	How well is the drawing progressing in relation to a subgoal?
	Evaluation of part	How well is this portion or aspect of the drawing going?
	Evaluation of whole	How does the whole drawing feel?
	Decision	Deciding to proceed in a particular way
Metacognition	Meta-description	comparing points in time, describing own perception
	Meta-plan	evaluation of plans, awareness of own strategy
	Meta-goal	monitoring own progress, statements about own ability, or difficulty of task,
	Meta-evaluation	Judgement of evaluative procedure
	Rationalisation	Explaining or asking why
Misc		Anything unclassifiable

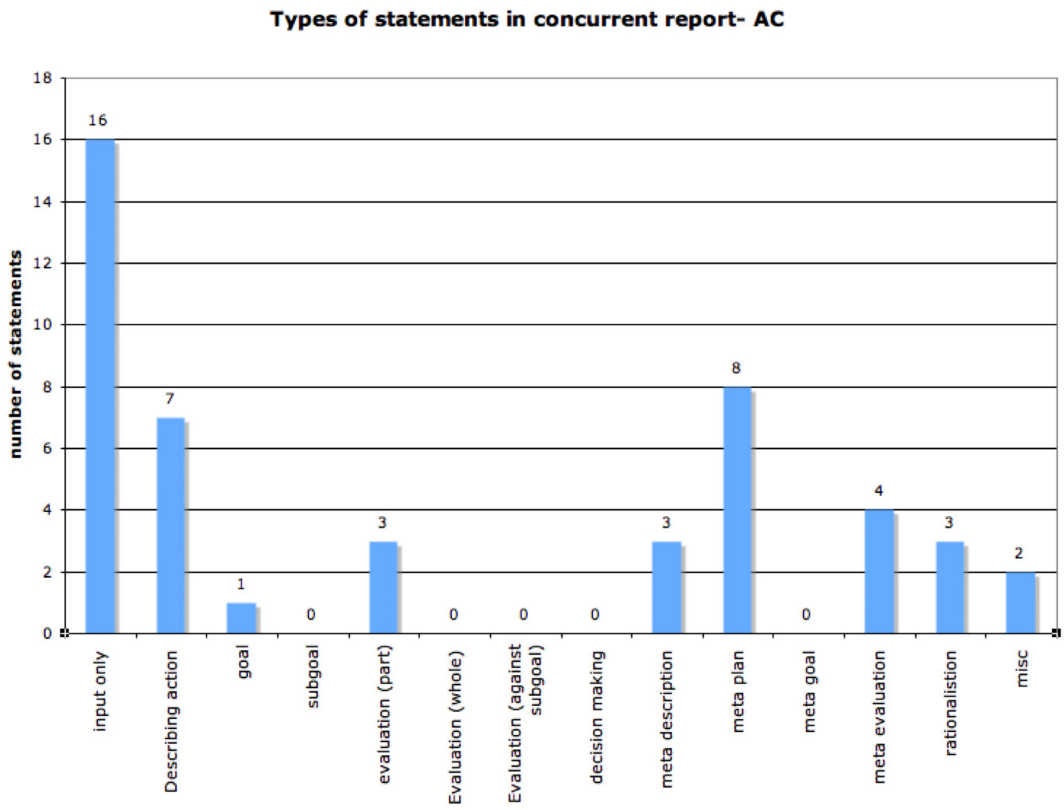
Box 2. Categories defined for parsed transcripts and definitions of labels used.

There are a number of issues with this scheme, particularly with 'meta' categories: It was unclear if the meta statements reflected true metacognition, or if the artists were simply using familiar turns of phrase in a conversational way, to indicate more direct cognitive processes, e.g. describing themselves looking at something, rather than simply describing the thing they are looking at. It is unclear which statements reflect typical metacognitive activity, and which might be the result of an awareness of the researcher's presence (the meta-statements outnumber direct ones in all the reports). It is also difficult to tell the extent to which rationalisations or other digressions were indicative of typical thought process. Presumably artists would rarely feel the need to justify their actions to themselves when drawing alone. Despite this issue, it was still possible to categorise statements at face value. However, having done so, the distinction between cognition and metacognition could not be considered reliable. Furthermore, it was unclear if that distinction would offer any useful threads of enquiry. While it would be interesting to pursue an enquiry into cognitive and metacognitive activity in drawing process, it was clear that this could not be reliably measured using concurrent verbalisation methods.

The distinctions within these categories (relating to planning and goals) seemed more reliable; they could be observed in each artist's report. These types of statement were common to all four, although the emphasis varied. Brew's concurrent reports were concerned mainly with describing drawing actions, sub-goals and visual descriptions. Roberts' contained few direct descriptions or reports of drawing actions, being concerned mainly with decision making and evaluation, also including a number of rationalisations. Connolly's were predominantly descriptive, also referring often to his drawing actions, and planning with a few evaluations and some rationalisation. Cobley's contained many digressions and rationalisations but were also mainly descriptive (Figure 20 compares the number of instances of each type of statement between artists).


Types of statements in concurrent report- AB
number of statements
0
2
4
6
8
10
12
14
16
18
6
17
0
13
0
0
0
0
8
2
0
2
0
4
input only
Describing action
goal
subgoal
evaluation (part)
Evaluation (whole)
Evaluation (against subgoal)
decision making
meta description
meta plan
meta goal
meta evaluation
rationalistion
misc


Types of statements in concurrent report- AR
number of statements
0
1
2
3
4
5
6
7
8
9
10
1
1
0
2
6
7
0
9
0
1
2
2
5
2
input only
Describing action
goal
subgoal
evaluation (part)
Evaluation (whole)
Evaluation (against subgoal)
decision making
meta description
meta plan
meta goal
meta evaluation
rationalistion
misc



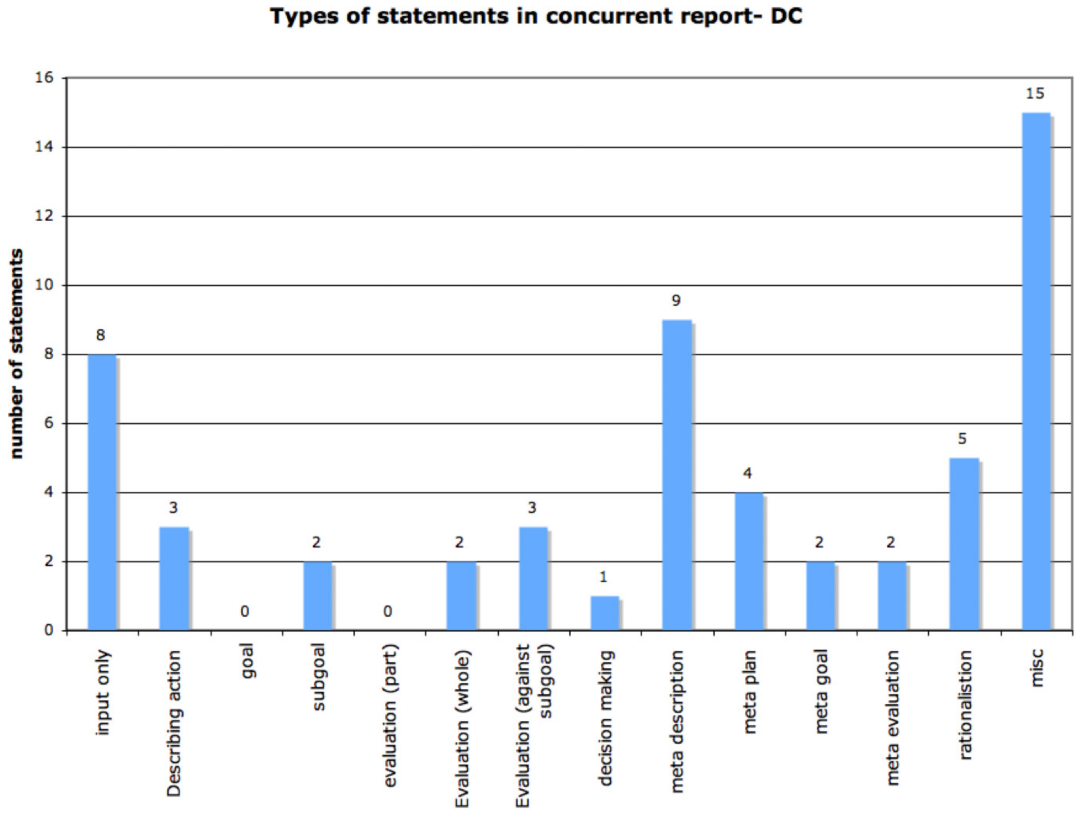


Figure 20. Comparison of incidence of types of statements made during concurrent reporting for Brew, Roberts, Cobley and Connolly. Each one shows a very different emphasis, indicating different drawing priorities, or different approaches to the verbalisation task.

This comparison shows that the artists took very different approaches to describing their activity, choosing different aspects of it as the focus. While this could be argued to reflect differing approaches to the verbalisation task, it is likely that these differences reflect differences in thinking (either directly, by emphasis; or indirectly, by what it was *possible* to report concurrently with other activity). That is, how they were thinking through the drawing process. A direct quantitative comparison of the instance of types of statement cannot offer much more than this but, when considered in relation to their differing drawing strategies, the artists responses to giving the verbal reports, and the timing of their drawing actions, the reasons for these differences become apparent.

These statements are the result of underlying thought processes, such as routines for selecting, locating and measuring salient features, or decisions about what to include in the drawing. As the statements were not made strictly in time with the drawing (that is, many statements referred to what was about to be done, or what had just been done), it was not possible to attach statements to specific lines or marks with any certainty. However, more general inferences could be made regarding the range of cognitive acts taking place and, to this end, a more fruitful scheme for categorising the statements was sought.

Various solutions for further categorising statements presented themselves. It was not possible to categorise statements by whether they were concerned with glances to the paper or mirror, as they often involved both, or it was difficult to attribute one to the other due to the time lag. Also, because glances shifted faster than the statements were parsed, so that one sentence or fragment would usually coincide with many glances back and forth. Grouping statements by tense (whether the statements referred to the past, present or future of the drawing) showed that it tended to be only the visually descriptive ('input') statements that were made in the present tense, while others referred backward or forward in time. Drawing actions were also sometimes described with reference to visual features in the present tense. The more strategic elements also relied on visual input, and it was clear that evaluative and decision-making processes also involved apprehension of visual features, but those were phrased in past or future tenses. So there was a temporal distinction between types of statement, possibly indicative of shifts in cognitive activity, i.e., the extent to which visual memory, or internal visualisation, is being recruited.

The category ‘input only’, clearly did not involve only looking – drawing actions were made simultaneously in response to the features observed. So, these references can be thought of as seeing-for-drawing, i.e., a particular way of looking that involves direct translation to movement, as opposed to more passive ‘watching’. (Other types of activity also involve translation of visual and spatial cues into movement - sports, driving, even reaching for objects - this seeing-for-drawing is comparable to those, but distinct, in that it includes the intent to re-produce visual features.)

The types of features noted at different stages of the process appeared significant and worth including in the scheme. The artists’ attention would shift focus from certain kinds of detail to others, and some of the retrospective reports also noted this. But this was true for all kinds of statement, not only visual input. It was possible then, to ‘nest’ a further level of coding according to visual feature types.

However, this nesting was problematic as, while not all statements mentioned features, all *types* of statements sometimes mentioned features, and often more than one. This was a complicating factor: many parses included either none, or more than one, type of visual feature. A solution to this was to parse and code twice, using two separate columns, titled ‘strategic’ and ‘visual’. For example, Roberts makes a decision to change a portion of the drawing:

> Ok. So that’s the sort of compositional size that I want the head to fill. That’s the sort of space I’m gonna use on the page. Ok. The problem there is I’ve just gone too long. So I just need to reassess the shape of the nose, the chin and the mouth in relation to the eyes, so it’s that sort of triangle bit (gestures) in the centre of the head. (Roberts, concurrent report)

Here she has evaluated the accuracy of her measurements, and is making a decision to change a portion of the drawing. In doing so, she mentions many separate features and spatial relationships, so there is a complex interaction between perception and decision-making. Table 2 shows an example of how the double coding was employed.

Statement	Strategic	Visual
Ok. So that's the sort of compositional size that I want the head to fill.	Evaluation (against subgoal)	Compositional size
That's the sort of space I'm gonna use on the page.	Decision	Overall composition
Ok. The problem there is I've just gone too long.	Evaluation (of part)	Global view
		Relative length
So I just need to reassess	Decision	
the shape of the nose, the chin and the mouth in relation to the eyes,	Subgoal	Shape
		Feature
		Configuration of points
so it's that sort of triangle bit (gestures) in the centre of the head.	Input only	Constructed shape
		Global view

Table 2. Example of coded transcript with two schemes (Roberts concurrent report).

This solution allowed each transcript to be coded twice. The two coding schemes were separate but related, corresponding to two distinct but parallel, interrelated types of cognitive activity. These categories are described in more detail in the following section, in which the codes and categories are considered in relation to time.

Finally, this double coding scheme was applied to the concurrent report transcripts. This meant that attention could be paid to the types of visual feature mentioned as well as planning and decision-making. This proved to be interesting as the artists' strategies appeared to involve differing approaches to segregating visual features, by type and level of complexity.

3.2.2 Categorising visual features described

The features mentioned in the concurrent reports varied in type and complexity: from single points and line segments to symmetry and proportion, and also to recognisory or interpretive views (considering, for example, direction of gaze or emotional readings of the face). Each artist's vocabulary varied, and it was possible to interpret and categorise specific features mentioned in terms of lower, middle or higher orders of complexity. Within these three main categories, many sub-categories emerged during the analysis. These are listed in table 3, below, together with working definitions of the terms used to define categories. They include not only strictly visual features, but also tactile and movement related ones. Memory or prior knowledge is also accounted for here as it is sometimes mentioned in the reports. Full transcripts of the concurrent reports used (chosen by the artists as the best reflections of their strategy) can be found in appendix A.

Category	Term	Definition
low level	point	A perceived or inferred one dimensional point in space
	line	The existence of an edge or line
	tonal shape	A two dimensional shape defined by a single tonal value
	distance between points	Distance between designated points, either along an edge or along an imagined straight line
	length	Length of a line segment
	direction	Direction of a line or between two points
	curvature	Curvature of a perceived or inferred line
	textural difference	Boundaries between or distinct areas of different texture
	tonal value	Darkness or lightness
	relative distance	Distance between points (as above) in comparison to other distances
	relative size	The size or length of a line, shape or patch
	compositional size	The size the subject occupies on the paper
	relative orientation	The orientation of one line segment compared to another
	relative curvature	The curvature of one line segment compared to another
	textural detail	Fine detail of a textural pattern
	relative tonal value	The tonal value of one patch relative to another
	tonal gradient	A tone which gradually changes
	configuration of points	The spatial relationship between several one dimensional points
	configuration of lines	Many line segments joined end to end, or at junctions
	complex line	A single line made of many line segments
	configuration of tonal patches	Neighbouring tonal patches of different tonal values
	constructed shape	A complex two dimensional shape constructed from measured line segments
	shape	Two simple dimensional shape such as a circle or triangle
	plane	A two dimensional shape with an angle or curvature into the third dimension
	configuration of shapes	A number of shapes

	tonal distribution over whole composition	Similar tonal values perceived over the whole drawing
	geon	A simple three dimensional form such as a cone or cylinder
	configuration of geons	A complex three dimensional form comprising a number of geons
	form	A solid three dimensional shape such as the head or nose
mid level	structure	A complex three dimensional form built from lines, edges and planes
	symmetricality	The spatial relation between the two sides of the head
	composition	The overall structure of the drawing
	tactile quality	Density or softness
	weight	The effect of gravity on something
	movement	Actual or imagined movement
	individual feature	An individual, nameable facial feature such as an eyelid or ear
high level	partial view	A view of a substantial part, but not all of the drawing
	global view	A view of the whole drawing or subject
	likeness	If the drawing is a good likeness of the subject
	direction of gaze	The direction the subjects eyes are looking
	mood	The facial expression or general
	relation between pictorial elements	A view of the relation between certain parts of the subject or elements of the drawing
	semantic meaning	A connotation, communicated or inferred
	overall feeling	The affective quality or atmosphere of the drawing or subject
	anatomy	Knowledge of anatomical structures
visual / schematic memory	familiarity with generic faces	Subset of anatomy – awareness of significant measurements to be taken and important visual cues
	familiarity with individual	If the subject is well known (the case studies are self portraits, but some have drawn themselves extensively before)

Table 3. Categorisation of artists' references to visual features.

Each artist's reports were characterised by different feature types. Unsurprisingly, all mentioned individual (facial) features, but beyond that the emphases were very different. Brew was concerned mainly with tonal values and configurations of lines, Roberts' with partial views of the head, direction and structure, tonal values and constructed shapes. Connolly's was the most varied, with many references to tonal value, but also including form, tactile qualities, weight, and anatomy. Cobley tended to refer to a global view of the head, and to form and mood.

As well as differing emphases between artists, there were also differences within each of their strategies. In general, Brew tended to remain focused on lower level features, while the other artists moved from only lower levels to both low and mid/higher levels as the drawing progressed. The emphasis from global to local also changed, with Brew and Connolly beginning locally, Roberts and Cobley beginning globally (i.e. across the whole composition) and working towards the specific, as described in the first part of this chapter. These patterns of activity are discussed further, in relation to the drawing strategies, in chapter 6.

These verbal reports are neither full, nor entirely transparent (as discussed further in chapter 7), and so they cannot be considered a complete or true description of the cognitive activity involved with these drawings. Further scrutiny and comparison of the details is therefore of limited value. They can, however, be considered to include many examples which are likely to be used by a range of artists in a range of strategies. That is, they represent an array of possibilities. The next part of the analysis, therefore, generalises the instances mentioned above.

3.2.3 Understanding the verbal reports in relation to time

Samples of the transcripts can be considered in relation to time. As mentioned above, strategic statements tend to relate to the immediate past or future, while visual attention is employed in the present moment, especially when directly informing drawing actions but *also* often to inform strategic judgements. This dual temporality is demonstrated by the two axes of the model below (figure 21) using Roberts' report.

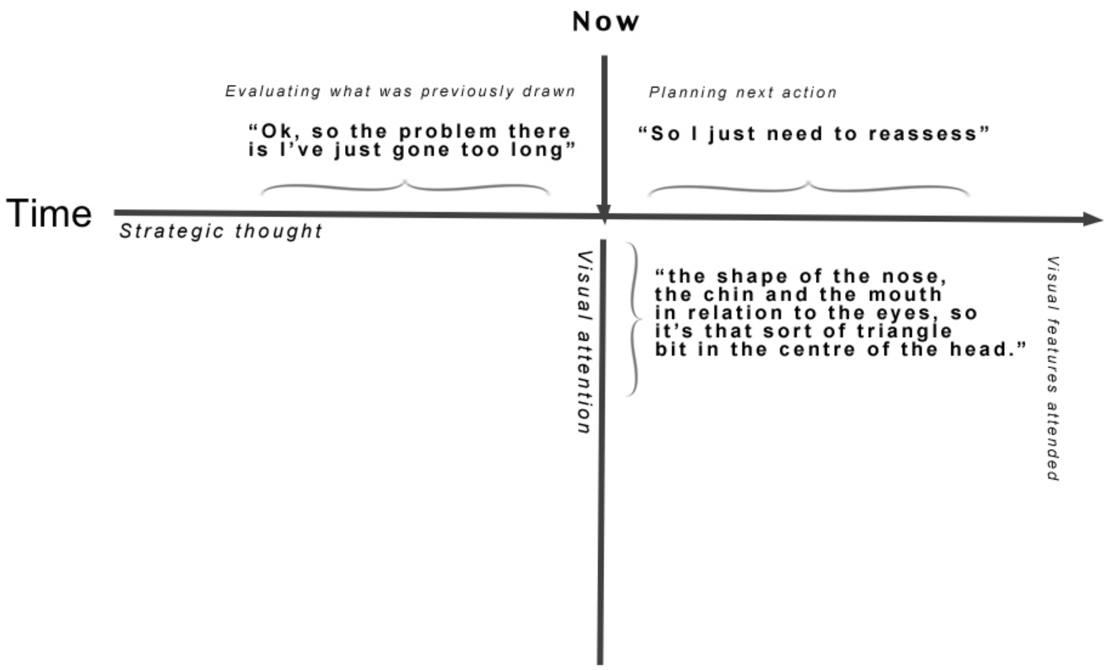


Figure 21. A portion of Roberts' concurrent transcript considered in relation to past, present and future.

This kind of categorisation can be generalised as below. Figure 22 includes only examples of the various feature types mentioned, to represent the gamut of visual complexity.

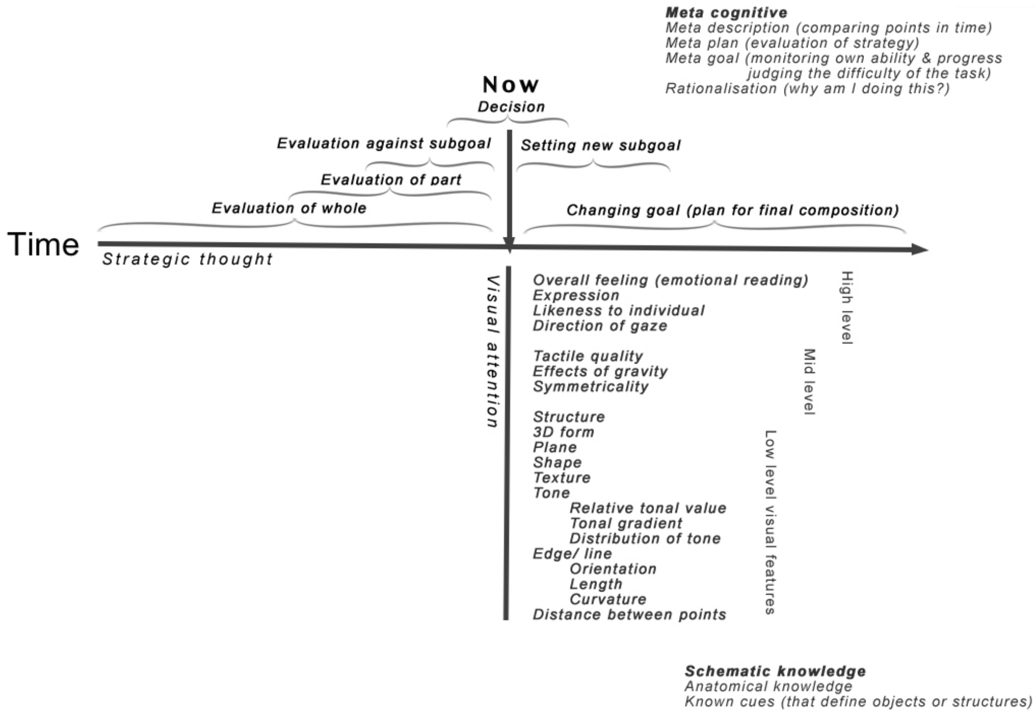


Figure 22. A 2-D cognitive model of observational drawing process. The two dimensions are temporally distinct. The horizontal axis represents strategic elements, concerned with the past and future of the drawing (at various scales), while the vertical axis pertains to the perceptual elements attended in the present. Elements on the vertical axis can also be involved with strategic thinking. Two further elements are included: a metacognitive category accounts for thoughts not concerned with the duration of the specific drawing, and schematic knowledge accounts for visual information retrieved from memory.

The horizontal arrow represents the time spent making the drawing, with a notional present moment indicated. The brackets represent thoughts pertaining to parts of the drawing already completed, and not yet completed. Statements reflecting metacognition are more general, or refer to moments outside of that time-span, for example they might judge the difficulty of the task, the progression of their own skill, or compare the drawing with one made previously. For this reason, they are not directly linked to the timeline. Similarly, schematic knowledge may also inform the drawing process in addition to perceived details. This kind of knowledge can be thought of as part of the visual attentive dimension (this is discussed further in chapter 6).

It seems that, within each of these two dimensions, one thing at a time is possible. For example, the artists might be evaluating the whole drawing in relation to the quality of the likeness, or the part just drawn in relation to, for example, the curvature of a specific line segment. In this way, strategies are devised to contend with the many levels of analysis involved in drawing. It is also possible, that activity on the horizontal axis is entirely replaced by the activity of drawing. That is, that attention is paid at one level on the vertical axis, while activity on the horizontal axis varies in temporal direction (past or future) and duration, with direct drawing activity occupying the present (centre).

There are likely many more possible ‘dimensions’ of drawing this model does not cover. Emotional involvement, for example, or procedural knowledge of drawing ‘routines’, or the way in which schematic knowledge interacts with perception. Other studies might investigate these aspects further. But this model is still an adequate tool for comparing the reports given in this study, and could potentially be extended to other drawing practices. The following section briefly considers the artists’ behaviour and reports in regard to this model.

3.2.4 Using the ‘2D model’ to describe drawing process and skill

While the incompleteness of verbal reports mean the model cannot be used to exhaustively describe drawing processes, it is still useful in a number of ways. It provides a framework within which drawing strategies can be described, and through which other theories of drawing and cognition may be seen. It also allows a consideration of this dichotomy as two potential domains for learning: strategic and attentive (in addition to more familiar learning domains, e.g. schematic, psychomotor, affective).

The artists displayed skills relating to meta-cognitive control in these two domains through attentional strategy and evaluative strategy. Although the model does not include every possible element of strategy or every perceptual level, it can be used to generally describe each artist’s strategy, and sub-routines within those.

All artists mentioned that in a longer drawing they would tend to ‘take a step back’ periodically in order to re-assess the whole drawing (perhaps every 5-10 minutes or so). In shorter timeframes, evaluative routines of varying resolution are evident, from periodic evaluation of the whole drawing (Roberts) to frequent evaluation of parts of the drawing (Brew). On the finest scale there are immediate evaluation of single marks (Connolly). Cobley used a combination of these strategies.

Periodic evaluations tend to be initially concerned with global and high-level features such as likeness and whether it 'feels right'. This may locate an area that requires further attention at lower levels, i.e., considering what about it feels 'wrong' (not symmetrical, not 'sitting right'), which would create the need to look again at the subject at lower levels still, in order to re-measure. In this way, a typical evaluative sub-routine will tend to 'drill down' from high to low levels. More frequent evaluations, such as those used by Brew and Connolly, may skip this procedure and simply 'double check' measurements at a lower level.

In addition to structuring routines for evaluation by order of complexity, the overall drawing strategies also seemed to be modulated in a similar way. Roberts demonstrated this most clearly, changing the emphasis of her looking between each evaluative pause. In between evaluations, she would limit herself to using few types of feature at a time to inform the drawing actions. Initially she was concerned with global features (planning the final composition), first considering size and scale, then features such as the main structural elements, angles and measurements. After a quick review of the whole thing, she proceeds to observing shapes and planes. In the next phase, more precise contours and outlines. In the next, textures and quality of line. On discussion, she reasoned that she usually proceeds in more or less the same order: structural, three dimensional qualities at first, and later finer detail describing edges, contours, textures and finer tonal variations.

Brew's drawing (and verbal report) proceeded in the opposite direction, from lowest level upwards. She begins by focusing on points joined by lines of particular orientations, lengths and curvatures. Once a few marks have accumulated, she checks that part of the drawing. She later moves on to considering tone and only towards the end (or even only after the drawing is completed) will she look for higher-level features, such as likeness and expression. In this way, her visual attention focuses mainly on lower level features, but moves methodically upwards (see retrospective report), again, accounting for very few feature types at any time.

Cobley's strategy seems to be to maintain an awareness of the whole and its symmetricality throughout, or at least to return to global features frequently. Areas of tone are often added across large parts, or disconnected patches, across the drawing. The drawing seems to emerge from the whole page, rather than growing out from a specific point. In his retrospective report he describes considering higher-level features only in evaluations later on, while initially he relies on the accuracy of his measurements to construct a good likeness. Connolly's strategy is quite different again. He is clearly measuring low level features (distances, tonal values, the direction of planes) as this can be seen in his drawing. However his *report* was more concerned with mid-level features. He describes 'fleshyness', the effects of gravity, and anatomical details.

The strategies described here are typical of the artists studied, although they acknowledge that they also use different strategies, for example when using different media. Either way, the artists are familiar with a range of strategies. These strategies involve cognitive control on both dimensions, visual and strategic. This control, and the strategies that make use of it, could be said to constitute part of these artists drawing skill.

The 2D model presented here will be taken forward in following chapters as an analytical tool for considering existing cognitive accounts of drawing. It will also itself be scrutinised in relation to more extensive literature addressing vision, attention and memory, as will the strategies described. Prior to that, the next part of this chapter considers the quantitative data.

3.3 Quantitative analysis: the timing of looking and drawing activity

The following analysis is made with reference to the video data, from non-verbalised trials, using the scheme below (box 3). Glances to the mirror and paper were timed, as were different drawing activities. Two parallel groups of behaviours (drawing and looking), each contained mutually exclusive categories.

- Looking:
  - Looking at the paper
  - Looking at the mirror
  - Looking away
- Drawing
  - Drawing
    - Drawing rough lines
    - Drawing contour
    - Drawing tone
    - Defining patch
    - Drawing scaffold marks
    - ‘Other’ drawing
  - Not drawing
    - Pausing
    - Rubbing out

Box 3. Final coding scheme for video data.

3.3.1 Comparison of looking activity

Despite considerable differences in approach and strategy, the timing and distribution of looking is remarkably similar between these artists when considered over the whole duration. Figure 23 shows that over 5 minutes, each spent just over a third of their time looking at the mirror.

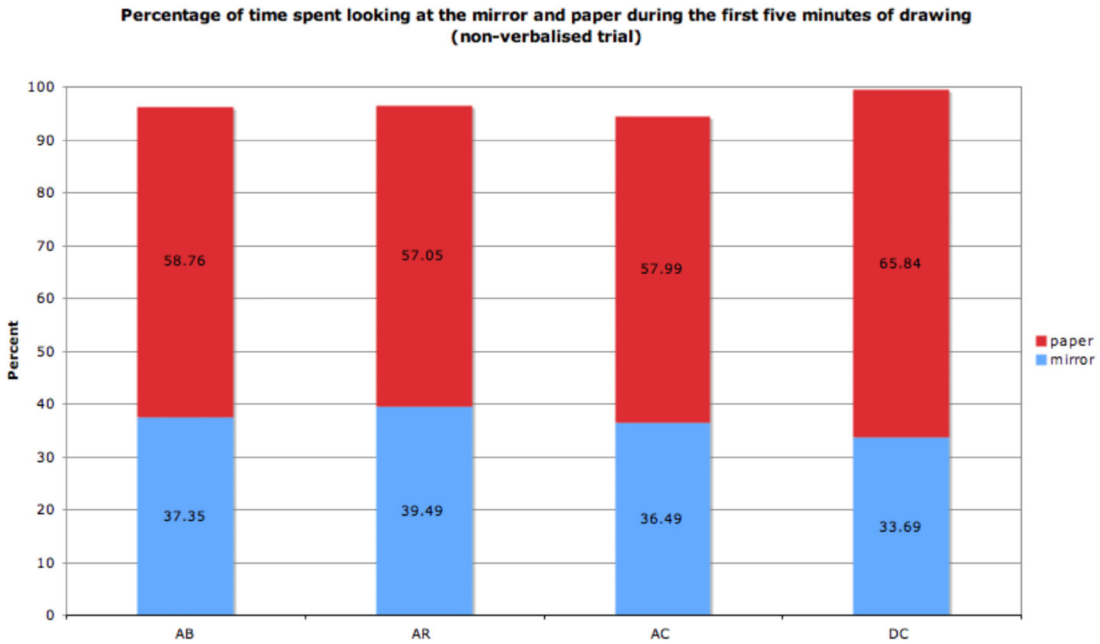


Figure 23. Allocation of time spent looking (the sum is not 100 due to brief glances away).

However, while the proportion of distribution was similar, Connolly and Brew's glances were longer on average. Figure 6a showed that the mean duration varies from around half a second, to almost two seconds. In Brew's case, this was skewed by a few very long glances to the mirror (during early periods of blind drawing), her usual timing being more similar to Connolly's, at just under a second and a half on average (see fig 24).

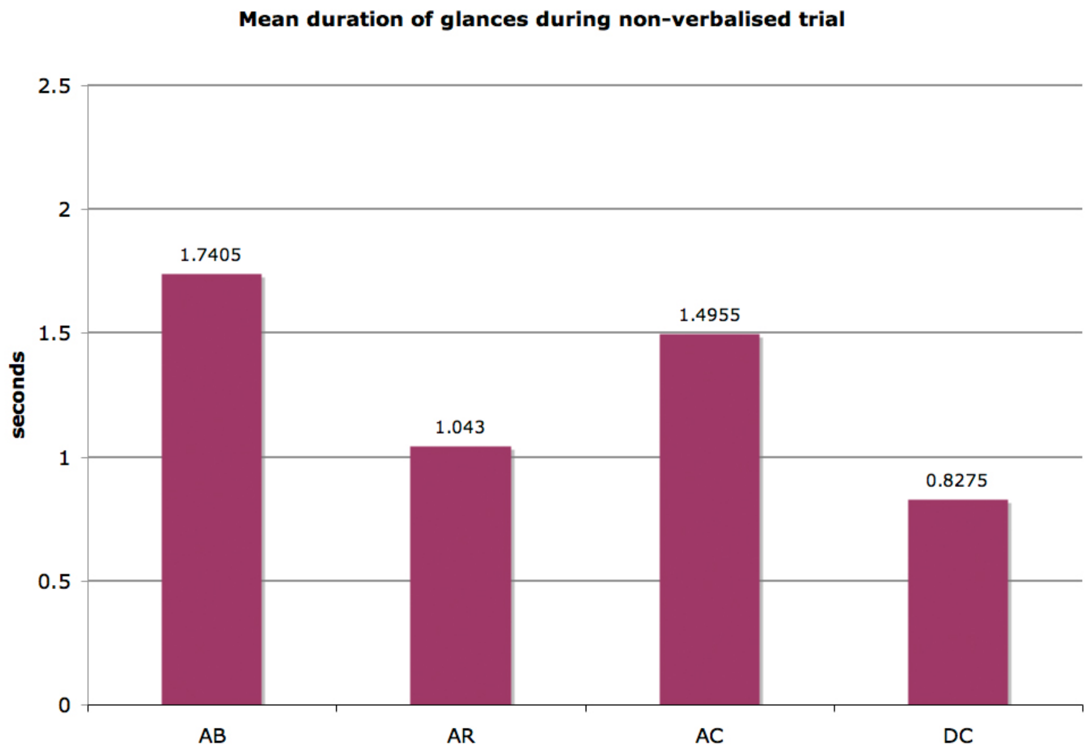


Figure 24. Mean duration of glances during the first five minutes of drawing.

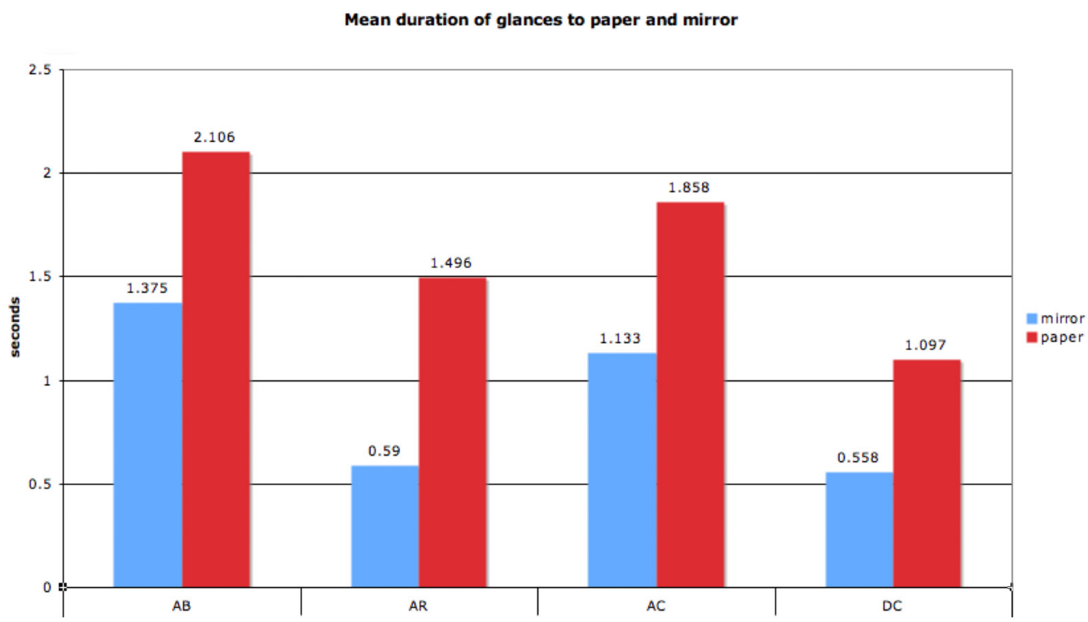


Figure 25. Mean duration of glances to mirror and paper.

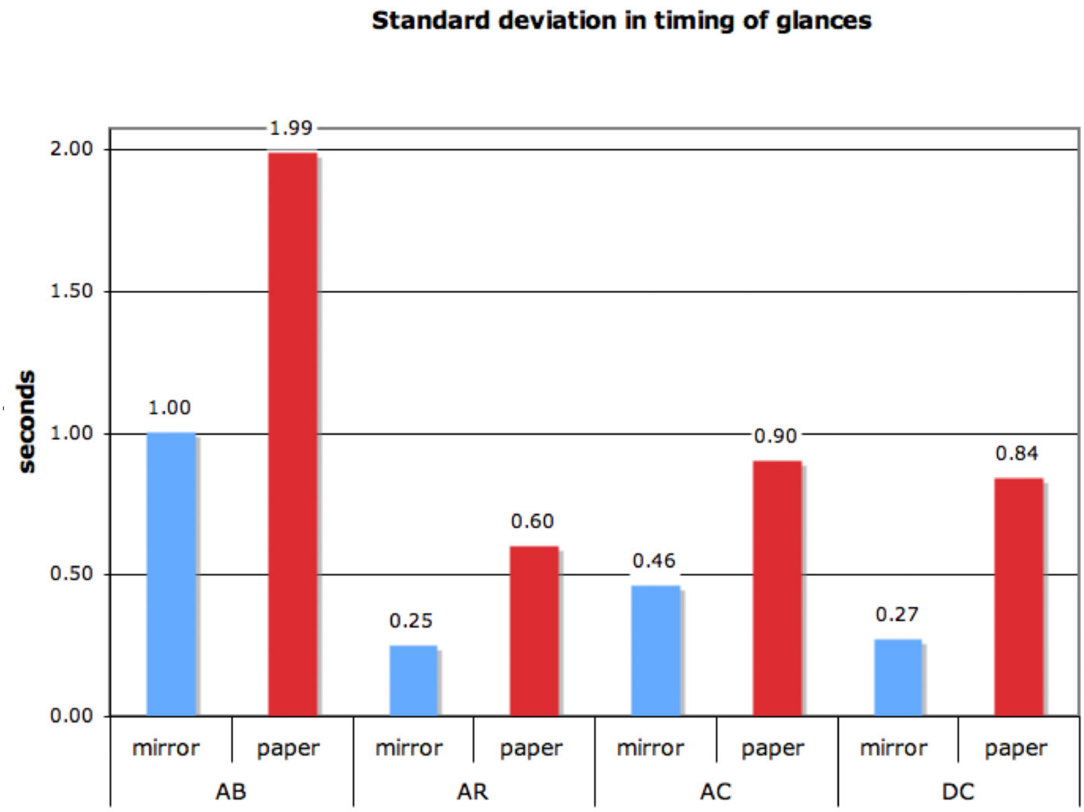
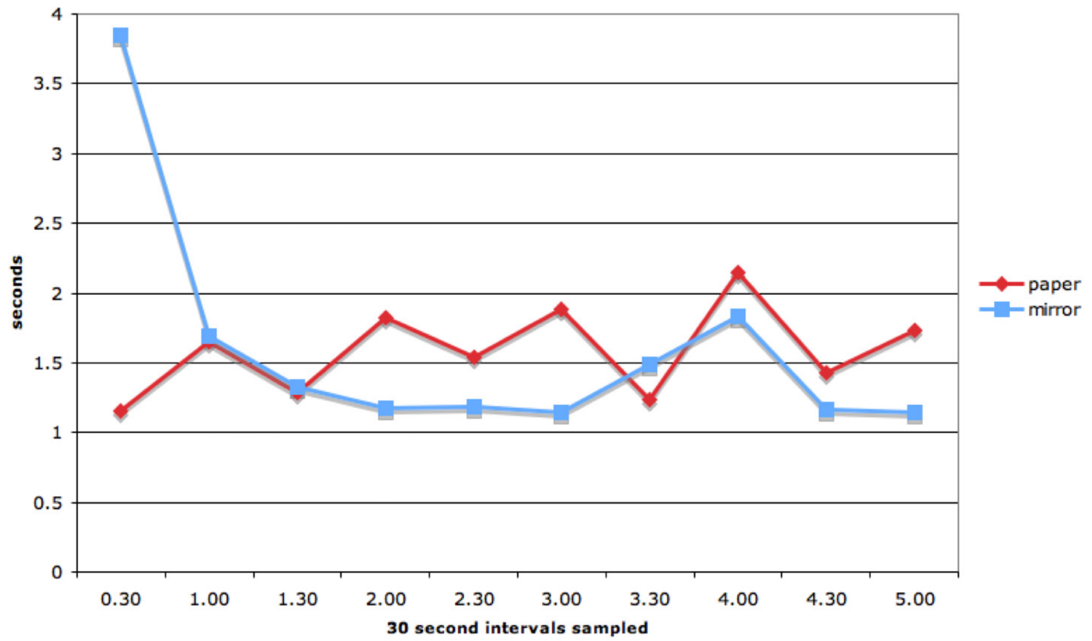


Figure 26. Standard deviation in timing of glances.

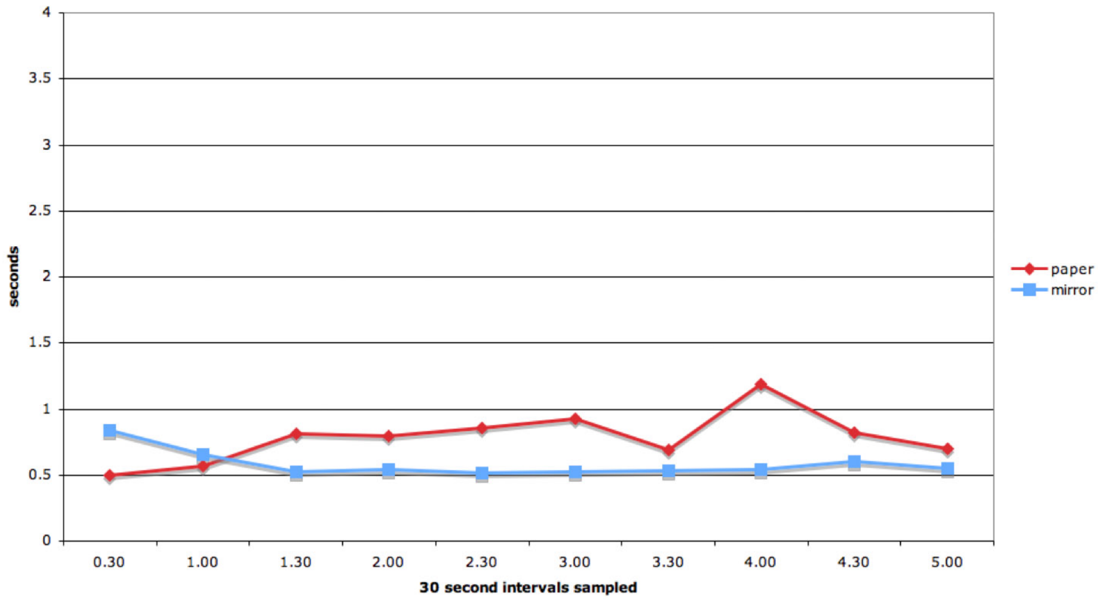
The standard deviations show that while Brew demonstrates much longer durations on average, these are also subject to greater variation. Also, that glances to the paper vary more than glances to the mirror for every artist.

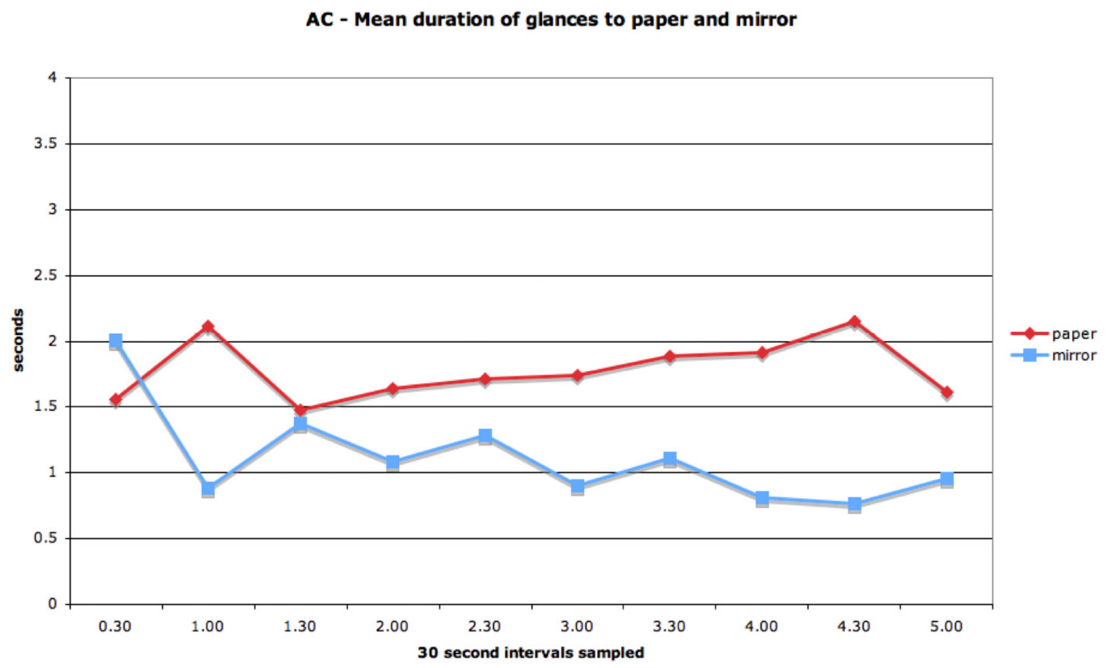
The duration and proportion of looking is not consistent throughout the drawing. When sampled at 30s intervals, it is clear that there is usually an initial emphasis on the mirror (figure 27). With time, glances to the paper become longer in both proportion and duration. This pattern is most clearly pronounced in Brew's drawing, but is present in others too. Although Cobley does not demonstrate an initial emphasis on the mirror, there is still an increase in duration of glances to the paper in the first minute (initially there is nothing on the paper to look *at*, so as the drawing progresses, more reference can be made to what is there). Figure 27 also shows that this tends to even out although, notably, each artist displays a temporary increase in interest in the paper around the 4 minute mark. This could be attributed to an evaluation in an anticipation of the end of the 5 minute period, although the artists were not timing themselves (they would stop when instructed).

AB - Mean duration of glances to paper and mirror



AR - Mean duration of glances to paper and mirror





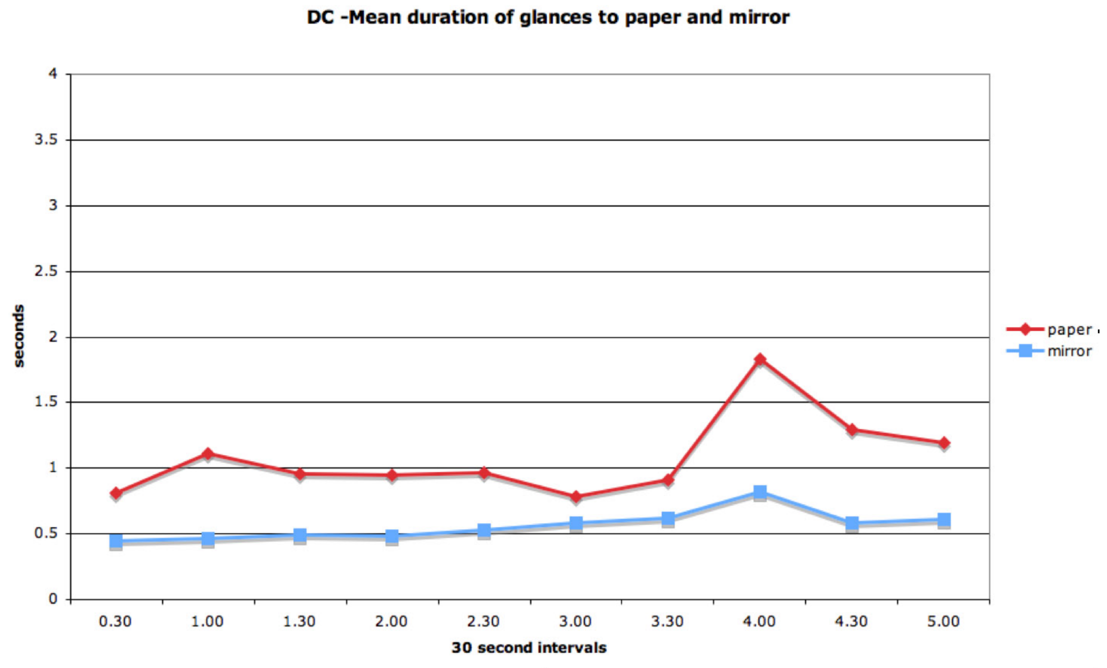


Figure 27. A comparison of timing, sampled at 30 second intervals for the first 5 minutes of drawing.

Overall, there is a correlation between approach and timing: those using an additive approach use longer glances, those using the heuristic approach use shorter glances on average. This is not conclusive, as there are only four examples it is possible that this is coincidental. However, it still demands explanation, and a more detailed consideration of timing reveals further details within gaze cycles. When the coincidence of looking and drawing activity is considered, similarities between Roberts and Cobley are still present, but Brew and Connolly appear very different, illustrated further in the following section.

3.3.2 Coincidence of drawing and looking activities

Figure 28 shows that Roberts and Cobley draw most of the time, more or less regardless of whether they are looking at the paper or mirror. Brew's shows a larger proportion of time spent not drawing, but this is still similar during glances in both direction.

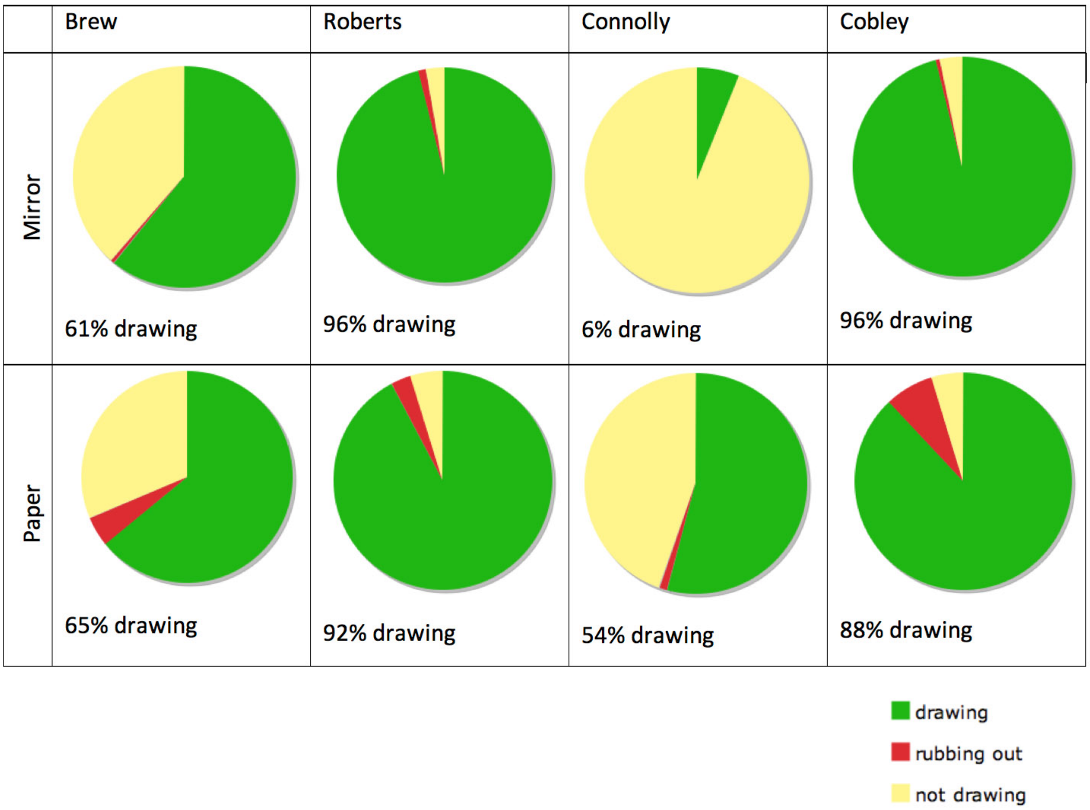


Figure 28. Co-occurrence of looking and drawing activities.

Again, Roberts and Cobley are similar, with few pauses while looking at the paper and even fewer while looking at the mirror. Brew and Connolly both draw less, so while their glance durations are longer, this additional time is spent 'not drawing'. Connolly In particular draws less, and also demonstrates a more significant difference between directions of looking, i.e. he rarely draws 'blind' (while looking at the mirror – only 3% of the overall time, discounting time spent looking away) as the others do. These differences are explained further by the timing of activity within gaze cycles, presented in the following section (figures 29-33).

3.3.2.1 Patterns in looking and drawing activity

While Brew's glances were longer on average, this can also be attributed to periods of blind drawing. She does not refer back to the paper after every single mark, but continues drawing while looking at the mirror (see figure 29). She looks back and forth continuously whether drawing or not, also pausing sporadically while continuing to look in both directions. Her looking pattern is very different at the start (figure 30) with longer glances and longer pauses, but after around one minute it becomes quicker and more regular. Here, longer glances to the paper correspond to rubbing out (purple), but glances back and forth are otherwise quite regular, although much slower than the other artists', with drawing patterns also less regular. Here, each instance of rubbing out was followed by a glance to the mirror and back to the paper again before resuming drawing during the second glance to the mirror. Periods of looking back and forth while not drawing probably equate to what Brew referred to as 'double checking' measurements.

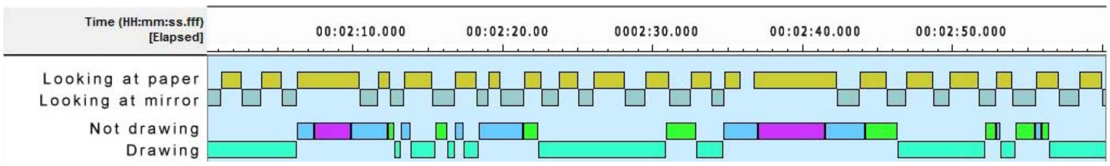


Figure 29. Timeline showing typical timing of Brew's drawing & looking. Looking back and forth continue whether drawing or not, at a slower rate to the other three artists.

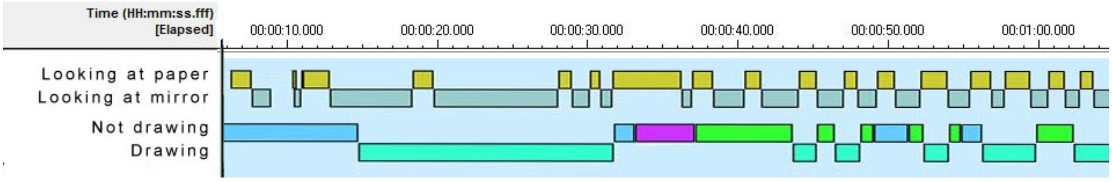


Figure 30 Timeline showing Brew's timing early on in the drawing. Initial looking patterns included much longer glances to the mirror.

Connolly's glances are also considerably longer than Cobley and Roberts'. This cannot be attributed to blind drawing but to pauses included in each cycle. Connolly's drawing rhythm is regular and more predictable than the other three artists'. Unlike them, he almost never draws blind, instead he holds the pencil hovering slightly above the surface of the paper, moving it as though he is drawing, rehearsing the marks he is about to make. This is similar to the behaviour Tchalenko observes in Humphrey Ocean, which he describes as 'practice strokes'. Connolly repositions the pencil while looking at the mirror, but checks its location before drawing, watching the paper as he makes the mark. Usually, he will complete the mark and continue to look at it for a short time (around .25sec), before returning his eyes to the mirror. This pattern is the same whether he is drawing line (light blue) or tone (darker blue), although he can take much longer to draw a patch of tone. There are exceptions, but these are very few. This pattern is repeated throughout most of the process, with occasional longer pauses.

The pattern of behaviour shown in figure 31 is typical of his process. It can be clearly seen that drawing usually begins immediately after the eyes return to the paper, but ends before the eyes return to the mirror. This can take several seconds, or a fraction of a second.

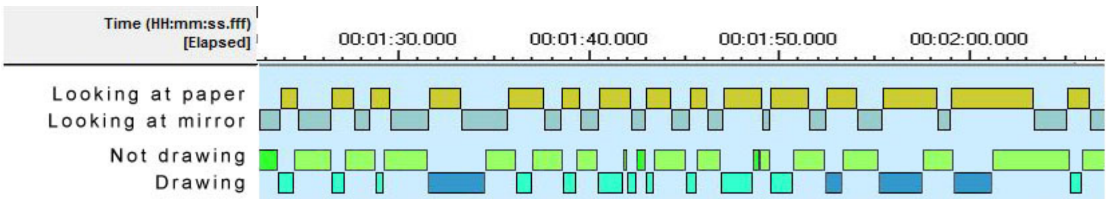


Figure 31. Timeline showing timing of Connolly's looking and drawing. Drawing always occurs immediately after the eyes move to the paper, before looking back to the mirror the eyes remain on the paper for a short period.

In contrast, Roberts draws continuously, repeating marks many times and only pausing at longer intervals. She looks back and forth with regularity whether drawing or pausing, and much more quickly than Connolly or Brew. (The footage shows Roberts drawing much larger marks and more vigorously.) Occasionally there will be a longer pause as she stops drawing to review her progress. Figure 32 shows the shortest glances to the paper coincide with drawing rough sketchy marks (purple), the longest with drawing 'scaffold marks' (brown) which define the structure of the head, on which to build further detail.

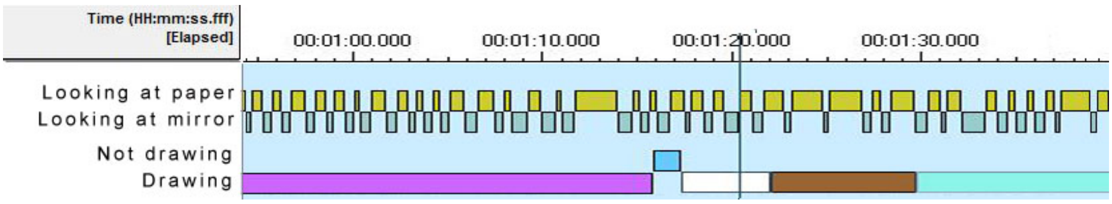


Figure 32. Timeline showing timing of Roberts' looking and drawing.

Cobley also draws continuously while looking back and forth at a similar rate (glances to the mirror are of similar duration to Roberts's, but glances to the paper tend to be slightly longer, particularly when drawing tone (indicated in white in figure 33). He stops occasionally to lower his hand and look at the paper. Variations in timing seem to be more regular, with longer glances grouped together.

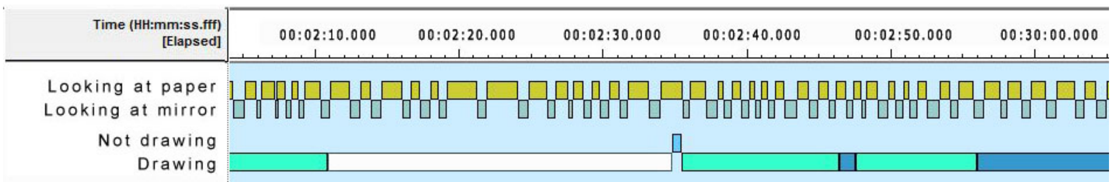


Figure 33. Timeline showing timing of Cobley's looking and drawing.

All four artists show characteristic patterns, although there are also distinct similarities, especially when patterns are generalised (as in the earlier figures).

3.3.3 Summary

It can be seen that, despite divergent approaches to drawing, there are similarities in terms of the proportion of time spent looking in either direction over the course of the drawing and the duration of glances. There is some correspondence between approach and timing: those using a heuristic strategy (Cobley and Roberts) tended to glance back and forth rapidly while continuously making provisional marks. The additive strategy (Brew and Connolly) was characterised by slower mark-making, slower looking, ongoing evaluation and a gradual building up of the drawing piece by piece.

All the artists demonstrated similar proportions of distribution of time between the mirror and the paper. They also all demonstrated an increased emphasis on the paper as the drawing progressed, peaking between at, or just after, 4 min. There were also similarities in the regularity of their looking activity, although Brew and Connolly's glance durations were longer on average.

Connolly's gaze cycles were different, in that he rarely drew blind. Brew's were different due to much longer glance durations early on. Roberts and Cobley demonstrated similar looking patterns, although his strategy relied on working symmetrically across the composition, relying on the location of key points, while hers shifted in emphasis from structural 'scaffolding' towards finer detail. General comparisons are summarised below in table 4.

	Brew	Roberts	Connolly	Cobley
Strategy	Additive	Heuristic	Additive	Heuristic
Mean duration of glances	Slower 1.74 sec	More rapid 1.04 sec	Slower 1.49 sec	More rapid 0.82 sec
Blind sighted drawing	Both	Both	Rarely draws blind	Both
Pauses in drawing while looking at mirror	Some pauses 36.32% not drawing	Mostly drawing 2.87 % not drawing	Mostly pausing 88.46 % not drawing	Mostly drawing 3.47% not drawing
Pauses in drawing while looking at the paper	A third of the time pausing 31.19%	Little time pausing 4.82%	Many pauses 44.53%	Little time pausing 5.74
Co-occurrence of looking and drawing	Drawing activity timed similarly during glances to paper and mirror. Includes long periods of 'blind' drawing	Drawing activity timed similarly during glances to paper and mirror.	Disparity between drawing activity while looking at the mirror and paper. Never draws 'blind'	Drawing activity timed similarly during glances to paper and mirror.
Pausing/ stopping	Often pauses while continuing to look back and forth	Draws continuously, stopping occasionally while continuing to look back and forth	Regular, very short pauses just after marks are made. 'Hovering' while looking at mirror.	Draws continuously, stopping occasionally while continuing to look back and forth.
Increase in duration of glances to the paper (mean duration during 1st and 10th 30 second periods)	1.158sec 1.734 sec	0.499sec 0.7 sec	1.562 sec 1.616sec	0.813 sec 1.191 sec
	Similarities			
Emphasis of looking	Two thirds at paper			
Distribution of glances	Similar overall proportion of time spent looking in either direction, roughly 2 thirds to the paper.			
Variation of glance duration	Glances to the paper vary more than glances to the mirror			
Variation with progress	Glances to the paper become longer as the drawing progresses			

Table 4. Summary comparison of looking and drawing activity.

3.3.4 Discussion

Cognitive strategies can be said to differ in two ways: visual (what kind of features/qualities receive attention) and evaluative (how the ongoing drawing is monitored). Differences in timing correspond with the visual strategy in a few ways (e.g. tone takes longer to draw than line, shifting the looking ratio toward the paper, and precise measurements require slower looking), but many more subtle variations are due to evaluative strategy.

The strategies observed can be considered as falling on a continuum – at one extreme Roberts relies on very short glances with fast and continuous drawing, only pausing periodically in order to review the whole. At the other, Connolly draws more delicately with smaller, more precise groups of marks, reviewing each immediately after having drawn it. Brew and Cobley fall between these two extremes**.** Both demonstrate regular looking activity, but drawing activity is less regular.

Glances to the mirror remain relatively constant in duration, as these function to take in a certain amount of information, be it for directly transposing into the drawing, or for comparison with what's already drawn. There appears to be a consistency in the 'portion size' of visual information to be used in this way, which takes roughly .5 to 1.5 seconds to 'see'. There is some variation in each artist's preferred portion size. Glances to the paper are more variable, partly during tonal marking which is more time consuming, but also as later on includes additional reflection about how the drawing is progressing. Hence the variability and increasing attention to the paper as the drawing progresses, although this is least evident in Roberts' timing, likely because she does not seem to use the kind of ongoing evaluation that Connolly demonstrates so clearly.

As described in the previous section, these variations demonstrate that evaluative strategies vary in resolution and frequency (how much of the drawing is reviewed and how often) influenced by the criteria applied. Connolly reviews each mark immediately, but he also takes time to occasionally stop and view the whole drawing. His immediate reviews seem to be concerned only with the small areas most recently drawn, but there is also evidence that these are considered in the context of the drawing as a whole, as Connolly will sometimes return to earlier areas to make amendments, usually to refine tonal values, after such a review (while drawing the mouth he notices that the eye should be darker, for example).

The emerging drawing becomes more complex, and demands re-considering: ‘It starts to become visible or necessary when you give it that much context. […] ‘as you accumulate more drawing, it seems to me you have to create the drawing you’ve already done’ (concurrent report). This may be connected with his unusual looking behaviour. It’s possible that his looking pattern may facilitate this kind of monitoring; rehearsing and reviewing the marks before they are made could allow two opportunities to consider the features, as both fragments and parts of a whole.

Roberts relies only on the second strategy, stopping the drawing process completely in order to take stock and decide how to proceed. This is often followed by ‘taking back’ large parts of the drawing. This strategy is characterised by a faster shifting of gaze back and forth, and periods of continuous drawing. The other two use a combination of both strategies. These evaluative strategies can be called ‘ongoing’ and ‘periodic’.

The evaluative strategies and the visual strategies relate, in that the evaluations are concerned with features of various types. Ongoing evaluations tend to be concerned with localised features, while periodic ones are more concerned with the whole. Periodic evaluations tend to progress from more objective features like distances and angles, to more subjective and complex ones such as likeness or mood, although if something awry is identified, this likely entails then drilling down to a more structural level to identify the problem or re-consider a measurement.

However, even the ongoing evaluation seems to take place in designated periods, short as they may be. The drawing strategies therefore share a common characteristic: the monitoring and evaluation of the drawing seems to take place during discrete periods – the artists stop drawing in order to reflect. This stopping does not usually interrupt the pattern of looking back and forth. It seems that glance cycles can perform these two functions: *informing* and *monitoring* the drawing, although within the cycle the two are separable. If we think of these two functions as distinct ‘modes’ of cognition, they can be labelled as *constructive* (non-reflective) and *reflective* modes. The first is concerned with *doing* the drawing, while the second is concerned with *thinking about* the drawing.

This constructive/reflective dichotomy is more useful and subtle than that of cognition and metacognition. It does not rely solely on the tenses of the verbal reports, nor on the phrasing of comments, but is apparent in the content and timing of both drawing and speaking activities. The segregation is most visible in Roberts footage, how discretely the two activities are segregated is less clear in Brew's drawings, although specific instances can be isolated, it is inconclusive. Connolly's footage suggests the most regular and fine-scale segregation, and so, in order to consider this further, a simpler task was devised for use with the eye-tracking device, which would look more closely at Brew and Connolly's drawing process at a finer scale.

3.4 Eye-tracking data

In order to better understand the distribution of the two functions identified above – *constructing* and *reflecting* – the eye-tracker was employed. Eye-tracking data can offer finer detail, dividing each glance into saccades and fixations. However, the drawing task (‘draw as you usually would’) presented to Connolly resulted in very complex scanpaths. Individual measurements were discernable, but the complexity and fine scale of features and lines drawn meant that identifying any evaluative ‘way of looking’ was difficult (fig 34).

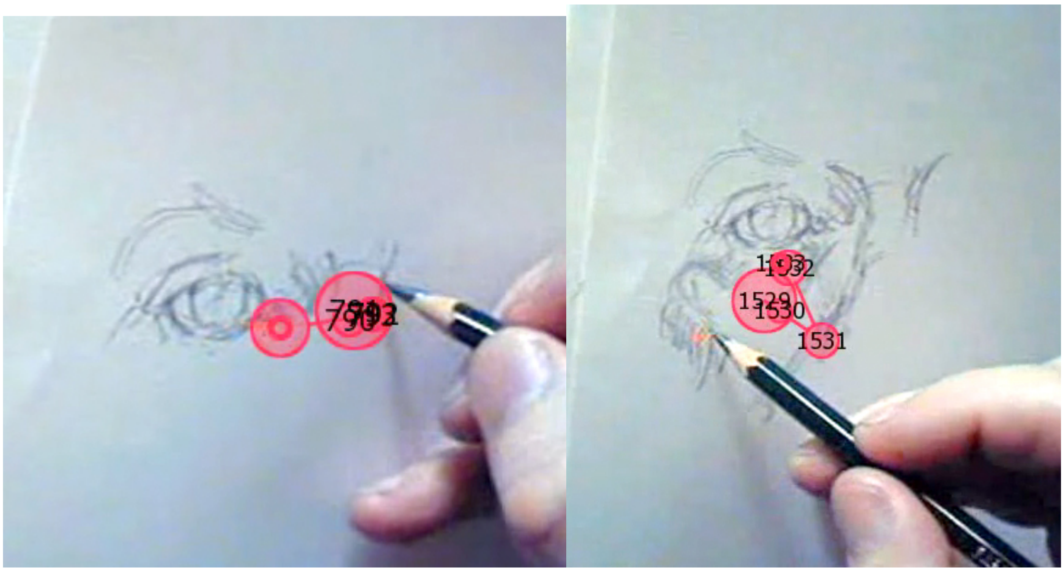


Figure 34. Connolly’s scanpaths showing moments after taking the pencil from the page, before returning eyes to the mirror. Here circles correspond to fixations (numbered), larger circles signifying longer fixations. Here the longest is 0.3s. These potentially show evaluative scanpaths, but a simpler drawing task was devised to identify any differences in scanpath pattern between constructive and reflective activities.

This trial revealed some further subtleties of eye movements, Connolly made several fixations on the drawing before returning his eyes to the mirror, although this is difficult to discern (some of the fixations represented here are ones made while still drawing). This prompted a simplified drawing task, in which a single profile line was generated and copied (the procedure is described in the methodology chapter).

The drawing strategy in the simplified task does not correspond to that of the ‘draw as you usually would’ task. Many variables were minimised, for example, only line was used, and the need to translate form to line was minimised in the copying task. Drawing the face in profile allowed a simpler, more continuous line. The simple task was also much shorter.

Figures 35a-e illustrate Brew's scanpaths during drawing, and immediately prior to and after drawing (similar patterns were observed after each drawing). Figure 35a shows a very regular pattern of fixations for measuring and mark-making, while figure 35b shows her scan path immediately after completing the drawing. This second pattern seems to involve an evaluative procedure for double-checking key measurements. Brew was initially surprised to see these looking behaviours, but on closer inspection it became obvious to her that we were observing an evaluative comparison (how good is the copy?). This pattern also presents itself mid-way, indicating that an evaluation or 'double checking' has taken place. In some trials, a different pattern of looking can also be seen before the drawing begins, as the line to be drawn is anticipated and measured. Figure 35c shows Brew measuring and planning the line she is about to draw. While this planning pattern of looking appears somewhat similar to the evaluative pattern, both are easily discernable from the more regular looking pattern associated with drawing the line. It can be seen that the evaluative/planning looking also occurs during the drawing process (see figure 11d). Eye-tracking data from Connolly completing the same task also demonstrates similarly distinct scanpaths for planning, measuring and evaluating(figures 36a – 36e)

In the images below, the coloured line represents 10 seconds of eye movements. Fixations are represented by dots, saccades by straight lines. The fixations here are defined as anything over 50ms duration. Blinking has been discounted from the visualisation.

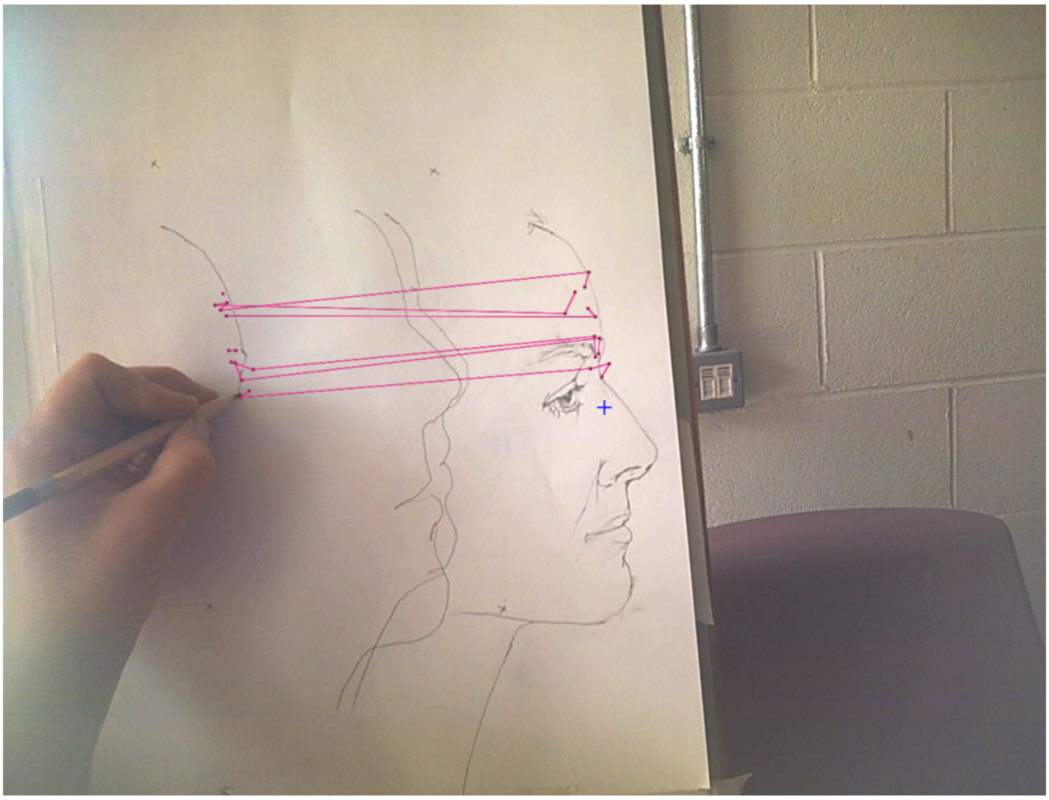


Figure 35a. Brew's typical scanpath during mark-making. Brew usually demonstrates a very regular pattern of fixations, usually two or three to the original and one to the copy.

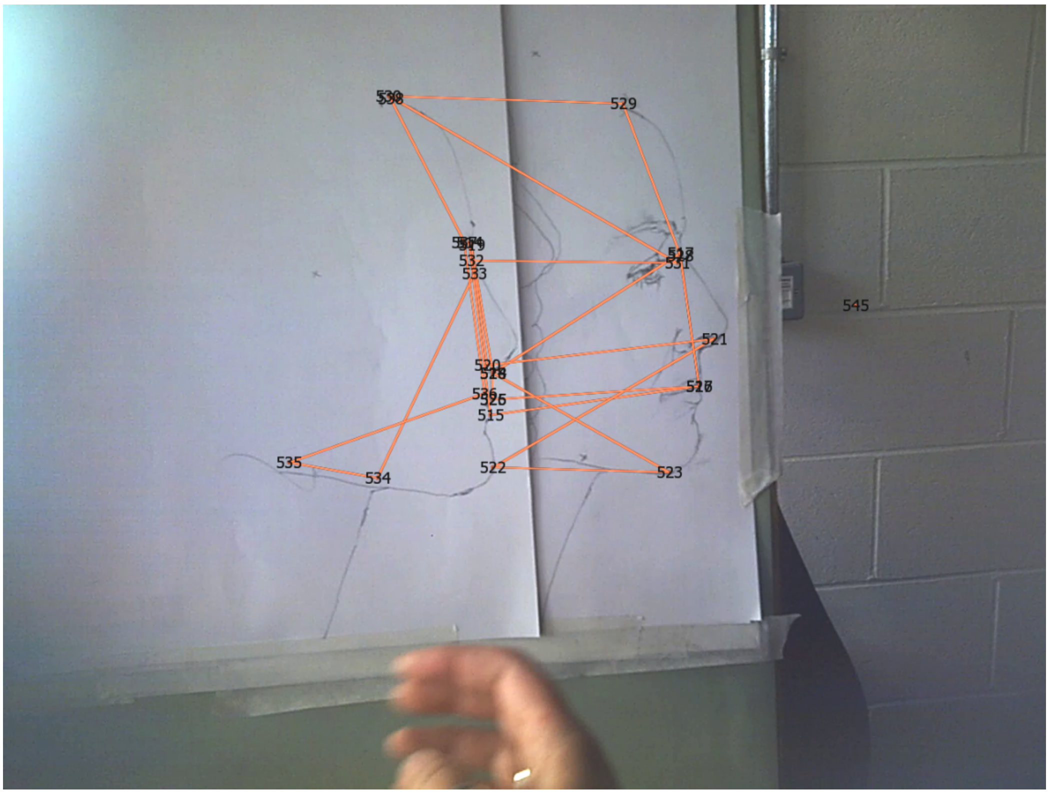


Figure 35b. Evaluative pattern of fixations. The whole line was reviewed and compared to the original immediately after completion. Key measurements are compared. Here the fixations are numbered to indicate the direction of the scanpath.

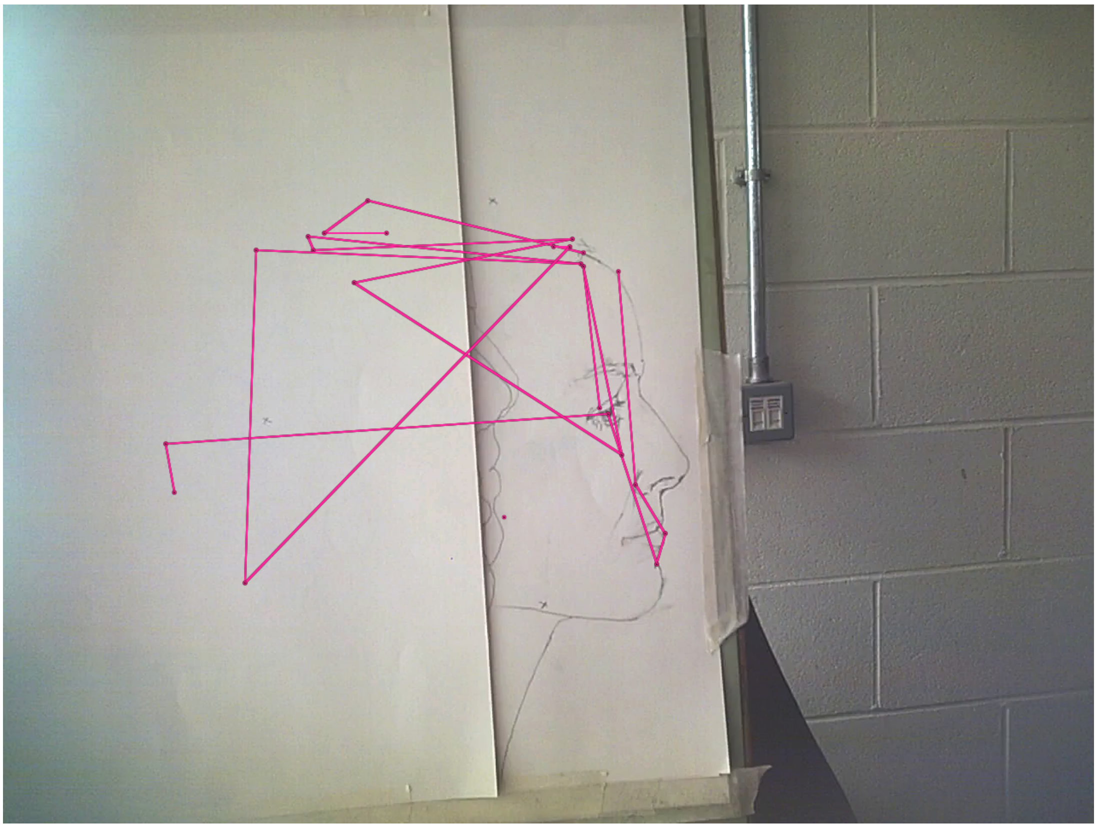


Figure 35c. Patterns of fixations immediately prior to beginning a copy.

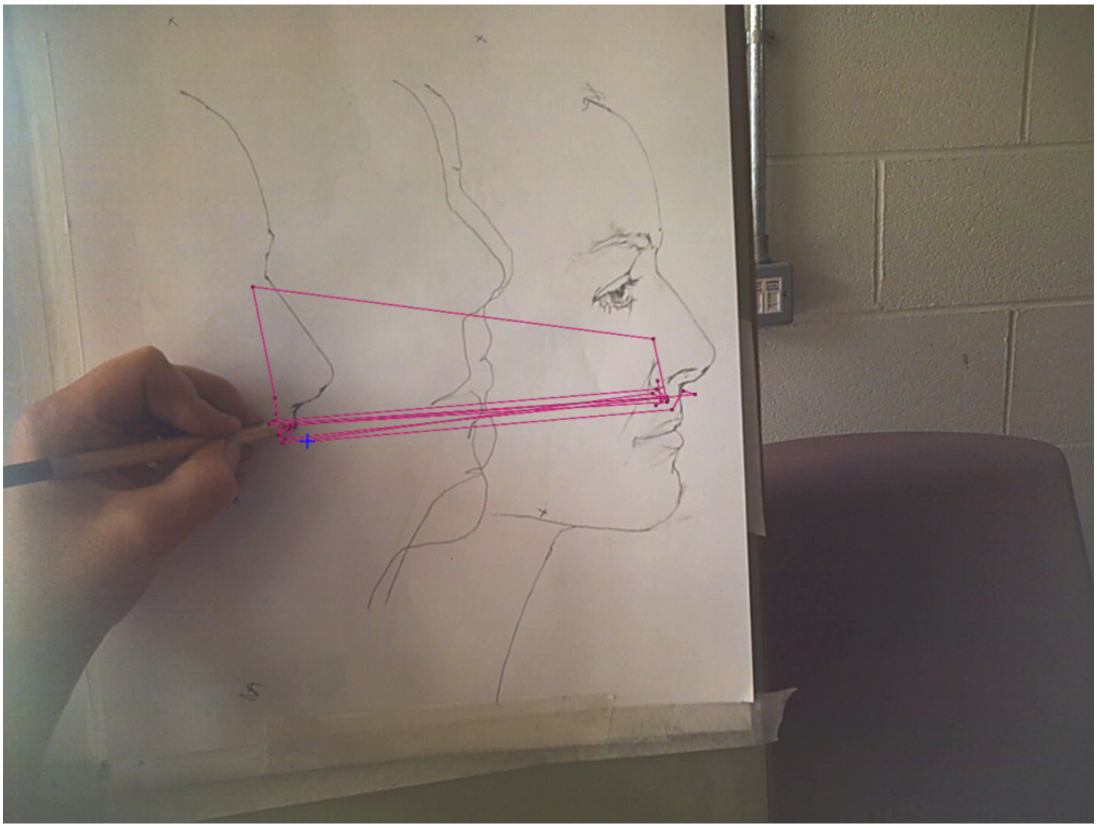


Figure 35d. Another pattern of fixations half way through the drawing, similar to the final evaluative pattern (35b). Here Brew seems to be double checking the size or angle of the nose during a pause in drawing activity mid-way.

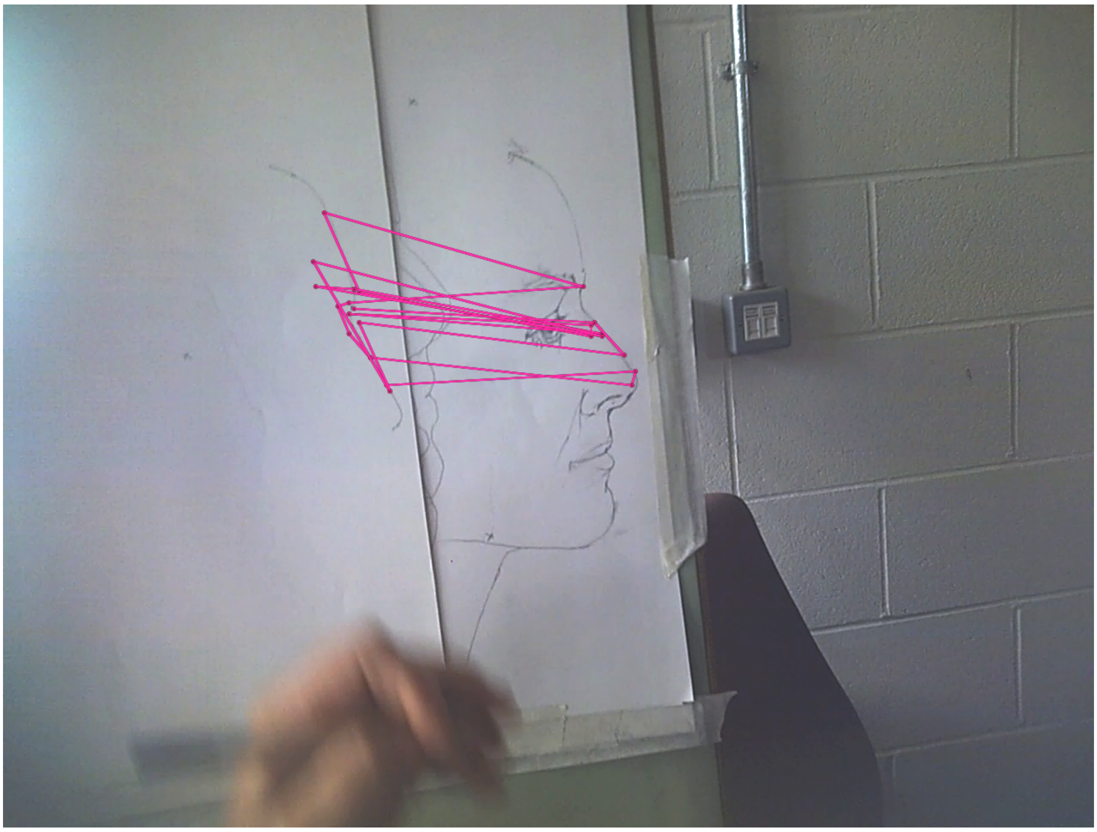


Figure 35e. Similar to 35d, measurements are evaluated prior to rubbing out a portion of the drawing.

These results illustrate distinct scanpaths associated with ‘informing’ and ‘monitoring’ the drawing, or ‘*constructive’* and ‘*reflective’* modes of drawing.

Similarly, Connolly also demonstrated clearly differentiated patterns of looking. Planning and evaluating can be distinguished from direct drawing (figures 36a-36e).

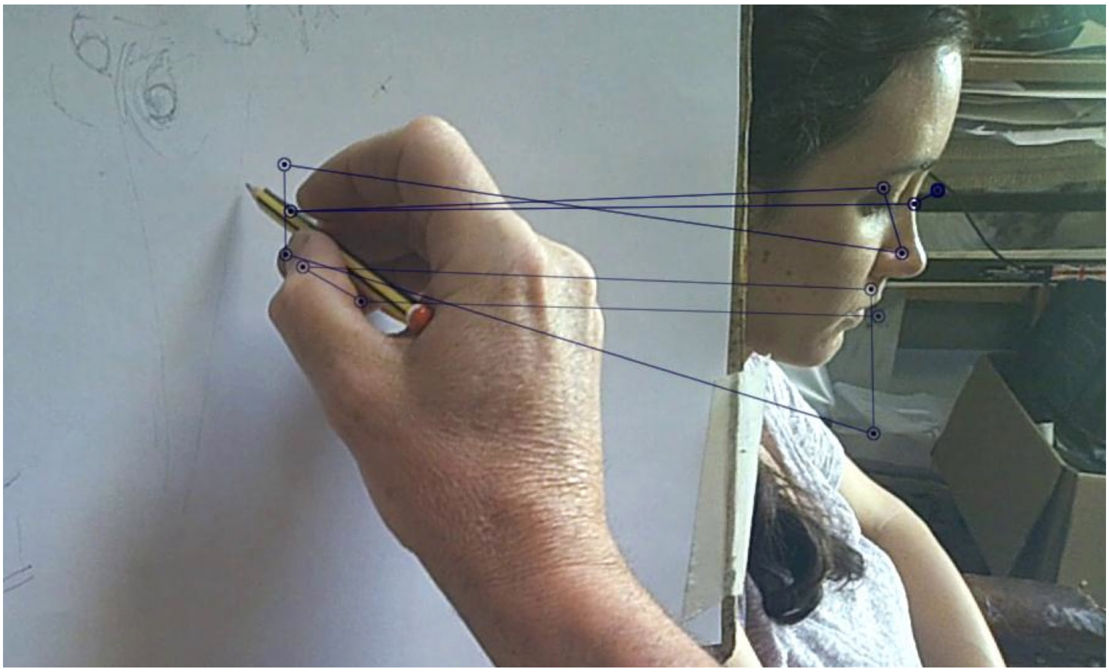


Figure 36a. Connolly plans his next actions, scanning the model and paper immediately prior to beginning the drawing.

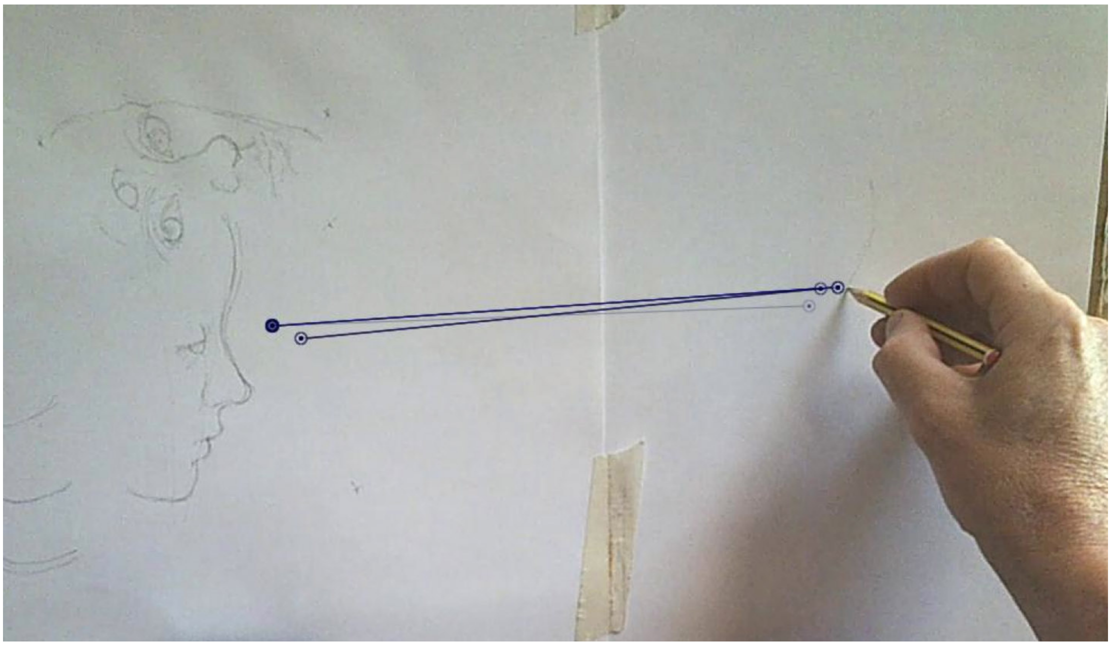


Figure 36b. Connolly reviewing the drawn profile line immediately on completing it.

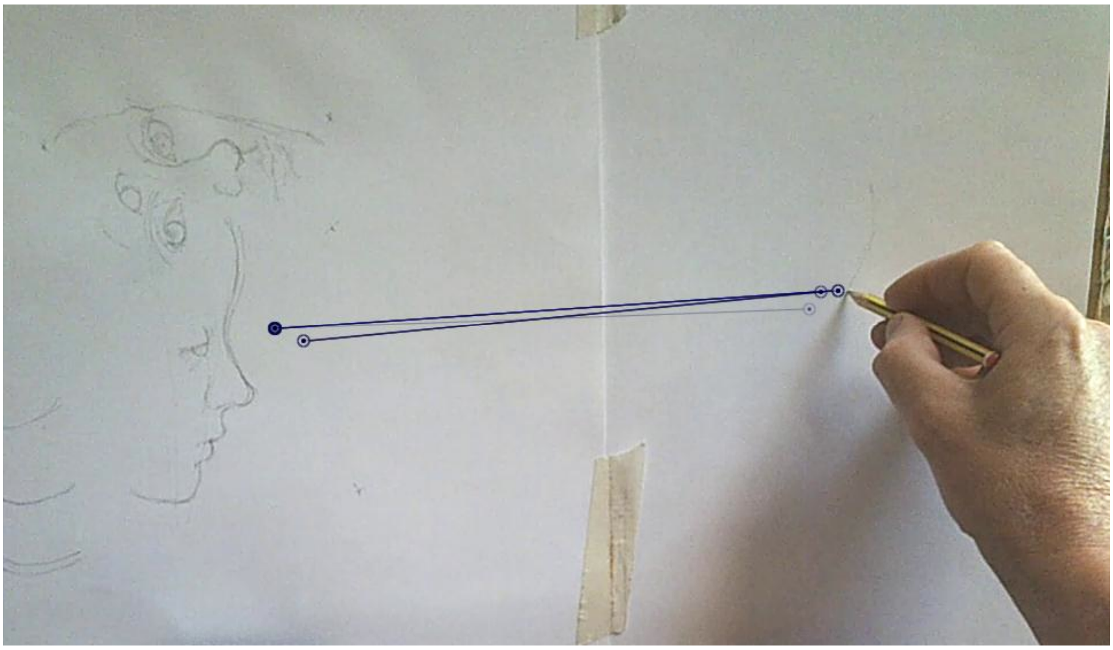


Figure 36c. Connolly copying his previous profile drawing. The pattern of fixations is similar to Brew: a regular, progressive looking back and forth at small intervals. Again, one or two fixations on either side is typical.

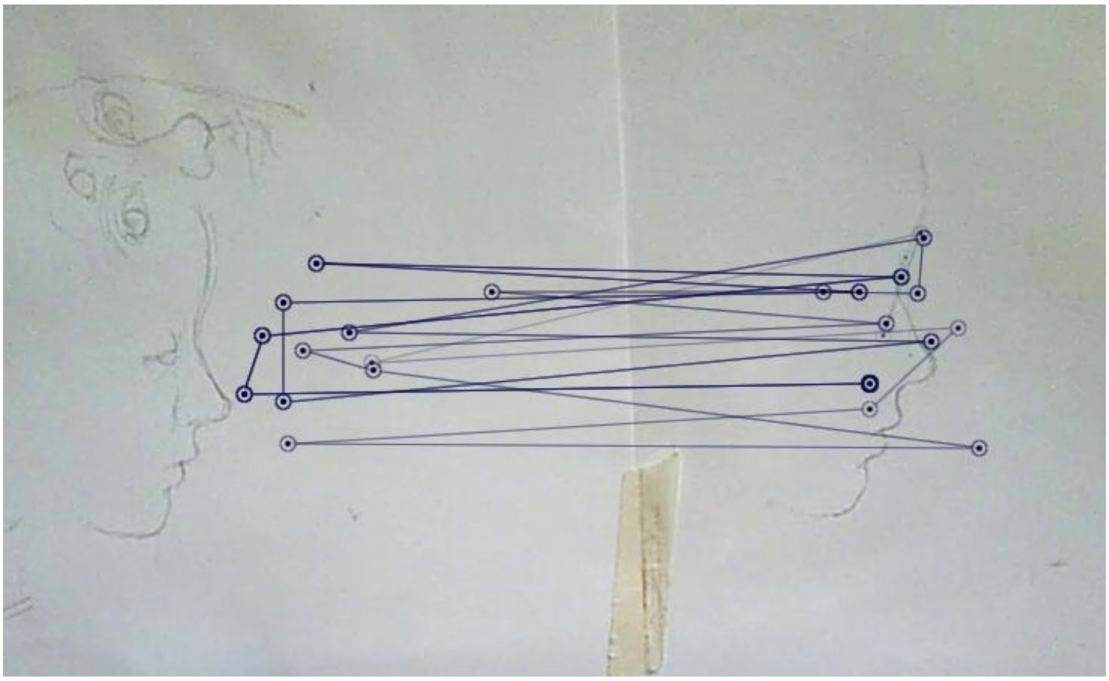


Figure 36d. Connolly reviewing his line immediately after copying it. Again, one or two fixations at a time are made on either side as he evaluates the line. (The line on the right is the one just drawn.)

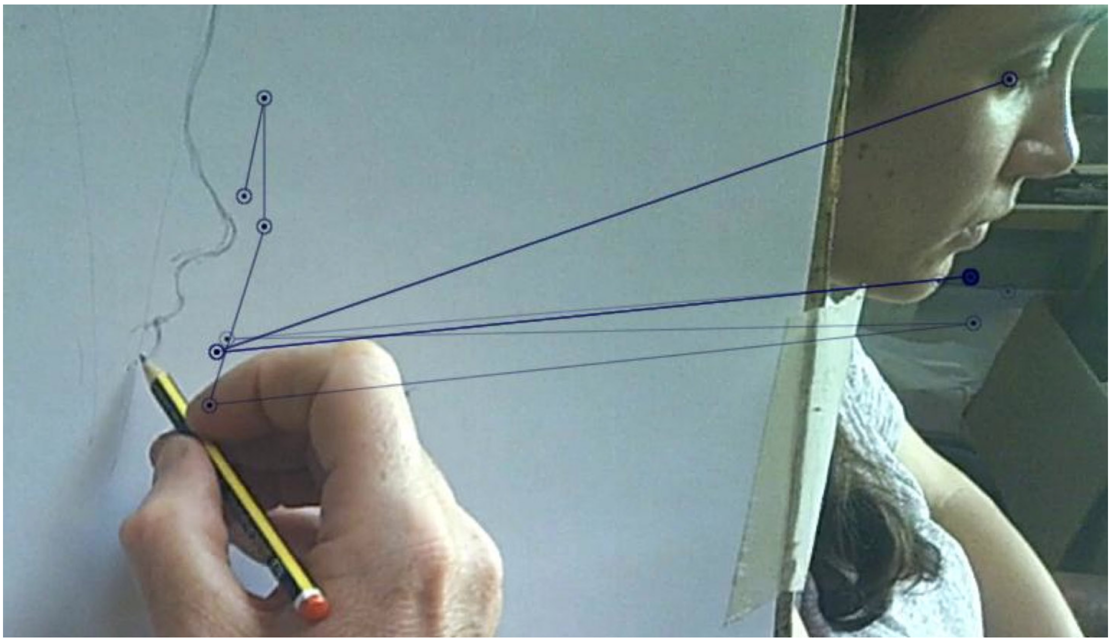


Figure 36e. Connolly performs a similar evaluative routine during the original profile drawing. He reviews the line immediately after having drawn it, before returning his eyes to the sitter**.**

These scanpaths suggest different cognitive activities. These can be categorised as: direct drawing/transposing, planning and reviewing. While it is possible that there are still less obvious evaluative processes occurring ‘below the radar’ so to speak, this evidence shows that, in terms of eye movements at least, the two activities of performing and reflecting on the drawing seem to be discrete.

This segregation of doing and monitoring is interesting when considered in relation to the verbalisation task. Roberts and Connolly demonstrated very different responses, and indeed *abilities*, when it came to verbalising their process. The next (final) section of this chapter considers how the artists responded differently to the instruction to verbalise their activity, considering this in relation to their strategy and its effects on their timing.

3.5 Responses to the verbalisation task & effects on timing

The specific content of the verbal reports, reviewed above, allowed some insight into the strategies of the artists; or at least what they believed their strategies to be. The retrospective reports were particularly rich sources of insight about the reasoning behind those strategies. The retrospective reports were given easily, but the task of drawing while concurrently verbalising presented a problem to the artists. Each responded in a different way. This invalidated any direct comparison, for example, of the number of instances of statements of specific categories, as each artist demanded new categories particular to them. However, they were still a source of insight about the drawing strategies and, beyond that, the way in which each artist approached the task seemed to be related to their drawing strategy.

There are many factors potentially leading to differences in concurrent reporting: the drawing strategy itself, which elements of that were actually verbalised (presumably many details were omitted), and what the artist felt *able* to do without interfering with the drawing act. Each settled on a different solution to the verbalisation technique which they felt enabled them to still draw 'as they usually would' while also adequately reflecting elements of their drawing process. This section discusses those differences, and then reviews data comparing the timing of looking and drawing activities between verbalised and non-verbalised trials.

Each artist responded very differently to the concurrent verbalisation task. Some found the task relatively easy, while others struggled. Cobley took to the task quickly, although much of his report cannot be considered *direct* verbalisation (it included rationalisations and some digression, although this may indeed be typical of this thought process while drawing). Connolly was able to report his process, but still found this difficult, and tended to use broken sentences and some uncharacteristic stuttering when attempting a description of his activity. Brew found the task difficult but settled on a method of verbalising after five attempts and extensive discussion. Roberts found the most difficulty in verbalising her process, feeling that it changed the outcome of the drawing itself. For this reason, her response deserves additional consideration as this response seems related to her particular drawing strategy. The nature of her strategy proved to be especially un-conducive to verbalisation as it involves periods of deliberate 'not thinking', as described below.

3.5.1 Further discussion of Roberts' concurrent reports

More than any of the other artists, Roberts described how she 'found it hard' to verbalise concurrently. The quick speed of her looking and continuous mark-making left no pauses during which to speak, and no slower moments that might better accommodate talking. However, the problem proved to be more than a question of speed.

On first attempt she named the facial features she was drawing (mouth, nose, eye) but this interfered with the drawing. She reported that she would not usually think of then as discrete or nameable features, describing a frustration that the drawing did not look like her usual work (the facial features were more isolated and she felt the drawing was not as closely observed). Roberts noted after four attempts that any verbalisation she tried seemed to affect her drawing process in various ways. It did not seem obvious with what terms she should describe her activity, and so this required attention, which detracted from the drawing process. The problem was not with being able to articulate her strategy, as she did so fluently in the retrospective report; it was a problem with doing it concurrently.

Roberts explained that she could not verbalise her approach as it was deliberately unconscious – her mark-making benefited from an intuitive approach. Chatting with her model would usually help facilitate this intuitive mark-making by distracting her mind from the drawing activity. She described this as an integral part of her approach. She would not normally talk through what she was doing in her head, but think about unrelated matters. However, on further discussion, she also mentioned there would be times when she would need to stop chatting with her model, and be silent. So, verbalising would interfere with the drawing but chatting would not, apart from at certain times.

On further attempts it became clear that those (usually silent) times, were actually periods during which the drawing activity paused temporarily, and during these moments she was able to verbalise easily. It was agreed that she would attempt a further trial in which periods of silence would be acceptable, and she would only verbalise what felt natural and did not interfere with the drawing.

The content of those verbalisations was concerned with assessing and decision-making (for example whether to 'take back' parts of the drawing before proceeding further). These periods occurred spontaneously but quite regularly (roughly every minute), and it became clear that these moments were evaluative periods, and that evaluation was reserved for these moments.

In this way, Roberts was breaking the process down into two distinct phases: intuitive bursts of observation and quick mark-making; and evaluative periods during which she would not draw, but would continue to look back and forth with regularity while deciding how to proceed. These evaluative moments were easy for Roberts to verbalise, indicating that she 'thought through' the evaluative process consciously and propositionally. During these pauses she was able to verbalise decisions, evaluations and sub-goals for the drawing. She also indicated the type of looking she would be doing immediately after the evaluation, i.e., the type of features she would be observing. For example, re-measuring a configuration of points, or re-assessing tonal values. (These features varied between each evaluative period.)

This rendered the content of her report different to the others', which included much more visual description (of what was to be drawn). While this meant that a direct comparison would not be valid, it was nevertheless interesting, and can be thought of as a 'result' of the study.

3.5.1.1 Understanding Robert's response to the verbalisation task

During the periods in which Roberts felt unable to verbalise, she was fully able hold a conversation about unrelated matters (for example, what to have for lunch). In discussion, she held that not only did this type of speaking *not interfere* with drawing; it actually *facilitated* it in a way that pleased her. So the problem was not related to the use of language per se, neither with an inability to describe her process. This also suggested that the language faculty was not recruited by the drawing task until the moment for evaluation, leaving it available for other activity.

These events can be summarised in the following way: evaluative thinking was easily verbalised, but not conducive to chatting. Continuous drawing (without evaluation) was not easily verbalised, but was conducive to chatting (at least in the case of this artist). Figure 37 illustrates this relationship.

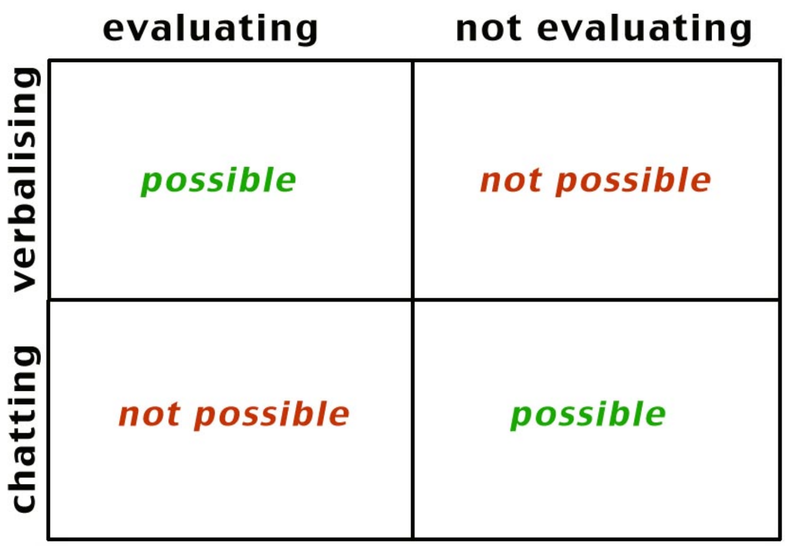


Figure 37. The relationship between verbalising and evaluating in Roberts' drawing process.

As in previous results, this points to a segregation of constructive and reflective modes of drawing; although the other artists seemed able to verbalise both, at least to some extent. The possibility of chatting while drawing demonstrates that the language faculty is not employed (in Roberts' case) with making the drawing (only with reviewing it).

So, can this model be applied to the other artists? Were they also segregating the two processes in this way? If so, it would have been on a much faster timescale than Roberts, as they do not use such a coarsley segmented strategy. This model would imply that Connolly, in particular, would not be able to talk during the short periods when he is mark-making, although this is difficult to gauge as they were so short (around a quarter of a second long). However, it was noticeable that Connolly was less eloquent than usual. His concurrent report reveals unfinished sentences and some stuttering, which were not present in his retrospective report. Cobley's report contains many pauses, and Brew slows her drawing activity considerably during the verbalised trial (as described in the following section) possibly to allow time for the additional cognitive activity of forming sentences.

While this evidence is circumstantial, it does support the emerging hypothesis that these artists segregate constructive and reflective activities. As Roberts' segregation was timed more slowly, it follows that her behaviour demonstrates the division most clearly.

The fact that certain aspects of the drawing process were more difficult to verbalise, raises issues about the effects of the verbalisation task on the drawing process. The artists indicated that their drawings (used in the analysed trials) were typical of their usual work, and certainly appeared similar, but there still seemed to be differences in timing, and it was also possible to compare verbalised and non verbalised trials.

3.5.2 Comparing timing between verbalised and non-verbalised drawings

A comparison between verbalised and non-verbalised conditions shows that verbalisation effectively slows the drawing process down. Drawings progressed more slowly, and the quantitative analysis shows that Connolly and Brew's drawings, in particular, involved slower glancing and more pauses.

Figure 38 shows that Brew, Connolly and Cobley used longer glances on average in the verbalised trial (respectively 23.15%, 28.58% and 1.93% slower than their own previous times), while Roberts' average glance duration actually decreased by 13%.

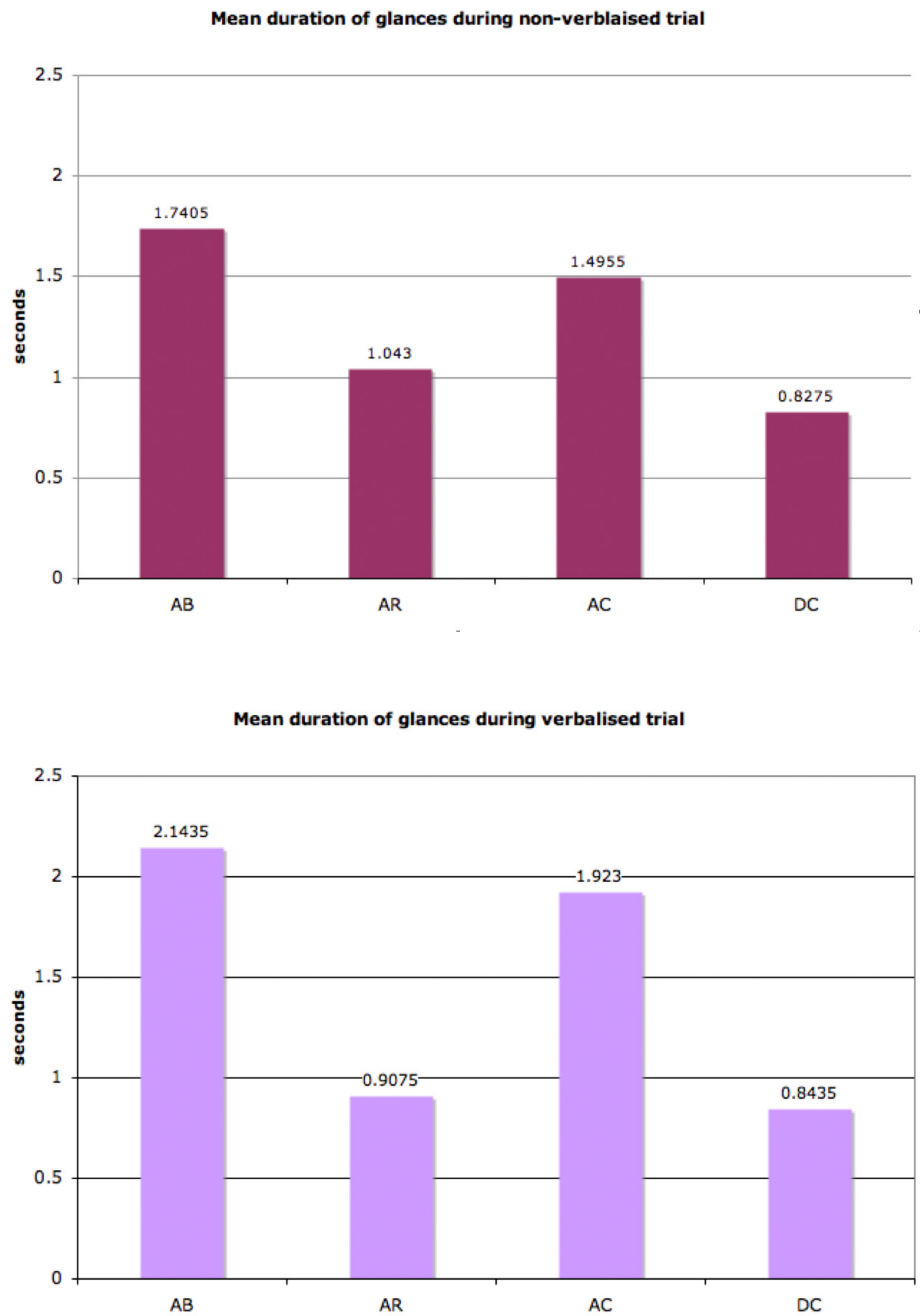
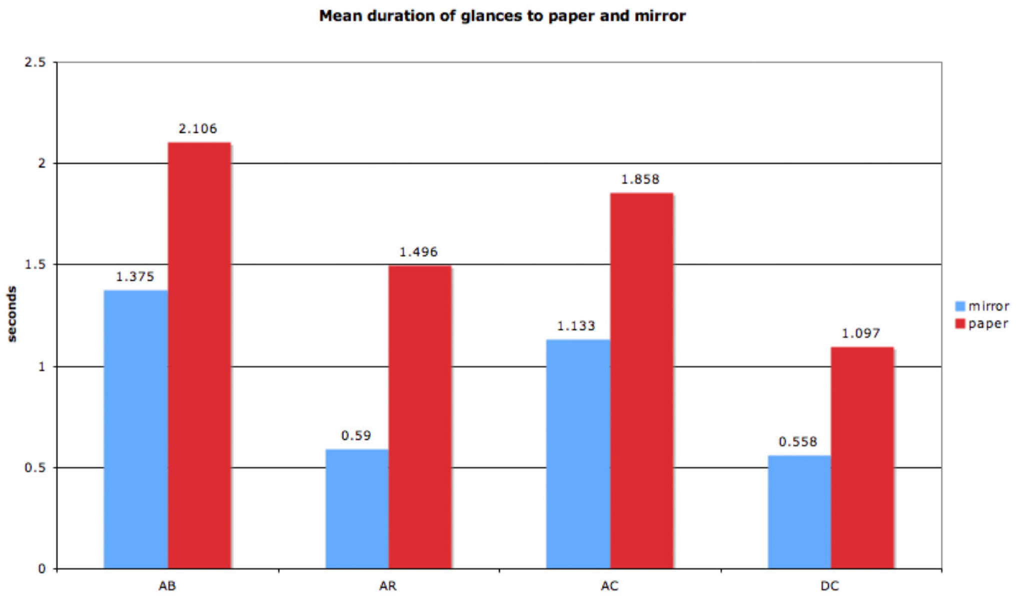


Figure 38. Comparison of glance duration during verbalised and non-verbalised conditions.

While this is a small sample (further trials would be needed to fully validate any hypotheses about the potential slowing effect of verbalisation on drawing process), the results are consistent with the idea that verbalising leads to increased glance durations (i.e., slowing down). Brew and Connolly verbalised most continuously and show the biggest slowing effects, while Cobley included more pauses in his reporting, and pauses in his drawing to accommodate reporting, and shows only a minimal difference. Roberts' decrease in glance duration is not consistent with such a hypothesis, but she did not talk while drawing and her shift in emphasis is towards the paper, rather than towards the mirror, as discussed below. Figure 39 compares timing of glances in both directions, in verbalised and non-verbalised trials.



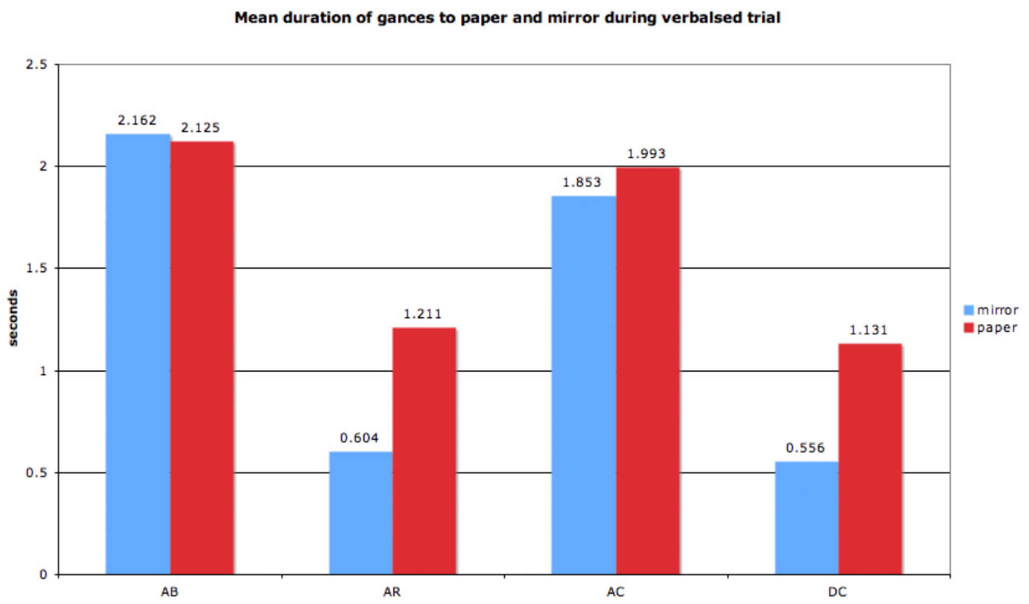


Figure 39. Comparison of timing between verbalised and non-verbalised trials, broken down into glances to paper and mirror.

From this break-down, it is clear that Brew's slowing down was concerned almost entirely with the mirror (showing a 57.24% increase in duration, with only 0.9% increase in glances to the paper, her overall distribution of looking changed with 13% more of the total time spent looking at the paper). This indicates that her report was mainly concerned with what she was looking for in the mirror (informing the drawing), rather than any ongoing evaluation of the drawing itself. This may reflect a bias in the report, but is perhaps indicative of her awareness of her emphasis on looking methods as the distinctive part of her strategy (and therefore something to be reported) that is, perhaps any monitoring of the ongoing drawing took place more implicitly. It may also be that the instructions given influenced her idea of what the report should include. Similarly, Connolly showed an increase of 63.55% in glances to the mirror and only 7.26% in glances to the paper, with an overall increase of 9.7% more of the total time looking at the mirror. In both cases then, we might assume that the monitoring of the ongoing drawing is either taking place implicitly (sub-consciously), or is simply not reported, or (in line with the relationship illustrated in figure 37) indicating that, when not actively drawing, verbalisation of evaluative thinking does not present too much additional cognitive load.

Cobley's result is minimal, showing a decrease of .36% to the mirror and an increase of 3.1% to the paper, with a general shift of only 1.29% towards the paper. The verbalisation appeared to have little effect on his drawing rhythm, presumably for the reasons suggested above (perhaps experience of demonstrating his technique has lead to effective strategies for reporting his process).

Roberts' break-down shows that there was, in fact, a small increase in duration of glances to the mirror (perhaps negligible, 2.37%) but a decrease of 19.05%, compared to her usual average duration, of glances to the paper. However, an overall shift of 7.25% more time looking at the paper demonstrates that although these glances to the paper are shorter, *there are more of them*. It makes sense for her effect to be concerned with the paper rather than the mirror, as the content of her report was with reviewing, rather than making, the drawing. (Again, the reasons for a decrease in duration is unclear, but it is a result of faster looking behaviour during additional time spent looking at the paper while talking.)

These results are also reflected in differences in the standard deviation of glance duration. Figure 40 shows that, in general, the verbalisation leads to a much wider range of glance durations, apart from in Cobley's case, and when Connolly is looking at the mirror, where the variation is slightly smaller.

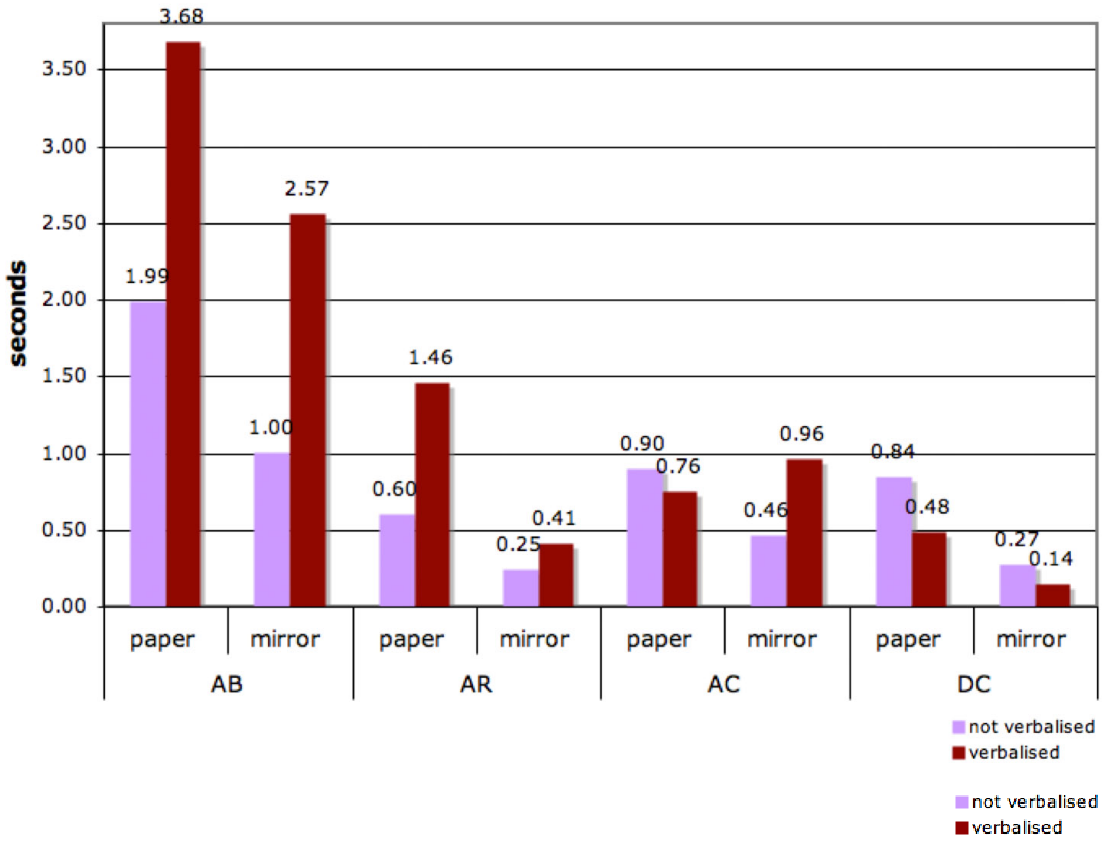


Figure 40. Comparison of standard deviation of glance duration between trials.

While the effects of verbalisation on timing here are only circumstantial[1], on analysis they show consistent results: drawing reports concerned mainly with descriptive details involve longer glances to the mirror, while the report concerned mainly with evaluation involves (more) shorter glances to the paper. This supports the relationship, indicated in figure 37, that the verbal faculty plays a different role in the evaluation and the construction of the drawing. While this does not conclusively evidence a discrete segregation of the two modes of constructing and reflecting, it is evidence of interference between them.

[1] These results are indicative, rather than conclusive, and additional studies would be needed to ascertain if these correlations withheld over larger samples. However, these studies also demonstrate that any investigation into the effects of verbalisation on drawing process would need to account for a large number of factors, including: how the instruction to verbalise is given, different drawing strategies, pauses in reporting and drawing, emphasis of glance durations and proportional distribution of looking time, and the emphasis of the content of the report (descriptive or evaluative). The effects of other types of talking might also prove fruitful avenues of enquiry.

3.5 Preliminary conclusions

The four case studies have been viewed through various means, both quantitative and qualitative. Collectively, these forms of evidence have enabled a number of observations:

1. The artists use a range of strategies which can be described in relation to two dimensions: strategic and attentional (represented in the '2D model'). 'Strategic' refers to monitoring, evaluating and planning ahead, while 'attentional' refers to present-moment apprehension which varies by order of visual complexity.

2. Glance durations differ considerably, both within drawings and between artists, and differing patterns of looking and drawing activity accompany differing strategies.

3. Despite differences in strategy there are many common features:

    - Similarities in proportion and distribution of looking (around two thirds towards the paper)
    - Patterned rhythms of timing, characteristic of each artist.
    - Strategic use of discrete 'levels' of visual attention.
    - Glances to the paper vary more than those to the mirror, getting longer as the drawing progresses.
    - Periodic reviewing at fine and coarse scales, apparently separate from making activity. Informing and monitoring seem to be temporally discrete processes, described here as comprising 'constructive' and 'reflective' cognitive modes.

4. Verbalisation appears to slow down drawing process.

5. Certain types of drawing and talking activity seem to interfere, while others do not.

The ‘2D model’ (figure 22) is presented here (tentatively) as a working model of drawing and cognition, which can be used to break down elements of drawing process and describe strategies. Implicit in the model is also the idea that there are two types of cognitive activity going on: one informing the drawing, the other monitoring or reviewing it. These activities are described here as two modes: ‘constructive’ and ‘reflective’. The evidence indicates that these two modes are mutually exclusive and, although each of them can be further divided into various possible activities from moment to moment, they could be thought of as two ‘modes’ of cognition involved with drawing. This idea is taken forward as a hypothesis to be discussed in relation to other literature later in the thesis.

The accounts of drawing surveyed in chapter 1 variously referred to certain cognitive ‘modes’ for drawing that are comparable to those presented in this chapter, and chapter 5 will compare those ideas, using the model proposed here as a comparative tool. Chapters 6 and 7 go on to further analyse the ‘2D model’, the constructive/reflective dichotomy and the interference between drawing and talking activities. Those chapters will inform the final discussion of this thesis, which considers the set of abilities drawing skill constitutes, the extent to which they may be considered transferable and how this can be talked about.

In order to further inform those discussions, chapter 4 will first survey relevant concepts and models of cognition that have emerged from the analysis so far. The evidence presented here provides some answers about drawing skill, but also raises many questions: it has been possible to observe patterns of activity and describe a range of drawing strategies, but it is still unclear *why* those strategies are manifested in such patterns, also, why certain kinds of activity can occur concurrently while others appear to interfere.

The following part of the thesis inquires into why drawing process is like this, looking to the brain and cognitive models for an understanding of the mind as a drawing tool. There is scope for better understanding how the artists are managing their attentional resources, how they are using visual memory, and what might be occurring unconsciously. Visual attention, memory and consciousness are themselves complex phenomena, subject to debate, and therefore those are the topics the following chapter surveys in order to inform the subsequent theoretical analysis.

Chapter 4.

Literature review part 2: visual attention, memory and consciousness

The insights provided by the reports and observational data from artists' drawing processes offer room for further explanation regarding the roles of attention, memory and internal imagery. The following chapters will scrutinise the preliminary conclusions of chapter 3 in the context of cognitive psychology's present understanding of visual cognition. I will ask if those conclusions are consistent with existing theories and models, and, in doing so, seek to further explain them. This will also allow me to address specific examples of the artists' activity and their cognitive basis. Such an analysis stands to benefit from prior clarification regarding key terms and paradigms that provide frames of reference. This chapter will therefore survey relevant theoretical sources, departing from studies of drawing to take a broader sweep of present attitudes to the various cognitive faculties involved, in order to clarify relevant concepts and distinctions.

The aim of this chapter is to inform subsequent chapters' analysis by reviewing existing theories of vision, visual attention, memory and consciousness, and describing the relationship between their functions. It will not identify 'gaps in knowledge' but survey existing knowledge and paradigms, in order to remain pragmatic about issues that do not currently enjoy consensus within the discipline of cognitive psychology. It is not the intention of this project to resolve such issues, neither will any stance be taken. Rather, their complexity reveals a wealth of understanding, and a diversity of perspectives, based on differing epistemological and methodological approaches to understanding cognition, each of potential value to interpreting drawing behaviour.

Visual attention is of particular interest, and current theories will be outlined in section 4.2. This is pre-empted by a review of paradigms and perspectives on vision which inform such theories (section 4.1). In particular, differing stances on the nature of internal visual imagery and internal 'representations' are compared. Pre-attentive cognitive stages have been described as making use of such representations, although different theories of visual attention distinguish between stages of the attentional process in very different ways. Section 4.2 provides an overview of the main theories and offers a pragmatic view of their usefulness to the subsequent analysis in chapter 6.

Section 4.3 clarifies distinctions between terms used to label types of memory. These can be categorised as long-term, short-term and working memory, and can also be thought of as comprising multiple sensory modalities. Relationships between these types and modalities have recently been better understood, and the distinctions and relationships outlined here become relevant to explaining the timing and arrangement of cognitive activities observed in the case studies.

In section 4.4, definitions of the conscious, sub-conscious and unconscious are reviewed in relation to visual awareness, attention and self-awareness more generally (beyond vision). In order to make a cogent analysis of the role of the unconscious in drawing process, it is crucial to be precise about what those terms actually denote. As noted in chapter 1, many accounts of drawing refer to the subconscious mind, or to intuitive or tacit aspects of drawing process but, without a clear idea of what those processes are, such accounts can appear to explain more than they actually do. Of course, the real nature of phenomenal consciousness remains hotly contested, but at least it is possible to establish working definitions of key terms, and to consider contemporary theories which clarify distinctions and relationships between conscious and unconcious cognitive processes. These matters are dealt with in chapter 5, which compares the accounts offered in chapter 1 in relation to the outcome of the case study analysis; in chapter 6, which analyses and builds on the 2D model; and in chapter 7, which further considers distinctions between conscious and unconscious in relation to the verbal mind and its role in drawing.

The length of the present chapter reflects the complexity of these matters. Many of the issues covered in it are relevant to both theoretical and methodological matters, but I do not return to the questions raised by the case studies until later chapters. It is my intention that, by postponing those discussions to first concentrate on establishing conceptual and terminological clarity, the following chapters will be able to proceed more straightforwardly, without the need to digress into matters of definition or paradigm.

4.1 Theories of vision: competing paradigms

This section briefly reviews computational, ecological, embodied and neural theories of visual perception. Existing perspectives offer different conceptual frameworks for considering visual experience. Some rely on intermediate representations as part of a 'language' of thought, describing various stages of visual processing, while others contest the existence or explanatory value of such representations.

Computational accounts are prevalent, but do not give a true picture of visual process, as they simplify the 'stages' relying on information processing models (not actually representative of the way the brain works). Nevertheless, computational models are useful, offering a paradigm within which theories of visual attention can be framed. There are a number of computational theories of vision, influenced by Jerry Fodor's (1983) modular account of cognition, in which specific functions are conceived of as separable units within a system analogous to a Turing machine, described though information processing language. These theories involve the representation of visual stimuli in a 'language' that can be dealt with by the brain. David Marr (1982), Stephen Kosslyn (1980; 1996) and Zenon Pylyshyn's (1973; 1894; 2003) ideas are worth noting as seminal computational accounts of vision that informed later accounts of drawing process. (Van Sommers drew from Marr's model, while , and Guérin Ska and Belleville favoured Kosslyn's model.) However, computational theories were not uncontested; James Gibson's earlier (1961) 'ecological' theory took an alternative, anti-representationalist, action-oriented view, which – while discredited for some time – is regaining popularity as more recent embodied and situated perspectives in cognitive psychology gain ground.

4.1.1 Computational models of vision

Marr's (1982) model of vision describes sub-processes that occur prior to the event of seeing. His account comprises three stages. These are: the 'primal sketch' based on feature extraction such as edge detection and identification of regions; the '2½ D sketch' which incorporates textures; and a '3D model' in which the scene is visualised as a three dimensional map. The first and second deliver incomplete representations to the following stage for further processing. The third stage models objects using 'generalised cones', with a cross section and two axes, similar to the 'geons' of Irving Biederman's (1987) 'recognition by components' theory. (Marr acknowledges that his model focuses on form, and more work could be done concerning movement, texture and colour.) The third stage is considered to be the final representation; the only one consciously experienced.

Marr's theory describes vision as a staged, one-directional, bottom-up process with a final destination. However, his theory includes concepts of 'frames of reference' and 'co-ordinate systems' which suggest top-down mechanisms (although these are not acknowledged as such). Three frames of reference are listed as 'scene centred', 'object centred' and 'viewer centred', in which co-ordinate systems are attached to parts of the visual scene (in relation to the whole, to objects or object parts, or the relationship between objects and the viewer).

Marr's staged model influenced Kosslyn's (1980) theory. Rather than propose a strictly linear progression, Kosslyn includes a central 'quasi-pictorial' imagery, in which the visual buffer draws on three sources to create the mental image: retinal input; the 'interpretive function of the mind's eye' which extracts relevant information; and 'deep representations' from long-term memory (LTM), which can be thought of as propositional or symbolic in nature, rather than pictorial. This model was a significant departure, as it recognised the role of prior knowledge in constructing and defining the perceptual experience.

Pylyshyn (2003) argues that mental representations (like Kosslyn's 'deep representations'), be they perceived, remembered or imagined, are not pictorial at all. Rather, they involve underlying *propositional* representations. Pylyshyn also claims that visual processing is (mostly) cognitively impenetrable, i.e., intermediate processes inform vision unconsciously, and are not available to consciousness.

Pylyshyn's work does not *disprove* the existence of pictorial mental representations; rather, it explores explanations of vision that do not rely on them. To replace the concept, Pylyshyn develops the notion of 'visual indexes': mechanisms deployed prior to attention, which identify separate objects, allowing them to be 'monitored' *before their properties have been perceived*. He emphasises his belief that the focus of attention is 'objects' (rather than locations, or properties of objects or scenes). Such monitoring implies (but does not account for) an unconscious level of processing that organises visual information to individuate separate objects. To distinguish separable objects requires some mechanism for grouping features. This is described more clearly by Anne Treisman's (1964) concept of 'pre-attentive grouping' in Feature Integration Theory (FIT) (see also Fellenz & Hartman (2003) for a discussion of pre-attentive grouping).

Pylyshin's notion of *object based* 'visual indexes' is useful in explaining vision in the general sense, but vision may be deployed very differently during drawing. Drawing requires a more detailed visual construction, and what constitutes an 'object' for drawing purposes may well be different to what would usually be considered an object, and so the question remains of how such an 'object' might be defined. Given the evidence presented in this dissertation, a very broad definition may be applicable to Pylyshyn's visual indexes. The 'object' might simply be considered as that which is segmented pre-attentively, rather than an object in the conventional sense.

Other computational theories of vision include those described as 'primal soup' theories. In these, the set of neurons in the primary visual cortex (V1) is seen as a homogeneous mass, from which meaningful patterns aggregate and accrete towards object recognition (see Shapley et al. 1990 for a review). These models suggest a gradual evolutionary progression, rather than clearly demarcated stages, although they still suggests a one-directional flow of information (from unconscious to conscious) and point to a final destination for the percept. Ulric Neisser's (1967) work offers a third possibility, describing simultaneous top-down and bottom-up processing, with complex feedback loops, therefore rejecting the notion of a final representation (i.e., one that might be located somewhere in the brain) in favour of a distributed awareness. This re-frames the notion of an *intermediate* representation as there is no final representation, only many related ones.

The conundrum of the pictorial quality of internal visual representations is symptomatic of the computational approach. That is, any concept of the encoding of experience (visual or otherwise) into a 'language' will raise the issue of how similar that language is to its source, and how it is translated back again when scenes are recalled. Other paradigms are less reliant on the concept of a 'language of thought', notably Gibson's 'ecological theory' and following embodied, situated and (especially) 'radical embodied' paradigms.

4.1.2 Gibson's ecological theory of perception

Gibson's (1961) 'ecological theory' challenged models that relied on intermediary representations. Those models assume the purpose of vision to be representational, but Gibson was interested in the relation between perception and action. He emphasised visual 'information' over 'representation', proposing that the purpose of perception is not to *describe* an objective reality, but to serve biological needs, i.e., to inform behaviour. He defined 'affordances' – information pertaining to possibilities for interacting with objects, e.g. the properties of materials, possibilities for change and constraints on change – as examples of the kind of task relevant information animals need. Eleanor Gibson and Anne Pick (2000) offer more extensive examples of affordances, such as causal relationships, suggesting the development of 'a range of cognitive competences' involving vision.

Gibson's denial of intermediate representations is distinct from Pylyshyn's. Both denied the pictorial quality of internal imagery, but Gibson's ideas extended beyond this, denying the need for internal representation as an explanatory concept. Although he acknowledges what others might consider to be intermediate representations, for example, he distinguished between retinal images and the optic array: the optic array being an aggregated representation made from many samples with converging viewpoints; retinal images being samples contributing to the optic array. (For a more extensive review of literature surrounding the representation debate, see Zalta 2011; Chemero 2009.)

Gibson used a somewhat mysterious concept - 'direct pickup' of 'invariant properties' – to replace computational descriptions of vision. Direct pickup was defined as a retrieval of information (affordances) from visual scenes, translatable into action. Gibson's theory has been widely disputed, generally on the basis of the wooliness of the terminology. Fodor and Pylyshyn claim that the concepts of direct pickup and invariant properties are not sufficiently constrained to be theoretically valid (2002: 142). However, direct pickup is defended by contextualists (e.g. Turvey et al. 1981) on the grounds that it deals with different parameters to information processing models. That is, Gibson's theory is concerned with the relationship between the animal and its environment, accounting for visual cognition as a relational phenomenon, not as one constrained to the mind. He aimed to explain real world behaviour-relevant cognition, rather than simplified laboratory tasks, accounting for the situated and embodied nature of cognitive processes. In this sense, despite incongruities and ill-defined terms, Gibson's theory can be seen as paving the way for later 'radical' embodied accounts that disregard altogether the informational processing models and algorithms used in computational approaches. In place of this, it adopts (non-linear) dynamical systems theory[1], in order to model interactions *between* cognitive systems and their environments without the need for notional representations (see Chemero 2009 for a review of 'radical embodied cognition' and the 'dynamical stance').

Marr's consideration of frames of reference does indicate that he considered vision in relation to tasks, but the underlying assumption that the purpose of vision is to 'represent' remains apparent. It is perhaps circular logic to explain vision in this way: any model that involves multiple representations of the optic array (albeit in several stages) also re-presents the problem of how each representation is dealt with and made useful (both practically and phenomenologically). Gibson's denial of the need for representations may be seen in this respect – they do not really solve the problem of how vision occurs. Nevertheless, multiple staged representations can be a useful explanatory tool, as they allow the distinction between attentive and pre-attentive vision on which many theories of visual attention rely.

More recent embodied perspectives consider perception as a more holistic, multi-modal faculty. George Lakoff and Mark Johnson (1999) describe how 'image schema' in long-term memory (LTM) influence perceptual recognition and interpretation. This concept is comparable to Kosslyn's 'deep representations', but Johnson stresses the experiential source of such schema, and therefore their multi-modal nature. That is, in Johnson's view, these schemata recruit all faculties – visual *and* propositional, as well as spatial, auditory, tactile, and so on. The implication is that, when something is recognised, we are able to infer non-visual qualities due to our prior experience of similar phenomena.

Whatever the basis of internal or 'deep' representations, these theories present the purpose of vision as recognising things and enabling action. For this, much pictorial detail is superfluous, and can pass by unconsciously or pre-attentively. The notion of an 'intermediate representation' helps explain how relevant information would be filtered. Gibson points out that the purpose of vision is not to pictorially represent, but the purpose of representational drawing *is*. The drawing task requires an understanding of how such superfluous details contribute to recognition or incentivisation for action, in order to

[1] "A dynamical system is a set of quantitative variables changing continually, concurrently, and independently over time in accordance with dynamical laws that can, in principle, be described by some set of equations" (Chemero 2009: 25).

manually re-present them, translating visual or spatial information into movement. The drawer must engage not only with the object itself, but with that aspect of it he wishes to represent – its low level features and affordances, and the relations between these. Gibson would have it that affordances are perceived via 'direct pickup' without our being conscious of the low-level details that contain them. This presents a problem for the drawer: he must become aware of those details in order to select them from an array of mostly irrelevant ones. He must also become aware of specific variations, rather than 'invariant properties'. In addition to this, he must monitor the drawing in terms of the success with which those affordances are conveyed, and make judgements about how to proceed. In this sense, the drawer must have access to representations that would usually be 'intermediate', making them final instead.

It is plausible that during blind drawing memory is not needed; drawing actions might be informed directly, in the same way as reaching or grasping actions. But drawing during glances to the paper must require some form of memory or persistence. It's possible that propositional memory informs drawing actions, rather than internal visualisation. However, many people do report experiencing vivid mental imagery, and significant individual differences in its reported extent (and associated abilities) have been found (e.g. Keogh & Pearson 2011; Yoon & D'Souza 2009). So we can expect that artists in this study possess differing propensities for mental imagery, and this may be a factor in their approaches to drawing. That is, the extent to which mental imagery is used in drawing may vary because of individual differences.

More recent neuroscientific models of the visual system account for both low-level feature extraction and high-level processes such as recognition – that is, intermediate and final stages, and (respectively) pictorial and propositional/schematic elements. Neural accounts offer a more concrete (functional-anatomical) basis for understanding various stages of processing, and the complex feedback mechanisms involved. These appear to be modular systems, relying on functionally specific regions of the cortex.

4.1.3 Neural models of vision

In order to understand complex things, we tend to categorise its constituent parts. Anatomical and functional divisions in the brain coincide, and computational models of cognition are now informed by functional neural anatomy. Despite criticisms of neuro-reductionism (such as its difficulty in accounting for subjectivity and context (Goldberg 2009; see also Whiteley 2012 for a recent review of criticisms of neuro-reductionism), a neural understanding can contribute to an understanding of vision, especially when considered alongside other theoretical vantage points, including experimental psychology. It can help address questions such as how the visual image is constructed, what the visual primitives might be, and how they can be categorised. These can be thought of quite precisely in terms of the functional specialisation of cells, cortical areas and networks. The issue of visual primitives then becomes more a question of the level at which to stop dissecting functions and their relations, and how far ’down’ conscious access extends. It seems that different functionally specific modules, and even different cells, have different parameters for what constitutes an integral unit and, indeed, for distinguishing ‘something’ from ‘nothing’.

Neuroimaging studies show numerous ‘representations’ in the visual brain, usually referred to as ‘projections’. They (literally) re-present the retinal image many times, with varying degrees of topographic similarity depending on their modular function. How exactly these ‘modules’ contribute to visual experience is still under scrutiny, but their functional division can help resolve longstanding contentions in theories of vision, and in cognition more broadly.

These functional divisions will prove valuable when considering how the artists in this study were dividing and allocating their attention, and why their particular patterns of activity were appropriate to their drawing strategies. The notion of an intermediate representation is useful in the sense that it describes a pre-conscious level on which visual selection can occur, accounting for subconscious elements of the drawing process. When this is coupled with distinctions between propositional, visual and otherwise multi-modal qualities of internal representations (be they perceived or remembered), it provides a framework in which we can think about how the artists’ were navigating and balancing these elements, and how they would have been employing different modalities to different ends. Identifying propositional elements will also be particularly interesting in regard to how the artists were (and were not) able to verbally report their activity.

The division of the mind into modalities or 'modules' reveals the multi-faceted nature of cognitive process. What these functional divisions are, and how they may be categorised, will therefore be relevant to questions of attentional strategy and are discussed further in the next section.

4.1.3.1 'Modularity of mind'

Jerry Fodor reasoned that "what perception must do is to so represent the world so as to make it accessible to thought" (1983: 40). He proposed a functional division of labour in the mind/brain, arguing that "*modular* cognitive systems share a certain functional role in the mental life of organisms" (1983: 38 emphasis in original). These ideas heavily influenced subsequent computational models of cognition such as those reviewed above.

While modular models were unable to account for higher cognitive processes, which proved to have more distributed connectivity, 'input systems' such as vision can be described in modular terms. Modules and sub-modules perform different complementary functions by the presence of specific cell types. The most concrete and precise accounts of where and how functional divisions in vision lie can be found in contemporary neural accounts, as these offer detailed functional-anatomical models of the visual cortex, particularly its early stages.

4.1.3.2 Feature detection by attribute selective cell type

Single cells in the visual system detect the presence of various attributes. Groups of cells detect features by assessing centre-surround differences within receptive fields. The earliest destinations (the retina and lateral geniculate nucleus) contain circular receptive fields, assessing local contrast in colour or luminance. These communicate to the striate cortex (early visual cortex or 'V1', see figure 41), with each cortical cell receiving input from a number of retinal ganglion cells, giving them larger receptive fields. The majority of visual cortical cells have elongated 'stripe' fields for detecting edges (contrast boundaries). These cells are tuned to fire in the presence of particular orientations and lengths of edge, horizontal and vertical ones being detected most easily (they have stronger 'event potential'). While the majority of striate cells are orientation selective, many are tuned to other attributes: binocular disparity, direction of movement, and wavelength (centre-surround colour opponency based on input from retinal cone cells). (For a detailed account of cell function in visual cortex see Farah 2000, for a more popularised account see Kandel 2012.) This information is passed through various cortical layers, some of which communicate to further areas that detect the presence of more complex features - conjunctions, curves, corners, and subsequently shapes and forms and so on, at increasing orders of complexity.

We can therefore imagine vision to be divided into multiple 'projections', responsible for detecting various feature types at various orders of complexity. While functional-anatomical divisions don't neccessarily correspond to what might be happening in the mind on a phenomenal level, we can understand that the modules are active simultaneously and represent a certain distribution of neural resources that will dictate cognitive constraints. I.e., finite resources are allocated to detecting each feature type, and this occurs in parallel, which will dictate what can occur simulaneously in visual processing. Neural models are also relevant to questions regarding what might constitute a visual 'unit' or a 'scene primitive' ('one thing' in visual attentional terms), offering an anatomically grounded framework for the deconstruction of vision. How artists deconstruct their visual experience in order to reconstruct it on the page will be bound, in some sense, by the way in which the brain defines and recognises features and how such recognition processes are structured.

4.1.3.3 Functionally specific modules in visual cortex

Prior to the publication of Fodor's *Modularity of Mind,* Semir Zeki (1978) had already proposed that visual information is segregated into multiple projections within the (primate) brain, each of which performs a specialised function. These areas were extensively mapped by Van Essen et al. (1981) and their cooperative determination of form has since been studied widely (Treisman 1977; Barrow & Tenenbaum 1978; Treisman & Gelade 1980; Marr 1982). Recent studies have shown the arrangement of cortical modules (as multiple projections) in the human brain. Brewer et al. (2005) and Wandell et al. (2005) map primary and secondary (striate and extrastriate) retinal image projections (see figure 41) and illustrate the topography of reconstructions of the visual field. Sixteen maps have been identified (see figure 42).

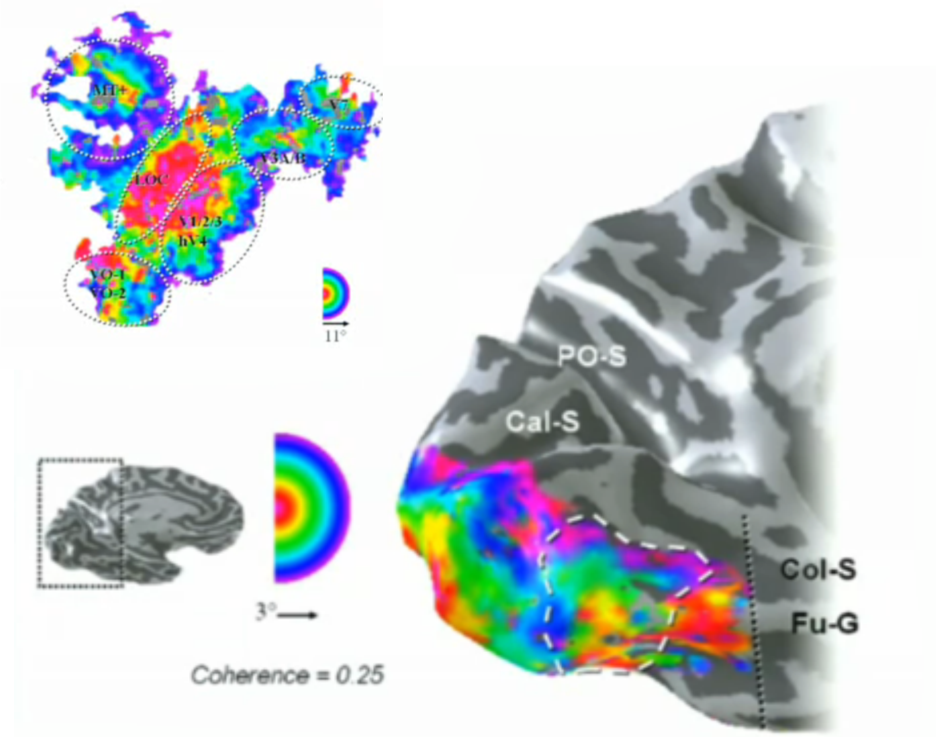


Figure 41. Visual field map clusters in the human brain (from Brewer et al. 2005: 1106). The colours here represent the coloured hemifield as it is reconstructed at various locations in the visual cortex, when the viewer foveates on the centre. Note that the red central area reappears in several locations, with the peripheral colours surrounding. V1 topographically maps the retinal image most faithfully, magnifying the central region (the fovea). The inlaid image (top left) represents a flattened version of this topography, and labels the modules. Here V1, V2, V3 A&B, hV4, V0-1&2, MT(V5), and V7.

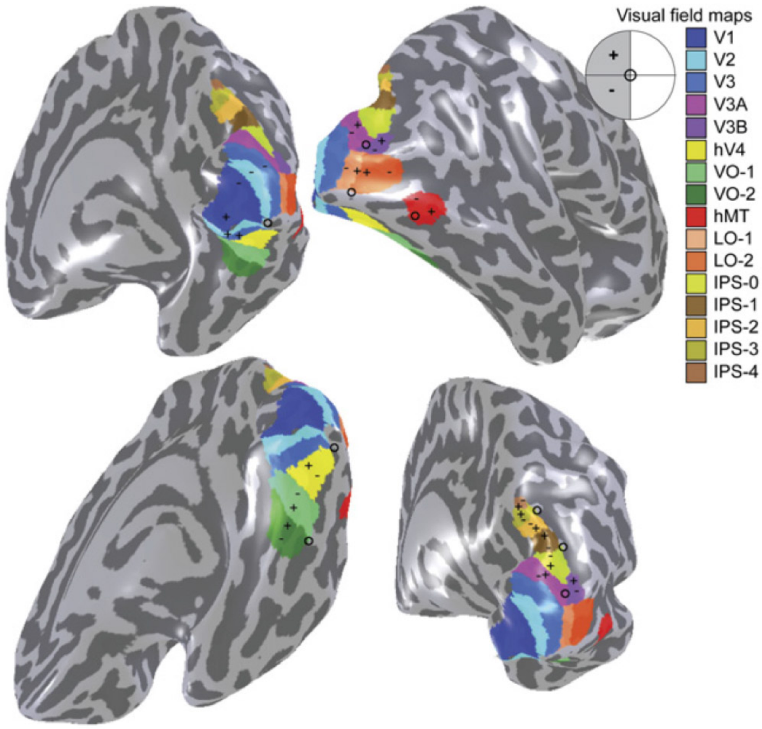


Figure 42. Sixteen different maps have been identified in striate, prestriate and extrastriate areas (from Wandell et. al. 2005: 368).

Functional differences between modules can be inferred from imaging techniques such as fMRI, and from anatomical studies of the prevalence of cell types and the relative thickness of cortical layers. The topography of 'projections' and their deviation from the retinotopic map also infer functional differences. MT are, for example, is primarily concerned with movement, and is characterised by the presence of many cells sensitive to change (and direction of patterns in change) and a larger area dedicated to peripheral regions, as can be observed in figure 41. V4 is concerned with colour and dedicates more resources to the centre of the visual field. V3 is concerned with form and texture discrimination, and shows a more equal centre-periphery balance.

Each function occurs over a number of modules and each module is involved with many, if not all, functions. However, it is possible to generalise that each area specialises in particular functions. David Van Essen and Jack Galant's (1994) schematised model of the primate visual system illustrates this (figure 43).

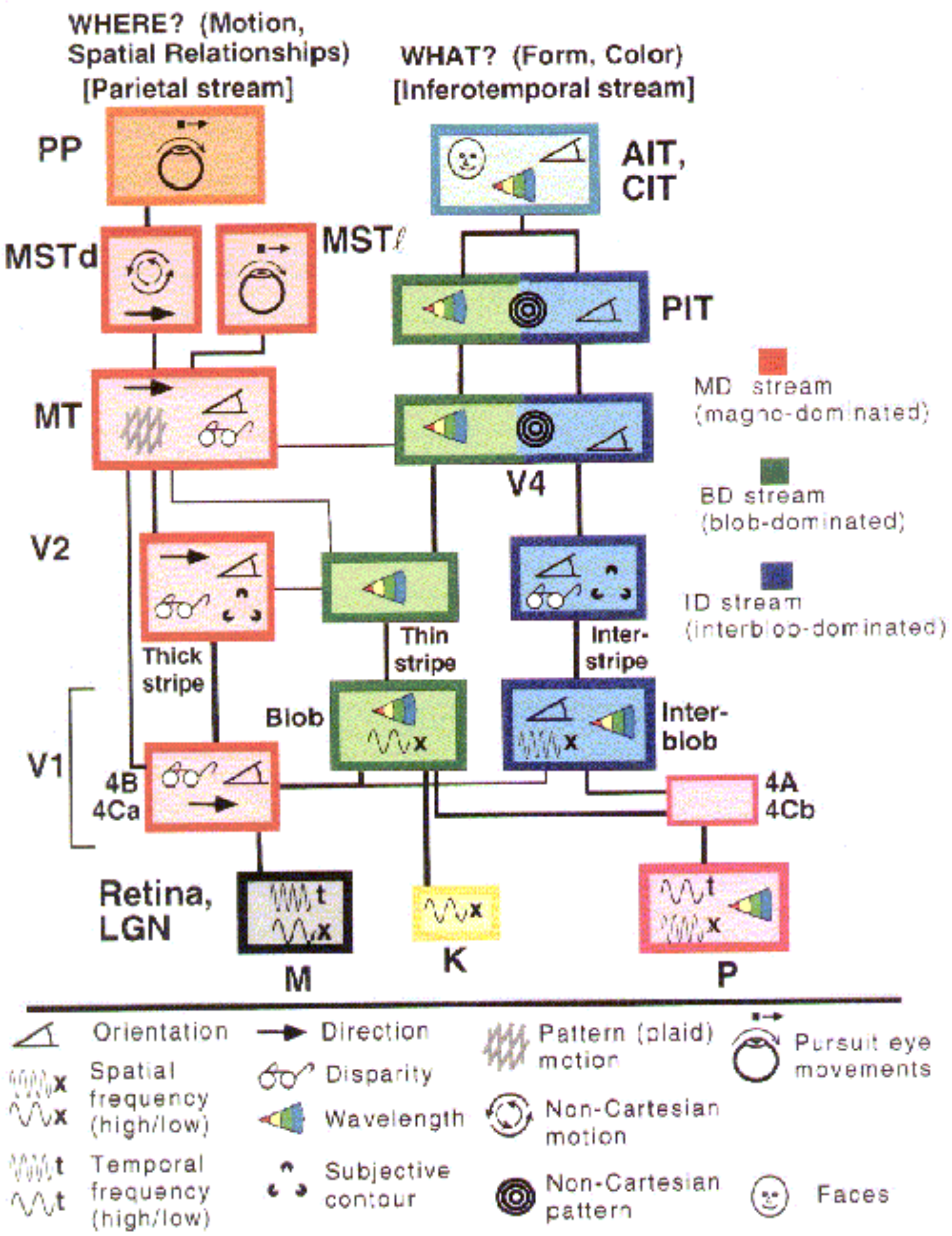


Figure 43. Hierarchy and connectivity of form and motion processing in the primate visual system (from Van Essen & Galant 1994:3). M, K & P here refer to the magno, konio and parvocellular pathways, originating from M, K and P cells in the optic nerve. M cells being specialised for coarser perception of movement and edge, with finer temporal resolution, P cells being specialised for colour with finer spatial resolution. K cells are less well understood, but may play a role in colour and brightness contrast perception, and perhaps to eye-movement (Casagrande 2004). While this refers to primates, the human system is very similar, although more complex. For the present study, the significant thing is the distinction between specific feature *types* within this hierarchy. These can also be thought of as ‘dimensions’ of vision.

Van Essen and Galant's diagram demonstrates a simplified model of the functionality and interconnectivity between modules. Generally speaking, earlier areas receive information and prepare it into manageable chunks for output into higher areas, but there are also horizontal and parallel connections. V1 receives reciprocal projections back from other areas (this is discussed further in the following section). V1, in this sense, can be thought of as a sort of 'post office' (Zeki 1992); receiving and distributing information to relevant modules.

The earlier areas have been more extensively mapped. V1 presents a topographical mapping, decomposing local contrast at various frequencies (finer and coarser detail). Initial filtering of visual information responds to individual elements, while subsequent coarser filtering responds to texture boundaries already detected. In this way, a meaningful picture of the optic array can emerge. Various layers of striate cortex are connected to various other cortical regions, including prestriate (V2) and extrastriate (including V3, V4 and V5/MT) areas/modules. Each of these modules has a distinct population of cells tuned to a particular attribute type, performing specialised functions.

Earlier areas deal with feature extraction, while later areas deal with recognition, and rely more on top-down processing. Functions progress from edge detection to shape segmentation, contour integration and surface parsing, to shape recognition, and then utilising those shapes for purposes such as such as face and object recognition, extracting meaning, and a sense of the possibility for interacting with the environment. Visual information also influences motor coordination through spatial awareness. Higher order functions are characterised by the presence of cells responsive to invariant properties, that is, regardless of variables such as viewpoint and retinal image size (as opposed to cells dedicated to particular areas of the visual field, which populate the earlier regions). They also involve more distributed activity across the brain[2].

The levels at which recognition takes place are, of course, of great importance in processes of visual selection. What features it is possible to recognise and select will be determined by this taxonomy, and the influence of knowledge over how they are perceived will vary by order of processing – lower orders in this hierarchy will be less influenced by prior

[2] Although certain key functions have been found to rely heavily on localised activity. For example, face recognition is associated with activity in the 'face area' of the fusiform gyrus. Localised areas involved with perception of places and food have also been identified.

knowledge. The extent to which those are available to attentional access without the aggregate influence of other areas is questionable, but their existance indicates that early processing may contribute more to the kind of perception Ruskin refers to as the 'innocent eye'. Gibson's 'affordances', on the other hand, seem to correspond to higher orders of processing, relying more on schematic knowledge. This will become relevant in chapter 5, when the concepts of the 'innocent eye' and 'schematic knowledge' are again compared. The roles of these different levels of perception also become relevant to understanding the artists' allocation of attention, which, in chapter 3, was seen to be strategically shifting between levels of resolution at different stages of the drawing process. This will be discussed further in chapter 6, which considers how both resolution and feature type should be thought of as separable variables within attentional strategy.

When seen in this anatomical-functional context, the role of intermediate representations is clearer. We can say with some certainty that the brain (literally) employs multiple projections of the visual field, many more than the three presumed by Marr. His model of 'stages' still stands, but this is not commensurate with the orders of processing presented here, rather it corresponds to stages of *attentional selection* processes which will be discussed further in section 4.2. Marr's stages refer to the way in which information is processed, rather than the organisation of the physical substrate (to further the computational analogy – the software, rather than the hardware).

Also relevant to questions of internal imagery and internal representation, is the division of the visual system (illustrated in connectivity models) between two major pathways. Many argue that only one of these results in visual phenomena, while the other gives rise to a more exclusively spatial awareness. Although this remains unresolved, the different functions have been understood to some degree and are discussed below.

4.1.3.2 Two visual pathways

Van Essen and Galant's model (figure 43) demonstrates how the functional divisions described earlier correspond to upper and lower brain regions, comprising two distinct (but interconnected) pathways: dorsal and ventral (see also figure 44).

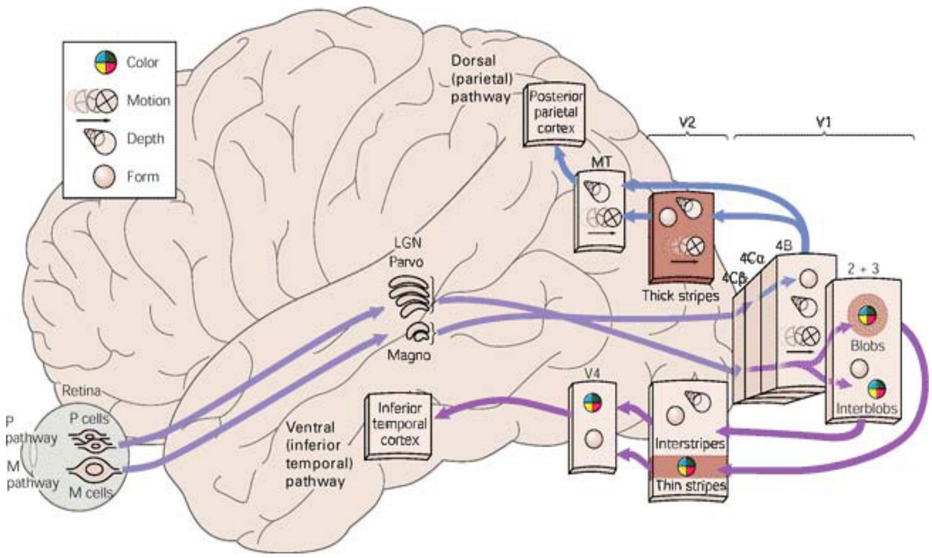


Figure 44. Functional differences between modules in dorsal and ventral streams (from Wurtz & Kandell 2000: 502, originally adapted from Van Essen and Gallant's model).

While the exact roles of these two pathways is still a matter of debate, broadly speaking, it can be said that the ventral pathway is concerned with object identification and recognition, leading towards auditory and language centres in the parietal lobe, while the dorsal pathway is concerned with location and movement, feeding into pre-motor areas and superior colliculus (associated with eye movement). There is complex connectivity between the two streams at various levels, and between them and frontal cortex (not accounted for in this model).

Some argue that the dorsal stream contributes to conscious visual phenomena (Gallese, 2007; Jacob & Jeannerod 2003) but it is generally held that it does not (Brogaard 2011). Rather, it contributes to 'vision for action': navigating, reaching, grasping, and saccadic eye-movement. Berit Brogaard posits that while information in the early dorsal stream 'is broadcast to working memory' (2010: 449) (and is therefore involved with 'cognitive consciousness') information processed after V3 (in the parietal lobe/dorsal stream) contributes directly to movement without perceptual phenomena. David Milner and Melvyn Goodale (2008) argue the same, suggesting that dorsal stream information pertaining to, for example, the absolute size of objects and their relative position (e.g. whether they are in reachable grasp) is unconsciously translated into immediate action. (This is demonstrated by the phenomena of targeted reaching behaviours in individuals with 'blindsight' due to lesions in the ventral stream.)

This division is reminiscent of divisions of opinion between the earlier accounts of vision – vision for representation on one hand, vision for action on the other. Dorsal perception is perhaps equivalent to Gibson's concept of 'direct pickup', when the proximity or spatial location of the object is in question, for example, when gauging whether or not an object is within reach. This is distinct from 'pickup' of information that relies heavily on schematic knowledge for inference and interpretation, but still constitutes the gleaning of information without detailed visual phenomena. This is not to say that it occurs unconsciously: whether the absence of visual experience is strictly equivalent to an absence of consciousness is arguable, that is, the spatial sense may be experienced while the visual is not, both contribute to phenomenal consciousness.

Both spatial and visual perception clearly contribute to drawing, and both pathways must play a role. Whether or not we accept that the dorsal pathway gives rise to vision, the distinciton between them offers an interesting viewpoint. If the spatial and visual modalities are separable, how do their roles in drawing process differ? Chapter 5 will discuss this, asking if these two pathways could be a more apt brain based explanation for the dichotomy Edwards was describing. Chapter 6 goes on to consider the differing roles of these two aspects of visual awareness, particularly with regard to Tchalenko's 'motor memory' hypothesis, which proposes that visual memory and internal imagery are not neccessary components of observational drawing process.

Before moving on to discuss visual attention, I will briefly survey models that make other distinctions between types and hierarchies of visual process.

4.1.4 Other models of connectivity

Pavan Sinha's *Parallel and Hierarchical Model* of visual functions is comparable to Van Essen and Galant's in its functional divisions (Figure 45), although it was derived using entirely different methods – from case studies of recently sight restored individuals.

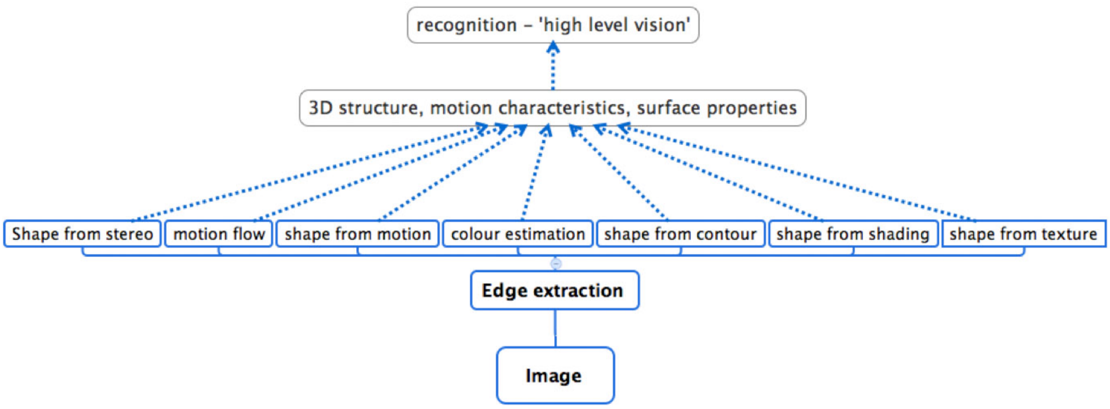


Figure 45. The Parallel and Hierarchical Model of Vision (adapted from Sinha 2003).

Sinha's model distinguishes function and level of complexity, the highest level being the usual concern of our visual awareness, containing the most sophisticated information about our surroundings. As Gibson pointed out, we can perceive relevant (high level) information without superfluous detail, and lower levels are not equally available to consciousness. However, Sinha describes how, for congenitally blind people with newly restored sight, this is not the case. Like babies, they must learn how to infer, for example, shape from contour and shading, and to distinguish one object from another. Until this learning occurs, lower levels demand attention, while sighted adults 'see' (extract information form their environment) by performing this automatically.

In this context, it is worth noting that the accounts of drawing surveyed in the first literature review often mention or allude to an absence or inhibition of recognition, and a direction of attention towards lower levels. Ruskin's 'innocent eye' can be likened to the type of vision Sinha's patients experienced, while Gombrich's argument stresses that voluntarily regressing to this state would be impossible. If it were, expert drawers would be able to direct their visual attention back to a state akin to Sinha's newly sighted case studies, re-segregating shape from shading and so on with a degree of control: accounting for each level, selecting details and attributes on the basis of how they contribute to the final recognition. More than a simple regression, this implies self-knowledge and mindful control of visual attention.

The fact that Sinha arrived at a model with many similarities to Van Essen and Gallant's, using an entirely different methodology, supports the idea that functional-anatomical divisions can be related to phenomenal experience, and that the functional anatomy brain correspond to functional distinctions in visual experience and perceptual capability.

4.1.5 Connectivity and feedback loops

Functional-anatomical models offer a more structured consideration of the way in which information reaches the highest level described by Sinha. Laurent Itti and Cristof Koch's (2001) diagram (figure 46), based on Koch and Shimon Ullman's 'saliency map' hypothesis, includes a feedback loop, accompanying the extraction and combination of features. The function of this loop is attentional - it determines what we notice and where to look next.

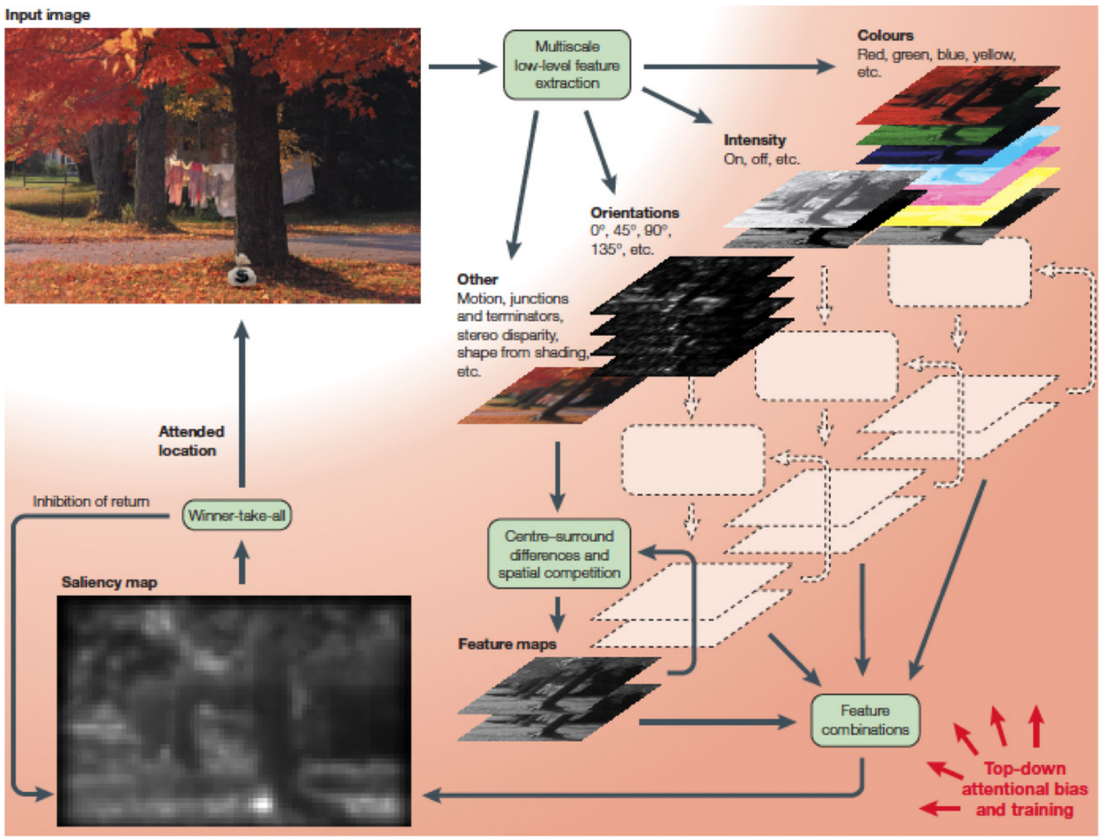


Figure 46. Flow diagram of a typical model for the control of bottom-up attention (from Itti & Koch 2001).

This can be understood in relation to the function of V1. Higher areas feedback to V1 if activated strongly enough, indicating the presence of certain attributes at certain locations, which in turn trigger associated activity in V1, which communicates back to higher areas, creating a feedback loop. We can think of this feedback as electrical resonance, maintained and reinforced by networks of cells. When resonance reaches a threshold strength, it results in phenomenal awareness. In the case of moving or flashing objects, this can occur exogenously (bottom-up) but endogenous (top-down) attentional bias may influence the 'saliency map', by heightening or inhibiting receptivity for certain attributes or at certain locations, for example in visual search tasks.

Ilja Sligte et al. (2008) describe this resonance as 'persistence'. They distinguish three 'phases' of visual persistence:

1. Short - akin to seeing. This phase is high capacity but very short (over by 100ms).
2. Fading (being maintained but not for long).
3. Similar to working memory phase.

In phase 3, representations are maintained for longer in order that they be utilised in cognitive operations. This occurs by the intervention of frontal cortical areas, responsible for executive control, which maintain signals in posterior regions (see Supèr, Spekreijse & Lamme 2001a; Curtis & D'Esposito 2003), i.e., to 'hold' something in mind.

In this model, it is the *strength* of the signal that corresponds to phenomenal awareness, rather than the cortical location or the level of processing. This indicates that much visual processing takes place 'under the radar', so to speak. One is able to exert control by weighting certain locations or features, influencing what is recognised as salient, and therefore what is reinforced by feedback loops, and ultimately what is seen (and not seen).

So, while much visual processing takes place under the radar of consciousness, the act of attending to a subset of the visual field (literally) amplifies and maintains it, making it available for mental operations. This is another sense in which perception and thinking are connected – to dwell on something seen causes the visual experience to persist, to anticipate seeing something is to prime the brain to recognise and amplify it. We can see from this, that questions regarding what occurs consciously can be understood in many ways. There are varying degrees of visual 'persistance' and what is seen does not fully overlap with what is *attended to*, although the act of attending strongly influences perception. Furthermore, looking is an active process that can be driven deliberately, but nevertheless entails complex pre-attentive mechanisms for visual selection which are influenced by conscious activity. The artists' conscious experience of drawing therefore omits much of the processing involved.

4.1.6 Discussion

These accounts suggest that the distinction between seeing and not seeing is less clear than one might assume. 'Information' can be 'picked up' without the need for pictorial detail. This is possible because vision involves pre-attentive selection processes that identify task relevant features, be they to directly inform movement or to create a visual experience. The evidence from neural models of vision indicates that pre-attentive vision is able to directly inform movement, as models of the dorsal/ventral division suggest, perception for action may occur without visual phenomena. This makes sense in terms of behaviours like reaching for an object, catching a ball or getting out of the way of a moving car. Since few visual details are needed, spatial awareness is more important. Too much visual information may even interfere with the task at hand, so the brain naturally filters unnecessary detail. 'Direct pick up' might be considered a less pronounced version of such filtering, in which visual features that do not constitute task-relevant cues are filtered, and those which do indicate relevant information may even occur below the attentional threshold. For example, identifying one's own car in a car park would require only a few visual cues, perhaps colour and shape. Once the car is identified, those cues themselves become irrelevant. 'That's my car' would be the information 'picked up'.

Gibson argued that much of our everyday perception occurs through direct pick up, with visual details giving way to more complex information in our phenomenal awareness. This being the case, we might consider visual phenomena to occur on a sliding scale: not only attentive or pre-attentive, but many variations in between. That is, visual processing occurs on many levels; which of those are consciously experienced is variable. (Again, this raises the notion of intermediate representations, which is discussed further in the following section.)

How then, might we think of seeing-for-drawing? Drawing demands a more pictorially detailed 'seeing' than typical in direct pickup. It is also more complex than simple reaching action as it seeks not only to locate but to recreate visual phenomena, requiring more spatial and visual information at lower orders of complexity, and also some awareness of *which* low-level features give rise to *what kinds of* 'direct pickup'. Selecting features is therefore a crucial part of the drawing task, and drawing must therefore involve some 'attentional strategy' for serially identifying and segmenting relevant attributes and details.

The neural accounts of vision offered in this section explain how (although very complex, and containing feedback loops) the visual system can be thought of as consisting low to high orders of visual processing. Early levels perform feature detection, while higher levels are responsible for recognition, and this involves more top-down, associative processing. It is interesting to compare this to measured and analytical approaches to drawing (described in chapter 1); the measured 'innocent eye' approach relies more on perception, while the analytical method actively employs associative memory (e.g. knowledge of anatomy). It is also comparable to Luquet's distinction between 'visual' and 'intellectual realism'; 'visual' being more photographically accurate, intellectual being influenced greatly by schematic knowledge. We can deduce that visual realsm and the 'innocent eye' recruit lower orders of visual process than 'analytical' and 'intellectual' approaches. However, as the following section describes, existing models of visual attention associate lower orders of vision with 'pre-attentive' processing. This raises the question that drawing ability may entail greater access to pre-attentive visual processing. This matter is discussed further in chapters 6 and 7. In order to inform those discusions, the following section reviews theories of visual attention in order to clarify how attentional mechanisms are thought to operate, and what constraints might be placed on 'attentional strategies'.

4.2 Visual Attention

This section begins by considering eye movement, as this is the most immediate demonstration of attention. However, *where* one looks is not the only variable, what one looks *for* is also subject to attentional control, and constrained by physical limitations (i.e., what the brain is capable of).

4.2.1 Eye movement

The control of eye movement has been widely studied and theorised (e.g. Findlay 2009; Malcolm & Henderson 2009; Kowler 2011). Neuro-anatomical models have been developed and can inform our understanding of attentional control.

The executive role of the prefrontal cortex is described by Itti and Koch (2001) as mediating attention by influencing resonance between striate, posterior and inferotemporal cortices (see figure 47). It is involved with 'decisional processes governing oculomotor behaviour' (eye movements) by communicating between spatial memory and perceptual information in regard to task-specific priorities (see also Pierrot-Deseilligny, Milea, & Müri 2004: 17). In this way, top-down control can be exerted over which percepts 'persist' and where the eyes focus next. Stimulus driven (bottom-up) shifts in attention also occur, and both systems operate in parallel.

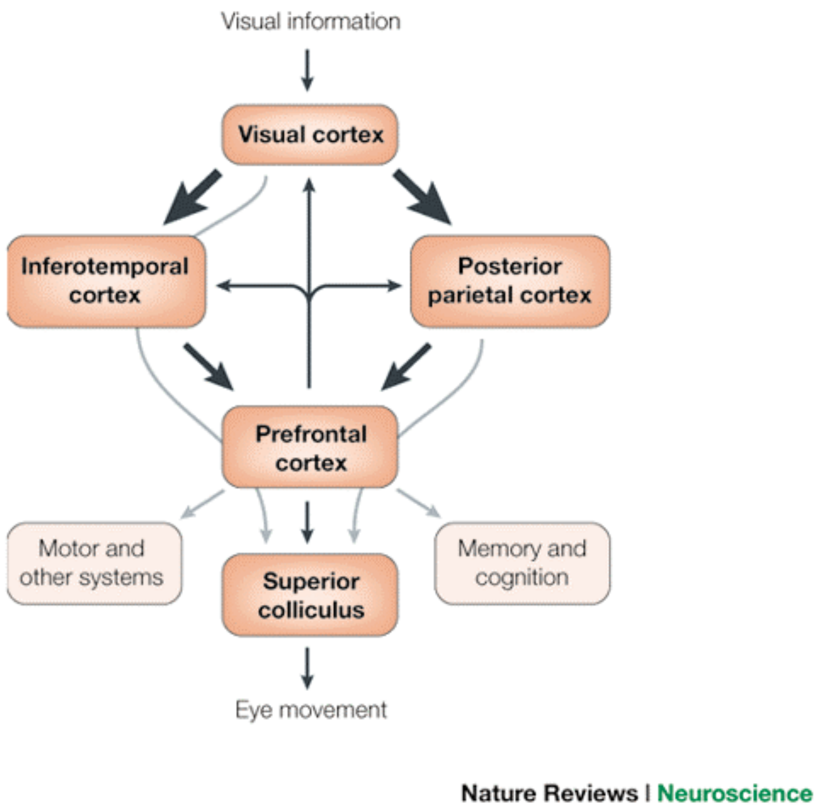


Figure 47. Computational model of pre frontal cortex connectivity (from Itti & Koch 2001: 195).

4.2.1.1 Pre-motor theory of attention

The ‘pre-motor theory’ of attention claims that sensori-motor mechanisms share control of both attentional shifts and goal directed movement, linking the two processes closely (Rizzolatti et al. 1987; Sheliga 1995). The theory provides a description of how eye movements are preceded by anticipatory changes to ‘covert’ attention (distinct from ‘overt attention’, which is characterised by eye movements). In covert identification and selection, potential locations for fixation are selected immediately before the saccadic movement occurs (see also Deubel & Schneider 1996; Kowler et al. 1995; Schneider & Deubel 2002).

This covert attention can be directed to the peripheral visual field, beyond the central region of about 12° from centre (Findlay 2009) and possibly to more than one location. This is demonstrated by combined eye tracking and fMRI studies (Fairhall et. al 2009; Perry & Zeki 2000). Pre-motor theory is also supported by John Findlay’s (1997) demonstration that certain types of target can be located with a single saccade.

While some details of pre-motor theory have recently been contested (e.g. Smith & Schenk 2012), it remains the most widely accepted model of eye movement control. Essentially, it explains how the eyes do not scan around before settling on their next target. This mainly occurs in the brain before the eye movement is made, involving decision making (influenced by attentional ‘priorities’) at the order of milliseconds. (Viviani 1990 measured minimum processing durations at 100 to 150ms, with average fixation length being 250 to 300ms. Yarbus 1967, reported similar fixation durations.) Goal directed movements, such as reaching, can be informed similarly. This is reminiscent of Gibson’s notion of ‘direct pickup’: what we see can influence our actions prior to (or even in the absence of) visual experience.

Eye movement studies offer insights into attentional strategies, yet attentional processes occur *prior* to eye movements. Such processes are concerned with visual attributes as well as locations. The following section therefore reviews thinking around how visual attention deals with attributes, and offers further conceptual distinctions regarding attention, pre-attention and awareness. The majority of such theories is derived from experimental psychology, using tasks such as visual search and change recognition to gauge the capabilities of the attentional system.

4.2.2 Attributes, dimensions and features

Ronald Rensink describes how

> in the absence of attention we can, at most, be aware of object attributes but not how they are related. For example, if an object is composed of a red vertical bar and a blue horizontal bar, then, in the absence of attention, we might be aware that there was a vertical bar and a horizontal bar and that there was red and blue. However, we would not know which bar was which color. To be able to relate (or 'bind') a bar's color to a bar's orientation requires that the bars be attended. (Rensik, in Banks 2009: 47)

Here, Rensik is describing the 'binding problem' in relation to visual phenomena: how separable elements are segregated and combined. The distinction between awareness and attention should be noted. In general, it is considered that awareness does not depend on attention (it happens automatically). In this account, awareness is not equivalent to bottom-up, salience-based attention, but to the pre-attentive array, perhaps synonymous with the notional 'intermediate representations' discussed earlier. This implies that such a representation is not entirely unconscious, but presents some visual experience or 'awareness' (as distinct from attention).

In order for recognition (the final representation) to occur, visual features must be conjoined, or 'bound', by attention. The notion of 'features' is common to many theories of attention: featural 'dimensions' include colour and orientation, while 'feature values' are specific instances, e.g. blue or green, horizontal or vertical.

Figure 48 demonstrates these distinctions. We are aware of the array in both instances, but once it is above a certain level of complexity (when the search target is unique in two dimensions) attention is required to locate the target (demonstrated as serial search). If the array differs in only one dimension, the target can be identified peripherally and pre-attentively.

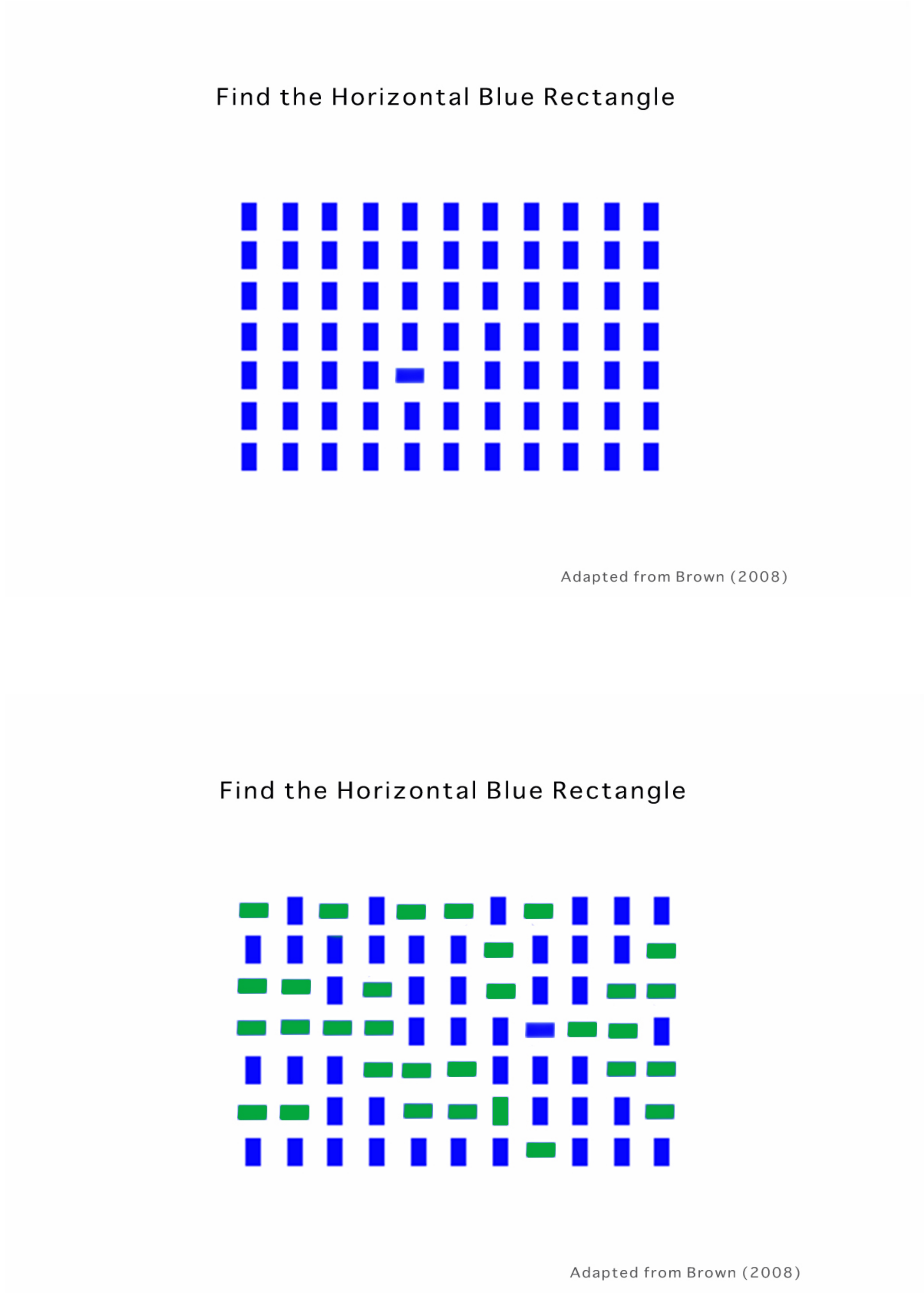


Figure 48. Attention is required when the search target is unique in two dimensions (adapted from Brown 2008).

There are a number of theories offering explanations of how the visual attentive system is constituted – how it segments the array into manageable pieces and how it is limited. What comprises an integral or separable feature is not exhaustively defined, but clear examples are offered.

4.2.3 Early accounts of visual attention

The study of visual attention has presented many differing models over the past century. Early models were not feature based, but considered visual attention to function as a 'spotlight' (Eriksen & Eriksen 1974) or 'zoom lens' (Eriksen & James 1986). This model quickly gave way to the view that attention is directed not to locations or regions, but to objects or groups of objects (Duncan 1984; Duncan & Humphreys 1989; Driver & Baylis 1989; Egly, Driver & Rafal 1994; Humphreys, et al. 1996; Kahneman & Henik 1981), and can be split over two or more locations (Duncan 1984; Kramer & Hahn 1995; Awh & Pashler 2000; Franconeri et al. 2007). Earlier 'gestalt' theories suggested that apprehension of the whole preceded analysis into constituent parts (Monahan & Lockhead 1977; Neisser 1976), a position that was refuted by contemporaneous associationist theories, and by most subsequent theories.

The notion of a shifting attentional focus points to a pre-attentional selection process. As early as 1958, Donald Broadbent, in his 'Filter Theory', suggested that the majority of processing occurs pre-attentively in visual and other modalities. Treisman also addressed this, referring to Wendell Garner's (1974) distinction between integral and separable dimensions. In her seminal 'Feature Integration Theory' (FIT) (reminiscent of Marr's staged model), she defined distinct sequential stages: the pre-attentive stage registers all separable features in parallel, as 'free-floating' features (Treisman & Gelade 1980), or in 'feature maps' (Treisman 1982)(both notional 'intermediate representations'), later proposing that *identifying* and *locating* features are two distinct processes (1985). The attentive stage then selects and integrates features into 'objects'. For example, a red ball is both red and round. These features are identified, located and bound in order for such a ball to be identified. Treisman also describes pre-attentive 'grouping' processes that operate on the level of 'feature maps': "features within a given map could form into coherent clusters" (Quinlan 2003: 3), for example, in texture segregation and figure-ground grouping. (See Quinlan 2003, for a full review of developments in FIT and rival theories.)

The mechanism for pre-attentive selection was assumed by earlier theories to operate unconsciously. That is, it would reveal percepts to consciousness, but the selection process itself was believed to be unconscious. This accounted only for bottom-up, salience based attention, but later versions of FIT (and subsequent theories reviewed below) acknowledge that top down processes also contribute by influencing 'feature weights': criteria for what is deemed to be salient in the context of a specific task. When based on recent exposure to a cue, this is referred to as 'attentional priming'.

Koch and Ullman (1987) proposed another of the earliest computational models of visual attention. Similar to FIT, their model contained a 'parallel feature extraction stage' and a 'master map' (for integrating saliency) with a top down inhibitory process to deal with irrelevant distractors (figure 49).

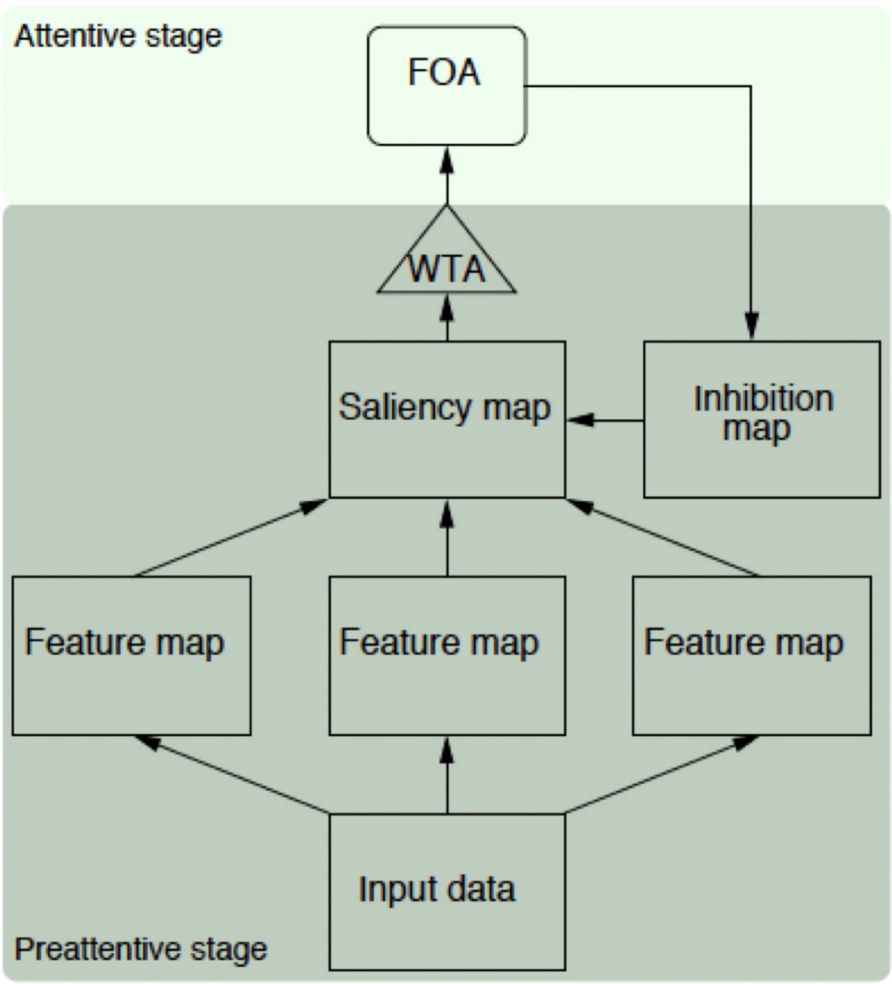


Figure 49. Simplified version of classic attentional models (from Backer & Mertsching 2003: 9) [FOA: focus of attention; WTA: winner takes all].

This 'classic' computational model resembles FIT, and Jeremy Wolfe's 'Guided Search' model (Wolfe, Cave & Franzel 1989; Wolfe 1994).

Gerriet Backer and Bärbel Mertsching (2003) offer an elaborated model with two selection stages, introducing a 'semi-attentive' stage (figure 50). In their model, the pre-attentive stage extracts features by saliency (including symmetry, eccentricity, colour contrast and depth), as in Koch and Ullman's. The semi-attentive stage represents a small number of discrete items by generating 'symbolic descriptions' of each, making them available to the attentive stage, which selects a subset of the previous selection using top-down mechanisms defined by the system's aim. In this way Backer & Mertsching's model proposes 'objects' to be the units of attention (borrowing the notion of 'object files' from psychophysical modelling).

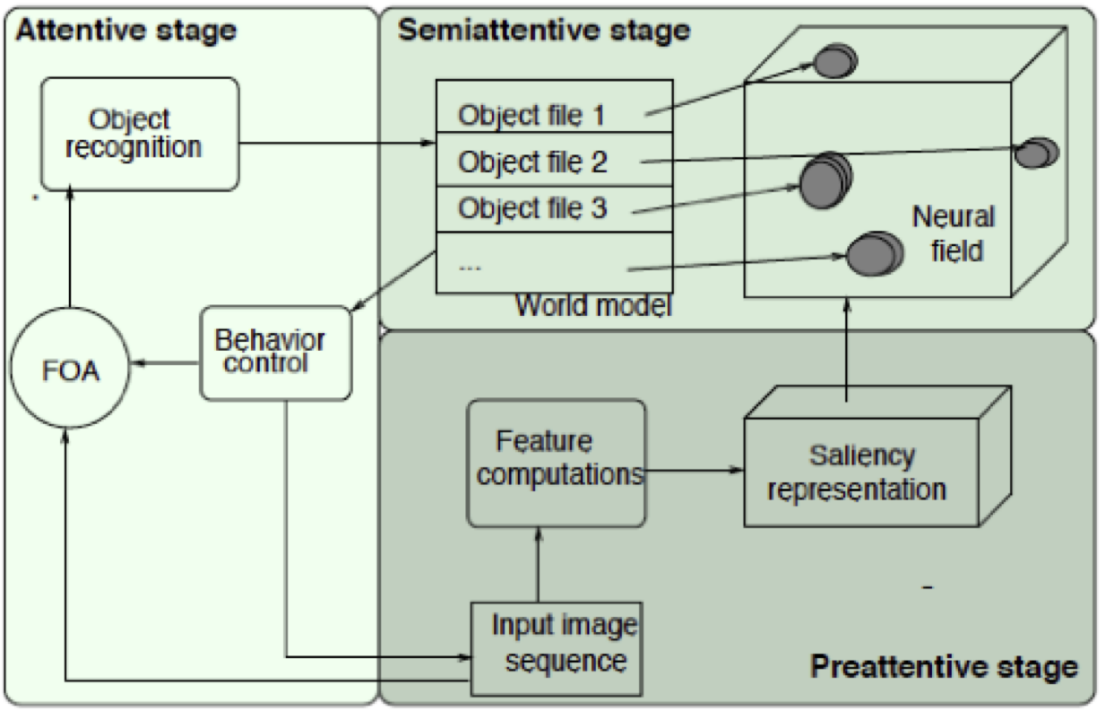


Figure 50. Backer & Mertsching's proposed three stage computational model of visual attention (from Backer & Mertsching 2003: 11). The neural field contains 'three-dimensional activity clusters'.

A definitive list of all possible features or dimensions has not yet been presented. Clear examples like colour and orientation are most commonly used to illustrate attentive mechanisms, although different studies cite other examples. Treisman and Gelade list "color, orientation, spatial frequency, brightness and direction of movement" as dimensions (1980: 98), referring to Zeki's (1978) description of functionally specific modules in the visual cortex. These were used to devise the visual search tasks that substantiate FIT. Liqiang Huang and Harold Pashler cite (Triesman and Gormican's 1988) examples of feature maps as "presumably [including] those computing motion, size, color, spatial frequency, orientation, and perhaps others" (2007: 603). They acknowledge that there is ambiguity in existing theories about what constitutes a feature, also citing 'depth' and "certain aspects of shape (e.g. curvature, closure, digit/letter identity)"(2003: 615) as examples of features. Others make distinctions between *colour* and *form* (Gottwald and Garner 1975); *size* and *form*; *size* and *brightness* (Attneave 1950); *hue* and *brightness* (Garner & Felfoldy 1970; Callaghan 1984); *circle size* and *inscribed diameter orientation* (Shepard 1964). There seems to be no review of literature regarding what constitutes all separable dimensions; neither does this seem to be a primary objective in these studies. Nevertheless, this list of candidate features is interesting in relation to the present study, which questions the ways in which artists focus visual attentional resources.

The distinction between integral and separable features has been questioned. Garner (1974) suggested the possibility of a 'continuum', with degrees of separability. Smith and Kemler (1978) also proposed a "continuum of dimensional primacy" apparently at odds with the notion of distinct, integral features. Patricia Cheng and Robert Pachella later demonstrated that "apparent 'degrees of integrality' could arise from differing degrees of correspondence between physical and psychological dimensions" (1984: 299), suggesting that their findings indicate "the possibility that integral dimensions may be a myth" (1984: 302).

Object based theories differ in their stance regarding 'scene primitives' and separable units. Irving Biederman describes a "modest set of generalized-cone components, called geons […which] can be derived from contrasts of five readily detectable properties of edges in a two-dimensional image: curvature, collinearity, symmetry, parallelism, and cotermination" (1987: 115). These function as a lexicon of templates by which perceptual information is organised, leading to more complex compound shapes which are then recognized as familiar objects. This theory refers to a different set of features, suggesting a stage of vision, prior to object recognition, but after feature integration, similar to Backer and Mertsching's semi-attentive stage, but operating under more three dimensional, geometric primitives.

The experimental evidence used to support each theory does not directly disprove the others, so these accounts are not necessarily contradictory. It is perhaps misguided to see to explain attention with any single frame of reference – the frame of reference seems to be variable and task-oriented. When viewed in light of the more recent neural models reviewed earlier, each description of attention – location based, feature based, geometric, object based – seems to have a corresponding visual 'module'. This suggests that all these ways of paying attention are valid, each one being demonstrated through a different experimental task. In relation to attentional strategies for drawing, we may therefore consider all of the examples offered here as potential frames of reference with many possible objects of attention available for attentional access at many levels of complexity. The visual scene must be deconstructed in order to be drawn one element at a time, but the way in which this occurs is not fixed, but open to many possibilities.

4.2.4 Recent theories of visual attention

More recent theories depart from contentions around the basis of attentional selection, clarifying the relationship between feature detection and location, and identifying more specific parameters within which attention is constrained. FIT "is reasonably vague about how the location of any given feature was to be specified at [the early] stage of processing" (Quinlan 2003: 2). Also, FIT is unclear exactly what takes place on one feature map as opposed to another, what the relationship between feature maps are, or what the role of pre-attentive grouping is. These matters are clarified by Boolean Map Theory (Huang & Pashler 2007; Huang, Treisman, & Pashler 2007; Huang 2010a; 2010b), using further experimental evidence to clarify the processes involved in visual search.

4.2.4.1 Boolean Map theory

Boolean Map Theory (BMT) describes visual attention as operating via maps of the visual field with two categories: that which is attended and that which is not. Boolean maps are distinct from 'feature maps', which are thought to be generated earlier in visual processing and represent the distribution of various features. The Boolean map is the *means* of attentional control.

BMT deals specifically with the question of what the human mind can apprehend *in a single moment*. It can be distinguished from earlier theories by five main tenets.

- single feature access
- multiple location access
- obligatory encoding of location
- feature by feature selection
- availability of Boolean operations (Huang & Pashler 2007: 602-603)

While FIT proposes that features can be accessed instantaneously as long as they do not need to be bound in another dimension (demonstrated in figure 48), BMT differs in proposing that what can be accessed at any instant is 'one feature value per dimension' (Huang & Pashler 2007: 600) as illustrated in figure 51.

Another departure in BMT is the role of location. The question had been raised many times as to whether spatial and featural selection are separate processes (see Põder 2001; Shih & Sperling 1996; Posner 2011).While colour, shape, orientation and hue, etc. are considered dimensions which can be bound by attention, BMT states that location is a given, in that it is always processed in parallel to feature types. A Boolean map is defined as "a collection of locations […] exactly covered by relevant stimuli". Feature values are "perceived to occupy one or multiple locations" (Huang & Pashler 2007: 601). By this definition, to apprehend is to locate. The possibility of simultaneously perceiving one feature value over multiple locations is a significant development in BMT, demonstrated below in figure 51.

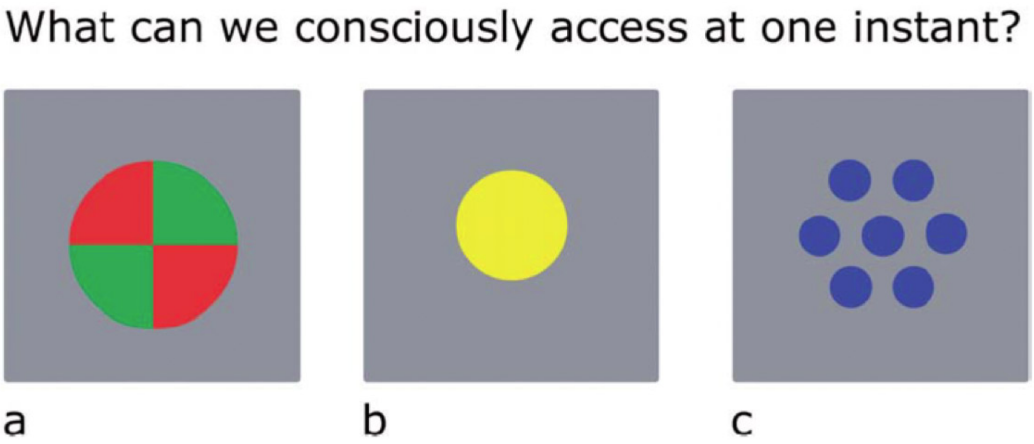


Figure 51. What can we consciously access at one instant? (from Huang & Pashler 2007: 600)

Huang and Pashler devised Figure 51 to demonstrate that the configurations in panels *b* and *c* can be apprehended at a glance, while in panel *a*, each coloured configuration (red and green) can only be accessed through separate feature labels, not at the same time.

Figure 52 illustrates the operation of the ‘Boolean map’, which can locate items using one featural label only, in this instance, colour or shape.

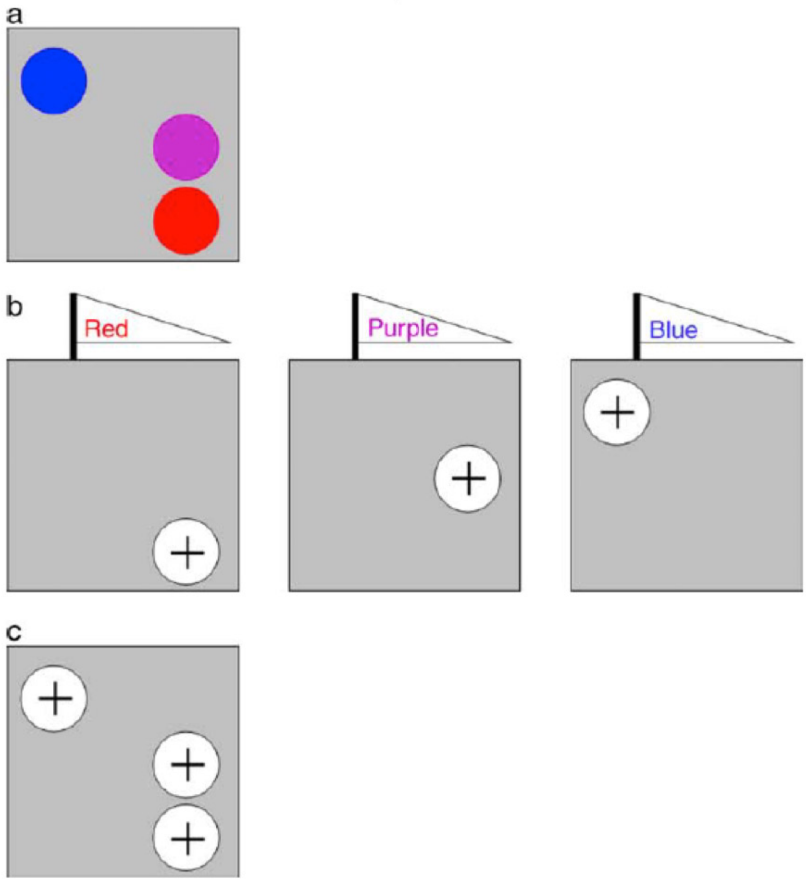


Figure 52. Multiple colours can be accessed only one at a time (one Boolean map has one featural label), but multiple locations can be accessed simultaneously (from Huang 2010b: 3).

Another significant clarification is between access and selection. John Duncan (1980a; 1980b) first offered experimental evidence to clarify the distinction, but his (1984) 'Object Theory' presented the object as the unit of access rather than the feature (as in BMT). Most recent theories have focused primarily on selection (e.g. Egly et al. 1994; Scholl, Pylyshyn, & Feldman 2001; Watson & Kramer 1999), but BMT has challenged this by exploring access, and the relationship between units of access and selection. (The maps presented in figure 52 refer to *access*.)

Huang defines the distinction as follows:

> Access describes the limit on the content (or, in some sense, quantity) of visual information that is able to reach the stage of consciousness at any one moment. Selection is the separation of relevant from irrelevant information and thus governs what gains access to the stage of consciousness. (Huang 2010a: 162)

This means 'selection' makes use of the Boolean map, while 'access' refers to the information it contains. Huang's argument is that the map is the 'unit of access'. That is, visual awareness uses a set of locations as the basis for access, from which selection may then take place (see also Huang, Treisman & Pashler 2007). (Michael Posner (2011) links the selection-access distinction with the 'binding problem'[3], suggesting that the Boolean map is essentially the process by which features are 'bound' via 'mapped' feature labels.)

Huang and Pashler argue that all top down visual attentional control is achieved by the creation of Boolean maps (2007: 622). A map is created by either selecting one feature value in one dimension (e.g. the set of all red things) or by combining the existing map with another through 'Boolean operations' such as intersection or union (see Huang and Pashler 2007, Huang 2010a, Huang 2010b for further discussion of intersection and union). In this way, task-relevant features are located and identified in a two-stage process. In terms of the feedback loops described in the previous section, we can think of selection as a process of amplifying the resonance of certain percepts. That which is selected is amplified, and visual phenomena are strengthened.

This account of attention seems more useful to an analysis of drawing, as it does not privilege the 'object' as the unit of attention, nor simply the level of resolution, but considers the role of feature types and locations more closely, offering specific definitions of the limitations and constraints of visual attention. This type of limitation represents the constraints within which cognitive strategies for drawing must operate. These will be discussed in greater detail in chapter 6 in relation to the case studies.

The theories of visual attention surveyed so far are derived mainly from experimental evidence that relies on simplified visual search tasks, using specially designed stimuli that segregate visual elements. While these can be useful for measuring visual capacities, they do not resemble drawing either in visual complexity or goal orientation, and are therefore not best placed to act as an example of what may occur during drawing process. Wolfe's more recent studies account for attention in more naturalistic scenes (discussed below) offering a

[3] Revonsuo & Newman define the binding problem as "how the unity of conscious perception is brought about by the distributed activities of the central nervous system" (1999: 123). the term is used with reference to both perception and consciousness.

more realistic (and complex) model.

4.2.4.2 Wolfe's 'guided search' and 'two-pathway' architecture

Jeremy Wolfe discussed the limits of object recognition capacity (2003), and created a model that accounts for the role of scene-based information in 'guiding' visual search (Wolfe et al. 1989). He argued that *real-world* search tasks involve the selective recognition of candidate objects. As such, his work consolidates models of visual search and object recognition, by accounting for the ability to apply semantic and episodic knowledge about a scene or environment (see also Wolfe 1994). The 'guided search' model describes how serial recognition is not random but based on basic attributes which can be perceived in parallel. For example, "'bread' would be defined by some set of features" (Wolfe et al. 2011: 79), which could be selectively used in guiding search, prior to selective object recognition. This guidance reduces the 'functional set size' of searched objects (see also Neider & Zelinski 2006), staging the process. This is comparable to Backer and Mertsching's two-stage selection process, but stresses the role of prior knowledge in defining 'objects'. The implication is that the pre-attentive 'representation' is influenced by knowledge.

Wolfe's later work considered how this involves some level of vague 'awareness', as discussed earlier. He offers a parallel 'two-pathway' model as an alternative to the sequential attentive/pre-attentive model. As Wolfe explains, the 'gist' of the scene is recognisable at a glance. For example, one can judge whether the scene is a kitchen or a forest, prior to object recognition. This is explained using a two-pathway architecture including 'selective' and 'nonselective visual pathways' (see figure 53).

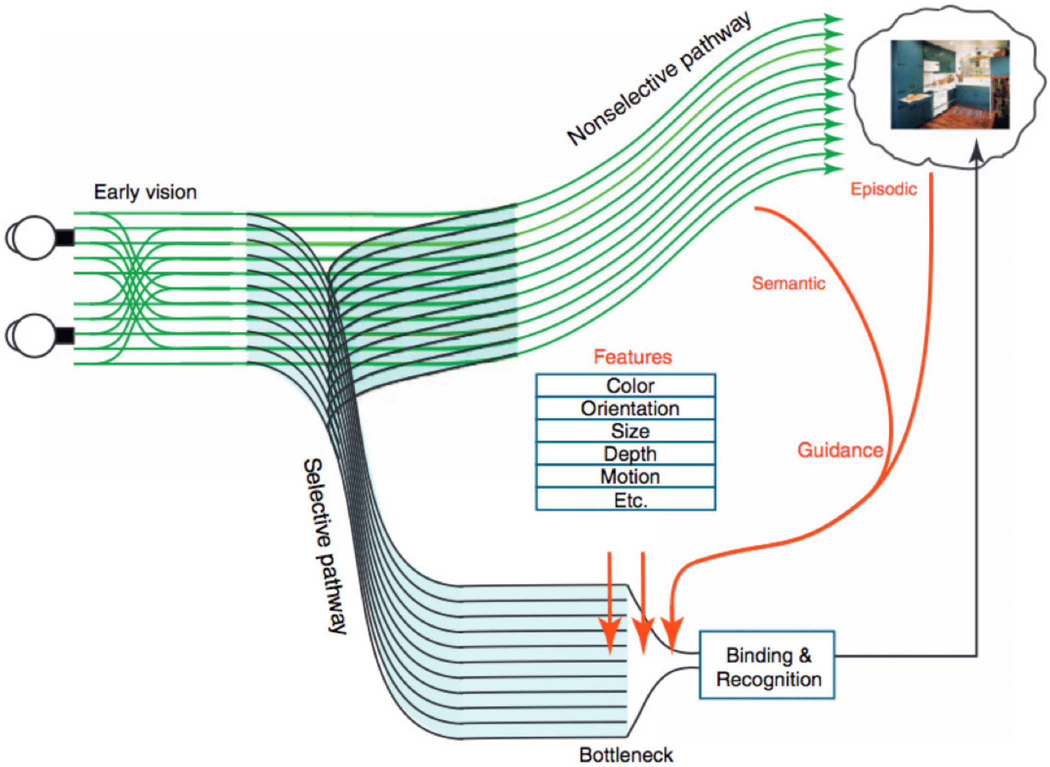


Figure 53. A two-pathway architecture for visual processing (from Wolfe et al. 2011: 81). "A selective pathway can bind features and recognize objects, but is capacity limited. The limit is shown as a 'bottleneck' in the pathway. Access to the bottleneck is controlled by guidance mechanisms […] statistics from the entire scene, enabling a certain amount of semantic processing, but not precise object recognition" (2011: 81).

Essentially, this model differs from two-stage models by proposing that both occur simultaneously, and both contribute to phenomenal visual experience. The nonselective pathway involves parallel processing, which "allows observers to extract statistical information rapidly from the entire image" (Wolfe et al. 2011: 81). This re-frames the 'binding problem': in staged models segregation precedes combination, the pre-attentive stage is simply an array of features waiting to be bound by attention. The two-pathway model more closely resembles earlier gestalt models of vision, which believed the whole to precede the parts.

Wolfe et al. cite a number of studies that mention types of attributes, the ‘gist’ or statistical properties of which can be processed nonselectively:

- size (Chong & Treisman 2003)
- orientation (Parkes et al. 2001)
- some contrast texture descriptors (Chubb et al. 2007)
- velocity & direction of motion (Williams & Sekuler 1984)
- magnitude estimation (Demeyere et al. 2008)
- centre of mass for a set of objects (Alvarez & Oliva 2008)
- centre of area (Melcher & Kowler 1999)
- emotion and gender (Haberman & Whitney 2007)
- presence of classes of objects in a scene (Vanrullen 2009)

These studies suggest that, as the whole scene is processed at once, many types of ‘gist’ are immediately discernible. For example, we might enter a room to have an immediate sense that it is full of people milling about, mostly large women, and they’re generally not happy, before we (serially) recognise who they are or what they’re doing. Wolfe describes how this takes place in the first moments a scene is perceived (i.e., more quickly than recognition), and that it continues to be processed in parallel.

This model posits that both pathways operate in parallel, but in moments when the selective (attentional) pathway is not yet active, the non-selective pathway still presents itself to awareness. While Wolfe et al. do not discuss the possibility that the viewer may hold some degree of control over which pathway takes precedence, or that the ‘eye’ can be trained as such. It appears to be a possibility that selective visual attention could be employed to inhibit the selective pathway, allowing access to (or at least greater awareness of) the non-selective pathway. If this were the case, the viewer would have a choice between apprehending features vaguely and generally (via the nonselective pathway) or in a specific and particular way (via the selective pathway), i.e., gist or recognition. Certainly, the artists in the present study demonstrated a high degree of attentional control that seemed to include a more generalised awareness of the types of attribute listed above. This suggests that detail can be sacrificed to allow more general information to become apparent. We may therefore list ‘gist’ as among other modes of attentional selection (location, feature and object based).

This two-pathway model is interesting in relation to Guérin, Ska and Belleville's (1999) account of drawing process (discussed in chapter 1), which includes two parallel systems: one involves processing 'single-part images' the other "allows the addition of parts to the global image". The two pathways in these two models are not congruent: the notion of the 'single-part image' is not the same as the (binding and recognition) bottleneck, as it isolates rather than 'binds' features. Also the notion of the 'global' image' is not congruent with the 'nonselective pathway', as it too is said to be constructed from 'single-part images' rather than a generalised, holistic impression. However, the fact that Guérin, Ska & Belleville's model includes the deconstruction of the image into 'single-parts', and their reconstruction into a global image with the influence of associative and long-term memory, indicates that the drawing process *mimics* pre-attentive stages of visual processing in some way, as this too involves many fragments being bound together to form representations. Guérin, Ska and Belleville's model will be discussed again in chapters 5 and 6, which consider it in relation to the outcomes of the case studies in chapter 3.

The fact that gist properties have been shown to be processed non-selectively (pre-attentively) raises an issue for any explanation of drawing – in order to evaluate the success of a drawing in progress, the artists must gauge how effectively these properties are represented, and identify errors or omissions that occur at a lower order of complexity, in order to plan the next phase of the drawing process. This would require selective attentional access to visual stages described here as 'preattentive' and 'semi-attentive'. That is, if indeed there are 'intermediate representations', the artists demonstrated some attentional access to them. This is discussed further in chapters 6 and 7, which argue that drawing ability must entail a greater range of attentional access than is typical of non-artists (or in more everyday visual tasks).

4.2.5 Summary

Whether we think of attentional selection as operating on the basis of a spotlight, object files, features, or Boolean maps, it can be said that there is a filtering process which narrows what is accessible to consciousness at any moment, and a selection process which amplifies the neural signals for whatever is selected. These are influenced by prior knowledge and task-related attentional priorities. Drawing must involve such 'priorities', influencing how attention is delegated in terms of attribute perception, eye movements, and possibly even other types of movement, and recruiting knowledge. That is: where to look, what to look for, how to physically respond, and how to interpret what is seen.

It can be argued that actions can be influenced 'directly' without conscious visual phenomena, although what exactly that refers to is questionable – we may experience *spatial* phenomena without visual recognition but this is still 'conscious'. The pre-attentive, or nonselective, aspect can be described as making use of 'intermediate representations', but whether we think of the process as staged or parallel, these seem to give rise to some kind of visual phenomena – 'awareness' or 'gist' – that allows some general, statistical properties to be gleaned very quickly, and in the context of our prior knowledge (i.e., not simply an array of abstract features, but a meaningful impression).

The number of processing 'stages' remains inconclusive. Computational models tend to include fewer 'representations' than functional-anatomical ones, but the feedback evidenced by neuro-imaging studies suggest that the process involves so much complex connectivity that these arguments are academic - the closer we look, the more 'stages' we will find – and so the problem is creating a model that is *useful.* In general, it can be said that the divide between conscious and unconscious vision is not clear cut, and a 'grey area' which involves some awareness may be proposed. We can think of this as synonymous with 'access' that narrows and filters the visual scene, beyond which visual selection takes place. Selection is capacity-limited, while parallel processes are not. While we may think we 'see' the full visual scene, this is an illusion; we only ever apprehend a small amount at once. Figure 54 represents this summary.

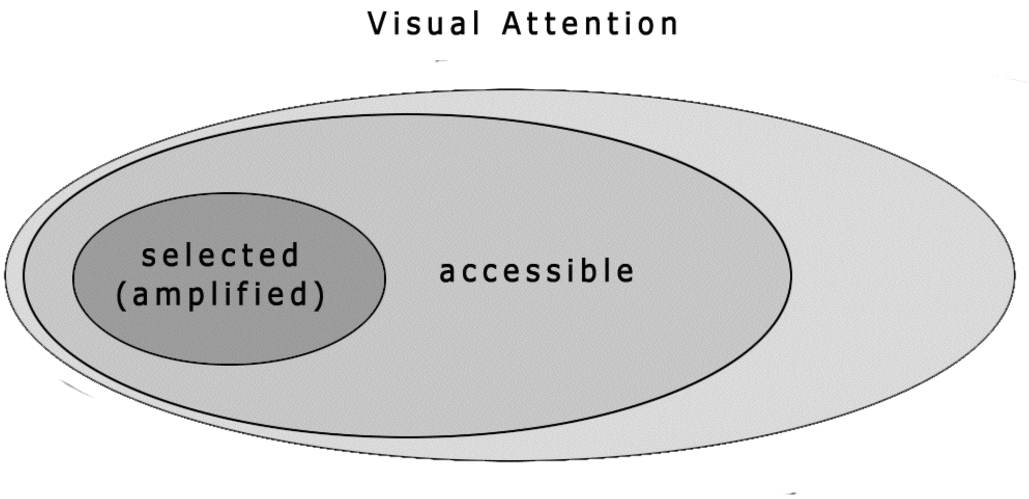


Figure 54. A subset of the full visual field is accessible, and a subset of that is available for attentional selection which is serial and capacity limited. The accessible is processed in parallel (through the 'nonselective' pathway) and may also be subject to pre-attentional filtering. There is also some 'awareness' of it.

In general, theories of attention overlap on a number of points, allowing us to take as working assumptions the following premises:

1. Visual attention involves access and selection process, which can be goal-directed or stimulus-driven (top-down or bottom-up).
2. Selection processes are capacity-limited. BMT claims selection is limited to locating only one feature value per dimension at a time, although this may involve multiple locations.
3. Access consciousness (i.e., that which is accessible to attentional selection) involves some level of visual awareness, and is influenced by knowledge.
4. That which constitutes integral and separable features and dimensions has been defined. Not exhaustively, yet enough to inform experimental design with clear examples. A grey area remains, regarding what else may constitute an integral feature, and whether there are 'degrees of integrality'.

The theories reviewed here account for four levels of resolution concerning what might be apprehended in an instant:

1. particular 'feature values' (possibly across multiple locations)
2. 'feature conjunctions'
3. 'object files'
4. 'gist' (meaningful statistical properties of the scene)

4.2.6 Discussion

These studies, combined, indicate that attentional selection can operate on differing levels; it may even be a sliding scale. The attentional 'unit' need not necessarily be an *integral 'feature'*. The concept of an integral feature may itself be mistaken. Rather, attentive mechanisms can access different feature types at different levels of resolution, as appropriate to the task at hand.

We can consider this in relation to the pictorial/propositional debate around intermediate representations – objects and gist can be labelled, with irrelevant pictorial details disregarded (as in 'direct pickup'). In drawing, more abstract -level features may also themselves be 'objects' of attention.

These theories draw heavily from evidence collected through visual search and recognition tasks, and are therefore of limited applicability to understanding the attentional processes involved in drawing. To detect a target among distractors is a relatively simple task, further simplified in experimental trials by the use of contrived visuals with limited variables. While Wolfe broadens the scope by considering search in more complex visual arrays, attention studies still continue to focus on visual search and recognition as the appropriate tasks for testing hypotheses concerning visual attention. We can generalise findings (e.g. that knowledge and task-related priorities must influence access and selection in all types of visual task, including drawing), but these models are not directly applicable to drawing. The task is so different: recognition is not the goal and there is no search 'target' to provide a template. Rather, templates or maps must be devised as part of longer and more complex attentional strategies. In other words, recognition and search are finite attentional tasks, while drawing is a continuous process; the process involves repetitive cycles, but the purpose of each cycle varies, and the way in which attention is focused does not remain constant, and must be managed. To be studied in the same manner as visual search or object recognition, drawing must be thought of as comprising many separable tasks. Drawing is multi-faceted and includes a variety of sub goals and routines, which differ depending on strategy. It is therefore problematic to offer any definitive model of drawing process. Chapter 6 will tackle this by considering the management of attention and other cognitive capacities in relation to the two types of task identified in chapter 3 (constructive and reflective).

Despite the difficulty of translating these results to an understanding of drawing, each theory offers potentially useful findings in terms of how attentional control occurs, and concepts to aid in describing it. FIT and related theories offer the notion of the feature map, and the weighting of feature values to influence perceived salience, suggesting a potential model for how drawers might filter relevant visual details. BMT defines attentional capacity limitations (what can be apprehended in a moment), its clarification of the role of location being particularly relevant. Wolfe's model reminds us of the existance of generalised awareness and gestalt perception, offering a reconsideration of what type of thing it is possible to apprehend instantaneously.

All these concepts help to explain the parameters of attentional control. In these terms we can say that the drawer applies attentional control in a top-down manner, by influencing the perceved saliency of certain feature types at certain locations. This must occur differently in each gaze cycle and, therefore, attentional strategies for drawing must account for the *serial* selection of a range of feature types, for the combination of features perceived separately, and for the management of that process over the duration of the drawing. Therefore, the executive control of attention over time must also be accounted for. Attention may operate from one instant to another, but cognition occurs over periods of time, it relies on memory. This review ends by considering memory, its various forms, constraints and its relationship to vision and perception.

4.3 Cognition, temporality and working memory

The previous sections of this review offered clarification of the parameters, limitations and processes involed in visual attention. It explored various ways in which attention can be controlled and focused, and discussed what it means for attention to be limited to one 'object' at a time. It also discussed concepts such as perceptual phenomena, awareness, attentional access and consciousness in relation to vision. While this contributes much to understanding the visual faculties employed in drawing activity, it only represents the tip of the iceberg. Attention informs working memory (WM) where cognitive operations occur. This is not limited to 'one thing' but is still subject to limitations that constrain drawing process). The various components of perception and memory, and their related limitations, collectively represent the parameters within which cognitive drawing strategies must be devised. Further to this, long-term memory (LTM), including 'schematic memory', also plays a role, offering knowledge to inform and influence the drawing process, as Gombrich insisted.

This section reviews terminology and frameworks for understanding perception and memory, and recent findings regarding their interaction. It also considers the temporal dimension of cognitive activity; specifically, when 'thinking' can be considered to operate serially or in parallel, and what the relationship is to phenomenal consciousness – echoing the same debate in study of vision, and extending it to cognition more broadly. This will inform discussion in chapter 5, regarding the roles of perception and schematic memory in drawing, and in chapter 6, regarding the parameters that constrain cognitive strategies for drawing.

4.3.1 Long-term, short-term and working memory

William James (2007 [1890]) and Edmund Husserl (1991 [1966]), among others, described our experience of the present as 'specious': a 'moving window of now'. The specious present is said to be around three seconds long, roughly the length of a bar of music or a line of poetry. We attach timelines to objects and our surroundings, and we are able to hold a certain amount of information in mind in order to manipulate and process it. Psychologists now generally consider this to be synonymous with working memory. They now consider it limited by capacity more than duration, although duration is still a factor and 'retention intervals' used to study WM vary between 1 and 7 seconds (Andrade 2002). The most extensive research around this has been done in relation to auditory (rather than visual) stimuli, but some research comparing musicians and non-musicians has suggested that musicisans demonstrate an "extended temporal range of auditory working memory" (Repp & Doggett 2007: 373). Chapter 6 will go on to discuss the possibility that the artists in the present study could also have been using *shorter* WM durations to maximise visual attentional resources. The following section outlines different categories of memory, in order to clarify terminology used in those discussions.

Three types of memory are generally distinguished in cognitive psychology: short-term memory (STM) refers to the limited capacity holding of information, for a maximum of around 20-30 seconds (although Information can be rehearsed in order to keep it in STM for longer); long-term memory (LTM) is unconscious and considered *not* to be capacity limited; working memory (WM) is a more recent concept, sometimes referred to as 'working attention'. It is shorter than STM, and acts as a temporary workspace for consciously holding *and manipulating* STM information. (Cowan 2008 offers a review and clarification of the recent uses of these terms.)

Although duration estimates have been made for WM, information can be deliberately rehearsed and refreshed to keep it in mind, rendering the duration flexible. Presumably, this would also be determined by the complexity of mental operations. WM's capacity limits have been determined, but this is also related to the way in which its various components are employed.

4.3.1.1 Working memory and visual working memory

Working memory was first defined by Alan Baddely and Graham Hitch in 1974 as "a temporary store for recent activated items of information that are currently occupying consciousness and that can be manipulated and moved in and out of 'short term memory' " (Colman 2009: 822). They proposed a tri-part structure, with a central executive and two 'buffer stores' (short-term storage mechanisms): the 'phonological loop' and the 'visuo-spatial sketchpad'. Baddeley (2000) later added a third buffer, the 'episodic buffer', which provided "limited-capacity storage for integrated episodes or scenes using multiple codes" (Colman 2009: 822). Baddeley's 'visuo-spatial sketchpad' is now generally referred to as 'visual working memory' (VWM), although visual and spatial working memory are sometimes treated as distinct. The notion of VWM as a 'sketchpad' is apt for the current analysis - perhaps holding visual details before they are recorded in the physical sketchpad - but, unlike a sketchpad, it can only hold a limited amount of information at once.

Cognitive Load Theory proposes that WM capacity is limited to around 7 items of information (Sweller, Ayres & Kalyuga 2011), which can be augmented by proceduralisation and chunking. 'Chunked' information acts as a single unit once learned. For example, a seven-digit number may include a memorised six-digit phone number, therefore presenting only two information 'units'. Likewise, familiar *processes* can become proceduralised and parts are dealt with unconsciously.

VWM, being only one component of WM, has been estimated as having a capacity of 3 or 4 items (Fukuda et al. 2010; Luck & Vogel 1997; Pylyshyn 1994; Pashler 1988; Sperling 1960), with minor individual differences correlated to 'general intelligence and scholastic aptitude' (Cowan et al. 2005). Steven Luck and Edward Vogel (1997) describe this capacity as object based, although this again raises the issue of what might constitute one 'object'. Numbers are relatively easy to categorise as 'units', even accounting for 'chunking', but what constitutes a single unit in visual attention seems to be variable, as discussed in the previous section.

4.3.1.2 Visual working memory involves two dimensions: number and resolution

There has been some contention around whether VWM capacity is determined simply by the number of objects (e.g. Irwin 1992; Luck & Vogel 1997; Vogel, Woodman, & Luck 2001) or if the complexity of those objects is also a factor (Alvarez & Cavanagh 2004; Eng, Chen & Jiang 2005). Clearly, one object with many attributes represents more than one piece of information. Edward Awh, Brian Barton and Edward Vogel clarify this matter by demonstrating "a two-factor model of [visual] working memory, in which the number and resolution of representations in working memory correspond to distinct dimensions of memory ability" (2007: 622, see also Fukuda, Awh & Vogel 2010). Similarly, Hing Yee Eng, Diyu Chen and Yuhong Jiang show evidence that "perceptual complexity [is] an important factor in determining VWM capacity" (2005: 1127). The number decreases with more complex stimuli (although that correlation declined as the stimuli were presented for longer durations). This is likely also affected by the intended *purpose* of the objects, i.e., how much detail is actually task relevant. How 'visual' such representations are is, again, questionable – propositional representations may label objects more efficiently than visual representations.

That memory operates multi-modally raises the question of the relationship between modalities. VWM capacity is estimated at around half the overall WM capacity. However, there are many modalities whose combined capacities equal more than the total WM capacity. This points to a partial sharing of cognitive resources across working memory function, and therefore a competition between modalities for WM resources.

4.3.2 Vision and other modalities

Attention operates in many modalities. In addition to vision, we can pay attention to time, space, the position or movement of our body (proprioception), tactile stimuli, auditory stimuli (see Recanzone & Cohen 2010), temporality (Lawrence & Klein 2013), and to *internal* mental imagery (Griffin & Nobre 2003). WM therefore needs to deal with multi-modal input.

Multiple-resource theory (MRT) (Wickens 1984) has been an influential model of multi-modal attention, offering an understanding of competition between modalities. It proposes that information processing has separate**,** fixed capacity resources which can be characterised along three dimensions:

1. The processing stage (early vs. late processing)
2. The processing code (spatial vs. verbal information)
3. The information modality (visual vs. auditory encoding) (Kramer, Weigmann & Kirlik 2007: 187)

Later versions of MRT considered additional sensory modalities. MRT predicts that *task performance can improve if competition is reduced by spreading the informational load across different modalities*. In other words, information processing can be enhanced by using more than one sense.

It is acknowledged that this may not necessarily be due to separate perceptual resources, as in 'hybrid' accounts which includes separate, modality specific attentional sub-systems and a higher-level supramodal system (see also Bushara et al. 1999: 764; Woods, Alho & Algazi 1992; Farah et al. 1989: 469-470). Indeed, more recently, models with independent perceptual resources have been discredited by evidence that points to spatial and temporal cross-modal links and attentional constraints which both enhance and limit multi-modal processing (see Spence & Driver 1997, 2004). Charles Spence and Jon Driver (1996) argue against the existence of a centrally controlled supra-modal system, on the basis that there is no need for it; the same purpose can be served by strong cross-modal links. Either way, we can assume that capacity limits are related: each modality is capacity limited, and together they share an overall capacity limit, which can be optimised by working multi-modally.

This literature indicates that there are a number of related factors constraining how much processing can occur at once. It also shows that multi-modal processing can deal with the greatest quantity of information, but how this might relate to drawing process is not made clear by existing research. As drawing is a a visually demanding task, we might expect experienced artists to make efficient use of the cognitive resources they have (this is certainly implied by the regularity of their patterns of movement). This suggests two possibilities: that the drawer could diminish activity in other modalities in order to maximise the visual capacity; or that they might spread the informational load over multiple modalities in order to maximise the overall capacity. Chapter 6 will discuss further whether either or both of these possibilities seem to occur in the case studies.

4.3.3 Visual working memory competes with perception for cognitive resources

In addition to related capacity limits between modalities, there are also related capacity limits *within* modalities, i.e., between perception and working memory. The visual sense is the best understood in this respect, and it can be said that VWM competes with perception for cognitive resources. As we will see in chapter 6, the insights presented below are sufficient for us to consider this 'competition' a further parameter within which drawing process is constrained.

Rebecca Keogh and Joel Pearson (2011) describe 'interference' between visual working memory and perception. They show that, regardless of individual differences in cognitive strategy, information held in VWM reduces capacity for perception. This is because both faculties recruit the same neural substrates to 'maintain visual information', creating a direct competition for limited resources, particularly early visual cortex (see also Magnussen 2000). Mental imagery has also recently been shown to involve activity in early visual cortex, likewise interfering with perception capacity (Pearson, Clifford & Tong 2008). Other studies also show high-level visual are also implicated in VWM (Cornette et al. 2001; Fuster et al. 1981; Smith & Jonides 1999).

Keogh and Pearson illustrate individual differences in how visual working memory is used. They describe how two types of individual - with strong or poor mental imagery - each use "different cognitive strategies to solve the same visual memory task" (2011: 6). Those with strong mental imagery utilise sensory-based imagery mechanisms in working memory, supporting mnemonic performance for example. While those with poor mental imagery rely on alternative strategies. It is unclear the extent to which strong mental imagery affects the shared capacity of VWM as described above, but we can expect to see individual differences in the role of working memory in drawing that may be visible in the case studies.

These studies demonstrate that working memory has an overall capacity limit which is shared with perception, making the two capacities inversely proportional, while different modalities are also capacity related. This is also relevant in light of recent 'embodied' accounts of perception, which argue that 'core' cognition (i.e., abstract conceptualisation, logic and reasoning) also recruits these same neural substrates. That is, it also competes for the same cognitive resources. What can take place simultaneously (while drawing) will therefore be limited in very particular ways, which may help to explain the coincidence of drawing and talking activities observed in section 3.5. This will be addressed in chapters 6 and 7.

Similarly to vision, internal cognition also involves parallel unconscious processes, and a selective mechanism which brings the most salient thoughts to consciousness for further scrutiny (see Chun, Golomb, & Turk-Browne. 2011), as in dual processing theory (see below), which contends that core cognition or 'thought' is only serial when presented to consciousness. In other words, thought is 'perceived' in a similar way to other modalities like vision and audition.

The conscious mind acts as an 'executive' that oversees WM processing, but how it contributes to drawing process remains unclear. Edwards and Ruskin's accounts implied a heightened visual emphasis to the drawing experience, at the expense of more propositional functions, but Gombrich's account stressed the role of knowledge and reflective assessment regarding the ongoing drawing. These offer very different ideas of what the drawing experience must be like, certainly both these functions play a part, but it is difficult to compare these accounts without a theoretical framework to differentiate between conscious and unconscious activity.

The final part of this review therefore looks at the conscious/unconscious division in cognition more broadly (beyond vision and other sensory modalities). This will also become relevant to discussions around what can be reliably reported in chapter 7, in which the artists awareness of their own drawing process, and their ability to describe it, will come under scrutiny.

4.4 Cognition and consciousness

Awareness and attention to one's internal 'thinking' is also subject to similar constraints as vision, regarding cognitive access and selection, and the same relationship between serial and parallel processing applies. In the present context, this constitutes another parameter to be accounted for in drawing process. That is, the artists is not only selecting which visual features to attend to, but which aspects of their cognitive operations to monitor.

4.4.1 Thinking: serial and parallel

Andres Ericsson and Herbert Simon write that "[s]ince the time of Aristotle, thinking has been viewed as a temporal sequence of mental events" (1993: xiii). Ericsson and Robert Crutcher (1991) review the history of the study of thinking, claiming that this assumption 'has never been seriously questioned'. Serial processing is also characteristic to information processing models of cognition, which are often the outcome of Protocol Analysis methods.

Thoughts certainly *appear* sequential when viewed through the medium of verbal reports, but this does not mean that they are always so. The serial assumption has, indeed, been seriously questioned. For example, Neisser (1963; 1976) noted that most situations involve simultaneous attention to multi-modal input. He gave examples such as interruptions caused by peripheral events (as in the cocktail party problem, first posed by Cherry in 1954) and the role of emotion in motivation and decision making, (bottom up and top down attentional mechanisms), as evidence for parallel cognitive processes.

Simon shares Ericsson's serial view, arguing against Neisser's notion of parallel thoughts. He asserts that even while thoughts *seem* to be happening simultaneously, this is only because of "high frequency time sharing of a single serial processor" (Simon 1967: 34). While this may be true of *conscious* thought, it appears that Neisser was correct, in that the attentional mechanisms he describes inform a serial selection from parallel pre-attentive events.

It is now generally acknowledged that unconscious processes occur in parallel, while conscious thought processes are serial, be they perceptual or otherwise (see Richardson 1996; Bayne et al. 2009: 197; Schneider in Velmans & Schneider 2007: 318). Susan Blackmore describes the unconscious as a 'parallel system which produces serial outputs'

(2010) analogous to the accounts of vision reviewed earlier. Figure 55 Illustrates this relationship.

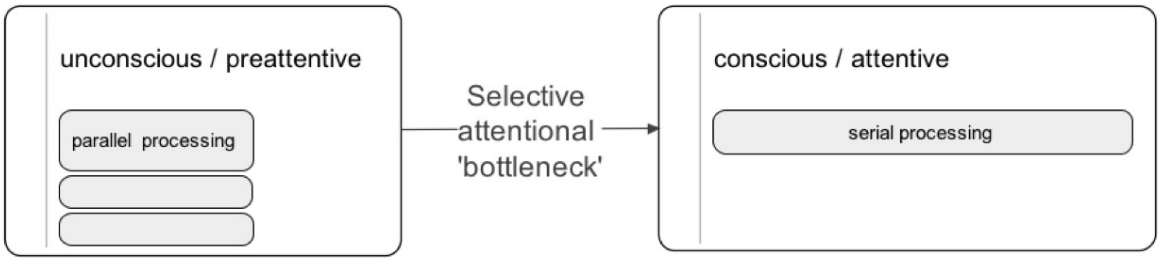


Figure 55. Unconscious parallel processing is monitored by a selective attentional 'bottleneck'.

This monitoring and selecting function is also subject to 'chunking'. That is, we may be conscious of a labelled 'object' of thought, but much of the complexity it denotes remains unconscious. For example, one might think, 'I know this person's phone number' without recalling each digit. Schemata operate in this manner, with labelled concepts connected to many related features and other concepts. In this sense, we can think of the conscious mind as monitoring and influencing the surface of a deeper pool of (unconscious and parallel) cognitive activity. 'Dual processing theory' describes how this serial/parallel relationship is integral to judgement and decision making.

4.4.2 Dual Processing Theory

Dual processing theory (Evans & Over 1996; Sloman 1996; Evans 2003; Kahneman 2003a; 2011) posits two ’systems of judgement’, which Daniel Kahneman calls “thinking, fast and slow” (2011): ‘system 1’ operates in parallel, quickly, intuitively and unconsciously; ‘system 2’ operates in series, slowly, consciously and with careful reasoning. System 1 – the default – allows for fast action, snap judgments and routine behaviour to take place more or less automatically, with minimal conscious effort. System 2 deals with novel situations and complex problems.For example, consciously deliberating over potential consequences when there is some uncertainty, i.e., before making an important or unexpected judgement. Kahneman describes how, as learning occurs, processes ‘migrate’ from system 2 to system 1, freeing cognitive resources for system 2 to deal with further learning and more complex behaviours. In addition to this, system 2 *monitors* system 1 for potential errors (which snap judgements are likely to entail), flagging up uncertainty and novelty for conscious deliberation. This relationship is illustrated by figure 56.

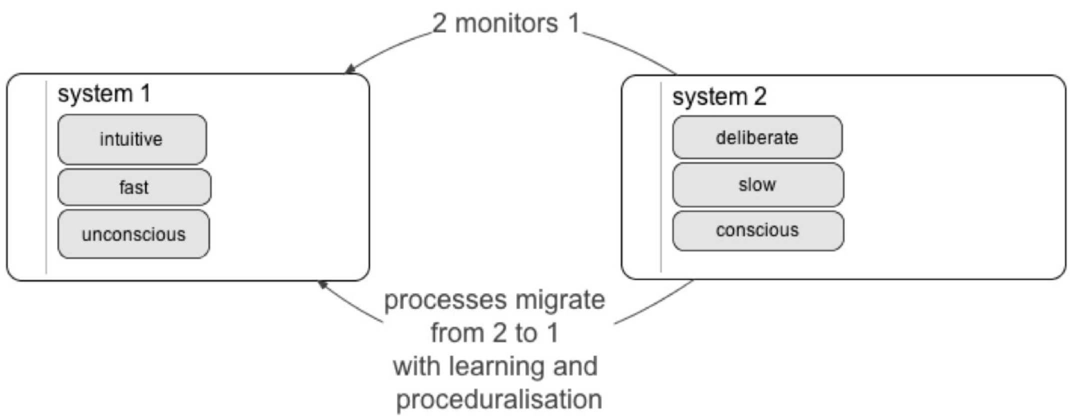


Figure 56. Dual Processing Theory posits a relationship between conscious and unconscious processing. System 2 monitors system 1, which deals with omre familiar processes.

Dual Processing Theory is consistent with other models of learning and skill acquisition, which account for chunking and proceduralisation – the migration of ‘thinking’ to the unconscious with familiarity.

John Anderson (1982) describes three stages of skill acquisition: ‘declarative’, ‘knowledge compilation’ and ‘procedural’. The declarative stage is dependent on instruction. During this stage, performance fluctuates as strategies are tested and discarded, and verbal expression is imperative for communication between student and instructor about these strategies. The knowledge compilation stage involves less need for instruction, as this is gradually replaced by an *internal* monologue which directs and monitors activity, helping to focus attention on novel goals and strategies. In the procedural stage, this is no longer needed, and the skill can be performed more automatically. Of course, skills are not usually learned all at once; the learning process is on-going, and so this process allows increasingly sophisticated behaviour and learning.

In this model, knowledge becomes inaccessible once a task has been fully learned or proceduralised (Anderson & Fincham 1994: 1322). It informs the execution of the skill, and perhaps recognition of when it is done wrong, but is not explicitly available to consciousness. Explicating basic details of a task may even be detrimental to performance at higher levels. In this way, long standing knowledge may contribute to the ‘illusion of explanatory depth’: the common misperception that one’s explanations are more detailed than they actually are (Keil et. al. 2004) even when ones understanding is deep.

This has contributed to contentions that ‘overlearning’ – practicing repeatedly beyond the point of automaticity – can have detrimental effects on explanatory ability (rendering knowledge cognitively inaccessible (Langer & Imber 1979). However, overlearning has been shown to lead to better and longer retention as well as improved performance (Driskell, Willis & Copper 1992).

In neural terms, the transition from unskilled to skilled task performance correlates to a shift in areas of the cortex recruited for the task. This is described as a ‘scaffolding-storage’ framework:

> [f]or unskilled, effortful performance, a scaffolding set of regions is used to cope with novel task demands. Following practice, a different set of regions is used, possibly representing storage of particular associations or capabilities that allow for skilled performance. The specific regions used for scaffolding and storage appear to be task dependent. (Petersen et al. 1998: 853)

It is also associated with a more efficient use of existing neural circuitry, through the strengthening of synaptic weights through repeated use (see Mishkin & Petri 1984), and thus the ability to process the same information under the conscious threshold strength. In these ways, deep learning leads to implicit or 'tacit' knowledge which is not necessarily accompanied by declarative knowledge, although there may be a 'feeling of knowing' (Nelson et al. 1982). As Michael Polanyi observed, "one can know more than one can tell" (1966: 18).

For drawing in general, and this study in particular, the implications are of three orders: first, that the artists ability to describe their activity may not equate to their performance; second, like vision, the act of attending to cognitive processes in order to report them can influence them, bringing the verbal methods into question, as will be discussed in chapter 7; third that attentional allocation plays an active role in learning and skill aquisition which will also be discussed in chapter 7.

4.5 Summary

The literature reviewed here offers a picture of visual experience as a process subject to attentional mechanisms. Those mechanisms filter information processed in parallel, influencing perceived salience and enabling serial selection to occur. 'Paying' attention amplifies neural activity, holds it (causes persistence in phenomenal consciousness) and influences it, making information available for cognitive operations. Whether this occurs through intermediate representations or some other 'language of thought', it seems that the information 'accessible' to attention also involves some underlying form of phenomenal visual 'awareness' although this may be vague and generalised.

Attentional selection can occur on the basis of locations (possibly more than one at a time), features or 'objects', we may even have some control over how we perceive 'gist'. In this way, we can think of many 'dimensions' and levels of resolution at which a scene can be perceived, and in which attentional control can be manipulated.

Salience and attentional selection are not the only factors in whether visual percepts are consciously 'seen' - spatial awareness may occur independently of pictorial visual awareness, and may influence movement directly (both eye and bodily movements). Spatial awareness should be thought of as a separate modality operating simultaneously with vision (relying on distinct but related neural circuitry).

The ‘direct pickup’ of information is characteristic of search and recognition processes, in which processing of lower level features can occur pre-attentively, and therefore below the conscious threshold. Drawing is a different type of process, as lower level features are also subject to attention and are presented to consciousness. So, while information may be ‘picked up’ from a visual scene without the need for a detailed conscious visual experience, drawing process calls on ‘stages’ of processing that usually occurs pre-attentively. Another way of describing this would be to say that drawing process changes the status of some ‘intermediate representations’; as those levels of processing become task-relevant they pass through the selective attentional bottleneck, in order that they can enter working memory and inform cognitive operations. Such cognitive operations include translation to movement as well as more propositional thinking (e.g. decisions about what to include in a drawing).

While visual attention is limited as a serial process (one ‘object’ at a time), working memory is capacity limited to around seven items. Although, the notion of an ‘item’ is dubious as this is constrained in two dimensions – number and resolution. Working memory capacity may be optimised by using multiple modalities simultaneously, but there is an overall shared capacity limit, and so different modalities are still capacity related. Working memory (or internal imagery) and perception are also capacity related – effectively, the more we imagine, the less we see. We can therefore list three relationships with proportionally related capacities:

- Between number and resolution (of visual details)
- Between modalities: e.g. visual/spatial and verbal/phonological load
- Between external and internal attention: perception and mental imagery/visual working memory

Self-consciousness of the *internal* workings of the mind (including internal imagery) is subject to similar mechanisms and constraints – i.e., parallel processing with a serial attentional ‘bottleneck’. Conscious problem solving and decision making occur in series, while unconscious process can be parallel. The parallel system is informed, monitored and influenced by the serial one. Processes migrate from conscious to unconscious as learning occurs, meaning that what takes place consciously and unconsciously is subject to individual differences and to change. With such change, the role of language shifts – initially it facilitates learning through declarative knowledge, but with familiarity this knowledge becomes a hindrance and is discarded, replaced by 'tacit' knowing. In this sense the 'tacit' is an important concept when considering the relationship between conscious and unconscious processes. If something is known tacitly, it no longer needs to be present in working memory in order to inform cognitive operations, at least not in its full form (a single label or concept may be connected to a rich LTM schema). The tacit includes not only 'knowledge' but also procedures and routines. In this regard, the notion of 'tacit' skill is somewhat de-mystified as it corresponds to more recent accounts of proceduralisation and the role of working memory in routine and non-routine tasks, and how this evolves through learning and skill acquisition.

In terms of the present study, we can think of these as the cognitive capacities, constraints and relationships within which drawing strategies must be played out. Chapter 6 will return to the case studies, interpreting them in this light. That is, real-world observed examples of drawing strategies and processes might be explained with reference to these theories, and better understood as a result. In particular, we can address the question of 'attentional strategy' in terms of mechanisms for attentional control at multiple levels of resolution and between many modalities. We may also consider the role of memory, both in terms of working memory that performs cognitive operations, and long-term memory that provides a context for interpreting perceived visual phenomena.

In addition to cognitive strategy, we can also further scrutinise the verbal reports. That is, with reference to the questions outlined in the introduction, as well as what is involved in observational ability,we can consider *how to describe it*. The question of 'how to describe it' relates not only to the need for a description that uses scientifically grounded set of terms and concepts, such as the one offered in chapter 6, but also to the need to understand authentic reports of drawing process, and consider their validity. By reflecting on the nature of self-knowledge in relation to the verbal modality, to learning and to unconscious cognition, as presented in this review, chapter 7 will discuss the extent to which artists' self-reports truly reflected their thinking and, by extension, how an updated understanding of that might inform attitudes to talking about drawing in learning situations.

Before discussing attentional strategies and self knowledge, the following chapter (5) will return to the existing accounts of drawing that were reviewed in chapter 1. The discrepancies within that literature can, in part, be resolved by updating the definitions of key concepts, and they may also be re-appraised in light of the case studies. Both sets of evidence will be used to redress key cognitive accounts of drawing process, in order that the observations made in chapter 3 and their resulting hypotheses can be situated in relation to previous claims, within an updated theoretical context. This precedes the more in-depth theoretical treatment of the case studies, so that my observations and hypotheses are distinguished from those of other authors.

Chapter 5.

Comparing popular accounts of drawing that propose distinct 'modes' of cognition

The first half of this thesis outlined observations about drawing strategies and processes. In particular, it was noted that two modes of cognition were distinguishable: one concerned with *informing* the drawing act; the other, concerned with *monitoring* the ongoing drawing and planning ahead. These were labelled 'constructive' and 'reflective' modes. These modes appeared to be mutually exclusive and carefully timed, taking place at different moments within complex drawing strategies. Of course, cognitive activity varied more subtly than just switching between these two modes, and a '2D model' was proposed to describe the range of variation of the artists' attention along two dimensions of cognitive activity: one strategic and involved with monitoring and forward planning; the other, momentary and perceptual, varying in visual complexity.

Several popular accounts also describe distinct 'modes' of cognition for drawing, or ways of thinking, as reviewed in chapter 1. Notably, Gombrich, Ruskin and Edwards make strong claims, although these authors are sometimes contradictory, using different terminology and likely talking about different ways of drawing (for different purposes and to different audiences). In this chapter, I compare these existing claims using the 2D model as a comparative tool, and referring to the body of theory presented in chapter 4. I aim to resolve apparent discrepancies within these accounts, and to situate the two 'modes' proposed in chapter 3 (constructing and reflecting) in relation to them.

I begin by revisiting the 2D model and clarifying distinctions between the two 'modes' it is used to describe (section 5.1). I then go on to address apparent contentions between Ruskin and Gombrich's accounts, concerning the role of schematic knowledge and the possibility of the 'innocent eye', and then to reappraising Edwards' notion of 'L' and 'R modes' (section 5.2). This chapter concludes with a contextualised reconsideration of the case-studies and the two cognitive 'modes' they demonstrate (sections 5.3 and 5.4).

I also beirfly note distinctions between my model and those of Van Sommers, and Guerin Ska and Belleville (reviewed in chapter 1). By comparing the two 'modes' and the 2D model proposed in chapter 3 to similar existing accounts, I aim to make clear how these hypotheses differ from existing ones.

5.1 The 2D model and two 'modes' of cognition

The model represents two elements: strategic and visual thinking. It does not propose that these two elements are entirely separate; strategic thinking involves visual aspects. After all, strategising is always concerned with how the drawing looks in some way. The 2D model is a way of describing how these two dimensions of thinking interrelate, representing two aspects to be simultaneously accounted for: various levels of visual complexity on one hand and, on the other, multiple elements of strategising and problem solving. Expertise seems to involve attentional control on both strategic and visual 'dimensions', with rhythms and routines for navigating these embedded in the drawing process.

The proposed segregation of cognitive modes is not between strategic and visual, as such – goals seem to be held in mind for periods to guide attention and drawing actions – rather the segregation is between *drawing* and *thinking about* the drawing characterised by the presence of evaluation. That is, there are regular periods during which strategic activity is inhibited, in order that visual attention can be fully recruited to inform drawing actions. In this model, evaluation and decision-making are temporarily postponed to allow periodic bursts of concentrated drawing activity.

The ability to shift between constructive and reflective modes could be thought of as an element of 'expertise' in observational drawing, another sense in which the artists are switching back and forth with regularity, in addition to physical gaze shifts. Cohen (2005) and Tchalenko (2009b) both found that expert drawers use more regular and frequent cycles of eye and hand movement than novices; it follows that the same may be true of constructive/reflecive cycles – novices would likely demonstrate less consistent patterns of switching between the two. Although further work would be needed to confirm this (to compare timing of evaluative strategy between experts and novices), this study shows that experts use characteristic cycles of constructing and reflecting, although the rhythm differs widely between artists, according to strategy.

Chapter 3 noted that there seems to be a relationship between these two modes of thinking and the kinds of talking that are possible concurrently. Strategic, reflective thinking is easily verbalised but does not seem conducive to simultaneous chatting, while constructive, visual activity is difficult to verbalise, but does not seem to interfere too much with chatting about unrelated things (see figure 37, section 3.5). This suggests competition between the two processes for cognitive resources, which is discussed further in chapters 6 and 7. For now, this chapter will consider the constructive/reflcective dichotomy in relation to similar claims.

5.2 Comparing accounts of drawing and thinking

Gombrich emphasised the role of schematic knowledge in drawing, while Ruskin and Edwards described particular ways of thinking that involve certain attitudes to the drawing process. To return to Reif's (2008) distinction between knowledge and thought process, we could say that – generally speaking – Gombrich describes the role of *knowledge* in representational drawing, while the artists' (Edwards and Ruskin's) accounts tend to describe *thought processes*. Famously, Ruskin proposed the notion of the 'innocent eye' as a specialised mode of perception. Chapter 1 mentioned how other artists (such as Constable, Nicolaides, Robert Hale and Bridget Riley) also similarly describe ways of looking and thinking for drawing as distinct from looking and thinking for other purposes. The focus of this chapter will be on Ruskin, Gombrich and Edwards' accounts as these in particular have been the most influential and yet appear to remain contentious.

Edwards made the idea of 'modes' of thinking most explicit when she proposed her 'split-brain' model. Her ideas have been very influential, but also widely criticised. Her account is of particular interest here as it strongly polarises two ways of thinking, only one of which is said to facilitate drawing, the other is said to be detrimental and more typical of our ususal thought processes. This, and Gombrich's issue with Ruskin's ideas, will be revisited in the following two sections.

Inconsistencies between these accounts (and also sometimes within the same account) can be attributed not only to their different periods, by authors with different relationships to drawing, but also – I would suggest – to the fact that they refer not to a single 'mode' of thought, but to many. As such, these accounts collectively distinguish and polarise many aspects of cognition (summarised in box 4).

1. Perceptual:
   perception of details vs. the whole;
   feature perception vs. object recognition.

2. Knowledge based:
   prior knowledge (schematic, Gibsonian affordances, long term memory) vs. directly perceived imagery.

3. cognitive/metacognitive:
   thinking through the drawing vs. thinking about the drawing

4. Conscious/ unconscious:
   mindful actions vs. automatic/intuitive actions

5. Modal:
   visual vs. verbal

Box 4. Distinctions between modes of thought mentioned in accounts of drawing (summarised from chapter 1).

While it may seem equally logical that these kinds of cognitive variations could be thought of as sliding scales rather than binary switches, there are a number of reasons why it is useful, and perhaps more correct, to think of them instead as oppositions. Namely, because the *conscious* mind is limited, sequential and modular (see section 4.4). Also, because modalities (language, vision, spatial awareness, audition, proprioception, and so on) are capacity limited, both individually and collectively (see section 4.3). Therefore, some simultaneous processing can occur, but greater activity in one module creates competition for others. However, there are not two modalities, but many, with complex relationships, and each divisible into sub-modules.

This means that if there is a particular 'mode' of cognition for drawing, it will be defined by multiple variables, not by a single pre-existing duality (such as cerebral hemispheres). While the faculties listed in Box 1 are strongly associated, they are separable, and the present study indicates that drawing likely involves both aspects of each at different times, rather than favouring one side over another.

This being the case, any explanation that relies on a single specific 'mode' of cognition will only account for parts of the drawing process. The following sections consider what those parts might be, and sees that the accounts reviewed in chapter 1 are, in fact, compatible.

5.2.1 Gombrich & Ruskin

As mentioned in chapter 1, Gombrich's stance against Ruskin's innocent eye seems to polarise the distinction between drawing (and interpreting drawings) from schematic knowledge and drawing from directly perceived details. This could be attributed to the kind of drawing Gombrich and Ruskin described; illustration or memory drawing relies on schematic knowledge, observed drawing relies also on perception. Although Gombrich does not note this distinction, Ruskin refers specifically to observation, and it is this Gombrich took issue with. In observed drawing, perception and memory both play a role. However, the two accounts may be describing different aspects of observational process.

Gombrich's account focuses on the role of knowledge. He suggests that prior experience of the visual world, and of other drawings, informs the drawer about which features are key to the representation, facilitating decisions about what to represent (and by implication what to look for, if the drawing is observed) and what to leave out. This also includes knowledge about what those features should look like (including representational conventions, but also in the archetypal sense) and how manipulating them on a formal level changes their appearance and meaning. He also refers to the role of knowledge in the monitoring and evaluation of the drawing, enabling the drawer to identify, on a formal level, which features are successful and which need further attention. In this sense, he seems to be pointing to two functions for schematic knowledge: informing the drawing actions, and informing the ongoing evaluation of that drawing. Gombrich's dictum 'making precedes matching' is thus in keeping with the construction/reflection divide: if making *precedes* matching, this implies a series with separate periods of drawing activity and evaluative thinking. These two roles are illustrated in figure 57.

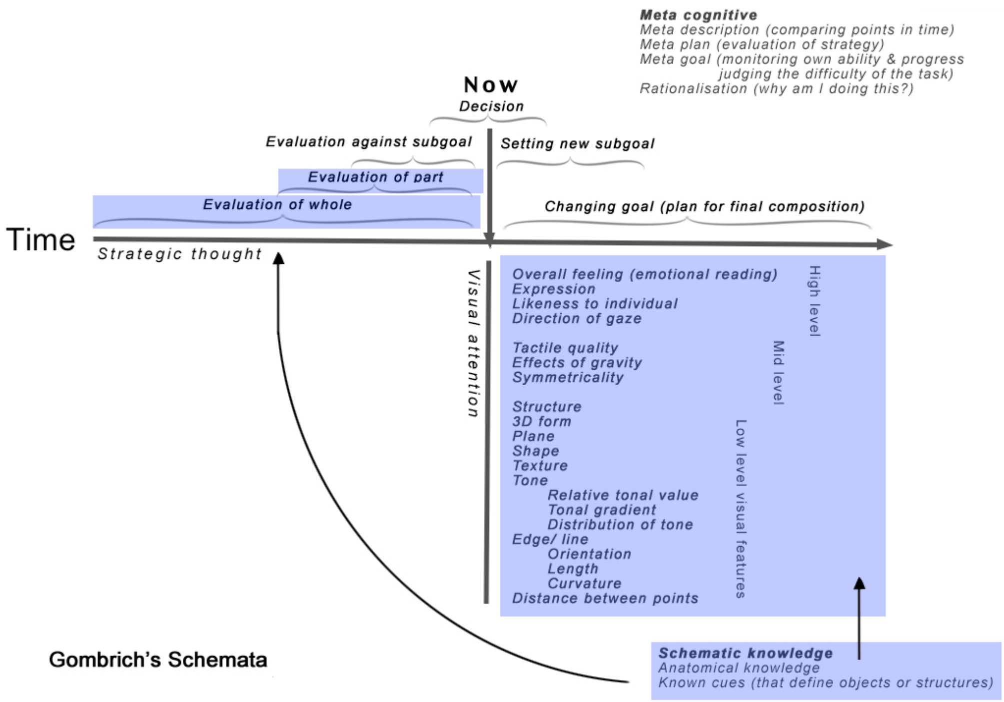


Figure 57. Gombrich's schematic account of drawing, in relation to the 2D model. Schematic knowledge informs both making and evaluating the drawing.

In contrast, Ruskin's account focuses on the more immediate task of observing. His notion of the 'innocent eye' can be interpreted as a mindful disregard for higher levels of visual attention (which are more influenced by prior knowledge), in order to more directly observe natural phenomena 'without consciousness of what they signify, as a blind man would see them if suddenly gifted with sight' (1991 [1857]: 4). This kind of looking negates schematic knowledge, allowing the drawer to make representations through methodical observation and measurement, avoiding the influence of what they already know, in order to better draw (and perhaps *experience*) what is actually there.

However, Ruskin's drawing manuals also describe things such as perspectival systems and methods of representation. He discusses, at length, certain optical effects that the drawer should be aware of, such as the geometry of reflected images. While these could be considered examples of the kind of schematic knowledge Gombrich is describing, their purpose is usually to *avoid* the influence of schematic misunderstandings that may lead to representational errors (such as those demonstrated by Broderick & Laszlo 1989; Lee 1989; Cohen & Jones 2008; Mitchell et al. 2005, see section 1.4). For example, Ruskin describes how a reflected image of a tree above water does not appear as an identical reverse of that tree, as we might expect, but as though there were another tree upside down, directly below the actual tree. And so, depending on how close the observer is to the water level, the disparity between the two images will vary. Misunderstanding this kind of natural phenomena (false schematic knowledge) will lead to unconvincing representations.

These two things seem to be contradictory. Ruskin is telling us both to forget and to be aware of, what we know (or think we know) things look like. However, it seems that the kind of neutral observation he advocates, is intended to *inform* the student's knowledge of the visual world, enabling her to not only make better drawings but also to experience the world more richly. Experiencing the world afresh is an important part of Ruskin's view of the purpose of drawing. His manuals contain extensive descriptions of natural phenomena he has observed while drawing, with a sense of awe, as though celebrating his surprise at the way things appear and their natural beauty.

So, in Ruskin's account, the purpose of drawing is to *acquire* knowledge, visual and experiential. Figure 58 illustrates an opposite relationship than figure 57: attention to lower-order visual features informs the depiction of higher order ones, and results in knowledge about the visual world.

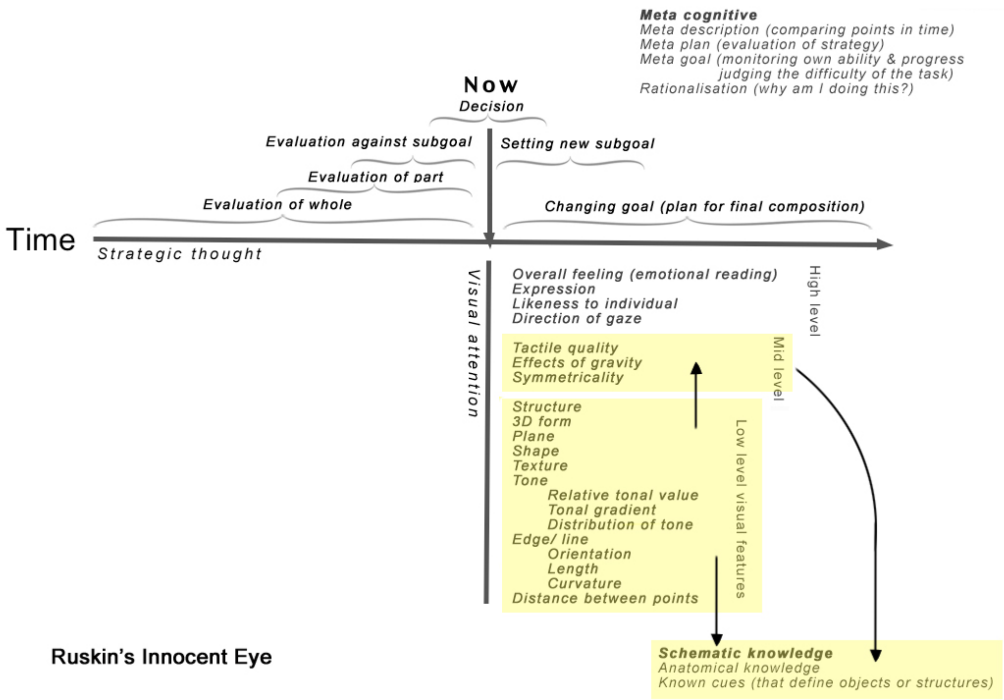


Figure 58. Ruskin's notion of the 'innocent eye' in relation to the 2D model. Direct observation informs our knowledge of the world and how it appears.

It is also implied, indirectly, that the 'innocent eye' may be a mode of looking that does not involve judgement. To be unconscious of what things signify, indicates that it would be impossible to judge if the drawing effectively conveys those signifiers. This does not preclude the kind of 'double checking' of measurements described by Brew, as this remains on the abstract low level. It does, however, preclude the kind of periodic evaluation that considers the whole drawing in a more distanced manner. Whether Ruskin is advocating this way of looking exclusively, or whether it might be applied only during the actual mark-making activity as part of a broader strategy, is unclear. Ruskin never categorically states that the innocent eye be used at all points of the process, so we can infer that it depends on the purpose the student has in mind for their work; presumably they would not remain 'innocent' throughout, but would pause occasionally to review the drawing and how well they were achieving such innocence.

It can then be argued that Gombrich's account refers to the *application* of knowledge in drawings, and Ruskin's refers to the *acquisition* of knowledge through drawing process.

5.2.2 Betty Edwards

Edwards' distinction between 'R' and 'L' modes can also be compared in this way, although what she is describing is more complex. In her account, only 'L mode' facilitates drawing; 'R-mode' interferes. Her various references to these modes mention many things (figure 59 is her own summary of the terms).

L-mode		R-mode	
Verbal	Using words to name, describe, define.	Nonverbal	Using non-verbal cognition to process perceptions.
Analytic	Figuring things out step-by-step and part-by-part.	Synthetic	Putting things together to form wholes.
Symbolic	Using a symbol to stand for something. For example, the drawn form stands for eye, the sign + stands for the process of addition.	Actual, real	Relating to things as they are, at the present moment.
Abstract	Taking out a small bit of information and using it to represent the whole thing.	Analogic	Seeing likenesses among things; understanding metaphoric relationships.
Temporal	Keeping track of time, sequencing one thing after another: Doing first things first, second things second, etc.	Nontemporal	Without a sense of time.
Rational	Drawing conclusions based on reason and facts.	Nonrational	Not requiring a basis of reason or facts; willingness to suspend judgment.
Digital	Using numbers as in counting.	Spatial	Seeing where things are in relation to other things and how parts go together to form a whole.
Logical	Drawing conclusions based on logic: one thing following another in logical order—for example, a mathematical theorem or a well-stated argument.	Intuitive	Making leaps of insight, often based on incomplete patterns, hunches, feelings, or visual images.
Linear	Thinking in terms of linked ideas, one thought directly following another, often leading to a convergent conclusion.	Holistic	(meaning "wholistic") Seeing whole things all at once; perceiving the overall patterns and structures, often leading to divergent conclusions.

Figure 59. Edwards' summary of L & R-mode characteristics (from Edwards 2008 [1979]: 44).

Edwards' account assumes this grouping of 'L' and 'R' characteristics to be universal, not only applicable to drawing but inherent to the structure of the brain. Her definition conflates so many elements (evaluative, schematic, modal, meta-cognitive) that it is hard to conceive of only two 'modes' of thinking. But these can perhaps be thought of as broad categories that include many ways of thinking.

It is currently acknowledged that, while certain functions are weighted to one hemisphere or the other, this model is generally inaccurate. It is tempting to reconsider Edwards' dichotomy in relation instead to an upper/lower brain (dorsal/ventral) dichotomy. The ventral pathway being concerned with symbols, language and object recognition, while the dorsal pathway offers a viewer-centred frame of reference and allows more direct communication to motor areas (see section 4.3.1.2). However, as Irene Schiferl points out, this too is an over-simplification as "constant feedback loops complicate this simple division" (Schiferl 2008: 77, see also Schiferl 2002; 2007). It might also be compared to higher and lower levels of visual perception – higher ones being concerned with feature *recognition*, lower ones with feature *detection* ('symbolic' and 'actual' in her terms). But this too falls short of Edwards' dichotomy as it does not account for many of these elements.

I would like to propose that Edwards' polarisation is better served by more recent 'dual process' theories of cognition (see section 4.4.2), which instead divide thinking into 'fast and slow', or parallel and serial, unconscious and conscious. She uses the terms 'linear' and 'sequential' in opposition to 'holistic', 'intuitive' and 'simultaneous'. This also accounts for the role of language, as dual process theory explains how conscious thinking recruits the verbal faculty in explicit, serial, conscious reasoning and judgement; the kind of thinking Edwards associates with L-mode, while the unconscious mind remains implicit.

However, to associate Edwards' model with 'dual process' theories presents an issue: while split brain theories proposed the differences as fixed – hemispheric lateralisation of functions does not change – dual process theories offer a more fluid and connected model. The boundary is not fixed, and most tasks involve *both* processes, especially if learning is happening. It is fluid in two ways: first, cognitive processes *migrate* from the conscious to the unconscious with learning, secondly, the conscious mind *monitors* the unconscious mind. We therefore cannot generalise which specific aspects of the drawing process might take place in each 'mode', as this will differ with experience.

This fluidity must be accounted for in any model of drawing and cognition, particularly models concerned with learning. The first point – that processes migrate towards the unconscious, accounts for the impression that successful drawing happens 'intuitively' and 'holistically'. While more experienced drawers will be able to rely more on their unconscious capacity (this is true of any skill), it does not follow that to draw intuitively is itself a helpful aim; elements of a skill not yet sufficiently practised will not reveal themselves intuitively. The second point – that the conscious mind monitors the unconscious is more complex and requires some consideration. Chapter 6 further discusses this monitoring function in regard to evaluative thinking.

In this context, to suggest that one mode of thought facilitates drawing, while the opposite one does not, is misleading. Drawing, like any other activity, must entail many processes and many modes of thinking**.** Furthermore, if we accept that there are two modes of thought, we cannot assume that the division, in terms of the actual content of these two modes, remains fixed. More likely, the kinds of thing under scrutiny by the 'monitoring' process will change and progress, as the types of processing that are able to take place 'intuitively' will develop and become more sophisticated. This thesis argues that we can usefully conceive of drawing cognition as consisting of two types: one that involves evaluation (the reflective mode), another that does not (the constructive mode), and that these form a repetitive cycle of drawing activity.

The distinction between 'symbolic' and 'actual' is also related to knowledge. 'Actual' likely refers to more bottom-up perception, and lower level functions such as feature detection, while 'symbolic' indicates higher order perception which includes more top-down influence from associated knowledge, and is more propositional in nature. As shown in chapter 1, there is evidence pointing to schematic knowledge as both informing drawing, and as a potential source for error (see section 1.4.1). This is also reflected in the Ruskin/Gombrich comparison above. Interestingly, Edwards' references to L-mode associate schematic knowledge and higher order features with evaluation and meta-cognition, indicating that to think about how things should look in the final drawing will interfere with the making process. She also associates these things with language as opposed to vision, which she frames as two competing forms of cognition, the visual mode being the favourable one[1]. However, this is more questionable than the previous dichotomy. Vision and language are two of many faculties, which are able to operate simultaneously in working memory.

It could be said that, in Edwards' account, knowledge interferes with drawing process via higher order perception, which influences evaluation, goal setting and metacognition, via a linguistic mode of thinking (represented in figure 60a). The student is instead supposed to quiet the mind and concentrate on more abstract (low level) visual details, disregarding what they know or expect to see, without concern for the drawn outcome (represented in figure 60b). Certainly this is a simpler way of thinking, easier for a novice to approach, but to present it as *the* cognitive mode for drawing is misleading.

[1] Another dichotomy Edwards includes in her model is between rational and intuitive thinking. She conflates this with verbal and visual thinking. This is discussed further in chapter 8, which addresses the question of conscious and unconscious processing.

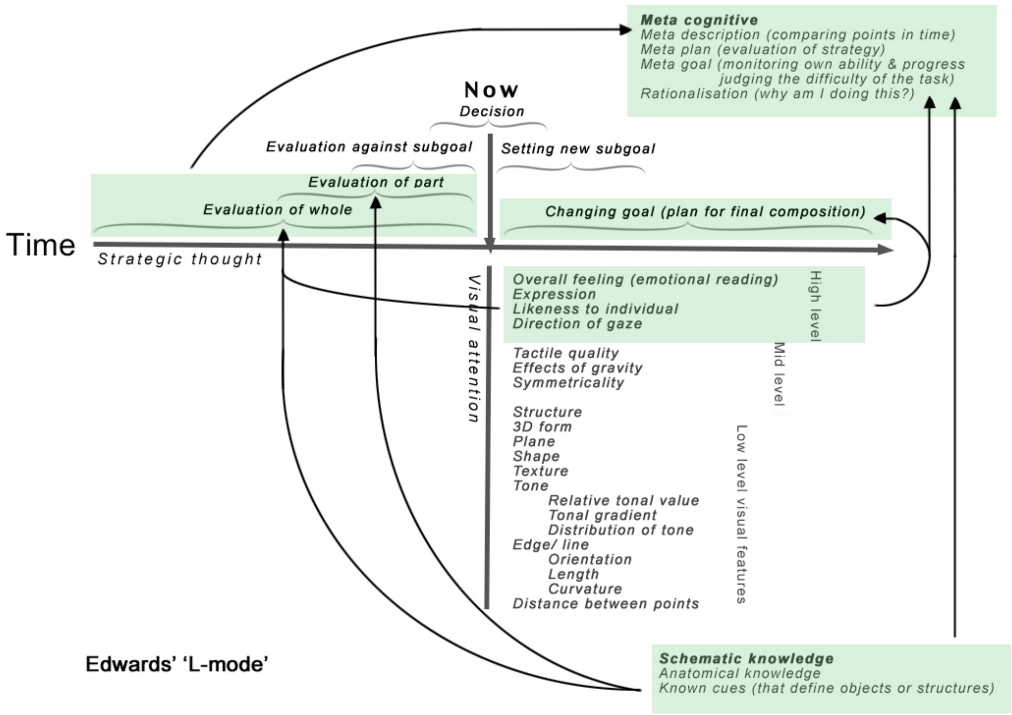


Figure 60a Edwards' L-mode in relation to the 2D model. Her many references to this mode describe that prior knowledge and higher-order visual features inform evaluation, goal setting and meta-cognition in a disruptive or distracting way.

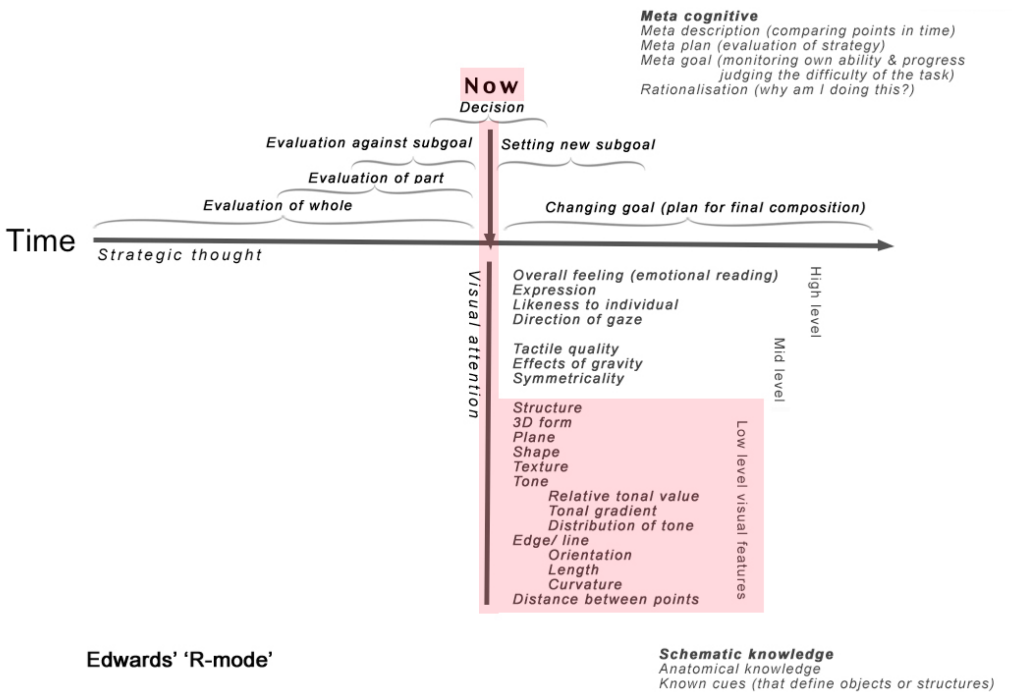


Figure 60b. Edwards' R-mode in relation to the 2D model. Attention is focused on direct measurements of formal aspects.

The case studies indicate that the relationship between visual and verbal thinking is not this simple. There certainly seem to be some interference between these two modalities (visual and verbal), best exemplified by Roberts' response to the verbalisation task (see section 3.4.1). But to attribute that interference to the *linguistic* nature of the thinking does not follow. The problem for Roberts was not the use of language, it was the content. Drawing and chatting about other things was not a problem, until it was time to reflect on how the drawing was progressing. At that point, she seemed to recruit her linguistic faculties in the process of evaluating.

The case studies also showed that evaluative subroutines would (at least initially) involve higher orders of vision, which are concerned with recognition that is influenced by schematic knowledge. Verbal thought is also involved, being propositional; evaluations were easily verbalised, perhaps even verbal in nature already (as an internal monologue). So Edwards' conflation of these things is not unfounded, it is only the extension of this to the whole drawing process, and to thinking more generally, that is an oversimplification.

So, while Edwards' dichotomy is not entirely unlike that of constructing and reflecting , proposed in this thesis, there are points of contention. The key difference seems to be that Edwards advocates avoiding 'L-mode' at all costs, on the basis that it is detrimental to the drawing, while the case studies demonstrate that drawing includes elements that could be considered part of L-mode, but at regular controlled intervals.

This is not to say that Edwards' manuals are misleading or unhelpful. Their continuing popularity with aspiring artists indicates the success of her methods, and she stresses that they are most beneficial to absolute beginners. We could infer that because the practice of postponing judgement is hard to master, an initial attempt to do away with it completely can provide short-term results. Once the student is able to use r-mode in controlled bursts, they might progress to allowing their verbal/rational mind to participate in monitoring and directing the drawing activity. As we have seen, there are a range of ways to manage and time this. Aware of such a range, the student would be in a position to experiment and devise their own strategies.

In this framework, Edwards' R-mode is similar to Ruskin's innocent eye, but more basic as it is concerned with making 'successful' drawings, while Ruskin is also concerned with the experience of engaging with the subject matter directly as experiential learning. In this light, her claim that L-mode thinking is detrimental to the drawing process is as questionable as Gombrich's refutation of the 'innocent eye'. As reviewed in chapter 1, there is evidence pointing to schematic knowledge as both informing drawing, and as a potential a source for error. Verbal/propositional thinking can also be either helpful or detrimental, depending on the type of drawing that is taking place concurrently. Language might even *facilitate* progress in drawing, if used in an informed way (this will be discussed further in chapter 7). All these ways of thinking can be involved in the drawing process, the question is *when*. Clearly they cannot all happen at once, and so the artist must devise strategies for structuring their thinking on the basis of their ability and purpose.

5.3 Knowledge, recognition and evaluation

Edwards' descriptions of L-mode tend to focus on its verbal and propositional nature, and she mentions that 'language' (i.e., L-mode) has a "censoring function" (2008 [1979]: xvi) which acts as a distractor from drawing process. Behind this statement are two assumptions. First, that language is synonymous with conscious thought (although she does use the word 'conscious', she alludes to it by conflating the terms 'sequential', 'linear', 'rational' and 'logical'). Second, that the censoring function is detrimental to the drawing process. To conflate language with consciousness is mistaken; conscious thought is not necessarily verbal, it can also be visual, tactile, spatial, etc. Unconscious cognition is also multi-modal. Even so, language does seem to play a role in drawing (as we saw in chapter 3), potentially interfering, but also utilised in certain moments.

Language can be associated with object recognition - in the brain they are both located primarily in the ventral pathway - the labelling of objects is related to their identification and their schematic or symbolic internal 'representation'. When an object is recognised and named, we become aware of it (and what it signifies), prior to that it is simply an array of visual features. As in Cheng and Patchella's account of ' degrees of integrality, higher order features have a 'higher degree of correspondence between physical and psychological dimensions' (see section 4.2.3). This is interesting in relation to Roberts' early attempts at verbalisation (discussed in section 3.5). She reported feeling that naming facial features as she drew them, interfered with her usual drawing process, which deliberately avoided that kind of perception in favour of more piecemeal measuring, at least during the constructive phase.

However, the artists' reports of their evaluative routines show recognition to be an integral component of evaluation. If an object or person is recognised, a judgement can be made about whether the representation feels right. Likely this entails a comparison between the drawn image and the artist's idea of what the image should resemble and what feel they would like to achieve. In addition, it seems that the linguistic faculty is recruited by the evaluative process in general, evidenced by the difficulty of talking about anything else simultaneously, and the relative ease of talking through an evaluation.

In the evaluative sub-routines described in chapter 3, many levels of visual analysis are used. Simple 'double checking' of measurements would involve just looking again at low-level abstract configurations, whereas the kind of evaluations that take place more periodically (during the reflective mode) tend to involve first perceiving the whole, at a higher order of complexity, before drilling down to locate the source of errors. *This suggests that there is a relationship between the order of visual complexity perceived and our propensity to judge* – an unplanned view of the whole might be disconcerting, prompting an untimely evaluation. As recognition is our usual mode of seeing the world, this is more than likely to be a problem for the novice drawer, who may lack control over when this happens, or not understand the necessity.

Language also seems to be an integral part of decision making, evidenced most clearly by Roberts' response to the reporting task. In her case, the evaluative phase was conducive to verbalisation, while the constructive phase was not; verbalisation actively *interfered with* those periods of drawing. This suggests that there were, indeed, periods during which Roberts was thinking in the way Betty Edwards and Ruskin describe: primarily visual, non-verbal, objectless, considering abstract details in a piecemeal fashion. However, between those periods the thinking was more verbal and logical, relying on prior knowledge in a process of 'trial and error' as Gombrich described. The other artists also showed evidence of this dual thinking, albeit with much shorter timeframes (at the order of seconds and fractions of a second, rather than minutes).

So, while linguistic thinking is not strictly synonymous with conscious thought, there does seem to be a relationship between language, recognition and evaluation. These all play a part in the reflective 'monitoring' mode of thinking. Schematic knowledge therefore also plays a role, as it informs recognition, allowing the drawer to quickly (and intuitively) judge whether the drawing is depicting a subject successfully, and make decisions about where to re-measure. To label knowledge a source for drawing error, as Cohen & Jones did, (see section 1.4) is perhaps misleading. Certainly, it *can* function as a source of error (when it interferes with the ability to perceive details such as shape constancy in a context-neutral manner) but it also plays a role in error detection, as Ruskin alluded.

Perception *without* recognition plays a role in the constructive phase, allowing measurements to be made without the interference of prior knowledge, and (as I will later argue, *crucially*) without evaluation. In this way, high-level vision and evaluation are connected, but are not the same phenomena. Low-level vision is recruited in the constructive phase, while both high and low-levels are recruited in the reflective phase, high-levels for recognising issues and low-levels for identifying their source and planning corrections.

Edwards' dichotomy is consistent with these distinctions. But, this study indicates that *both* the modes she describes are actually involved in expert drawing, at different and discrete times.

5.4 Other hypotheses that two types of processing are involved in drawing

Van Sommers and Guérin Ska and Belleville also proposed comparable distinctions between types of cognitive process involved with drawing. These will be discussed further in the following chapters, but, as they also constitute dual theories of drawing cognition, they are worth briefly mentioning here, in order to situate them in relation to the claims made in this thesis.

Guérin Ska and Belleville's model included differing processes for routine and nonroutine drawing, and within non-routine drawing (more significantly for the present comparison) "two parallel processing systems' for dealing with 'single-part' and 'global' images. As discussed in chapter 1, they posit that the 'single-part' system involves "encoding of coordinate and categorical spatial relations, and spatiotopic mapping" (1999: 472), while the global system "allows the addition of parts to the global image, goes through long-term visual memory, associative memory and the subsystems of top–down hypothesis testing" (1999: 472). This hypothesis is comparable with that offered in this thesis, with the 'single-part' system corresponding to the constructive mode and the 'global' system with 'top-down hypothesis testing' corresponding to the reflective mode. However, I propose that the two processes are not parallel, but sequential. Furthermore, the concepts do not exactly correspond and in chapter 6 I propose additional contentions with this model, regarding the use of the 'visual buffer' and 'associative memory'.

Van Sommers' (1989) 'global cognitive model' proposed two 'hierarchical systems': 'visual perception' (based on Marr's three-stage model) and 'graphic production'. This distinction is closer to the constructive/reflective distinction, although Van Sommers' account does not state that these two systems are discrete. Rather (as described in chapter 1), he proposes four stages within 'graphic production': depiction decisions, production strategy, contingent planning and economic constraints. These may be 'stages' in the sense that they represent various levels of processes underlying drawing, but they do not appear to be 'staged' (sequentially), in the case studies observed here. Certainly, 'depiction decisions' and 'contingent planning' were involved in carrying out 'production strategy', devised within 'economic constraints', but the strategies used were mainly established routines, devised beforehand, with only smaller decisions, goals and sub-goals being devised as the drawing progressed. Again, these matters are discussed further in chapter 6, which considers these 'economic constraints' in terms of cognitive capacity limitations.

5.5 Summary

Gombrich's issue with Ruskin seems to be based on a differing perspective about the role of knowledge in drawing. Gombrich described its role in reviewing the representation (during the reflective phase), while Ruskin described how drawing process could be a way of engaging with the visual world and gaining visual knowledge (through the constructive phase). The fact that Gombrich was a historian and Ruskin a practitioner, likely had some bearing on their differing accounts.

Edwards' divisio n of the mind, although based on outdated ideas, did prove consistent with the case studies and, to an extent, with more recent literature around cognition, but her stance against the linguistic mode seems to be misplaced. Like schematic knowledge, linguistic thinking can either facilitate or hinder drawing process, depending on the concent of what is being said and the phase of drawing activity (constructive or reflective). However, her student audience are beginners, and as R-mode (the more visual, constructive mode) will be the less familiar one, it makes sense to concentrate efforts first on learning this, before integrating it into more complex strategies, as the artists in this study do. Especially considering that the higher level vision, schematic knowledge and linguistic thinking all contribute to judgement, which can, all to often, be highly self-critical and unhelpful to beginners who need to learn to temporarily postpone such thinking in order that the constructive phase can proceed. Although this might entail a 'quieting' of the mind, as Edwards implies, the linguistic modality could also be employed in measurement or other lower level searching strategies, occupied by those tasks it would be less likely to interfere elsewhere (Brew, Connolly and Cobley's strategies seemed able to accommodate this kind of talking), and this possibility will be discussed further in chapter 7.

It appears that, above the level of learning Edwards is concerned with, drawing skill becomes more about a controlled switching *between* modes of cognition, than learning to postpone judgement and participate in the 'constructive' mode. Switching between these two modes and navigating within them are involved with more complex strategies for drawing. This kind of switching back and forth is analogous to the kind that occurs physically – looking from one frame of reference to the other, and between details within each. Beyond the ability to switch and navigate modes, acquiring strategies for purposefully managing and timing this switching is the next stage in developing observational skill.

Having clarified here the present findings in relation to existing theories of cognitive 'modes' for drawing, the following chapter will consider the phenomena of shifting between constructive and reflective modes in more detail. It will ask *why* these cognitive strategies take the form they do, and seek to further explain the patterns of activity observed in the case studies.

Chapter 6.

Cognitive constraints

The evidence provided by the case studies in chapter 3 has allowed an initial discussion of the questions outlined in chapters 1 and 2, regarding cognitive strategies for observational drawing. In particular, it was noted that two cognitive modes, or phases, appear to be involved in drawing process, and operating discretely in the observed strategies. These were labelled ‘construction and ‘reflection’. Later, in chapter 5, this dichotomy was placed in relation to existing claims that drawing involves particular cognitive modes. In chapter 3, it was also proposed that the range of possible cognitive activities could be mapped as a two dimensional space, including strategic and attentional ’dimensions’. These ideas will be discussed further here, with reference to the literature presented in chapter 4 and the case-study evidence brought forward from chapter 3 (summarised in section 6.1).

This chapter questions the cognitive basis of the observed drawing strategies, discussing (in sections 6.2 to 6.6) the ways in which memory and attention are recruited, and how the timing of those strategies is a result of the cognitive constraints within which they operate. Here, I aim to better understand *why* drawing process is orchestrated in the way the case studies demonstrate. I will explore how recent understandings of visual cognition can inform an explanation of drawing strategies, particularly in terms of the segregation and timing of cognitive activities. To do this, I ask how cognitive strategies for drawing are constrained by limitations of the human mind: how much visual information can be dealt with at once, in what form is it ‘held’, how can that be optimised to different ends, and – in addition to visual perception – how short and long-term memory contribute to drawing process.

The outcome of this analysis is a revised ‘3D’ version of the ‘2D model’ (figure 22, presented in section 3.2.3), which I use in the latter part of this chapter (6.7) to compare additive and heuristic drawing strategies, and the constructive and reflective modes.

6.1 Summary of case study observations

The case studies observed features of drawing strategies. Some were common to all four, others were associated with strategy and some were characteristic of one artist only. In summary:

1. Two types of strategy were identified. These were labelled:
   - heuristic (working from the general and vague towards the specific) and
   - additive (working from the specific and certain towards the whole).

2. Expert drawing involves repetitive patterns of looking and mark making activity, relating to dwell cycles:
   - each artist exhibited individual characteristic patterns;
   - average glance durations were longer for the additive strategy;
   - three artists drew 'blind', while one did not;
   - all artists demonstrated an increase in duration of glances to the paper;
   - three artists demonstrated a decrease in duration of glances to the mirror.

3. Artists employ visual attention selectively. Different 'levels' of perception (represented by the vertical axis of the '2D model') are employed for different purposes at different stages, as part of wider strategies for drawing:
   - the heuristic strategy began with larger features relating to the whole composition;
   - the additive strategy began with a single point;
   - both strategies employed 'anchor points'.

4. Drawing process appears to involve two discrete cognitive phases, associated with *constructing* and *reflecting on* the drawing, and a controlled switching between these, the timing of which is characteristic to individuals:
   - one artist showed this at much longer intervals only (at the order of minutes);
   - one artist showed this at very short intervals (at the order of seconds, as part of each dwell cycle), as well as at longer intervals.

5. Constructive and reflective phases of drawing interfere with qualitatively different types of talking:
    - evaluative and strategic thinking is easily verbalised ;
    - visual descriptions can be elucidated during the constructive phase, but this can interfere with drawing process if the terminology is uncertain;
    - rationalisation interferes with the constructive phase;
    - unrelated chatting interferes with the reflective phase.

Given these observations, what can we consider to be the roles of attention and memory in drawing? In order to further consider this, I shall discuss the way in which cognitive strategies are 'embodied', in the sense that they operate within the parameters dictated by human physiology – what the brain is capable of. (The 5th point, albeit relevant to this chapter, will be discussed in more depth in chapter 7.)

Although there are disparities between drawing and the kind of tasks usually investigated in cognitive studies of vision and visual attention (discussed in chapter 4), certain findings from this discipline are still relevant to a cognitive analysis of drawing. Various frameworks for describing visual attention are applicable to the drawing act at different times. Visual information competes for attention by *task-relevant* criteria. In visual search these are few, whereas in drawing the relevant information is complex (and spans the level of individual feature values, geometric forms, object recognition, gist, contextual interpretations informed by knowledge, and even Gibsonian 'affordances'). Furthermore, findings relating to the capacity limitations of attention and working memory can provide a context in which to consider and compare cognitive strategies. The following sections, therefore discuss the roles of memory and attention in drawing process, in relation to the points listed above.

6.2 The role of memory in drawing process

6.2.1 Dwell cycles and working memory

Chapter 1 discussed the role of visual memory in drawing, questioning assumptions about the use of visual memory and internal imagery. Tchalenko's findings indicate that motor encoding plays an important role and that visual memory may not be recruited at all in blind drawing, or what he described as the 'direct mode' of drawing: "a direct visuomotor process not requiring encoding to, and recalling from memory" (2012: 12), as opposed to sighted drawing, or (in his terms) the 'conventional mode' of drawing, or the 'conventional *interpretation',* which assumes a reliance on visual memory (see section 1.4.2).

Tchalenko was referring to the use of memory *within a dwell cycle* – how information is received and stored over durations of a few seconds at a time. After seeing a wide disparity in patterns of activity in chapter 3's case studies, we can say that this likely differs between artists and by strategy. Three of the artists often drew 'blind', while one (Connolly) barely did (only 6% of the time he spent looking at the paper was spent making marks, compared to 96%, 96% and 61% – see section 3.3.1). Also, dwell cycle durations differed between artists: those using the heuristic strategy showed shorter average glance durations (0.8 and 1.0 for the heuristic strategies, as opposed to 1.7 and 1.4 seconds for the additive strategies – see also section 3.3.1)

Brew, in particular, was aware of drawing blind. She actively sought a kind of temporal proximity between her eye and hand. Her retrospective report described how she aimed to hold information in mind for as little time as possible (if at all) before making each mark, wishing to synchronise her eye and hand movements, as in Tchalenko's 'direct mode'. Whether it is possible to do away *completely* with the time lag between eye and hand is arguable - there will always be some processing required[1] - but one can certainly aspire to shortening this if one wishes. A more detailed study of eye and hand interaction would be needed to ascertain the time lag between perception and action (between eye and hand movement) concerning specific details, but, nevertheless, whether or not 'direct' drawing

[1] However, it is worth considering that, whether or not there is an actual time lag, one's experience might *seem* instantaneous.

entirely avoids encoding and recall, it's plausible that a more direct approach could simplify the process.

As discussed in section 6.4, the crucial thing is not only for *how long* an 'image' is held, but *how much* of it is held at a time. Brew's strategy sought to minimise both these variables. Brew's periods of blind drawing are part of this direct approach. Nevertheless, she does often continue to draw while looking to the page (and back again), indicating that she is holding some amount of 'persistent' information in working memory while navigating both spaces.

Connolly, in contrast, would (consistently) only begin drawing once his eyes reached the paper (see section 3.3.1). It might seem logical to conclude that he is therefore using his visual memory, as in Tchalenko's 'conventional interpretation', i.e., encoding to VWM before mark making, recalling the visual detail as he draws it. However, on closer inspection, this seems not to be the case. As we saw in figure 29 (section 3.3.1.1), each time Connolly looks back to the mirror to begin a new dwell cycle, he rehearses the movement of the pencil, and the drawing movements made while looking at the paper closely followed those made while rehearsing. This implies that motor encoding occurs during glances to the mirror (as if he were blind drawing), and it is the motor signal that 'persists', rather than a visual one[2].

In terms of neural anatomy, this 'motor encoding' implicates dorsal stream activity, associated with movement and spatial awareness, rather than the more visual ventral stream (described in section 4.1.3.2). Once the mark is drawn, Connolly reviews it before moving on. In order to do that, he must use some form of visual reference, be it retained from what he just saw or retrieved from memory. This implicates the more visual, ventral stream activity. We can therefore interpret that the two activities primarily make use of different functional-anatomical areas: more dorsal activity for the constructive phase, more ventral activity for the reflective phase.

Combined, this evidence indicates that Connolly is using both motor encoding and visual memory, but for different purposes: *direct motor encoding to make the marks, visual memory to assess them*. The visual memory he uses to assess the marks could be retrieved

[2] While Tchalenko noted this behaviour in his (2001) study of Humphrey Ocean, he described this as 'practice strokes' but he did not associate it with his 'motor memory' hypothesis.

from STM (resulting from his examination of the image during the duration of the drawing) or from LTM (longer standing visual knowledge, or 'image schema').

This interpretation can be generalised to the other artists. While they do not rehearse their marks in the way Connolly does, their blind drawing activity indicates they are using the 'direct mode' at least some of the time. It follows that this would extend to their sighted drawing also, especially as those periods tended to be continuous with blind drawing (they drew continuously while looking back and forth). While their periods of reflection are not as finely or regularly structured as Connolly's, we can infer that they would distribute their cognitive resources similarly, using direct motor encoding for constructing the drawing and visual memory for reflecting on it.

6.2.1.1 The motor memory hypothesis is not consistent with Guérin, Ska and Belleville's account

It is worth noting briefly, that the interpretation offered above is not congruous with Guérin, Ska and Belleville's (1999) account of drawing process (reviewed in chapter 1). They describe two ('single-part' and 'global') 'parallel processing pathways'. Although their model includes 'spatiotopic mapping' it still relies heavily on visual forms of memory: associative and long-term memory, and the visual buffer (the visual component of WM).

My contention is that the constructive mode (or 'single-part system') appears much simpler than they describe: "the formation of a single-part image, goes through associative memory, long-term visual memory, *encoding of coordinate and categorical spatial relations, and spatiotopic mapping*, and ends in the visual buffer" (2009: 472). Their account implicates the 'visuo spatial sketchpad' in "in planning and executing spatial tasks" (1999: 471), but this concept conflates the visual and spatial elements. My interpretation of the case studies is that (although it does involve *procedural* long-term memory) the constructive mode requires neither associative visual memory nor retention of pictorial imagery in the visual buffer. Instead, the 'coordinate and categorical spatial relations, and spatiotopic mapping' they describe could be encoded directly to motor planning, as in Tchalenko's 'motor memory hypothesis', even for sighted drawing.

To a degree, their description of the 'global image' processing system corresponds with the 'reflective mode' in the present model, in as far as parts are added to the global image, enabling 'top-down hypothesis testing' (i.e. judgements about the representation informed by LTM Schema). However, I would argue that this description too, overemphasises the role of visual memory. As mentioned in chapter 1, they describe how "the addition of parts to the global image, goes through long-term visual memory, associative memory and the subsystems of top–down hypothesis testing" (2009: 472). The two processes are said to "*maintain and inspect the mental image* in the visual buffer or the working memory" (1999: 472 emphasis added). I would argue that, in the reflective mode, the *paper* can act to maintain the image, rather than the visual buffer, enabling VWM resources to be dedicated to the task of 'top-down hypothesis testing'.

By segregating these processes (rather than having them operate in parallel), cognitive resources are freed for bottom-up processing during the constructive mode. It is the simplicity of the constructive mode that allows the prevalence of bottom-up visual processing, while top-down processing is reserved for the reflective mode, with reference to the paper, rather than internal imagery.

6.2.2 Beyond the dwell cycle, the roles of short and long-term memory

We can also consider the role of memory in longer-term patterns, beyond the interval of the dwell cycle and the duration of the drawing. Figure 27 (section 3.3.1) demonstrated that glances to the mirror tend to become shorter in length as the drawing progresses (with the exception of Cobley, who I discuss further in section 6.4[3]), while glances to the paper become longer for all four artists. It is unsurprising that glances to the paper increase - the artists are referencing what they have already drawn, which becomes more complex as the drawing progresses, both in terms of accommodating new marks, and monitoring the overall progression. But what about the shortening of glances to the mirror? Presumably, growing familiarity with the subject allows the drawing to proceed with less reference to the original. STM would contribute to this: as visual details are cumulatively processed through WM, some aspects will become temporarily retrievable in STM, available for use in assessing the

[3] Cobley showed a very slight increase in the duration of glances to the paper, which were consistently very short (around 0.5s), although his timing still demonstrates a more significant increase in duration of glances to the paper, compared with glances to the mirror.

developing drawing, and helping locate salient features more efficiently. For example, the 'anchor points' used as measurement references would become familiar and easy to locate as they are held in STM. (There are other factors in glance duration that will be discussed in section 6.4.).

LTM is also implicated in the reflective mode. Visual features repeatedly measured, processed and recalled would, over time, inform LTM schema; building a library of visual imagery or representational conventions for use in later drawings (as we saw in the previous chapter, visual knowledge both informs and *results from* drawing process), although it remains arguable whether these are recalled visually or propositionally. Such knowledge may concern particular individuals and details, but its sum would be manifested in schematic memory as archetypes – typical, generic examples derived from many specific ones. Johnson describes these LTM image schema as 'rich and multi-modal', again, not overtly pictorial (see section 4.1.2). This could also be thought of as synonymous with Kosslyn's 'deep representations' (4.1.3). A schematic representation, or archetype, can become the standard to which measurements are anticipated, and individual differences are compared. Exaggerations of those differences would result in caricatures.

This cumulative LTM may also be procedural in nature - taking the form of positively reinforced methods for representing, and routines for drawing process - i.e., drawing experience leading to successful ways of depicting, based on which aspects to measure and include, in what order to consider them and how variation of certain features changes the appearance of the whole. Cobley, for example, described in his retrospective report the methodical routine he used to map the facial features, expressing an understanding that the distances between key features was crucial to establishing a recognisable individual.
In terms of the ongoing assessment of the drawing, LTM image schema may be oriented towards an intended goal, an ideal of what the final representation should achieve. That is, the artist may hold particular aims in mind for the drawing, and evaluate its progress with reference to appropriate schemata, perhaps associated with particular emotional responses or knowledge of the individual or the intended aesthetic. To be clear, the artist would not normally anticipate precisely what the drawing would look like. Rather, the image would be allowed to emerge through the process (the constructive phase), and serendipitous properties may be rejected, adopted or emphasised according to whether they are desirable to the representation (the reflective phase). It is the implicit *criteria* for what is desirable in

the drawing that would be a result of LTM image schemata (not in a fixed way, but subject to the artists' intention). This interpretation is commensurate with Gombrich's notion of 'making precedes matching' (see section 1.1).

Both visual and procedural knowledge/memory can be considered schematic – in Gombrich's sense – and they contribute to both constructive and reflective phases. Visual knowledge has the potential to inform or influence the construction of the drawing (as well as directly perceived details), but Connolly expressed an awareness of this and a wish to avoid such influence. He sought instead to engage fully with the image he was seeing. One could say he wished to maintain the 'innocent eye', yet this seems somewhat contradictory - Connolly was clearly *applying visual knowledge*. For example, his (schematic) knowledge of anatomy was applied to considering the internal structure of the head, informing the drawing through decisions about which aspects to measure and which anatomical features to seek to represent. Procedural knowledge of how to perform the drawing process also played a role, guiding his routine of regular dwell cycles and progressive measurements. The *type* of knowledge Connolly desired to negate, specifically concerned what *he* looked like (or whoever he was drawing). That is, he wished to maintain an open mind about features particular to individuals, rather than archetypal ones or, indeed, routines about how to proceed with the drawing. This seems closer to Ruskin's intended meaning of the 'innocent eye': not a complete negation of schematic knowledge but, rather, a selective one that is mindful of the possible influence of visual knowledge on perceptual experience.

Connolly's concurrent report indicated that his interest in the features to be drawn was not only visual, but could be considered multi-modal. Although the features were not touched, a strong tactile element to Connolly's thinking about them was apparent. His report reflects a concern with qualities such as softness, fleshiness, internal structure, and how flesh and bone sit together under the influence of gravity. This indicates that there were not only visual, spatial and motor modalities at play, but also the tactile sense. If we consider Multiple Resource Theory, and its claim that 'cognitive competition is reduced by spreading the informational load across different modalities' (Wickens 1984, see section 4.3.2), this indicates that a greater amount of information could be processed by using additional sensory modalities. In other words, Connolly's tactile sense is recruited in his reading of his subject, allowing a more complex engagement with it, and this is reflected by his choice of terms in the concurrent report. It was important to him that the drawing convey those tactile qualities, and so by holding them in mind as he reviews each group of drawn marks, he is able to check if they do so adequately. (Again, this does not necessitate any *pictorial* recall.) This is distinct from the kind of 'double checking' Brew described, which would rely more heavily on reference back to the original (the mirror) for measurements.

We can interpret this evidence as strongly suggesting that in WM, motor, tactile and spatial modailties can all be recruited to hold information during the time between perceiving a detail and drawing it, even during sighted drawing. The extent to which visual memory, or indeed 'internal imagery' is used remains debatable. It is likely subject to individual differences, as discussed in the literature review. However, visual memory represents only one possible modality out of many, and it seems that the most efficient use of cognitive resources would not be to encode sensory information visually, only to then translate it into motor movement. This can be done with reference to the original rather than a visual memory of it.

In summary, multi-modal WM resources are mobilised in the constructive phase, particularly the motor modality. STM is involved in the drawing process, reducing the need for reference to the original, without the need for pictorial internal imagery: repeated reference to the original leads to a temporary STM store that inform the constructive process, maintaining an awareness of what the drawing already contains, including specific locations (such as anchor points) which could also inform movement. (In this sense, it is useful to consider spatial awareness as distinct from visual awareness, as discussed in section 4.2.4.)

LTM seems to play a bigger role in the reflective phase, i.e., in monitoring and evaluating the ongoing drawing. We can think of the LTM image schema as rich and multi-modal (again, not necessarily overtly visual), and able to inform evaluations of specific representations, as well as drawing strategies and routines.

6.3 Focusing visual attention for drawing

6.3.1 Visual attention as feature selection

Chapter 3 observed that each artist varied the types of visual features they looked for at different stages of the drawing process. The details mentioned in the reports were categorised by both type and complexity (see section 3.2.2). The general trend was to progress from more abstract, simpler, low-level features to more complex and meaningful ones. Although this differed in scale and certainty between the two strategies (Heuristic strategies began generally and sketchily, while additive ones began in a central location with more certain measurements.) The heuristic strategy made use of a larger scale initially, moving towards finer detail. The additive strategy mainly used a smaller scale[4]. Within evaluative subroutines, the trend seemed to move from high to low orders of complexity, as features for re-measuring or re-drawing were progressively identified. Switching between perceiving parts and the whole was crucial to evaluative subroutines in both strategies.

The list of visual features mentioned in the reports (table 3, section 3.2.2) can be seen as a result of linguistic schema and denotations, i.e., a result of the verbalisations, rather than the drawings. At times, the artists discussed – in their retrospective reports – that sometimes it was difficult to find words to describe what they were looking at. Roberts, in particular, described how labelling facial features interfered with her process; this was not the level at which she would usually read an image to be drawn. However, in both concurrent and retrospective reports, the artists allude to various types of features at different times, corresponding to how the drawing was progressing. These are sometimes labelled as objects (‘head’, ‘eyeball’, ‘nose’), at times as feature values (‘dark’, ‘curved’, ‘round') including textural/tactile values as well as visual ones (‘soft’, ‘fleshy’, ‘hanging’); and at other times as gist (‘is it sitting right’, ‘does it feel wrong’).

Although Gombrich refuted the possibility of a truly ‘innocent eye’, we can say that visual perception and attention can certainly be focused at many levels, including more abstract

---

[4] Level of resolution and order of complexity are related, but not the same dimension. Resolution refers simply to scale, whereas order (low to high) refers to the order of processing, involving association with prior knowledge and experience for recognition and interpretation. They are related in the sense that higher order features tend to be larger(i.e., the whole head as opposed to measurements within it), although this is by no means the rule – the head might be measured as a single, flat shape, while a facial feature might carry much significance when perceived at a higher order.

ones, which are less susceptible to the kind of context-based errors described by Cohen and Bennet (1997, see section 1.1). It is the higher order, object-based perceptions that Cohen and Bennet claimed lead to such context effects, such as skewed shape constancy. Their study used novice drawers, however. The artists in the present study showed that those orders of perception were associated with reviewing – rather than constructing – the drawing. From this, we can see that it was not only gaze *frequency* that helped to avoid this type of error (as Cohen and Bennet claimed), but also the lower order of features they were attending to during the constructive phase.

The artists demonstrated attentional control in modulating the complexity of the features apprehended at different stages and phases of the drawing process. Theories such as Feature Integration Theory (FIT), Boolean Map Theory (BMT) and guided search theory (see section 4.2) support the idea that that specific features can be sought separately, explaining this through the top-down control of feature 'weights' using pre-attentive 'salience maps' . In other words, one has a degree of control over what is visually salient at any given time, and the artists demonstrated fine control of this – separately focusing on specific measurements, orientations, tonal values and so on. Drawing does not use this ability in the same way as visual search but, similarly, the drawer will be able to create a 'salience map' (an 'intermediate representation' that plots the *locations* of salient features), as a subset for access based on a particular feature. Rather than serially check each item with a particular feature until the target is found (as in visual search), or simply notice enough key features to identify the subject (as in recognition), the drawer will need to determine which features and relationships are of value to the drawing, measuring their key properties at a rate appropriate for encoding to motor action. We can say, therefore, that the artists use feature based attentional priming as part of their drawing strategy, but in a much more complex and demanding way than they would in more common visual tasks, such as searching or recognising.

The notion of an 'intermediate representation' is useful in describing this kind of feature selection, as it constitutes a background level of awareness, accessible to attention, which can act as a pre-attentive filter for visual features, enabling the drawing process by simplifying the set of things available to visual attention and, therefore (being spatial in nature), available for the eye to fixate on next, as in pre-motor theory (see section 4.2.1.1). BMT describes how this selection could occur with reference to single feature values. Other accounts of visual attention, which mention other ways of breaking down an image for attentional selection, are discussed in the following section. Those are.

6.3.2 Ways of focusing attention: a sliding scale

In addition to feature values, the literature reviewed in chapter 4 describes five further possible levels by which an image can be deconstructed: feature conjunctions, geons, object files, and gist. These distinctions could be thought of as a scale, from simple to complex, as each example is comprised of many of the previous type. A feature conjunction includes two or more feature values; a geon includes a number of simpler forms (conjunctions); an object is formed of a number of geons; and many objects form an image – which, if presented very quickly, can be perceived in terms of its gist, rather than any specific object (see section 4.2). There is also the notion of 'spotlight', referring to the changeable size of the attentional frame, and to the fact that attention can be location-driven (rather than feature or object-driven). At different times in the drawing process, each model of visual attention can be used to describe to the ways the artists were looking (as a spotlight, geometrically, feature-based, or with recognition or gist). Also in ways that could be collectively thought of as what Gibson describes as 'affordances'. For example, Connolly described knowing the shape and size of the bridge of the nose and eye socket because he could imagine his thumb would fit there. Reading emotion or other signified meaning could also be classed as 'affordance', or categorised as high-level vision, and this type of looking was associated with the reflective mode.

In this light, what constitutes a single unit of visual information (among the 7 or so that WM is said to be able to handle) is difficult to define, and appears flexible. Cheng & Patchella's (1984) 'continuum of dimensional primacy' in visual attention (see section 4.2.3) is therefore the most apt notion of visual primitives – with regard to this study – as it does not favour a single mode of attention, but recognises many possible orders of visual complexity. It makes sense to selectively limit visual attention while drawing by varying the feature type, complexity and level of resolution attended. Because WM is capacity limited, it can only process a limited amount of information at any time (as discussed in section 4.3 and further on in this chapter). Similarly, Awh et al.'s (2007) 'two-factor model' (see section 4.3.1.2) proposes a similar notion to degrees of integrality, but in relation to VWM rather than visual attention. They demonstrate that VWM capacity is constrained by both number and resolution, and these are proportionally related. Figure 61 illustrates how, while the overall VWM capacity remains fixed, fewer items allow greater complexity.

Wolfe et al.'s (2011) 'two-pathway architecture' (see section 4.2.4.2) explains how gist can be processed very quickly – i.e., fast enough to implicate parallel processing – considering the complexity of the information. In their account, speed is compensated by a probabilistic, rather than certain, perception of the number of features and their location. For example, walking into a lecture theatre, one might instantly note that the audience was larger than usual and mostly composed of women, without being able to say how many or where exactly they sat. In this way, general information about a scene can be processed almost instantaneously, regardless of its underlying complexity. Again, greater specificity involves greater *certainty* about things such as exact location and size.

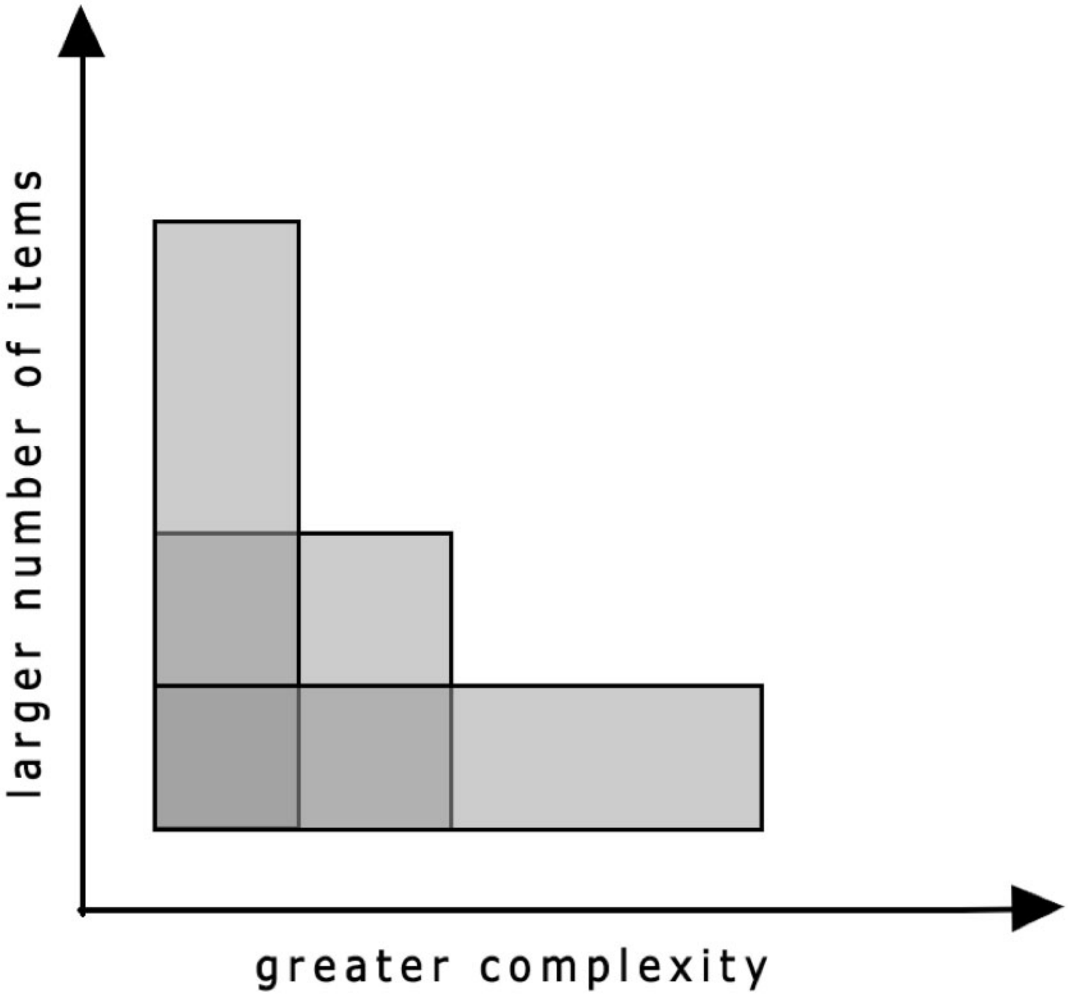


Figure 61. Fewer items allow for greater complexity, and vice versa, while the overall capacity limit of visual working memory remains constant.

While number and resolution are capacity-related, the content of VWM can also vary in terms of the *types* of feature (e.g. line, tone, shape, etc. as discussed above), which themselves have an order of complexity, related to their order of processing. That is, featural dimension represents a further distinction as well as resolution.

In addition to visual complexity, 'chunking' also affects what WM treats as a unit. For example, several line segments may make up a shape (a conjunction of features), but if that shape can be recognised, it may be processed as a single 'chunk'. A shape might be divisible into line segments, each of which must be drawn separately. If these are familiar, they may be chunked together and treated as a single unit in WM. At one point, Connolly mentions the line under the nose as being the shape of a bird, but this can also apply to geometrical shapes – when copying a square there is no need to judge each angle separately. This is not the same as level of resolution. To view something at a coarse level of resolution implies a loss of detail or certainty, while chunking retains the detail already committed to long-term memory (LTM).

It is worth mentioning Huang and Pashler's finding again: that location constitutes a distinct dimension (see section 4.2.4). They describe it as 'given', in that it operates in parallel with visual featural dimensions, and its encoding is obligatory. That is, to be aware of some visual feature, a colour for example, is to be aware of *where* it is (even if that is with a level of generality as Wolfe described). So, the artist attends to specific features of the visual experience, and does so always considering the *location* of those features (albeit to a degree of certainty – see below with reference to Wolfe et al.). Huang and Pashler (2007) also demonstrate that multiple locations can be attended at once, providing they share the same feature value, such as the same colour (as opposed to being seen as part of the same object, as Marr and Nishihara (1978) demonstrated, i.e., two things can be treated as part of one thing, even if they are separated in the visual field. For example, a tiger occluded by a bush: we might only see the head and tail, but safely assume it's one animal). This is interesting in relation to Cobley's approach to adding tone. He would often cover separate portions of the drawing with the same tonal weight, in one go, treating the whole surface at once.

This flexibility of visual attentional focus raises questions about Tchalenko's analysis of Humphrey Ocean. He claims that Ocean would "capture around 1.5cm of detail per fixation" (2001: 37). It is likely that this observation was a result of the simplified task given to Ocean, and not indicative of his usual drawing process, or of the way we would typically segment a line. The notion of a certain *length* of line being the unit of measure by which attention or WM is limited, seems erroneous: a straight segment of 6cm would not need to be broken into three for processing. It would be the complexity of the line, and how it can be 'chunked' that would determine its size in terms of cognitive load, and therefore how much of it would be apprehended in a single fixation, or a single glance, while drawing.

That 'number and resolution' represents a distinct dimension for attentional selection supports the idea of a sliding scale between levels of perception, one which is also characterised by variable certainty and precision. If an artist wishes to draw a small detail accurately, they may attend to isolated aspects of it, and at a low order of complexity, perceiving only a few measurements or values with a high degree of precision. In order to assess the success of their efforts to do so, they can zoom out to a broader view of those details in context.

6.3.3 Drawing skill involves fine attentional control across many 'dimensions'

As described above, one aspect of drawing ability is the fine control of visual attention, and the ideas discussed so far in this chapter frame this control as comprising *resolution* (size of items), complexity (number of items) also related to *certainty* about location*,* and perceptual dimension (colour, orientation, tonal value, etc.) of visual features. These aspects of attentional control represent related constraints.

6.3.3.1 Heuristic and additive strategies make different use of visual working memory resources

The drawing strategies studied exploit these constraints in different ways. The additive strategy involves weighting WM capacity with fewer details, but finer resolution and greater location certainty, while the heuristic strategy favours greater numbers of features at the sacrifice of location certainty. In the later stages of the drawing, the heuristic strategy involves increasingly specific aspects (as the drawing is fine-tuned) and the additive strategy must involve increasingly general aspects (at least for evaluation). Figure 62 illustrates this.

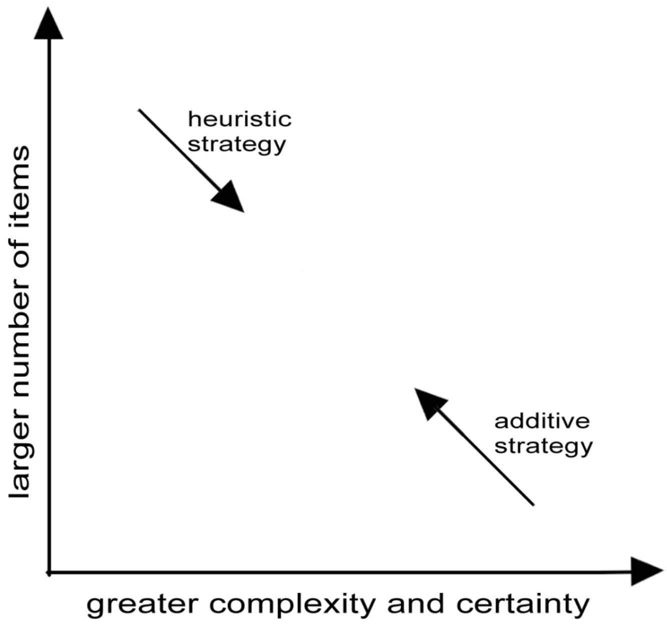


Figure 62. Maximum capacity for number and complexity of items in VWM are correlated, opposing strategies make use of this in different ways. The heuristic strategy initially focuses on larger, more general features, moving towards specificity. The additive strategy favours certainty and specificity, but increasingly considers more general features in monitoring the drawing.

To summarise, segregating features through selective attentional modulation helps to maintain cognitive load at a manageable amount, and this can be done in a number of ways. The artists in this study exercised attentional control by way of resolution, type and complexity of features processed. They applied this control in different ways, appropriate to their drawing strategies; apprehending, at different times, many general features, or fewer features with greater specificity and certainty. So, while multi-modal processing may augment overall WM capacity, VWM capacity remains limited and constrained by number and resolution.

These 'dimensions' of attentional selection can help us understand how drawing strategies exploit visual attention and working memory, as they represent the variables within which capacity limitations are defined. However, characteristic rhythms and slight differences in time frames used by the two opposing strategies, suggest that timing is another important variable. In other words, not only *what* visual information is held, but for *how long*. Both strategies demonstrated relatively regular dwell cycles, but the heuristic strategy demonstrated a significantly faster pattern of looking back and forth, and so the following section will discuss these differences.

6.4 Timing and cognitive capacity

The artist's strategies maximise different facets of visual attention and WM at different times, but any strategy must still work within the total capacity. Cohen's 2005 study (discussed in section 1.4.1) demonstrated that expert drawers use faster dwell cycles, and he explains this in terms of WM capacity – holding less in mind at once reduces distortion and other 'context effects' – but the present study also shows that gaze frequency varies between artists, between strategies, and within the duration of a single drawing, and that the changing distribution of gaze over the course of a drawing shares common features. (This is illustrated in figures 25 to 27 in section 3.3.1, which show the mean durations of glances to the mirror and paper, their standard deviation and distribution at 30 second intervals for each artist.)

The accounts of WM presented in chapter 4 suggest the amount of information readily processable is limited to around 7 'items' or 'chunks' at one time, or closer to 4 in VWM. This limits the possibilities for drawing from observation to a particular 'portion size' of information for each glance, which would account for the frequency and regularity of glances to the mirror – perceiving more detail than it is possible to hold in WM (and perform cognitive operations on), would not be useful to the drawing. If we consider Wolfe et al.'s 'two-pathway architecture' , in which gist is processed very quickly relying on parallel processing, it follows that it would take longer to perceive fewer features with greater certainty, as this would rely more on serial processing.

6.4.1 Variations in gaze frequency

As we saw in chapter 4, the artists' dwell cycles varied in frequency, both within a single drawing and, more significantly, between artists. This was not correlated to experience, or 'expertise', as Cohen's study would predict, but rather (in this comparison *between* experts) it is related to strategy: those who used the heuristic strategy demonstrated faster dwell cycles. As we saw in sections 3.1 and 3.3, they also tended to draw larger, faster, more numerous and less accurate marks, especially early on in the drawing process, while the additive strategy relies more on accuracy, and uses a slightly slower pace of looking. (Although four artists is a small sample, the results are consistent with this interpretation.)

The faster dwell cycles associated with the heuristic strategy indicate that less is perceived with each glance, and this is held for shorter periods. As discussed above, this is not at the expense of the *number* of features apprehended, but of certainty. *How much* detail to apprehend in each dwell cycle at different stages of the drawing is therefore an important part of the drawing strategy (in addition to what kind).

In this respect, Cobley's gradually lengthening glances to the mirror (mentioned earlier, see figure 27, section 3.3.1) can be attributed to his increasing need for certainty, as he refines the drawing from its early, uncertain, state. Roberts also shows a slight increase during the last minute of the drawing when she was beginning to refine details. Roberts, however, also shows the typical early emphasis on the drawing, with longer glances, as the other artists did. While this early emphasis can also be attributed to early periods of blind drawing (particularly for Brew) and to initial compositional planning, the two artists using the additive strategy (Connolly and Brew) continued to gradually decrease the length of their glances to the mirror during the middle portions of their 5 minute drawings. This could also be related to the need for certainty in the first marks put down. This is characteristic of the additive strategy, which relies heavily on the accuracy of the first marks drawn (those act as anchor points and are rarely changed).In the heuristic strategy, first marks tend to be vague and changeable, and become subsumed into the emerging drawing.

6.4.2 Bound and continuous drawing cycles

While the kind of gist Wolfe et al. were referring to is far more general than that the heuristic drawers were making use of, there is still a qualitative difference between the heuristic and additive drawers. The heuristic strategy enables a faster rhythm of looking and drawing by sacrificing a level of certainty and precision, also characterised by faster mark making and more revisions; but whether or not their faster gaze frequency means they are actually *segmenting time* into a shorter frame (in the sense of the ‘specious present’ –see section 4.3.1) is debatable. It would seem so, if we considered each dwell cycle to be bound as a separate episode. Yet, it may also be that the dwell cycles are not discrete, instead continually informing a persistent but constantly changing set of features held in WM.

The longer additive dwell cycles were more clearly bounded, particularly in Connolly’s case. Each episode began and ended with the eyes shifting back to the original and a new segment of drawing as the focus. The other artists’ drawing activity overlapped with their looking back and forth.

6.4.3 Summary

In summary, drawing strategies and their timing are confined by the limits of attention and WM. There are, nonetheless, many possible ways to make best use of those capacities. Multi-modal processing can augment cognitive capacity, and rather than *visual* memory, motor, spatial and tactile modalities are recruited as forms of working memory by the constructive phase, while STM plays a role in maintaining an awareness of key locations. Each artists makes use of their WM capacity differently, and this is manifested in the timing of their drawing routines. Whether their experience of making the drawing is as segmented as their dwell cycles appear to be is questionable when we look at how this overlaps with drawing activity – this overlap also varies between individuals.

Visual attention is modulated by top-down control. This modulation can occur at the order of feature type, at varying resolution resolution and by specificity/certainty. This refers to perception, but LTM is also involved, particularly in the reflective phase, and this is discussed below.

6.5 LTM image schemata both inform and result from drawing process

While it is generally accepted that working multi-modaly can augment WM capacity, the multi-modal thinking described in the previous section is different to Johnson's description of the 'image schema' as multi-modal (see section 1.4.2). Johnson was referring to schema in LTM, which is not capacity limited as WM is. Our LTM image schemata, in this sense, are rich, informed by cumulative experience, and play a role in parallel processing. LTM image schemata usually tend not to include specific low-level features or exact measurements, instead they include higher order features with more global, generalised and associative content. This makes sense, as these are the features relevant to every-day (non-drawing) tasks, and LTM is informed by experience and reinforced by deep processing and frequent of recall (Craik & Lockhart 1972; Lockhart & Craik 1990).

Lower level features are not normally processed as significant or task-relevant, and therefore don't become part of the LTM schema (although the schema would still be able to inform a judgement about whether a representation feels 'correct'). When we draw, however, we *are* attending to and processing low-level features, translating and encoding them as motor movements, storing them in WM, reviewing, recalling, comparing and scrutinising them. When drawing, such features become task relevant, and with repeated experiences they can become connected to the broader LTM schema. As proposed in Chapter 5, Ruskin was describing this process of gaining knowledge of the visual world through drawing, while Gombrich was indicating that these schema inform the making and evaluation of drawings.

Figure 63 illustrates the relationship between the three forms of memory and attention. These categories are not exactly subsets of one another, but can be considered to inform each other as illustrated (WM is comprised of recently attended features, STM is comprised of recent WM content, and so on). Features attended are held in WM where they can become part of cognitive operations. Repeated processing and recall leads to LTM storage. Attention can also be directed inwardly, to retrieve information from STM and LTM (discussed further in the following section) in order to inform judgements and decision-making. Similarly, recognition relies on LTM schema for context.

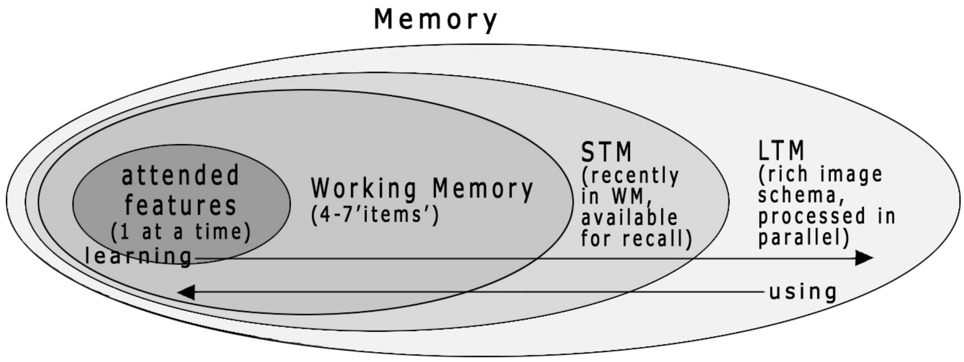


Figure 63. Relationships between attention and memory. Features attended are used in WM operations in groups. Processing and recall commit and reinforce short-term memory and long-term memory schemata (learning). LTM schemata inform judgement and decision-making (remembering/using).

These two directions can be associated with different elements of the drawing task: schematic visual memory is recruited in the reflective mode for the monitoring and evaluation of the drawing (be it from LTM or STM), while perception informs the constructive mode and leads to the retention of visual 'knowledge'.

6.5.1 Parallel processing informs experience and judgement

This concept of the multi-modal LTM image schema can also be connected to Wolfe et al.'s 'non-selective pathway'. Recognising the gist of a scene (for example, to tell instantaneously whether you are in a forest or a kitchen) relies on parallel processing of a large amount of contextual information, both from the visual scene itself and from LTM. Similarly, LTM must be recruited to inform ongoing judgements about higher order attributes, like whether the drawing is a good likeness, or conveys the desired mood or personality. These aspects are visually very complex, when broken down to the order of what visual features actually convey those qualities, and how they do so. Recognition and interpretation rely on existing contextual knowledge. The richer our LTM schema, the richer the interpretation LTM is able to inform.

That parallel processing is implicated in these phenomena is interesting in relation to the question of what occurs consciously and unconsciously in the drawing act. Dual processing theory associates parallel processing with the unconscious, with snap decision making and automatic or routine actions, although Wolfe et al.'s 'two-pathway architecture' proposes that parallel processing still gives rise to phenomenal (conscious) awareness (in visual perception). Like snap decisions, we can think of the phenomenal result of the non-selective visual pathway as the tip of the iceberg – the *product* of the parallel processing that reveals itself to consciousness.

This understanding of the relationship between forms of memory allows a reframing of the question of what happens unconsciously. We can instead ask a much easier question: '*what happens very quickly*?' The eye tracking footage showed that the artists were evaluating their drawings very quickly (see section 3.3.5) considering the number of criteria they must have been taking into account. We can also see that decisions to rub out portions of the drawing often occurred after very short pauses in drawing activity (usually less that 0.5s). As discussed earlier, this judgement making is informed by knowledge: schematic knowledge about how the image should look, and which features are important to the representation as the artist intends it. That these judgements can happen so quickly indicates that much of this processing must be taking place in parallel, pre-consciously. We can therefore think of the schematic knowledge informing the reflective phase as largely subconscious or 'tacit'. This will be discussed further in chapter 7.

6.6 Constructing and reflecting – why two separate processes?

In addition to fine control of visual attention, the case studies demonstrate the strategic timing of judgement and decision making to be important to expert drawing process, as discussed earlier.

So, why might it be that these processes are segregated? Why shouldn't construction and reflection take place simultaneously? Again, we can look to recent literature from cognitive sciences, regarding the constraints of WM, to seek an understanding.

6.6.1 Perception and memory are recruited differently by constructive and reflective modes

The previous section presented a simplified model of memory and attention (fig. 63), describing the processes of learning and recall as a flow of information in opposite directions – from attention and WM to LTM and back again. These two directions can be associated with different elements of the drawing task: (as section 6.2 explained) schematic visual memory is recruited by the reflective mode, informing the monitoring and evaluation of the drawing, while perception is recruited by the constructive mode, informing movement (along with procedural memory that drives drawing routines) and, over time, the retention of visual and procedural knowledge.

Of course, some perceptual input is also needed in the reflective phase – the drawing and the subject are reflected on. When assessing the drawing, comparisons will be made with the subject (the sitter), and comparisons will be made to 'double check' i.e., with reference to perceptual input, but the *need* to double check would be recognised with reference to LTM image schemata. Some strategies for observational drawing may include memory drawing, which obviously relies on the image schema for both the making and assessment of the drawing. However, in general, we can say that the two functions of construction and reflection can be associated with these two sources of visual information (external and internal). This distinction can help to explain the segregation of constructive and reflective activities.

6.6.2 Visual memory and perception share cognitive resources

Keogh & Pearson's proposed 'interface' between VWM and perception (see section 4.3.3) points to a shared cognitive resource: VWM and perception largely utilise the same neural substrates. That is, VWM can be informed by *seeing* or *recalling* imagery – either way, the visual brain is active. Although LTM and the non-selective visual pathway involve parallel processing, what is retrieved for use by WM is a limited product of that, suitable for serial processing. This implies competition for limited cognitive resources. So, attention can be directed outwardly or inwardly in retrieving details for use in WM operations, but once WM is at capacity those operations must be completed before further visual information can be taken on board.

The implication of the sharing of this resource is that *visual Information held in WM reduces ones capacity to perceive the external world*. Seeing and imagining/remembering effectively compete. A passenger might therefore cause a car crash by asking the driver questions about the pattern of their curtains at a tricky junction. This is not to say that we can use only one or the other at any time – that would be highly impractical – but there is an inversely proportional relationship between perception and working memory: the more we hold in VWM, the less we are able to actually see, and vice versa.

Other sensory modalities are presumably also of this nature – internal or external sources of multi-modal information can engage WM but, when already at full capacity, perception is compromised. While WM capacity can be maximised by 'spreading the load' across modalities, there is still an overall shared capacity limit. If we consider that in WM may include a 'supramodal' system (i.e., of a higher order than modality specific attentional sub-systems, see section 4.3.1), it follows that there is also competition for this system, and activity in other modalities may also potentially interfere with perception, memory or other WM activity. This is discussed further in chapter 7, in relation to the role of language.

From this, we can deduce that a strategy for drawing that minimises other VWM activity (and maximises perceptual input) during the constructive phase will effectively enable the drawer to *see more* at that time, in terms of resolution or number of features. If many details in the external world are to be perceived as accurately as possible, it makes sense to minimise other visual thinking – especially thinking concerned with how the drawing is progressing, and where it is going.

During the reflective phase, visual details perceived are not intended to inform movement, but to engage in cognitive operations that involve LTM schema. Operations that are demanding of WM resources, such as logical and propositional thinking ('if I do this, then what?'), possibly also meta-cognitive thinking (e.g. about the drawing as part of a series, or how a viewer might read it in a particular context). We can generalise that the reflective mode is concerned with the past or future of the drawing, while (although part of considered strategies) the construction of the drawing benefits from full perceptual attention in the present moment.

6.6.3 Postponement and distribution of cognitive activities

Given these processes and relationships, we can understand that when temporarily postponing reflective evaluative thinking concerned with the past and future of the drawing, WM capacity is freed, enabling perception to inform movement with access to the whole cognitive resource of VWM. In other words, sacrificing awareness of a longer temporal duration enhances perception in the present moment. Figure 64 illustrates this relationship.

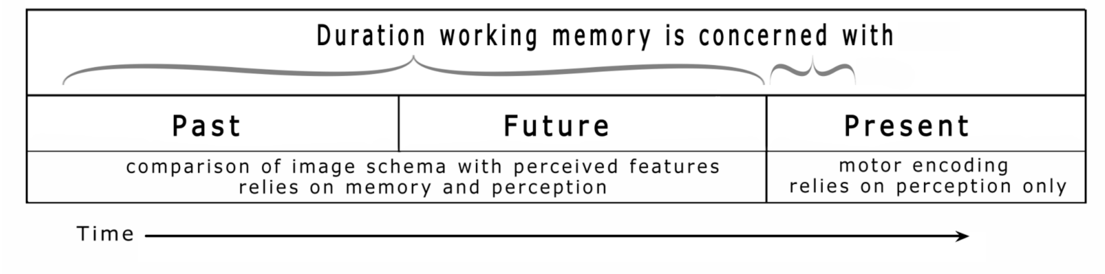


Figure 64. The duration working memory is concerned with is not fixed. WM performs operations concerning the progress of the drawing, and plans for how to proceed, or it may be concerned with encoding visual information as movement (in the present). Expert strategies seem to separate these two elements.

To put this in the context of the various facets of visual attention and WM discussed previously (by feature type and resolution/complexity), we can add two further ways in which attentional resources can be focused: *internally or externally*, and *over a longer or shorter timeframe*. The artists can be said to be exercising attentional control in these 'dimensions' while drawing.

6.7 Conclusion: cognitive resources are parametrically constrained

The previous sections describe how cognitive resources are subject to a number of constraints which must be navigated in drawing process. In this light, we can consider cognitive resources to be parametrically constrained within a number of capacity related variables, or 'dimensions': temporal; resolution/number; feature type; external/internal (perception and memory). There is plasticity among all of these dimensions and an overall capacity limit.

6.7.1 A 3D model of cognitive resources

Figure 65 represents the above in three dimensions, illustrating various stages of the drawing strategies. The additive drawing strategy focuses on specific external features, while the heuristic strategy focuses more generally, but still externally (although later in the process more specific features are also attended to). Both strategies utilise a short timeframe to maximise external perception during the constructive phase. Assessing and planning rely on both internal (recalled) and externally perceived visual information, and operate across a longer duration, considering past and future drawing actions. While featural dimensions apply primarily to attention, attention feeds WM, so it follows that WM will also be constrained similarly.

Whether assessing the drawing involves recalling past drawing actions is questionable. There's no need to recall what was done, as the drawing is a visible record of this. However, assessing it will rely on the LTM image schema, and probably STM information about the appearance of the subject. In this sense, the past element of the temporal dimension is related to the internal (memory) element. Also, the timeframe involved with propositional thinking about the drawing, will be longer than the timeframe involved with motor encoding alone.

While figure 65 is a simplification, omitting complexities such as feature type and not referring to the exact quantities associated with each dimension, it is useful for visualising the way in which visual attention and WM are plastic, but still limited. That the artists demonstrated such specific use of their attentional capacities, and with such controlled timing, indicates that they have a high level of control over the 'shape' of their attentional focus, at least in regard to drawing. Expert drawing process therefore involves controlled rhythms of looking back and forth, not only between the drawing and the subject but between these other dimensions of attentional focus: perception and memory, before and after, high and low resolution and feature type. We can therefore say that a crucial aspect of drawing skill is control over the 'shape' of this attentional window, the ability to postpone judgement being an important example of that.

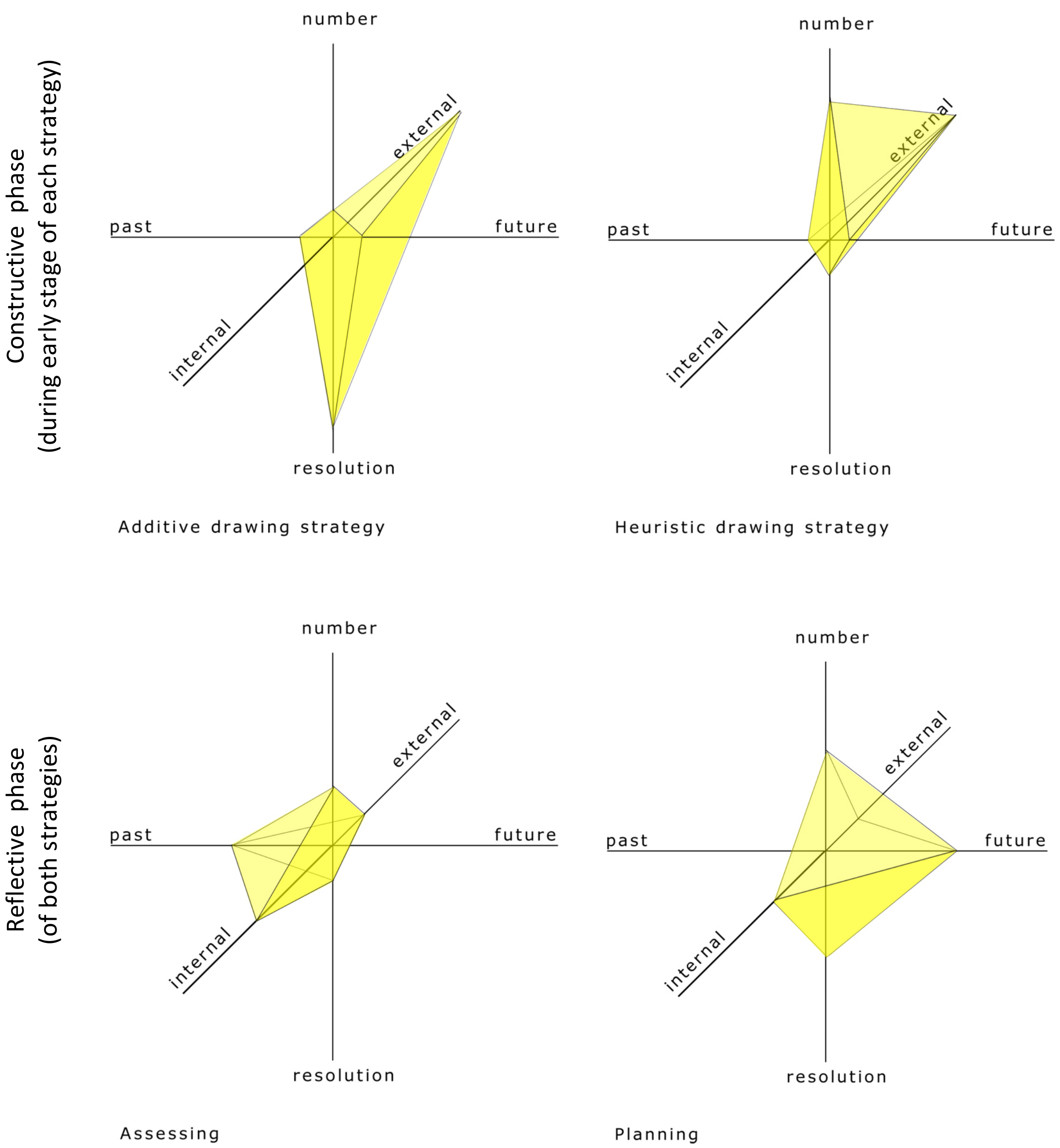


Figure 65. '3D model of cognitive capacity'. Cognitive resources (yellow) can be distributed across many capacity-related dimensions (feature type is not represented here for simplicity, but we can consider it related to resolution). Number and resolution (of visual features) are capacity related, as are internal and external focus (memory and perception). The time frame is also flexible – a shorter timeframe allows greater perceptual depth. The available capacity can be allocated to efficiently deal with different drawing tasks - here, mark making in additive and heuristic strategies, assessing and planning. The overall capacity may not always be used to its full extent (and may also vary between individuals) but in general these dimensions are capacity-related, and therefore represent multiple dimensions of working memory capacity.

6.7.2 Drawing skill involves cognitive control within the parameters of the 3D model

The '3D model' offered here represents the related parameters within which cognitive resources are constrained. The three dimensions represent different parameters, and the 'space' they define represents the range of cognitive states within which drawing strategies move, and the drawer must navigate. Working memory cannot deal with everything at once. It can focus on many generalised or gestalt aspects of a scene, or on fewer more precise details. It can also focus on external or internal information or 'representations', perceived or retrieved from memory (both of which entail sensory information beyond the visual modality). Additive and heuristic drawing strategies move in opposite ways through this 'space', and both types of strategy include rhythms that move back and forth in each dimension with some regularity, at varying tempo.

Crucial to this timing is the periodic switch between reflective and constructive modes: in order to assess the progressing drawing against pre-conceived criteria, the reflective mode relies on both LTM and perceived imagery simultaneously, while the constructive mode maximises precision by allocating as many cognitive resources as possible to perception, and directly translating that to movement rather than relying on retention in the visual buffer or internal recollection of the image, which would compromise the ability to take in further visual information. In this way, visual processing (in the constructive and reflective phases) is segregated, with bottom-up and top-down activity taking precedence at different times (respectively).

This analysis considers how drawing skill constitutes the ability to work within, and *to the limits of*, ones attentional and perceptual capacities. To exercise such control strategically, and with such regularity as observed in chapter 3, requires, on some level, self-knowledge concerning ones' own cognitive capacities, limitations and parameters. But this is not knowledge of the declarative type. Rather, it is a form of tacit knowing, or what can be referred to as 'knowing-in-action' (to use Donald Schön's term, 1983). This being the case, how can we ascertain the potential usefulness of this skill outside the context of drawing practice?

While this self-knowledge may not be *explicitly* known, it may implicitly inform approaches to all manner of visual tasks. That is, it could be considered a broadly transferable skill, including the ability to wilfully focus visual *attention*, and to postpone evaluative judgement in order to temporarily maximise cognitive performance. Chapter 8 will consider this issue in more depth, questioning the possibility of skill transfer.

A discussion of transfer must consider that processes occurring *subconsciously* (which drive the activities described in this chapter) are potentially transferable. These are less conducive to elucidation and may even be entirely ineffable. The possibility of describing or identifying them in a teaching scenario is uncertain, as isthe extent to which we can infer these subconscious processes from verbal self-reports is questionable. Therefore, before moving on to that discussion, chapter 7 will first question the roles of the subconscious and unconscious in drawing process.

The ‘3D model’ represents what takes place *consciously* (through attention and WM), but much cognitive activity also falls outside this conscious ‘window’, relying on LTM, in the form of subconscious process and ‘tacit’ knowledge; that activity is not necessarily constrained in the same manner. That is, although the total amount of visual information consciously processable at any one time remains constant, other aspects of drawing process can grow in complexity, such as proceduralised routines and sub-routines (informed by prior experience), and the LTM image schema that inform judgements. These can be processed in parallel, consuming fewer cognitive resources. This subconscious (or ‘tacit’) element is not limited by the constraints of serial processing, and can grow in complexity with experience and learning. In order to understand the relationship between conscious and unconscious activity in drawing process, and the possibility of elucidating these, the following chapter will discuss in more detail what can be considered conscious, subconscious and unconscious and how this corresponds to what is verbally reportable. In other words, how much can the verbal reports be considered to represent the contents of this ‘attentional window’, what might be omitted from the reports, and what occurs beyond their reach?

Chapter 7.
Drawing, thinking and talking:
to what extent are the cognitive processes involved in drawing conscious and verbally reportable?

This research was devised with the intention of elucidating drawing process in order to understand the set of cognitive strategies, skills and competences underpinning it. The previous chapters 5 and 6 offer a picture of those based on behavioural and verbal evidence. They described the management of processes for constructing and reviewing an ongoing drawing, involving strategic shifts in visual attention and the handling of perceived and remembered information. However, the verbal reporting was far from straightforward, both to elicit and to interpret, and the extent to which they reveal conscious thought is questionable. Certainly, much of the drawing process occurs subconsciously, a large part of it may not be verbalisable, and the extent to which the reports reflect strategies and processes that would typically be performed consciously is, currently, not entirely clear. Therefore, this chapter evaluates the validity of verbal methods for studying drawing, and ask what they can (and cannot) reliably reflect.

Working memory activity (discussed in the previous chapter) occurs with a degree of conscious awareness, as this comprises the focus of our attention and 'thinking' (effortful cognitive operations). Because much occurs subconsciously, this does not represent a full picture of the processing involved in drawing. The *allocation* of working memory operates through underlying pre-attentive elements, and these are driven by associated knowledge and implicit goals.

In order to consider the differing roles of conscious and unconscious cognition, this chapter discusses the reportability of cognitive processing in relation to recent thought regarding the conscious/unconscious divide. Here, I seek to understand what can be considered 'conscious' and reportable, and the factors influencing it, to clearly delimit what the verbal reports in this study reflect, and what they omit.

In questioning those factors, I consider the role of the verbal modality in the drawing process. Beyond an evaluation of the method, this is relevant to instructional design as it addresses the roles of discussion and *internal* narrative in drawing process. The final part of this chapter therefore briefly considers the potential influence of talking on drawing performance and skill acquisition (an issue that presented itself in relation to Betty Edwards' idea(discussed in chapters 1 and 5) that inhibiting the linguistic faculty facilitates drawing), and suggests further areas of inquiry.

This chapter outlines the various issues with verbal reporting (section 7.1), discussing distinctions between types of cognitive process, and the extent to which processing is consciously accessible and reportable in general, with reference to recent debate, before considering what the artists' verbal reports seemed to illuminate and the extent to which they can be considered accurate or neutral reflections of their thinking (section 7.2) and what may actually occur unconsciously or 'tacitly'(section 7.3).

I conclude this chapter by proposing a distinction between conscious and unconscious processing that is dependent on experience and intention, and I discuss the implications for this study, and for our understanding of drawing instruction as verbal interaction (sections 7.4 and 7.5).

7.1 Issues with verbal reports

Faculties recruited by drawing are primarily visual, rather than verbal, and, in that sense, the drawing itself can be considered a more direct record of the process than any verbal description. However, the artists were able to verbalise their process, at least in part. Each one reported a very different set of phenomena, and the differences in their experiences are only partly attributable to variations in the drawing process itself (the approach and method). Many fundamental activities were shared (locating, measuring and assessing visual features and qualities), and some artists spoke of those while others did not. This indicates that, whilst performing similar sets of activities, the artists were consciously aware of different aspects of them. However, this may have been due to the partiality of the reports (acting as an additional filter to their experience), rather than a reflection of differences in their typical thought processes.

The behavioural evidence reveals aspects of cognitive process and strategy not mentioned by the artists. It offers little, however, as to how *consciously* those were played out, or what the experience was like. Some activity omitted from the reports may still have been conscious. The question of what occurred consciously and unconsciously cannot therefore be answered by simply comparing the verbal reports with the behavioural evidence.

In addition, there is the issue that the act of talking might actively *bring* to consciousness thoughts that would otherwise have passed by unnoticed. This might skew concurrent reports, or even influence the drawing activity. This may be a function of what the artist chooses to report, but also what is more readily reportable.

Despite these uncertainties, verbal reports offer some insight into artists' thinking, by way of both what was said and when. It is still possible to understand what the reports *do* reflect. The specific content illuminated individual strategies for drawing (as described in section 3.1), while the *types* of thing it was possible to verbalise concurrently and retrospectively allowed a broader consideration of the relationship between drawing and talking as companion activities, both in terms of what is possible concurrently (discussed in section 3.5.1) and the effect of verbalisation on drawing activity (section 3.5.2).

This relationship between drawing and talking is relevant to methodological considerations regarding the validity of the reports. By questioning the assumptions underlying verbal reporting methods, we can better consider whether the reports really reflect thoughts typical of drawing process, and what they might omit.

7.2 Consciousness and reportability

Reportability is often assumed to equate to consciousness, and is used in many studies to indicate whether a phenomenon is consciously experienced: if something is reported, the experimenter can assume the subject to be conscious of it. Protocol Analysis (PA) methodology rests on the assumption that (conscious) thinking is reportable, although there is no guarantee that any subject will report all they can. It is also possible that some thinking occurs beyond both what is reported and what is reportable (figure 66). In other words, some cognitive processing is either not verbalisable or is entirely cognitively inaccessible.

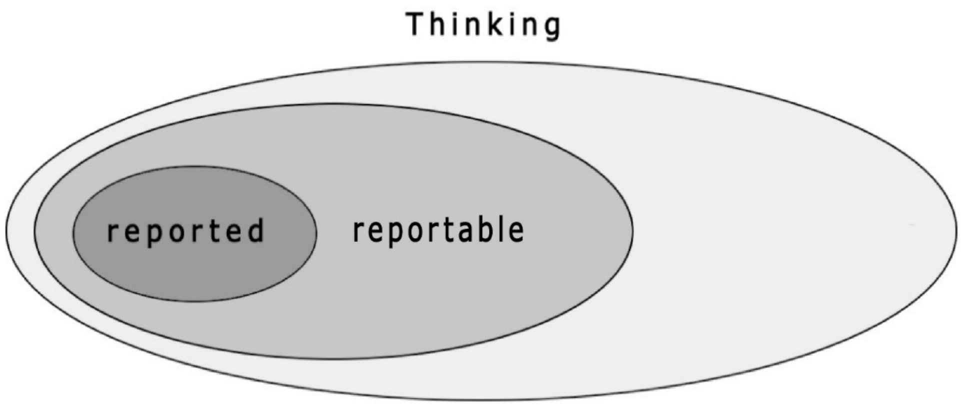


Figure 66. Three categories of reportability. What is actually reported is a only a portion of what could be reported, while some thinking cannot be reported at all.

If the verbal reports are incomplete in this way, how can we consider what might be omitted? Can we determine the nature of what falls into these three categories? We can consider this in regard to the content of the reports in this study, and also more generally in light of a more general understanding of reportabilty (what is easy and difficult to verbalise) and how that relates to attention and conscious 'access'.

7.2.1 The case studies

From the reports offered by the case studies, we can generalise that the most readily reported aspects of thinking tended to be concerned with planning, judgement and decision-making. The artists seemed to report this easily in concurrent verbalisations. Visual descriptions of the subject were also readily given, including features, qualities and measurements at various orders of scale and complexity. These varied greatly between artists. The concurrent verbalisations also contained some digressions and rationalisations, but it is unclear to what extent these were typical or a result of the instruction to speak continuously.

The retrospective reports contained more meta-awareness of goals and strategies. The artists were able to describe and rationalise their approaches and choices. Although this would sometimes only come about after extensive discussion, it suggests that, while the artists had a tacit knowledge of their strategies (in that they were able to perform them), they would not *necessarily* have a nominal knowledge of them. That is, the strategies would not necessarily be easily or readily explained. Having said this, on reflection, the artists were able to describe a great deal, and sometimes even had ‘rehearsed’ explanations to hand, previously given while teaching.

The retrospective reports given by the artists in this study offered a more reflective account of the strategies driving their actions and the reasoning behind their decisions. The comparative lengthiness of the retrospective reports is indicative of the complexity of the thinking underlying the drawing process. The artists were able to speak many times over, elaborating on previous statements about their thinking. This indicates that while not drawing (immediately after the task), the artist has access to much detail about their thinking; or at least is able to generate complex meta-narratives, given time and appropriate cues. The concurrent reports generally included a more limited kind of content, involving immediate goals and visual references (and occasional digressions). This seemed necessary, in order that reporting did not interfere too intrusively with the drawing process. Even so, concurrent verbalising still *slowed* the drawing down, as we saw in chapter 3.

7.2.2 What is easy and difficult to verbalise?

Protocol Analysis (PA) methodologies distinguish thinking that is easily vocalised concurrently and thinking that requires some level of translation. These are termed type 1 and 2 vocalisations, respectively (as discussed in section 2.4). Within type 2 verbalisations, there are two main factors determining whether or not some aspect of thinking is easily verbalised. Firstly, thought is multi-modal. Secondly, the majority of cognitive processing occurs subconsciously or unconsciously.

7.2.2.1 Modality

Modality is related to reportability, in as far as certain modes of cognition will be more readily verbalisable. Propositional thinking is easier to vocalise than other modalities. It may even be verbal in nature already, as an internal monologue. This is the type of thinking PA methods are well suited to, with problem solving and decision-making tasks – such as chess, mental arithmetic and even shopping – lending themselves easily to such studies. Drawing, however, poses more of a problem.

Much of the drawing experience is visuo-spatial, and it may also be experienced through other sensory modalities: tactile, auditory, proprioceptive, as well as on episodic, semantic or emotional levels. We can safely assume that all these faculties have some access by consciousness, but how easily verbalised they are is another matter. To express non-verbal experience is itself a creative task, and so to expect the artist to do this adequately off the cuff, so to speak, and without room for ambiguity, is too tall an order. We might therefore consider propositional thinking (more inherently verbal) to be easily vocalised, but other cognitive aspects of drawing to be more difficult – or even sometimes impossible to describe verbally. Therefore, although there is a relationship, we cannot strictly equate the reported and reportable to the conscious and subconscious.

Despite the possibility of skewing towards propositional thinking, the reports do contain many clues about other modes of thought, including many visual, tactile and even emotional references to the subject and the drawing. These references can be considered a verbal *translation* of multi-modal perception and cognition. The act of translation – choosing terms with which to describe visual, spatial and tactile qualities – requires additional processing. This can, at least in part, account for the slowing effect demonstrated in the verbalised trials. The drawer must make decisions regarding both *what* to report and with what *terms* to describe it. As well as incomplete, and possibly skewed, we can assume that the reports are also a somewhat *translated* version of the thinking that took place This being the case, how can we consider what might be missing, and in what sense the reports truly reflect thinking? What other factors determine how readily thoughts are exposed?

7.2.2.2 Subconscious processing

As the work of Kahneman, Evans and Sloman reminds us, the vast majority of our cognitive processing occurs below the level of conscious experience (see section 4.4). Furthermore, we are not passive observers of our mind's activity. We filter, guide and influence what we are conscious of. How then, can we consider the different roles of conscious and unconscious cognition in drawing? And how might this be reflected in the verbal reports.

Block (1990; 1995) points out that in order for a thought process to be reported, it must first be consciously accessed, suggesting an *active* relationship between thinking and speaking. That is, we sometimes access thoughts *in order to speak of them*. This functions via attentional selection, which actively participates in bringing thoughts to consciousness. As in visual attention, the distinction between access and accessibility (or *selection* and *access*, to use Pashler's terminology) is an important one: just as we have access to the visual field but only perceive a small portion at any time, we have access to (part of) the workings of our mind, but are selectively conscious of only a limited subset**.** Details that become conscious are those we access, or attend to. This is comparable to visual experience, in which we have the illusion of seeing the full visual field all at once but what we actually see is what we choose to, or that which demands our attention, both in terms of where we fixate and what we perceive.

Distinctions between the conscious, subconscious and unconscious are illustrated well by Stanislas Dehaene and Lionel Naccache's (2001) 'global workspace model' of cognitive accessibility (the 'workspace' here is synonymous with WM). The workspace hypothesis assumes attention to be a "pre-requisite of consciousness" (2001: 1) and therefore also of verbal reporting[1]. They define three levels of 'accessibility': 'set I1', permanently inaccessible; 'set I2', in contact with the workspace (could be consciously amplified if attended); and 'set I3', actually mobilised into the workspace (2001: 30)[2]. Obviously, within I3 there will still be an unreported subset. These categories are represented in figure 67. The contents of I3 (and possibly I2) are still available to retrospective recall, especially immediately after the task.

1. Dehaene later concedes that attention and consciousness are different processes, particularly in regard to their top-down influence on subliminal processing (Dehaene et al. 2006: 207). Nevertheless, conscious experience is influenced by attention.

2. Dehaene et al. (2006) propose a tri-part model of cognitive processing, suggesting three categories: subliminal, preconscious and conscious, which correspond to categories I1, I2 and I3. They offer extensive neuro-scientific evidence for these distinctions and their relationships.

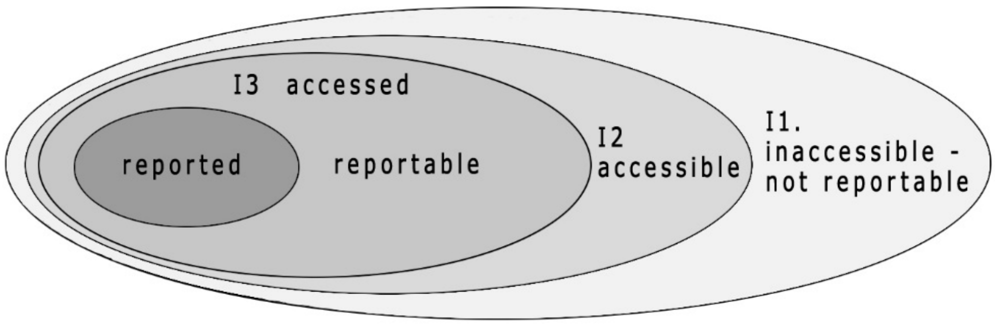


Figure 67. Three categories of accessibility, as defined by Dehaene & Naccache (2001). These relate to the three subsets of reportability.

Dehaene and Naccache describe the content of I3 as ‘amplified’: as in visual attention, the act of accessing (literally, in neural terms) amplifies that which is accessed. As it is ‘held’ in WM, more cognitive resources are devoted to it, and more persistently. I2 is not amplified, but remains within reach of I3.

If we think of this distinction between I3 and I1 in relation to the serial/parallel distinction (described in chapter 4: attention and WM operate in series, while unconscious processing can occur in parallel, see section 4.4), we can consider I3 to be serially processed, and I1 to be parallel processed . Although Dehaene and Naccache do not address this directly, it follows that I2 is processed in parallel *unless it is accessed*, offering an array of activity within the reach of attentional selection. I2 is then the ‘grey area’, including routine processing that can occur more or less automatically but is still potentially conscious (pre-conscious, to use Dehaene et al.s’ term). According to dual processing theory, when things are familiar and running smoothly, there is no need for conscious interference with parallel processing. It is when there is novelty, or possibility for error, that the conscious mind steps in to take an executive lead, serialising activity in order to devote more resources to it. In these terms, it makes sense to be unconscious of as much as possible, allowing more efficient parallel processing, and to reserve WM activity for non-routine elements. We can therefore consider what would be treated consciously by virtue of novelty or deliberately directed attention: bottom up and top down factors (respectively) that govern the conscious/subconscious divide.

7.2.3 What type of cognitive processes occur subconsciously

As described in chapter 4 (section 4.1), neuro-scientific evidence points to different *strengths* of cortical activation associated with conscious and unconscious cognition (Dehaene et al., 2006, review recent studies of this). Conscious activity is associated with electrical resonance above a threshold amount. Frontal cortex can intervene to maintain this neural resonance as 'persistence' through feedback (Sligte et al. 2008 describe various stages of persistence).

Conscious processing is, therefore, not *necessarily* of a different variety to unconscious processing. Rather, it involves stronger neural signals. Frontal activity plays an active 'executive' role, influencing working memory by amplifying or inhibiting sensory information or retrieving memory. This is done in order to moderate cognitive operations, usually orienting activity towards a non-routine task related goal. It can also function to monitor, postpone or interrupt automatic routinised behaviours in order to explore alternative ones.

Stronger neural activity is not necessarily *better;* Dehaene and Naccache (2001) describe how, as images become familiar and tasks become proceduralised, they are processed more efficiently (with weaker resonance) and frontal activity is minimised, freed for other (non-routine) tasks. Neural pathways become reinforced by activity, particularly if prolonged or repeated. This is how the brain becomes familiar, commits knowledge to long-term memory (LTM), 'learns' routines, procedures and fixed action patterns, and even gains a sense of what typical examples of things would be like (through repeated exposure to many instances). In this way, the structure of the neural substrate is determined by prior experience, neural signals passing more easily through familiar pathways than novel ones, as the following section explains.

7.2.3.1 Knowledge is the substrate for thought processes

Knowledge can be considered distinct from cognitive processing, be it conscious or unconscious, in the sense that it still 'exists', even when not active, in the physical structure of the brain. When we perceive or recall something, this activates a particular pattern of synaptic connections (a neural network). Each neural net is also part of wider overlapping patterns of connectivity. Repeated synchronous stimulation of connecting neurons reinforces (potentiates) the synapses associating them. As a result their 'potential' for future activation is heightened. That is, they require only a weaker signal to trigger firing (see Brown et al. 1988; Miyashita 1988; Lynch 2004 for detailed accounts of long-term potentiation in the cortex and hippocampus). In this way, memory and behaviour patterns are encoded by way of modified synaptic potentials and novelty activates unusual neural pathways. As Dehaene et al. describe, knowledge is "stored in a latent form as synaptic efficacies" (2006: 209).

In neural terms, we can think of knowledge as embedded in the neural substrate. Its structure is formed iteratively by repeated activation of neural networks, and is the cumulative result of experience[3]. Furthermore, behaviours and memories can be positively or negatively reinforced (through reward, via synaptic potentiation in the hippocampus and other brain regions). This understanding allows us, in a literal sense, to think of experiential knowledge as the substrate through which new information is received and thought processes occur. As Vinod Goel notes (citing Cassirer): "man does not respond to the environment per se, but to some complex interaction between the environment and the contents of his internal knowledge states" (Goel 1995: 17). This takes place in a more pronounced way at higher orders of vision – earlier stages being associated with feature detection, rather than recognition. Accrued visual knowledge enables us to recognise particular objects and individuals, and types of thing (such as the human head). That is, we also accrue schema by way of generalised sets of invariant properties; these function as generic or archetypal templates of common things, enabling recognition.

In this way, visual recognition, and therefore judgement (of the drawing), operates statistically. Thought processes, such as judgement or decision-making, are not necessarily dependent on recall of schematic knowledge. To use the language of dual process theory, we can recall knowledge in order to make conscious 'system 2' judgements, but we don't have to retrieve knowledge in order that it influence an intuitive 'system 1' judgement. In this way, knowledge and experience implicitly influence judgement, for example on whether a drawing feels as it is intended to.

So images can feel correct if they correspond to existing patterns of prior knowledge, or they may jar with those and seem counter-intuitive. Things appear familiar or novel, correct or incorrect, in a similar way (novelty corresponds to greater neural activation) and this can occur very quickly and without explicit recall. This explains how it is that one can make a snap judgement (that a drawing is going well) without necessarily being able to explain why: the artists were judging their drawings

[3] (Cloutier, Kelley and Heatherton 2011, provide a good example of the neural-behavioural relationship in their account of the effects of knowledge and familiarity on the neural substrates of face perception. See Bliss & Collingridge 1993, for a more thorough discussion of ideas around synaptic potentiation and memory, also Vartanian & Mandel 2011; and Martin, Grimwood & Morris 2000, for more general neural accounts of memory and decision-making.)

very quickly based on gestalt knowledge. Judgements that lead to some erasures or changes may have seemed slower, but this was due to the process of analysing, rather than recognising, the problem. So, while the artists were able to describe what they would change (e.g. 'I need to reassess the shape of the nose […] in relation to the rest of the head'), their explanations omitted the rich contextual knowledge (and the aesthetic intention) that influenced the initial judgement.

Procedural knowledge operates in much the same way, with familiar routines influencing actions implicitly. The notion of 'overlearning' is interesting in relation to this (continuing to repeat something after it has been committed to memory). This is said to lead to 'automaticity' (Rohrer et al., 2004). As in Anderson's 'three-stage model' of skill acquisition, attention to more basic details of a task becomes unnecessary as learning progresses. Of course, to think of a task as fully 'automatic' is to consider it finite, and skill acquisition in drawing practice can continue to build indefinitely. 'Automation' allows room for more complex experimentation and development. It is also said that, with overlearning, "the individual components of a task become relatively inaccessible to consciousness and therefore *unavailable to serve as evidence of task competence*" (Langer & Imber 1979, emphasis added)[4.]

The artists in this study appeared to have a 'feeling of knowing' their own abilities, and spoke confidently in their retrospective reports. After the drawing ended, they were able to describe, or at least rationalise, when prompted, the thought processes behind some of their decisions. They described measurement systems, ways in which they abstracted shapes, progressive sequences for staging the process, and the motivation behind their strategies. This thinking was accessible to consciousness after the fact, although the reasoning above tells us that we should still consider the most fundamental and familiar knowledge, the most difficult to access, the furthest from attentional 'reach'. We should also acknowledge (like Nelson et al. 1982) that, while there may still be a 'feeling of knowing' that accompanies competence, recall is not necessarily a 'predictor of performance': it does not equate to learning.

Thought processes are dependent on knowledge, albeit a potentially self-controlled and partial set of knowledge. Knowledge that need not be consciously accessed to play a key role in thought processes can be considered tacit or implicit. It reveals itself in our skills, informed judgements and decisions, and yet can elude our rational, conscious mind. This understanding can inform an

---

4 This was presented in a negative light, but that was clearly a problem with the notion of 'evidence', rather than competence, which could be demonstrated practically.

interpretation of the artists' reports, as we can consider longer-standing knowledge to be likely to be omitted, although possibly still accessible.

7.2.3.2 Processes become implicit with time

This relationship (described above) blurs the boundary between knowledge and thought process. It means our ability to 'think' is mediated by prior knowledge and experience, and our ability to learn new 'routines' relies on simpler ones having migrated to the subconscious in order for more sophisticated goals to be pursued. It is expectable, therefore, that attention is naturally being paid to the most unfamiliar and taxing processes, amplifying components and allocating WM capacity in order to process them in series. So, we can consider the conscious peak of the cognitive 'iceberg' to be associated with learning and novelty and, indeed, to *effort*.

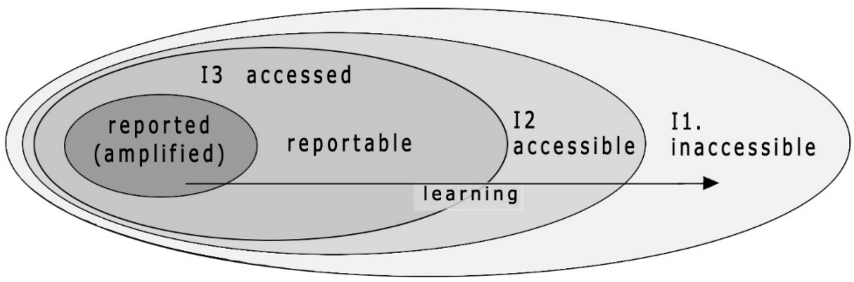


Figure 68. That which was learned most recently is most readily available to access, while routinised activity migrates to the subconscious or unconscious, moving towards the inaccessible category.

Figure 68 proposes a continuum of accessibility and reportability, in which attention guides learning, and the most recently learned is the most easily accessible. This leaves established knowledge and proceduralised skills less effortful to perform, less conscious, and less likely to be reported. Knowledge that becomes inaccessible can be thought of as 'tacit', as can processing that occurs inaccessibly. This is also commensurate with the third stage of Anderson's 'three stage model' of skill acquisition, in which the learner no longer needs to talk themselves through a process internally (as in the second stage) but can perform tasks more automatically.

Unconscious processing is more efficient, effectively involving less neural activity. Solso's (2001) fMRI study of drawing process demonstrated that, compared with novices, experienced drawers showed *less* activity in their visual cortex while drawing. One might assume that less neural activity equates to a less complex thought process, but that is not exactly the case. It corresponds to more *efficient* activity, which draws from deeper knowledge and more extensive experience. Such knowledge does not require conscious recall in order to influence behaviour or thinking, it does so directly.

This is consistent with Ericsson's observation (noted in chapter 2) that as "individuals change and improve their performance they appear able to verbalize their thought processes *during learning***"** (Ericsson 2006: 237, emphasis added). In other words, we can expect verbal reports to be concerned with the non-routine aspects of a task that are currently being developed.

Given this, we should consider what is brought to consciousness and what is verbalised to be matters of both experience (ability) and choice. Experience dictates what occurs routinely and what is *available* to conscious access. Of this, what is consciously accessed during a task is a matter of choice, i.e., which elements of the process to develop further and how. After this, selecting what to actually report will be governed by what the individual deems most important or relevant to the listener. That which requires most attention is most likely to be reported, and this will relate strongly to the immediate aims for that drawing, i.e., what the artist is trying to achieve.

7.2.3.3 What were the artists doing consciously?

Experienced artists' abilities will involve much that is well practiced and proceduralised, requiring little attention and perhaps even being unavailable to consciousness. We might call this their 'comfort zone'. In more positive terms, we can think of it as the tacit element, their goals and concerns lying just beyond this in a more conscious realm. These goals drive cognitive operations and also guide attention by influencing more implicit pre-attentive mechanisms, for example, by providing criteria for judgements. As there are likely to be many such criteria involved with drawing, it makes sense for these to be processed in parallel when possible. Arguably, the greater the number or specificity of criteria, the more sophisticated the resulting drawing will be.

For example, Connolly's concurrent report reflects the type of representation he was striving for. Having long mastered more basic elements such as measurement systems (described in his retrospective report), he was able to focus on more complex tactile and structural aspects (such as ‘fleshiness’) and, later in the drawing, also affective elements (a ‘forlorn expression’). His comments were referring to the specific qualities he was *aiming* to represent, and to those he recognised in the drawing that had *emerged* from more piecemeal actions (with respect to constructive and reflective phases of activity). Overall, he was pushing the drawing towards conveying certain qualities through planning and evaluation. In a broader sense, he was also slowly improving his ability to execute drawings with these qualities.

Roberts’ concurrent report includes judgements about how the drawing is progressing. These vary between general comments (‘I’m happy about the general structure of the head now’) and more specific ones (‘Fix the neck a minute, to make sure I’ve got the head sitting in the neck convincingly’), but still there are many details omitted from such statements. What, in particular, needed fixing was not stated although it was obviously considered as she proceeded to re-measure particular aspects (measurements and relationships) with confidence. This indicates that her explicit decision making process alluded to a much more complex and subtle thought process, and that her linguistic/propositional mind was recruited in monitoring how the drawing was progressing, rather than facilitating more piecemeal tasks. This is also evidenced by the fact that she was able to chat through much of the drawing process (during the constructive phases) without a detrimental effect on her concentration.

Cobley demonstrated a similar approach, beginning quickly and generally with a degree of automaticity. He reports how he is mapping general areas of the head (‘searching it out’), with the drawing emerging from many marks that vary in certainty and definition. Occasionally he notes resolutions: ‘now somehow, the head’s settled into position’. He also reports being ‘aware of the skull underneath’ and ‘the light’. So, like Connolly, his attention was recruited in monitoring how the drawing was emerging, being aware of certain aspects of the underlying structure and the lighting, while his drawing actions proceeded (at least in part) automatically. This makes sense as, although his work relies on accurate spatial measurements, beyond this it is also concerned with subtle qualities of light, and this is visible in his paintings.

Brew, on the other hand, included many fine details in her concurrent report. She elabourately described her measurements while drawing very slowly (e.g. ‘I’m drawing a line that slopes down and then I’m looking at how that connects to the first line I drew.’ ‘I’m drawing the edge of my eyeball and lining it up with the highest point of this line here’). Arguably, the slowness of her process (and the additional slowing effect of the reporting task) allowed for this level of detail to be reported. It also allows for this level of detail to be attended in her usual approach. She describes in her retrospective report how this small scale of detail is part of her strategy to ‘sync eye and hand’.

Events at this scale would occur too quickly to be duly noted in Robert's quicker, more intuitive approach.

We can see that the content of the concurrent reports differed because of the artists' differing intentions, and these were also a factor in the speed at which they drew. In a sense, these represent two opposite approaches: one which employs quicker, more automatic mark making to allow the drawing to emerge, while maintaining an awareness of certain key qualities; the other which employs slow, methodical, step-by-step measurements and actions that recruit conscious resources in the small scale of the activity. In doing so, the drawings are subject to fewer revisions. This is a good illustration of what Kahneman was referring to by 'thinking, fast and slow'. So, while processes become implicit with practice, there is still a range of levels at which we can choose to allocate attentional resources.

7.2.3.4 Drawing involves access to pre-attentive visual processes

The section above describes how processes become implicit with time. This is relevant not only in regard to learning to draw, but also learning to see. While most of us learn to see as adults, there was nevertheless a time when we had to learn how to see. Studies of newly sighted people (by Sinha, discussed in section 4.1.4) demonstrate how learning to see involves first integrating edge extraction to form coherent shapes, then inferring shape from shade, differentiating objects from their surroundings, and so on. Object recognition is the last stage to be mastered as it relies on the previous ones, which become inaccessible to consciousness with time. This occurs during infancy for most people, so learning to see is a perfect example of an ability that has become almost entirely automatised, to the point where it is not consciously accessible.

Large parts of visual processing have been designated 'pre-attentive' and 'non-selective' with various pre-attentive, and even semi-attentive, stages posited to explain the subconscious processing that underlies recognition (see section 4.1). However, the artists in this study demonstrated a high degree of understanding of visual processing. This is evident, partly through their retrospective reports that detail their methods for visual deconstruction, which entail perceiving visual features of a lower order: features that normally contribute to recognition and gist perception pre-attentively. To use Cheng and Patchella's terms, they selectively attend to features of a lower degree of correspondence between physical and psychological dimensions. There also appears to be an awareness of how statistical properties (as opposed to individual features) contribute to gist processing. Cobley's drawing process demonstrated this, in the way that he would sometimes use rough or uniform marks over the whole page, or large portions of it.

This ability to engage with pre-attentive processes can also be interpreted as one sense of the 'innocent eye', as Ruskin defines it: "flat stains of colour, merely as such, without consciousness of what they signify — as a blind man would see them if suddenly gifted with sight" (Ruskin 1991 [1857]: 3). The parallels between his description and Sinha's is striking. In addition to this, revising a drawing must entail an awareness of *how* lower order features contribute to recognition and gist, or at least the ability to identify errors at that level, to understand which areas or relationships require re-measurement in order for the representation to be more successful, as in Gombrich's 'making precedes matching'. That is, revising the drawing entails both the *ability* to selectively focus on low order features, and *knowledge* of how lower orders of visual processing contribute to higher ones.

The drawing strategies themselves can also be seen as evidence of access to visual mechanisms usually designated pre-attentive. As discussed in chapter 6, the ability to devise and perform individual strategies for drawing must entail a tacit understanding of perception. Through drawing, the artists are applying this understanding: of their capacity for attentional selection by feature type; the limits of their working memory capacity and the competition between perception and memory. It is fair to say that the artists drawing processes demonstrate a degree of access to (or at least *awareness* of) their visual processes. Even if this is not declarative, it is able to inform their actions and strategies. Those in Sinha's study who had only recently gained sight could recall the stages of the process, but the artists in this study had the ability to *apply* their understanding of vision to practical drawing strategies. So, in addition to schematic visual knowledge, there is also an implicit knowledge *of vision,* involved with drawing expertise. It is safe to assume that this knowledge was gained (at least in part) through drawing practice, and that drawing represents a way of becoming reacquainted with lower-order visual processing. It also follows that learning about visual processing by other (theoretical or demonstrative) means may also inform drawing practice.

7.2.4 Concurrent verbalisation involves attentional selection

The sections above outlined distinctions between what would have occurred consciously and sub-consciously in the drawing process. From this, we can deduce that the verbal reports omit much that is nevertheless accessible. An ideal concurrent verbalisation can be expected to pertain only to the most *recent* developments in the artists' drawing strategies, as those are most readily accessible, with ‘umbrella terms’ labelling chunked processes. However, the artists were also mentioning more routine elements (e.g. measurements and measurement systems) that may well have otherwise occurred automatically. Such familiar routines were likely reported because of an awareness of their importance to the drawing strategy, perhaps also due to episodic memories of having learned those routines.

For this kind of reporting, the artist would have been attending to processes that were accessible (parallel), but may not have been consciously accessed (in series) in the absence of the report. Figure 69 offers an expanded version of Ericsson and Simon’s (1993) serial model of think aloud verbalisations (see section 2.4) that accounts for parallel processing with a ‘selective attentional bottleneck’ (see section 4.2). The parallel processes would include ‘chunked’ information and proceduralised routines (or ‘scaffolding storage network’ see section 4.2.4) as well as multi-modal activity. Multi-modal processes may include propositional/verbal thinking, more easily verbalised (as in type one vocalisations).

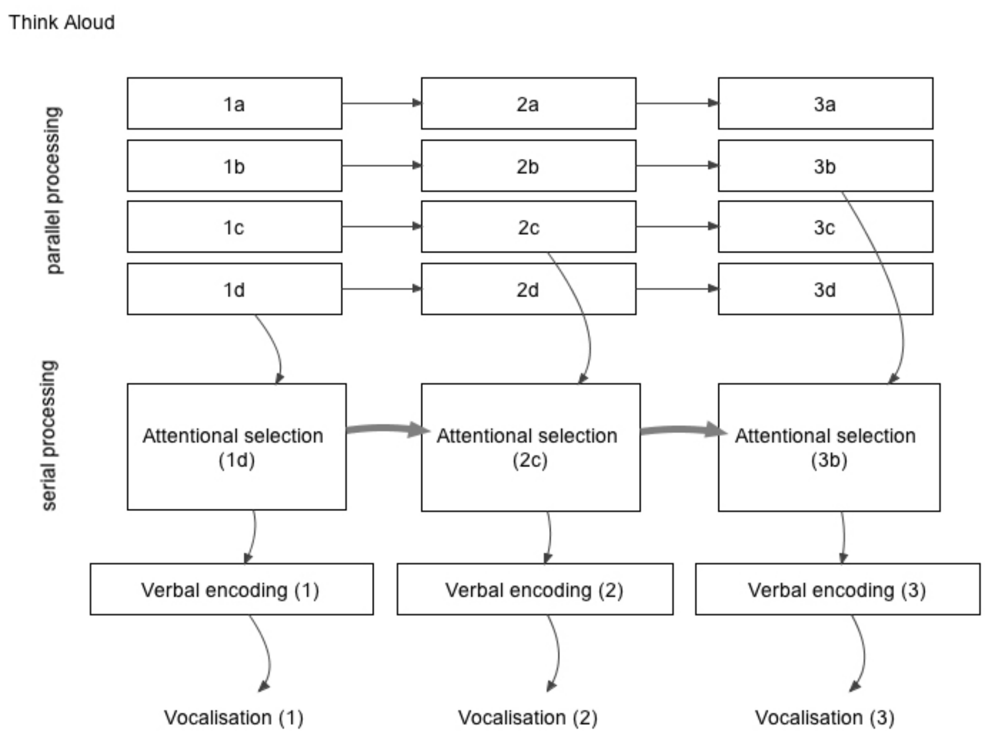


Figure 69. Think aloud protocols must also involve serial attentional selection from (accessible) parallel processing, in addition to Ericsson and Simon’s serial model of type-two verbalisation,. (adapted from Ericsson & Simon 1993)

Parallel aspects selected would be amplified by attention, influencing further stages. This highlights the possibility that attending and verbalising can influence the cognitive activity as well as revealing it. Ideally this would be a constructive function of attention, facilitating non-routing planning, but there is also potential for digression here as, in addition to routine drawing processes, there will also be potential distractors among the parallel processing (perhaps influenced by the presence of an observer).

The concurrent reports did contain digressions, parts of the drawing would sometimes be reminiscent of episodes or topics the artists wished to recall or discuss. While it's inconclusive whether these digressions were *caused by* the reports, it's fair to assume that being asked to talk continuously will likely present this as a problem, particularly if the verbalising task is poorly understood or if the artist has their own agenda about what they want to talk about. However, in Roberts' drawing, unrelated distractions usually functioned as part of the overall drawing strategy. That is, while talking about unrelated matters, the tacit element of the process proceeds in parallel (intuitively), and so unrelated thoughts can actually play a role – functioning to distract or inhibit other thoughts and, in doing so, facilitate intuitive action.

7.2.5 Summary

Given the above, we can deduce that the concurrent verbal reports point to aspects of the drawing the artist is currently grappling with and/or aspects they consider relevant to an account of their process, as well as possible digressions. That which is omitted from the reports reflects the extent of the proceduralisation of the skill – the tacit element – although this is still, at least partially, available for retrospective recall. This tacit element will include proceduralised routines and the majority of personal criteria by which the ongoing drawing is assessed. The explicit element guides non-routine activity and monitors routine activity.

In specific cases there will always be individual factors, for example a participant might be subject to inferential bias, they might repeat accounts they previously gave elsewhere, or even use others' words they recall, they might also recount phrases used in their own drawing instruction. It is difficult to discern if this is happening and so, on the whole, the reports cannot be considered impartial, or even true verbalisations throughout. However, the above account predicts the type of content we can expect in genuine type one and two verbalisations. This offers a pragmatic perspective from which to view the verbal reports in this study: partial and skewed towards the individual aims and sub-goals of the artist, omitting much of the 'tacit' element.

7.3 Potential effects of verbalisation on drawing performance and learning

The analysis above raises a complicating factor: that the act of verbalising, or even internally and silently 'talking' through activity, affects the allocation of attention and has the capacity to *influence* what is brought to mind and what can happen next. We cannot, therefore, consider verbal reporting a neutral process. While any biasing effect may be undesirable in a methodological sense (i.e., if the tool for measurement influences that which is measured), the potential effects of verbalisation are nevertheless interesting in themselves, in that they are relevant, and potentially beneficial, to learning situations. As Ericsson and Simon (1993) recommend, we should aim to understand the (often beneficial) effects of verbal reports and, by implication, of encouraging students to explain their actions. They review studies of the role of verbalisation in the extension of learning.

Attentional amplification of cognitive processes influences the following stages, and the extent to which those processes are committed to memory (by virtue of the strength and depth of processing, see Craik & Lockheart 1990). It follows that verbalistion can be a powerful tool for learning and skill acquisition. This is reflected by various findings indicating improved performance both during and after verbalised problem solving trials. Both concurrent verbalisation and retrospective explanation have been demonstrated to facilitate enhanced learning and task performance (Gagné & Smith 1962). These positive performance effects have been studied in most depth in relation to music (see Chaffin & Imreh 1997; Nielsen 1999).

The influential role of verbalisation in *guiding* attention, described above, indicates potentially fruitful uses of verbal reporting methods in drawing development/skill acquisition. However, (as Edwards alluded) speaking or internal verbalisation can also cause digressions or distractions, and may even arrest activity entirely if the task of translating thoughts into words is too taxing, or if a clear strategy is lacking to begin with.

Whether the reporting task had a positive or negative effect on drawing performance in this study is inconclusive (any performance or learning effect would be difficult to determine without a longitudinal study). Early trials in which the artists were practising the verbalisation technique were sometimes detrimental to the drawing (in the artists' own opinions, particularly Roberts' as discussed in section 3.5). Beyond that, the artists reported drawing ‘as they usually would’ although they indicated that they still found the concurrent reports difficult. Certainly, the reporting task *slowed* the drawing process down but this is expectable in PA studies.

7.3.1 Implications for drawing instruction

The understanding of conscious access and reporting presented above indicates that concurrent reports entail a *potential* performance effect, be it negative or positive. The slowing down observed in the case studies is due to the additional processing required in generating the report, which could function to either focus or distract the drawer, depending on which aspects they verbalise and whether they have adequate vocabulary to describe them. An undesirable effect would be to divert the drawer, either with unrelated matters or with an untimely appraisal of the drawing. A desirable effect would be to focus attention selectively on a relevant aspect of the drawing; on certain visual features, qualities, measurements; or to help ‘hold’ in mind the current task-related sub-goal while preventing distractors from interfering. Which of these effects occurs would be a result of the specific content of the report, and the drawer’s engagement with the drawing process. If a novice drawer were uncertain about their process or strategy, an open ended verbalisation would likely be too distracting. A more guided verbalisation may be helpful in maintaining attention and inhibiting other distractors.

The detrimental *or* beneficial effects of talking during drawing are an important consideration for drawing tutors. Directed verbalisations could be useful tools in learning situations, either in demonstrations (by the tutor) or as instructions (eliciting reports from the student). They might also be used in formative assessment, that is, to identify stumbling points or misunderstandings, and ascertain the level of the student’s understanding and the clarity of their drawing strategy.

Novices are uncertain about drawing process to begin with, and so the instruction to simply talk through the process would only add to the difficulty of the task. However, more specific instructions can encourage more focused drawing activity, such as talking through measurements or describing a particular kind of visual feature or quality as it is being drawn. For novices, slowing the drawing process down by eliciting verbal reports could provide the basis for more methodical practice, allowing mental ‘space’ for more careful measurements. Directing the content of the reports would allow shifts in attention to be guided; for example, from general to specific feature values. Guided verbalisations could also help to facilitate appropriate shifting between constructive and reflective modes. Periods of concentrated effort can therefore be facilitated by concurrent verbalisations in this way, focusing cognitive resources on pressing forward with each highly specified drawing task in turn, while inhibiting distraction.

This is in keeping with Anderson's (1982)'three stage' model of skill acquisition, which emphasises the role of the tutor in verbally guiding activity in the early stages of learning, and the learner's own 'talking through' of processes in the second stage. Suggested labelling of behaviours and strategies can contribute to more effective verbalisations, and more confident drawing process. Verbally labelling visual features beyond their usual designations (i.e., specific values and measurements, rather than general labels like 'nose' or 'ear') can also help develop awareness of selective attentional capacities, while simultaneously helping to maintain attention in the constructive phase (postponing judgement). Further to this, chatting as distraction can also be used as a tool to help students 'let go' temporarily, as Roberts did, and rely more intuitively on their routinised practices.

The value of these suggested practices is not categorically investigated by the present study, but the combined evidence indicates that these would be fruitful avenues of enquiry for pedagogic development. The framework offered in the present study could provide a logical basis for verbally guiding students through a range of drawing strategies. Also, the verbal reports of experienced artists – such as those given in this study – can themselves be tested as teaching tools, demonstrating and elucidating differing strategies and approaches to drawing. Offering students such a range of strategies, and a framework within which to compare them, would ultimately put the student in a position to gain ownership of the learning experience by experimenting with and devising their own strategies, and comparing their approach to others' in terms of process and intention as well as outcome.

Clearly, the psychological terminology used to formally describe cognitive strategies would not usually be appropriate to use in the classroom. Language familiar to the student, or terms they devise themselves, would be preferable. However, a cognitive understanding can still help to clarify *what* precisely those terms refer to, and when it is appropriate to use them. Labelling requires further consideration, as this too appears to be a factor in the routinisation of processes, and their becoming tacit.

7.3.2 Proceduralisation and labelling

Artists' descriptions of their activity are affected not only by choice and experience, but also by the migration of learning to the subconscious or unconscious, as described above. As routines and action patterns become familiar, single words may be used to denote ever more complex elements of drawing strategy. We might therefore question whether proceduralised routines are actually *omitted* from the reports, or whether they may instead be included under umbrella terms, which omit detail but still indicate that the artist is aware of carrying them out. For example, there are instances in which the artists refer to using measurement techniques such as ‘plumb lines’, without describing the process in full. There may, of course, be aspects that are omitted entirely, but the encompassing nature of umbrella terms is significant as it indicates an awareness that need not include fine detail. Again, an analogy can be made with vision: we can recognise a familiar object without consciously attending to every detail that renders it recognisable, just as we can be aware that we are carrying out a familiar task without needing to consciously think of every detail. This may seem self-evident, but it is an important consideration when labelling students’ drawing activities and strategies. It is all too easy for an expert to use umbrella terms of an order of complexity beyond the reach of the learner with apparently ambiguous instructions, leaving them baffled or even disrupting progress they may have been otherwise making. Encouraging students to reflectively label their own strategies and processes would therefore be an ideal approach, particularly with groups of mixed ability.

The potential use of open ended concurrent verbalisation tasks to facilitate drawing pre-supposes a clear strategy and aim. To define it prior to starting would enable a more focused and helpful verbalisation. This, in turn, relies on the drawer being aware of their own limitations, both the general limitations of their perception, and the specific limitations of their existing skill-set (i.e., what is routine and what is not-yet routine). That kind of meta-knowledge can be facilitated by timely reflection on drawing activity after the fact. The role of the tutor can therefore be twofold: to ‘talk through’ drawing process, labelling strategies, goals and the visual features relating to them, and providing aims and objectives for specialised drawing tasks; or to strategically elicit concurrent verbalisation and retrospective discussion in order to guide and focus attention. Ultimately, to perform these two roles, with the aim of revealing a range of possible strategies, would help nurture the development of the student’s ability to recombine elements and *devise* appropriate drawing strategies to their own ends, rather than simply imitate taught techniques. Again, this is not only facilitated by labelling, but also by comparing drawing strategies.

So, provided the student has adequate labels with which to refer to visual features and elements of a clear strategy, we can consider verbal reporting a useful tool for drawing instruction. Rather than polarise the verbal and visual modalities as Edwards does (as discussed in section 1.3, she holds that visual and verbal modalities compete, and that verbal thinking interferes with drawing process), I propose that the active verbalisation can play a positive role in learning to draw, focusing attention and inhibiting distractors, as long as appropriate guidance is given as to what to verbalise and when. Verbalisation techniques have the potential to offer evidence of, and to influence, learning. However, it need not (or sometimes should not or *cannot*) reflect what has already been learned to a high degree of familiarity, i.e., that which occurs outside the reach of conscious access.

7.4 What occurs unconsciously in the act of drawing?

The previous sections described how the conscious mind is concerned with unfamiliar, new and effortful aspects of the drawing process; and that the verbal reports (when true type-two verbalisations) will favour the novel and non-routine, and, of course, the modalities more readily vocalised. The unconscious mind, deals with the routine, proceduralised or 'tacit' elements that can occur with little need for conscious monitoring or intervention. It was also noted that we should acknowledge the potential influence of verbalisation over the cognitive operations it reports

In terms of the specific examples offered in chapter 3, reported activities and details were conscious, but the omission of activities does not necessarily indicate that those were unconscious. The fact that 'umbrella terms' (i.e., terms that relate to chunked knowledge) represent complex thinking that can be further unpicked retrospectively suggests that the conscious mind has access to *degrees of resolution*, as vision does, and that drawing expertise involves the ability to operate while being aware of less and less detail concerning the complexity of mental operations. As described in the previous chapter, the (conscious) tip of the cognitive 'iceberg' remains fixed in capacity, but can become more sophisticated as more is committed to the subconscious – the 'underwater' part can grow indefinitely as skills are acquired. To further the analogy, *where the surface lies* is not fixed – it rises with learning and experience, and the 'umbrella terms' one uses are indicative of the level.

7.4.1 Attention, awareness and effort

What occurs consciously is a function of experience, yet actually defining or locating the conscious 'surface' remains illusive. That is, when cognition can be designated subconscious or unconscious is still a matter of debate. As described in the previous section, Dehaene and Nacacce's three-category model equates selective cognitive *access* (by WM) with consciousness (I3), *accessibility* with the subconscious (I2),and movement between I2 and I3 subject to cues such as task relevance or questioning. The authors equate cognitive *inaccessibility* with unconscious processing.

These distinctions, however, assume that WM (I3) contains the only 'conscious' activity, fed by attention, which is questionable. Notably, Ned Block argues for a reconsideration of the relationship between cognitive accessibility and phenomenal awareness, claiming that there are *inaccessible* aspects of phenomenal experience. Similarly to Dehaene and Nacacce, Block (2007) describes how, in order for cognitive processes to be reported, they need first to be consciously 'accessed'. However, he argues that *access* is not an essential part of the cognitive mechanisms underlying the phenomenal experience of perceiving or thinking[5]. In other words, attention does not equate to phenomenal consciousness. For Block, attentional access is a distinct process, separate from consciousness and not necessarily a pre-requisite of it. To continue the visual analogy, we can consider that which we see to be independent of our mechanism for looking at it. We might consider Wolfe et al.'s 'non-selective pathway' (see section 4.2.4.2) to be analogous to Block's distinction:.: there are factors other than attentional selection that present phenomena to consciousness, and we are able to have some background awareness of parallel processing.

Essentially, Block distinguishes between 'attentional access' and 'phenomenal consciousness', arguing that the latter includes that which is accessible but not accessed, and even overflows that which is accessible[6]. Figure 4 illustrates this distinction in relation to Dehane and Naccache's categories. This may be dismissed simply as a matter of designation (i.e., the definition of phenomenal consciousness), but Block's definition offers a much wider concept of *what the object of*

---

5. Koch and Tsuchiya (2007) offer evidence to support this distinction, showing attention and consciousness to be separable.

6. Clearly, the truth of Block's claim cannot be verified using verbal methods. Block presents evidence to support his claim, but counter-arguments are still being put forward (see Block 2007 for a more extensive account of these arguments).

study might be, in phenomenological or cognitive analyses, and further separates that which is actually reported from it.

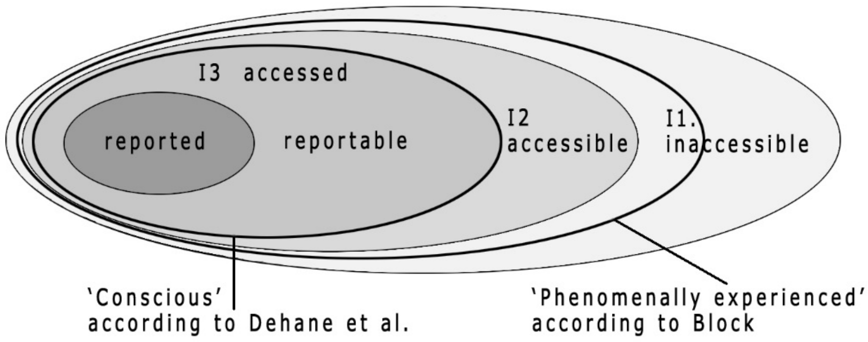


Figure 70. Comparing Block and Dehaene's definitions of consciousness. Block (2007) proposes a different boundary for the 'phenomenal', suggesting a category of cognition which is experienced, but not accessible to attention or working memory.

In the light of this definition of conscious awareness, we should consider the artists' phenomenal experiences of drawing to be far richer than any verbal report could ever describe. It also presupposes much of the unreported subset of cognitive activity to be subject to some form of potential or actual phenomenal awareness.

The implication here is that our phenomenal experience includes a level of awareness of what is within attentional reach, and also some elements we cannot attend to. How then are we 'aware' of them? If we consider this in terms of the distinctions between attention and awareness described in chapter 4, I3 would be concrete and determinate, while I2 and I1 would constitute an increasingly vague background awareness that could become more 'visible' in the absence of otherwise demanding, overshadowing cognitive activity in attention and WM. That is, when cognitive capacity is not fully loaded, we can be aware of more of the background processing.

The previous chapter proposed a model of how attention and working memory can be allocated efficiently by experienced artists, but we should not assume that maximum efficiency is always desirable. Block's definition of phenomenal consciousness implies that a more automatic approach to drawing (that does not fully utilise cognitive resources all the time) may involve a different level of awareness, entailing a very different experience in which the artist may be more aware of the intuitive element of their process.

7.4.1.1 'Effortless' drawing

Block's ideas imply that some elements of the phenomenal experience of drawing lie outside of attentional access. They are simply present in the background, as it were. What method of drawing that might entail this type of awareness? As discussed above, the verbal reports reflect what is effortfully brought to attention. There must also be the possibility of drawing effortlessly, automatically, intuitively. Drawing within the comfort zone of already familiar procedures and routines. In other words, with *awareness* rather than attention. Such awareness would be disrupted if it were reported concurrently as that would, by definition, entail attentional selection.

We can interpret that Roberts used such an 'effortless' approach when she was unable to offer concurrent verbalisation. These were the periods in which her early attempts to verbalise led to her drawing in a different manner that she found displeasing. As discussed in chapter 3, Roberts described a certain spontaneity that she wanted her mark making to capture, with which the verbalisation interfered. This is reminiscent of Edwards' description of 'L-mode's 'censoring effect' but, as described in chapter 5, this interference was not due to the *linguistic* nature of the thinking *per se* (Roberts could still *chat*), but to its being concerned with the drawing itself.

To determine what Roberts was really *experiencing* during those periods of silent drawing would require a phenomenological study. Whether she was truly 'aware' of background processes in the sense described above is questionable, and the fact that she sometimes sought 'chat' as a method for distracting her attention suggests that she may simply have been diverting her attention, rather than relaxing it to a broader state of awareness (although she would not usually chat continuously). Either way, she certainly appeared to be relying on practiced drawing routines during periods between evaluative pauses, and she recognised and valued the intuitive nature of that activity.

Whether Roberts was distracting herself by chatting, or otherwise allowing her activity to occur intuitively, the *possibility* of such a mode of drawing allows us to consider the cognitive capacity differently: the capacity to monitor one's own thoughts includes both active and passive aspects - attention and awareness. Attention deliberately guides consciousness to specific non-routine activity occurring in WM, while awareness remains generalised and effortless. Attention can function to focus our efforts, but it may also be relaxed, in order to allow for more intuitive action. When we consider attention and awareness this way, we can regard cognitive capacity as having not only *plasticity* (that is parametrically constrained with an overall limit, as described in chapter 6) but also *elasticity*. Just as we can focus visual attention toward fine detail or gist, internal attention regarding our thought processes can similarly be focused tightly on a single cognitive operation, or focused loosely, allowing a more generalised holistic awareness that includes activity outside of WM. To focus tightly involves effort and facilitates cognition and skill acquisition. To focus loosely involves a certain freedom of action that relies on routine. While this ‘loose’ approach might be called ‘effortless’, it may nevertheless be difficult to discipline oneself to ‘let go’ in such a way, and to do so is to create space for additional activity. *This too, can then be considered an element of drawing expertise – the ability to draw intuitively* relying on routines and action patterns established through experience. This is what Hale was referring to when he noted that in drawing the ‘subconscious mind takes care of a good deal’ (1989) and is an example of the type of knowledge and ability Polanyi referred to as the ‘instrumental’ aspect of the ‘tacit dimension’ (1966).

7.5 The tacit dimension

The analysis above describes how conscious processing is novel and effortful, while subconscious or unconscious processing is automatic. Pre-attentional mechanisms that underpin cognitive strategies are below the conscious surface of drawing process, and are informed by knowledge of the visual world and by a certain level of self-awareness regarding one's own attentional capacities. This constitutes what we can consider ‘tacit’. Both constructive and reflective phases of drawing involve tacit dimensions. One that filters the visual and translates it into action; another that provides aesthetic sensibilities, to inform strategic decisions and guide the drawing towards its final appearance. Of the two, the constructive mode is harder to elucidate (the case studies included only visual descriptions and nothing of the mechanisms that facilitate attentional selection).

Chapter 3 proposed that the ability to control the *timing* of each mode – the ability to temporarily postpone judgement to allow for more fully visual engagement – is a crucial aspect of drawing expertise. The ability to time this carefully represents a significant level of cognitive meta-control that the artists did not mention in their reports although it was demonstrated. Again, we can consider this meta-control a tacit element that may be disrupted by concurrent verbalisation. (As discussed in section 3.5, the constructive mode is potentially disrupted by propositional thinking and critical reflection). Strictly speaking, it is not *language* that disrupts this mode of drawing (as discussed section 7.3, language can be neutral, or even help to maintain a visual focus), but its reflective content (regarding the drawing itself).

So the tacit dimension includes activity that cannot be reported concurrently (but could be reported retrospectively), as well as activity that cannot be processed at all. We should therefore consider that while talking *through* drawing process may be helpful (or detrimental, in the ways described above), talking *about* drawing can never address the full picture, and the ability to describe drawing process is not commensurate with ability.

7.6 Conclusion: evaluating verbal methods

The verbal reporting methods used for this project allowed insights into the artists drawing strategies, enabling a better interpretation of behavioural evidence. Comparison between the verbalised and non-verbalised conditions also revealed how the reporting process slowed down the drawing process in particular ways (described in section 3.5). The artists' responses to the task also revealed some insights into what types of verbal activity were possible in tandem with drawing. Indirectly, this also shed light on the cognitive processes underlying the drawing task. However, despite these insights, verbal methods raise many issues, as this chapter has discussed.

Whatever definition of consciousness we adopt, we can presume that verbal reports alone cannot provide a full or definitive answer to questions regarding what cognitive strategies underlie drawing process, or which occur consciously. The reports are incomplete, omitting detail and tacit elements, but have credibility as partial data, especially when combined and/or contrasted with other sources. The specific *content* of concurrent reports, when elicited effectively, does reflect the artists' efforts, their aims, aspects of the skill they grapple with, as well as learning, and what they consider to be important about their process.

This picture frames verbal reporting as a useful tool in cognitive studies of drawing, but one to be treated with caution. It cannot be applied as straightforwardly to drawing as it can to more naturally propositional thinking, since other modalities must be accounted for. Any verbal report of drawing activity can reflect only a fraction of the cognitive activity it would be possible to report, and therefore the agency of both the subject and the researcher must be accounted for in the way the verbal reports are elicited.

The open ended instructions typically used in PA to elicit reports (e.g. 'please think aloud') offered some insights in this study regarding what it is possible to elucidate. Their incomplete nature means that concurrent reporting methods would be of limited usefulness to more extensive studies of drawing process. Studies with a specific hypothesis would require more focused questioning, to narrow the range of possible responses on the drawer's behalf. In such cases, the influence of the concurrent reporting activity would render the reports potentially invalid, as any specific focus would be likely to affect the drawing process in a manner relevant to the hypothesis. Retrospective reporting with directed questioning would therefore be a preferable method, in most cases.

Concomitantly, the potential for the reporting process to interfere with drawing activity (by influencing the allocation of attentional resources) can be useful. Skill acquisition results from effort. Effort can be focused and effective, or misguided and meandering. Guided verbalisation could provide a useful method of facilitating effort. Whether talking while drawing is helpful or unhelpful will depend on a number of factors: the order of complexity of labels given to drawing actions and sub-routines (which should be congruous with the students' skill level); and the type of drawing activity taking place (constructive or reflective) will determine what type of talking the individual is able to deal with concurrently (as we saw in chapter 3); talking during the constructive mode should be limited to visual description, with evaluative and strategic discussion reserved for intermittent periods . Visual description or even unrelated chatting could provide a tool to focus and facilitate attentional strategies, or as a distractor to allow more intuitive mark making and prevent untimely evaluation. However, verbal activity can only be helpful in this way if it is used within the framework of a guiding strategy for drawing, be it one dictated by the tutor or devised by the student.

The concept of cognitive capacity having an *elastic* quality extends the previous 3D model of attention. This spatial metaphor allows us to view the drawing act as involving not only a rhythmic shifting of attentional focus back and forth in a number of dimensions (internally and externally, between levels of resolution, between featural dimensions, between longer and shorter timeframes), but also the possibility for a *stretching* and relaxing of attention and cognitive capacity, either pushing the drawing strategy into new territory, or proceeding more automatically. Drawing, therefore, exercises attentional control in these ways, and we can consider drawing expertise to include these abilities.

A high degree of attentional control, both perceptual and cognitive, as described here, would be beneficial in many scenarios beyond drawing. Whether or not these skills are actually transferable to other domains however, remains to be seen, and the following chapter considers this.

Chapter 8

Drawing: ‘the ultimate transferable skill’?

This study aimed to assess the cognitive basis of observational process, on the premise that this could inform debates around its educational value. One aspect of those debates is the notion of transferability. Here, I will briefly recount the cognitive elements of drawing skill identified in this study, and consider the potential for transfer to other domains.

This thesis presents observational drawing ability as involving complex cognitive strategies and a set of aptitudes that facilitate them. The strategic use of these aptitudes indicates an implicit awareness of some cognitive and perceptual abilities and limitations involved. Such an awareness is potentially useful in other situations. It is generally accepted that observational practice can inform other types of drawing and representational skills and sensibilities, as well as being a strategy for acquiring visual knowledge (this is briefly discussed in section 8.1), but what about domains that are not overtly visual? Could there be a broader range of target domains for this set of abilities? To prove this would require a longitudinal study or a larger scale study comparing samples of expert and novice drawers. While this study does not extend that far, it is still possible to consider this question in light of how transfer occurs and what facilitates it, as the following sections (8.2 to 8.5) discuss.

Elements of drawing skill might readily lend themselves to other tasks, but the extent to which this actually occurs for any given artist or student would be hard (if not impossible) to measure. Especially given that much of drawing skill and process is implicit or non-verbal, and also because opportunities to apply these abilities are many, varied, and do not only occur within the confines of educational assessment. However, the question of transferability remains, and is important to debates around the purpose and value of drawing instruction. Therefore, this chapter discusses transferability and analogical reasoning in order to assess the *potential* for transfer of drawing skill. Here I ask what it means for knowledge or thought processes to ‘transfer’. Drawing from the present study, and with reference to theoretical explanations in recent literature, we can ask in what ways observational drawing can be considered transferable, to what domains, and how such transfer may be facilitated.

8.1 Drawing beyond representation

Observational drawing is generally held to inform other representational tasks, such as painting, design, sketching etc. It is also sometimes described, as Ruskin did, as a way of engaging with the world to gain an understanding of it . The methodical visual engagement afforded by observational drawing allows insights into observable phenomena that may have otherwise passed by unnoticed. Lucy Lyons' research is a testament to this, showing how methodical observation is of value to the drawer's understanding (2012).

Observational practice can inform other drawing practices by allowing the drawer to build visual knowledge and a repertoire of representational conventions (as Gombrich described) that can be used for visualisation, to externalise thoughts on paper. Visualisation forms part of many activities which themselves facilitate cognition, both individual and collaborative (generating and testing ideas, exploring design solutions, etc.). Drawing of this kind can both inform and extend the mind, facilitating greater creativity and problem solving through situated cognition. Suwa and Tversky label the process of cyclically externalising and re-imagining as 'constructive perception' (2003). Tversky also more generally describes drawing as a 'tool for thought' (2011).

Drawing practices facilitate knowledge acquisition and cognitive skills, and these may be informed by observational practice. In this sense, it is certainly a transferable skill. *Perhaps there are also less obvious advantages which go beyond drawing activities*, to more global or generalised 'thinking skills'. While this matter is possibly too complex and dispersed to trace definitively, it is still possible to look at the cognitive elements of observational drawing skill and consider in what sense they might be transferable, and how that may occur.

8.2 What cognitive abilities and aptitudes does observational drawing entail?

The artists in this study demonstrated strategies for optimising cognitive resources (attentional, perceptual and WM) by working within limited parameters and time-frames to deconstruct and reconstruct imagery, while guiding and assessing the emerging drawing via balanced and routinised patterns of activity. These routines relied on:

- fine control of selective visual attention
- the ability to postpone judgement
- an implicit understanding of perceptual dimensions and constraints
- schematic visual and spatial knowledge regarding the appearance of things, and an understanding of which features are important to a representation and how
- the capacity to devise creative strategies (for constructing representations) and procedures.

Clearly, these abilities are potentially applicable to a wide range of scenarios, but very few comparative studies have been conducted to seek evidence of drawing skill transfer.

One such study (Seeley & Kozbelt 2008), compared artists (who draw) with non-artists, demonstrating that the artists did show some ‘perceptual advantages’. Seeley and Kozbelt propose that these advantages are limited to perceptual tasks that are *similar to drawing.* They showed artists to have skills that confer “an advantage in visual analysis, which consists of the ability to focus attention on sets of stimulus features” and enables ‘attentional strategies’ that “enhance the perceptual encoding of stimulus features diagnostic for the identity of objects and inhibit the perception of potential distractors” (2008: 153). They demonstrate these ‘perceptual advantages’ through psychometric testing, although those tests are limited, and so a broader range of target domains is not ruled out. Arguably, this correlation does not prove a causal relationship – those with existing ‘perceptual advantages’ may be more likely to take up drawing practice – but it seems evident that acquired drawing skills would be transferable to similar tasks.

Seeley & Kozbelt’s study offers evidence for transfer of perceptual abilities, but the abilities identified in the current study suggest a broader range of potential ‘advantages’ the drawer might make use of, as listed above. Further to this, it is possible that the range of domains in which these skills are applicable may be wider than Seeley and Kozbelt demonstrated in their study. As the following section describes, recent thinking around skill transfer points to *analogy* (not only similarity) as opportunity for transfer, i.e., skills may be transferable beyond visual types of task, to other domains.

8.3 Analogical transfer

'Analogical transfer' refers to knowledge, understanding, abilities, routines and strategies applied from a source domain to a target domain – prior experience is applied to new situations, by analogy. Early theories of transfer, such as Woodworth and Thorndike's (1901) 'theory of identical elements', defined elements in terms of brain cell activity, which – at that time – could not really be measured. The problem of identifying common elements, or the 'loci of similarity', was reiterated by Osgood (1949), whose theory was based on 'degree of similarity', and also by Brown et al. (1983) in relation to problem solving. However, despite the problem of identifying neural 'loci', the notion of structural similarity remains fundamental to theories of transfer (see also Ahlström 1961 and Novick 1988). While it is easier now, but still problematic, to consider similarities in neural activity, we can consider behavioural and reported similarities between drawing and other tasks, be they superficial surface similarities or deeper *structural* similarities.

To draw an analogy can aid (and demonstrate) understanding of complex and abstract problems by virtue of concrete frames of reference. Holyoak, Gentner & Kokinov describe analogical reasoning as "the ability to pick out patterns, to identify recurrences of these patterns despite variation in the elements that compose them, to form concepts that abstract and reify these patterns, and to express these concepts in language" (2001: 2). Presumably this extends to *visual* language. In this sense, structural analogy can be seen as evidence of greater learning than superficial analogy. That is, analogy between more divergent domains is evidence of deeper understanding.

Cognitive linguist Mark Johnson (1988; 1990; 2007) holds that analogy is necessary in order to go beyond a certain level of conceptual abstraction, that is, beyond what is propositionally representable, including thoughts and statements *about* our own thinking (metacognition). In other words, higher, more complex orders of cognition are only possible due to the existence of lower ones and rely more heavily on prior experience, while metacognition relies entirely on analogy with concrete experience. He stresses the importance of the 'image schema' in this, as "crucial in establishing structural isomorphisms in our understanding" (1988: 34). We understand new information by analogy with existing schema (even superficially unrelated ones) by virtue of their underlying structure. Our understanding of our own thought processes ultimately relies on experience of the outside world . Douglas Hofstadter (2001) goes further, claiming that analogy '*is the core of cognition'*. All thinking is like this, he says. Any novel concept is possible only through analogy to something already familiar and ultimately experientially (sensorially) derived.

Similarly, Lakoff and Johnson (1999) argue that metaphor is not only a related lingustic phenomenon, but the result of analogy. It underlies the human conceptual system in general, whether this is manifested linguistically or not (it may also be revealed through gesture or other forms of non-verbal communication). This 'experientialist theory of meaning' implies that to gain knowledge of the external world (as we do through observational drawing) is to broaden and deepen the bank of knowledge available for possible transfer to more abstract conceptual domains.

Chapter 5 described how observational drawing involves the acquisition of visual knowledge. In this sense, it can help us to know better the world and how we experience it perceptually. We can therefore think of observational practice as a way of enriching image schema - the source domain. We may also think of the *thought processes* involved in drawing (described in chapter 6) as potentially transferable through deeper structural analogy. If drawing is potentially of use to a broad range of activities by way of knowledge and thought process, we may then consider visual or creative tasks as potential target domains, particularly ones that can be explicitly identified as analogous to drawing (as discussed in section 8.2.2).

While the drawer certainly possesses a set of specific cognitive skills or advantages as a result of their practice, we cannot assume that transfer occurs automatically. It may occur implicitly; if not, it would rely on explicitly considered ways of applying existing skills to novel situations. For drawing educators and students, the issue then becomes *recognising* how new problems and tasks are similar to drawing, in order to then transfer abilities, strategies and skills. In other words, *making analogies explicit can facilitate transfer*, as the next section discusses. While analogy does not necessarily have to be verbal to be explicit (it could be diagrammatic or gestural), verbalisation has been the main modality studied in this matter. Again, talking through drawing process becomes a consideration.

8.3.1 Talking through drawing can facilitate transfer

Talking through tasks has been shown to facilitate both performance and transfer. As early as 1962, Gagné and Smith (among others) demonstrated that the instruction to concurrently verbalise problem-solving tasks, such as the Tower of Hanoi, not only improved performance (by reducing the number of moves compared to a silent control) but also *improved transfer* to more difficult problems (also cited in Ericsson 1993[1980]: 227). To make analogies themselves explicit has been shown to be of even greater value to transfer. There is some evidence to support the idea that specific descriptions improve task-specific performance, while general statements are more effective in facilitating transfer to other (less similar) tasks (Schleser et al. 1981; Thackwray et al. 1985). Gagné and Smith's findings indicate that task-specific concurrent verbalisations also facilitate transfer to other domains. This makes sense, as the verbalisation would focus attention on specific elements of the task, making them more apparent and easier to recall/access, and therefore to apply to novel situations. This can happen spontaneously by effort of the student, but the role of the tutor can also be to make analogies apparent and encourage such explication and reflection(for example, by asking what drawing *is*, and what else it is *like*). It is in this way that Ronald Barnett suggests the identification of transferable skills could simply "become an exercise of making tacit notions explicit" (2004: 100) in activities that already exist within curricula (although he adds that what those skills 'offer students' should also be questioned). This is the kind of 'teaching for transfer' also described by David Perkins and Gavriel Salomon, whose seminal papers invite teachers to "shape instruction to bridge the transfer desired" (1988:24) by making explicit both the structure of the source domain, and the similarities to target domains.

Considering this, we can question what elements of drawing can be made explicit (as we did in the previous chapter) and what might constitute a target domain for the knowledge and skills involved with drawing. In short, what else is drawing *like*?

8.3.2 What is drawing process analogous to?

The previous chapters described drawing as comprising two alternate phases – labelled construction and reflection – which can be described as a cycle. Each phase relies on both procedural and schematic knowledge. This drawing 'cycle' can be compared to other 'cycles' involved in learning and creativity.

Like the drawing cycle, the 'design cycle' stages design phases, it segregates conceptualising from making phases, and even prototype building from testing and review. Research cycles similarly balance investigative and analytical/reflective phases. As this thesis describes, drawing strategies can take a wide range of formats, and routines can vary while still balancing these two elements. Additive or heuristic strategies can be applied to written tasks as well as design or problem-solving ones. To become aware of which type of strategy is adopted and – within that – when it is appropriate to take stock and re-evaluate (also to be confident about when it when it is *not* yet time to evaluate) represents a significant development in learning. In this sense, drawing process has the potential to act as a model for the creative process more generally, able to demonstrate the importance of balancing constructive and reflective phases in a structured way (but not necessarily prescriptive), through relatively simple means that are grounded in concrete experience.

The emotional journey one takes through such creative strategies can also be elucidated. For example, one can become attached to part of a drawing that needs to be erased despite the time invested in it. Similarly, one may feel uncomfortable sharing ownership of a drawing and allowing a collaborator authorial control to make changes. Obstacles such as these can be confronted through drawing tasks that can become guided exercises to bring such issues to the surface visibly, quickly and safely.

The mind has practical considerations of its own, and so learning naturally adopts a similarly segregated cycle, with active and reflective phases. David Kolb's 'cycle of experiential learning' (1984, later updated by Honey & Mumford 2000) illustrates this. It identifies four sequential stages: 'active experimentation', 'concrete experience', 'reflective observation' and 'abstract conceptualisation'. The first two correspond to the constructive phase (doing and experiencing), while the third and fourth correspond to the reflective phase (reviewing, strategising and decision-making**). T**his division of labour in drawing is analogous to that which occurs in learning and creativity in more generally. As early as 1981, Tom Hudson was advocating observational drawing in schools on this basis, renaming the activity of observation 'Construction'. He described it as "a piece by piece assembling of awareness, [which] was precisely the way in which children learned by trial, error, and the storing of resulting experience. He saw it therefore as the catalyst of creative education – pre-existing, assisting other matters" (Thistlewood 1981: 24).

In this sense, drawing can be seen a potential source domain not only for other creative tasks, but also for meta-learning (learning about our own learning). It is structurally similar as it includes the ability to segregate cognitive resources in order to allocate them efficiently and minimise interference and distractors. When drawing, we can complete a cycle very quickly (mark-making actions becomes instantly visible), as well as at longer intervals (between drawings), and so observational drawing presents itself as a potentially rich source domain.

James Zull (2002) provides a more recent validation of Kolb's model, describing it in terms of the structure of the human brain and how it learns through interaction with the environment. This too is described as a cycle of interacting with, and perceiving, the external world; then internally conceptualising about it and planning further actions. In Zull's account, we are reminded that the external world forms an integral component of the learning cycle, as well as the body and mind (when drawing, the paper plays this role.) Zull describes how every learning cycle is necessarily complete, and emphasises the central role of emotion in guiding and motivating it.

Much existing pedagogic literature focuses on the role of reflection, and how to foster this. Texts such as Donald Schön's *Educating the reflective practitioner* (1987) have been very influential in education and beyond. The sentiments of Schön's text are echoed in this thesis' consideration of verbalisation techniques as learning: those receiving real-time instruction learn more profoundly and become more effective (reflective) professionals if they receive encouragement to think through tasks explicitly, and to take time to reflect on what has happened[1]. The findings of the present study act as a reminder that 'constructive' phases (that suspend judgement) are also an integral aspect of learning and creativity. The ability to proceed *without* evaluation in a timely fashion, as part of considered evaluative strategies, might be fostered equally with 'reflective' aspects of practice (despite the fact that this type of activity is less readily verbalised).

[1] Schön also emphasised the importance of a sense of personal ownership of learning, in keeping with the earlier proposition (in chapters 7 and 8) that the ultimate aim of drawing instruction (beyond improving ability and technique) can be to enable the student to be self-sufficient in purposefully determining goals and objectives, assessing their own performance against those, and applying their learning experiences to other domains.

The idea that explication enables reflection, playing a facilitative role in experiential learning, is already familiar to educators. There are also quieter aspects to be accounted for: 'reflective practice' comprises both reflection and non-reflection. While non-reflection is not so conducive to 'instruction' (any explicit instruction *not* to reflect would probably have the opposite effect), it might still inform instructional design. Certain learning environments and methods might facilitate and encourage such 'quiet' 'non-reflective' practice in balance with more explicit, reflective learning, to provide 'food for thought', as it were. This thesis does not go as far as to propose drawing activities for this purpose[2], but I would like to stress the importance of maintaining a *balance* between the two phases. In drawing, a lack of reflective strategising and evaluation results in a haphazard or poorly composed image, while too much of it would inhibit the making process, by competing for cognitive resources, and possibly also by affecting the drawer's confidence.

Beyond generalised analogies with the creative process and learning cycles, specific opportunities for applying drawing skills in novel situations would be very diverse, situated, individual and context dependent, and therefore difficult to predict (let alone teach for, or assess). Therefore, the ability to 'draw' those analogies *oneself* is the key component. This would rely on explicit knowledge of the source domain (here, drawing process), but also on more abstracted knowledge concerning how analogies can be made, and ways in which source and target domains can be compared. It is perhaps no coincidence that analogies are said to be 'drawn', and the following section considers how observational drawing is similar to the process of making an analogy.

8.3.3 Drawing is analogy

Although drawing operates mainly visually, and analogical reasoning operates in a more abstract (higher order) way, they are similar and comparable. Drawing is, after all, a process of transfer between a source and target domain (the original and the paper), and an attempt to match those domains in particular ways, by reference to a particular set of features, defined by a specific set of goals. To draw from observation is to make repeated comparisons, to search for and understand differences, to identify elements of similarity,

[2] I would like to draw attention to Christian Monterou's recent discussion of the notion of 'mindfulness' in drawing process (2013). He compares it to Csikszentmihalyi's (1991) concept of 'flow' in creative process, and his application of these ideas to drawing workshops inspires creative activity.

and to question what aspects of similarity are important to the specific representation being made, and which can be disregarded.

A drawing need not be superficially (photographically) similar to its subject to represent some aspect of it, indicating that there are deeper and more complex elements to observational drawing that go beyond simple transcription. That is, drawing includes both superficial and deeper structural analogy. Not only structural in the physical sense, but also in the sense of how relations between representational elements interact to signify and communicate. This need not be explicitly understood – it can be arrived at through trial and error – but the possibility of reflectively explicating these aspects drawing exists.

Novick notes that transfer is most effective when analogies include both superficial and structural levels of similarity:

> The representations of better problem solvers include both the surface information […] and deep structure information, which consists of abstract, solution-relevant features of a problem. This deep structure information would include both higher-order relational information (stressed by the syntactic account of analogy) and problem solving goals (stressed by the pragmatic account of analogy). (1988a: 131)

Drawing not only involves analogy on both these levels but, as we saw in chapter 4, also strategies for managing these elements in tandem. The drawer must attend to relevant surface (visual) features (through construction), while managing higher-order relational information in relation to strategic goals to inform visual comparisons (through reflection). It could therefore be said that analogy is at the core of drawing skill, at least in visual form.

Making this apparent, or encouraging students to reflect on their drawings in this way, would constitute drawing 'as a training in' *analogical* thinking (to respond to Archer's call to teach drawing as 'a training in thinking'). It would enable self-reflection on drawing progress and, by extension, development of self-knowledge regarding learning and problem-solving capabilities. If we take Hofstadter's dictum seriously – that '*analogy is the core of cognition'* – we can consider drawing to, indeed, be 'the ultimate transferable skill', at least so long as the process is made explicit.

Lynn Goldsmith et al. encourage drawing instructors to “make explicit the connections across disciplines, both in terms of input and output”; “where drawing skills learned in the context of art have potential applications across disciplinary boundaries these should be made evident through examples, as well as suggestions for possible applications” (in press). They further suggest that artists collaborate with teachers from STEM disciplines in order to teach common principles together, and advocate the development of ‘boundary crossing minds’. (See Fava, Kantrowitz & Brew (in press) for a fuller discussion of drawing in STEM disciplines, with further examples).

8.5 The embodied paradigm

Aspects of drawing mirror more general patterns in our thinking, but whether these can transfer to other cognitive activities is debateable. Studies such as Kozbelt and Seeley’s offer some confirmation that they do, but the importance of making opportunities for transfer *explicit* should be acknowledged as potentially valuable to transfer. This can involve simply drawing attention to the structure of the drawing task and the processes it involves, or pointing directly to opportunities for transfer – be they specific instances of transfer across disciplines or more generally relating to meta-learning. However, transfer may still happen implicitly. Not all learning and transfer need (or can) be explicit. In regard to perceptual and cognitive abilities, we might consider the tuning of the visual sense and the cognitive capacities described here as a kind of *fitness*. Recent ‘embodied’ cognitive perspectives offer some insight into what this might mean.

In contrast to modular models of cognition, which give rise to notions of domain specificity, the embodied paradigm acknowledges that modules are highly functionally interconnected, and our capacity for reason is not separate from bodily capacities.

> There is no such fully autonomous faculty of reason separate from and independent of bodily capacities such as perception and movement. The evidence supports, instead, an evolutionary view, in which reason uses and grows out of bodily capacities. (Lakoff & Johnson, 1999: 17)

It allows us to revisit the notion of shared neural ‘loci of similarity’ without the need for consideration of specific examples. (While there is a growing body of evidence demonstrating neural activity associated with drawing and other tasks, it is still not sufficient for such a detailed consideration of transferability of drawing skill, and is further complicated by factors such as the changing intensity and loci of cortical activation with experience, as shown in Solso's 2001 study.) As we saw in the literature review, the embodied paradigm reframes notions of cognition and perception: we can no longer consider any thinking to be independent from perceptual modalities. Visual and spatial (and other) senses are employed in imagining more abstract concepts and meta-cognitive constructs, since the same neural substrates are employed. We can therefore consider perception and cognition to share 'loci of similarity'. Or, as Peter Carruthers describes, perceptual systems are involved in 'central cognitive' processes; there is no 'amodal activity' in the 'central workspace' (n.d.). Perceptual and cognitive abilities are therefore not *similar*, they are *the same* capacity, in terms of neural activity.

In other words, perceptual abilities *are* thinking abilities, and could be sought as an end in their own right. A strong example of this is that perception and VWM have been demonstrated as the same capacity, relying on much the same neural substrates (as we saw in section 4.3.3). We use the same neural pathways to see something, to recall that thing, to imagine it in the future or as an element of something more complex, or to employ analogy in understanding something else. It follows that any perceptual 'advantages' gained through drawing (such as those described by Kozbelt and Seeley, or those associated with an extensive 'library' of image schema, or the other various abilities outlined in this study) could be equally of benefit to more abstract reasoning and logic, be it literal or metaphorical. The patterns in our unconscious, accumulated from repeated sensory experience, become the substrate by which we are able to think, to 'make sense' of new concepts and to physically respond to our environment.

However, drawing does not only expand our knowledge of the visual world, it also informs our understanding of how we experience it. As Riley explains, drawing is not only a 'record of perception' as Gombrich holds, but also an *enquiry into it* (2001: 64). It follows that drawing can inform a meta-understanding of perceptual processes in addition to the percepts they are concerned with.

This understanding may reassure us that certain abilities would transfer regardless of whether they were made explicit or not. To take a sporting analogy, ability in one sport may transfer to others, especially when the same muscle groups or strategies are used, while fitness of the heart and lungs is beneficial in any context. We might think of drawing as strengthening certain ‘core’ faculties in that sense, not only perceptual/working memory ones, but also meta-control of cognitive processes.

8.7 Conclusion

In general we can say that observational drawing includes many abilities of potentially broader value: to steady and slow the mind; to discern details in relation to wholes; to inhibit distractors (both internal and external); to strategically manage reflective practice; to be receptive and selective to visual information; to devise personal strategies for selecting and organising (visual) information; to manage the process of acquiring knowledge from visual sources; to evaluate the accuracy and effectiveness of representations; and even to ‘draw’ analogies. The ability to make deep structural analogies and to apply existing knowledge to novel situations is the ability to be adaptable and resourceful, and this ability is perhaps of greatest value to contemporary students, given the uncertainty they face in their future careers.

These abilities can be acknowledged and made explicit in learning situations. In this way, explication and reflection on drawing strategies and processes can become opportunities for meta-learning, enabling the student to become more independent and self-sufficient. However, while reflection and verbalisation/explication can facilitate transfer (as well as performance), it likely also occurs *implicitly*, even automatically, particularly when source and target domains involve identical elements. The embodied paradigm allows a more holistic consideration of perception and cognition as overlapping domains and, by extension, a more holistic view of drawing practice and its potential benefits. This embodied re-framing could be interpreted as meaning that *any* experience or learning is potentially relevant to any other. While this may be so, the knowledge and skills associated with drawing are particularly broad in their potential for transfer due to their perceptual and analogical nature.

While such potentially broad transfer can be acknowledged, it would be difficult (at times impossible) to measure - by definition it would manifest unpredictably and over long periods of time. As educators, all we can do in this respect is encourage analogical reasoning by providing and explicating opportunities for transfer. As Nicolaides held, the job of the teacher can be "to teach the students, not how to draw, but how to learn to draw" (2008: xiii) and, by extension, how to learn in general.

Chapter 9.
Conclusion

In this study, I sought to lay out some of the necessary foundations towards an understanding of cognitive strategies for drawing, in order to consider their potential educational significance beyond the ability to make a representation. The thesis presented my analysis of observational drawing process, with reference to four case-studies and a body of literature surrounding cognition and perception. The timing of artists' drawing actions and their self-reports were compared, in order to build a picture of the underlying cognitive elements of drawing process in light of relevant recent research and theory.

The behavioural and verbal analysis offered insights into the artists' drawing process in terms of timing and strategy, which I was able to interrogate in the theoretical analysis. The combined evidence allowed some conclusions to be drawn regarding the roles of attention, memory and language in drawing process, and these were situated in relation to existing accounts and findings. The resulting picture of drawing process supports the notion that observational ability is a broadly transferable skill. It can be thought of as a kind of perceptual and cognitive 'fitness', although actual transfer of cognitive competences to new domains may rely on (or would at least benefit from) explication of the drawing process and of opportunities for transfer.

9.1 A range of strategies for drawing

The artists used a range of drawing strategies. Two used heuristic strategies (working from the general and vague to the specific and certain) and two used additive strategies (beginning with specific details, and constructing the drawing from more precise marks). Between these strategies there were similarities, but each artist exhibited different characteristic patterns of activity involving careful timing of eye and hand movements, and routines for making and assessing the drawing.

9.1.1 Attentional strategy and timing of dwell cycles

While existing expert-novice comparison studies have shown that expert drawers use faster and more regular dwell cycles, this study demonstrated significant differences *between* experienced artists. There were also variations in gaze timing and distribution of attention, within the duration of a single drawing, which were similar between all four artists. Differences between artists were not related to level of expertise, but to attentional strategy: the heuristic strategy used shorter glances to the subject to glean more generalised visual information (moving towards more specific ones as the drawing progressed). The additive strategy used longer glances to measure more specific details with more precision. Evaluative strategy also affected timing: shorter glances to the paper were used when evaluation was postponed for longer durations, while longer glances were used when evaluations were built into each dwell cycle.

9.1.2 Drawing involves two discrete phases: constructive and reflective

A common feature to both drawing strategies was the segregation of activity associated with making and evaluating, during both long and short timeframes (at the order of minutes and milliseconds). Although this evidence relates only to the four artists in the main study, the theoretical analysis explained that treating 'constructive' and 'reflective' activities as discrete phases within a cycle makes sense as a strategy for optimising limited cognitive resources. The constructive phase optimised perception by operating within short, dedicated windows of time. In this phase, cognitive resources are devoted to selectively perceiving strategy-relevant, low-level visual details, and encoding them as movement. The reflective phase is concerned with higher orders of visual feature, in relation to the past and future of the ongoing drawing: judging progress and planning how to bring the drawing towards a desirable outcome. These two activities could also be identified in the eye-tracking footage, characterised by different types of scan-path (section 3.4).

The reflective mode is in keeping with Gombrich's schematic account: schematic visual knowledge informs judgement and decision making. However, his refutation of Ruskin's 'innocent eye' appears to be out of place, as Ruskin's account is also consistent with the findings of this study, describing instead the *making* of the drawing (the constructive mode), and the capacity for that process to facilitate the acquisition of visual knowledge. Edwards' description of ‘R-mode’ is also similar to the constructive mode in that it entails an inhibition of certain types of thinking in order to focus attention externally, to selectively perceive low-level visual features (i.e., abstracted visual measurements, rather than higher-order visual processing that involves recognition and interpretation). The reflective mode also has similarities with what Edwards describes as ‘L’ mode. Edwards claims that this mode is detrimental to drawing (interfering with ‘R’ mode), whereas I propose that *both* are used by experienced artists. I argue that, beyond novice level, observational skill involves the ability to employ each mode separately and strategically, at appropriate times. Crucially, this involves temporarily postponing critical judgement, in order to proceed more fully ‘in the moment’.

9.1.3 A range of possibilities within a set of related cognitive constraints

The case studies describe a small sample, but represent a wide range of possible drawing strategies and processes. In section 3.2, I proposed a ‘2D model’ as a summary representation of the range of selective attentional states and strategic elements observed, representing these as two dimensions within which cognitive activity is directed at any given time. The model was used to describe how minimising strategic thinking , and operating within a shorter timeframe , enabled greater perception during the constrctive phase.

The second literature review revealed that this interpretation was consistent with current understandings of the nature of vision and cognition. In particular, capacity related modalities mean that perception and working memory effectively compete for resources. The literature also identified additional ‘dimensions’, and in section 6.7, I offer a revised ‘3D model’ to account for other capacity related limitations that can constrain drawing process. These represent the parametric related variables within which limited cognitive resources can be allocated. The 3D model illustrates the shifting of attentional focus within drawing process, which entails a ‘looking back and forth’ in each of these senses. That is, the artists demonstrated physical rhythms of looking back and forth as part of their drawing routines, but they were also alternating between other, cognitive and perceptual, dimensions represented by the ‘dimensions’ of the model. Those are: higher or lower orders of visual feature (number/complexity); perceived or retrieved/held information; and temporal duration. Feature type , scale and location certainty are also variables.

The artists' strategies also relied on knowledge to drive their process: schematic visual knowledge concerning appearances, and proceduralised routines and subroutines for making and evaluating. In this way, the artists demonstrated a high level of control over the 'shape' of their attentional 'window'. They exhibited controlled rhythms of 'looking back and forth' in each dimension concurrently. Those rhythms were individual to each artist, but existed within the range of possibilities illustrated by the model. That the artists exhibited this degree of attentional control (with personal routines and strategies for making use of it) indicates a tacit knowledge of these perceptual and cognitive capacities, and related constraints.

9.2 The role of memory in drawing process

By understanding drawing as comprising two alternate types of process, I was able to determine the roles of memory in each.

9.2.1 The role of memory in the constructive mode

Through the combined behavioural and theoretical evidence, I proposed that (rather than visual memory) spatial, tactile and motor modalities of working memory are recruited in the constructive mode – i.e., to 'hold' information during the short period between seeing and mark-making. This is in keeping with Tchalenko's (2009) findings, although they apply specifically to blind copy-drawing. My analysis, conversely, concludes that the motor memory hypothesis equally applies to sighted drawings. The rehearsing behaviour Connolly demonstrated is a good example of this: the visual input is encoded directly into movement, and the following drawing action mimics the initial movement, indicating that the memory is held spatially and motorically. This pattern is similar to Humphrey Ocean's (in Tchalenko's 2001 study). This strategy allows more careful monitoring of the emerging drawing, particularly when drawn marks are reviewed before the next dwell cycle begins.

While this does not rule out the possibility that other artists may use visual memory (or even internal visualisation) to draw from observation, the theoretical analysis inferred that this would be an inefficient approach. The other three artists in this study did not 'rehearse' marks, but did use periods of blind drawing. They demonstrated more distributed coincidence of looking and drawing activity. It seems logical that they would still be encoding directly to motor signals, rather than pictorially visualising the image on the page, as the visual modality is already in use. As Keogh and Pearson (2011) found, while it is technically possible to use both perception and visual working memory at once, these two faculties are capacity related, therefore while perception is recruited, visual memory will be compromised and vice versa.

9.2.2 The role of memory in the reflective mode

I propose that, while the constructive mode focuses on low-level perception, the reflective mode recruits higher orders of perception and memory (or visual *knowledge*), although not necessarily in the form of internal visualisation or even in conscious recall. In a sense, the two faculties are connected – higher orders of visual processing rely more heavily on existing knowledge (top-down processing) to interpret perceived details in the context of prior experience. These are recruited in the ongoing evaluation of the drawing.

As the visual modality is not involved with encoding low-level details to motor signals, it becomes available to access image schemata from Long-Term Memory, informing the *reviewing* of the image. This includes a sense of how the subject should appear as a whole (what feels correct) and also an aesthetic sensibility of how the artist wishes the drawing to represent the subject (what *about* the subject they wish to depict). This is not to say that the outcome is pre-emptively visualised. Rather, there is an implicit sense of 'correctness' that guides judgements about what to erase and how to proceed, as the drawing reveals itself through more piecemeal constructive methods. I believe this is what Gombrich was referring to by his dictum 'making precedes matching'.

This kind of judgement seems to occur very quickly (often during glances of less than a second), for example, when reviewing new marks in the context of the rest of the drawing, and sometimes just prior to erasure. The speed of such judgements indicates subconscious (parallel) processing. In other words, visual knowledge and memory are recruited in monitoring and guiding the drawing process, and this occurs largely below the conscious radar, so to speak.

9.3 The role of language in drawing process

The use of verbal reports raised a number of issues, both practical and methodological. My analysis was therefore concerned not only with the role of linguistic faculties in drawing process, but with the validity of the data, and the wider usefulness of the methods.

9.3.1 Evaluating verbal methods

On considering the role of the verbal faculty in directing attention, I concluded that the verbal reports themselves could not be considered neutral reflections of the cognitive processes underpinning drawing. Rather, I present them as skewed towards propositional elements and towards aspects the artists consider important on some level. More significantly, I argue that the concurrent reports (when true type-two verbalisations) were likely to also be skewed towards routines or tasks that were recently or currently being learned or developed, rather than those which were familiar and well practiced. They are therefore more indicative of what the artists were aiming for than the full extent of what they were actually doing. In other words, they omit tacit elements or only allude to them through 'umbrella terms' that refer to complex activities. Indeed, the role of the conscious is to guide and drive novel activity, while familiar routines are processed more effortlessly and implicitly.

In evaluating the verbal methods, I conclude that concurrent reports are only of limited applicability to studies of drawing. As the process is largely visual, it requires a degree of translation. It also requires attentional selection from elements that are processed in parallel. Therefore, the aspects reported concurrently represent only a small subset of what it would be possible to report. Due to this, the open-ended instructions usually used to elicit reports in PA studies ('please think aloud') can lead to very divergent results when applied to drawing. Any study wishing to test a specific hypothesis would do better to use more directed instructions, and retrospective reports would be more fruitful in most cases, as it avoids the potential performance effects of concurrent reporting. (Concurrent reporting can help avoid performance effects by acknowledging the need for silent periods.)

Having said this, the concurrent reporting method was useful to this study. It allowed an understanding of the types of talking and drawing activities that could occur simultaneously, and therefore insights into the role of the verbal faculty in drawing process, as discussed in the following section.

9.3.2 Effects of verbalising drawing process

A slowing effect was observed in the verbalised trials, both in the progress of the drawing, and in the duration of dwell cycles. Beyond this unsurprising result, performance effects would be difficult to determine from the primary evidence. Certainly, some of the artists felt the reporting task interfered with their usual drawing process, particularly in early trials when the task was not yet fully grasped. However, with practice, all four artists were able to produce drawings while talking similar to those they typically made.

From the artists' responses to the concurrent verbalisation task, I concluded that the reflective mode, being more propositional in nature, is more readily verbalised, while the constructive mode was difficult for some (when there was no adequate vocabulary for describing the kind of visual details they were apprehending). It proved possible to chat about unrelated matters during the constructive phase, especially if mark-making is done more intuitively, but only when phases are segregated by long enough timeframes. Chatting would interfere with the reflective phase, as it recruited propositional faculties. This suggests that (contrary to Edward's assertion that the linguistic faculty interferes with drawing process) it is the specific *content* of what is said, rather than its verbal nature, that has potential to interfere with the drawing task.

The case studies demonstrated that concurrent verbalisation tasks can slow down drawing process, or even interfere in ways that are detrimental to performance. However, the literature review indicated that, as attending (and therefore also verbalising) is an active process (amplifying and influencing whatever it is focused on), there is also potential for *positive* performance effects. As such, the additional processing that takes place when the process is slowed down can be either detrimental or beneficial, serving to either distract or focus attention.

Given this, I present ‘talking through’ drawing process as an activity that not only reflects, but has the ability to *influence,* conscious effort and learning. I therefore suggest that concurrent verbalisation is a potentially beneficial task for drawing students, providing there is clarity of strategy and appropriate labelling. It might also be used as a demonstrative method (artists’ verbal reports could be used as examples), or to identify gaps or issues in students’ thinking (as a tool for formative assessment).

Although this study does not go as far as to test potential educational applications of this method, it indicates that this is a potentially fruitful avenue for further research and development. It also presents models and accounts of drawing process as potential tools for devising drawing instruction.

9.4 The ‘bigger picture’ & scope for future research

The findings in this study are based on a small sample and concerned with a very specific type of drawing practice. However, they represent and elucidate a range of cognitive strategies for drawing which are of potential relevance to debates around drawing curricula, as well as instructional design. It is my hope that this thesis, and the drawing processes it describes, can be of use to educators and theorists, and provide a basis for future research and development in this field.

There are many more types of drawing, and aspects of it that deserve further attention. Further studies into drawing process could look into the role of emotion, or executive function to further extend cognitive understandings of drawing. There also seems to be much potential for innovating arts education by bridging the disciplines of drawing and cognitive psychology. However, in order for the relevance of this study (and others like it) to be recognised, it would be useful if there were a more comprehensive body of literature reviewing existing teaching practices, both traditional and new.

This project constitutes part of a larger discourse currently emerging around drawing, cognition and education. Many pieces of this puzzle are appearing and informing debates around the contemporary relevance of drawing practice. Further cognitive studies of observational drawing practice are scrutinising finer details, including eye movements (Coen

Cagli 2011), the role of the hand (Brew 2011). Other kinds of drawing are also subjects for cognitive study with the explicit intention of educational applications (Kantrowitz in press; Hetland et al. 2006; 2013; Winner & Hetland 2008; Bobek in press). Innovations regarding drawing as a cognitive tool are also being developed (Goldsmith et. al. in press; Carpendale & Walny in press). Combined, this research promises to inform teaching practices and wider debates around the place of drawing in curricula, both within and beyond art and design education.

9.5 The potential for transfer of drawing skill

I describe drawing as comprising a number of cognitive aptitudes and abilities, as well as visual knowledge, which could potentially transfer to many other domains including, perhaps, broader kinds of 'meta-learning'. Some research has already demonstrated that artists hold 'perceptual advantages' in tasks involving visual discrimination. While it is possible that transfer may occur in more divergent domains than that, it cannot be taken for granted. Further research would be necessary to understand the extent to which transfer actually occurs.

Aside from this, other research has shown that both performance and transfer are facilitated by explication of the underlying knowledge and structural features of the source domain. As such, chapter 8 argues that, the accounts of drawing in the present study – both the artists' own accounts and the comparative frameworks that result from my analysis – represent potentially useful tools for drawing teachers and students. It may also be fruitful to explicitly consider opportunities for transfer, in terms of what drawing process might *resemble* – that is, drawing *analogies.* I suggest that drawing process, as described here, can be seen as analogous to both creativity and learning in certain respects.

Elucidation of tacit elements of drawing is both an aim and a subject of this thesis, and this is presented as potentially valuable to learning, both in terms of the content of the reports and the methods used for eliciting them. However, I also acknowledge that there is a limit to how much expertise or learning can be elucidated, and that is not equal to actual performance or understanding. That is, the ability to *describe* knowledge is separate from the ability to *apply* it; judgements and actions are not necessarily dependent on overt recall.

This is related to the fact that, the verbal reports (and the conscious activity they represent) are related to novelty and to effort. There will always be large parts of drawing that are ineffable, or even totally cognitively impenetrable. These aspects are nevertheless important. Indeed, our ability to think and act – let alone draw – depends on tacit knowledge and abilities. So, elucidating drawing process (as this study does) can be useful to enhance learning and teaching, but it is also important to acknowledge that this will be limited, and that large parts of drawing process will be implicit and cognitively impenetrable, particularly in experienced artists.

Overall, this picture of observational drawing presents it as a practice that remains useful and relevant to contemporary students. In addition to the ability to represent, drawing encompasses a range of broader cognitive skills. It builds schematic knowledge of the visual world, it engenders tacit self-knowledge (of perceptual abilities) and the ability to 'steady' oneself; that is, to hold or inhibit particular ways of looking and thinking as part of drawing strategies.

9.6 Moving forward

It is my hope that the skills and practices observed in this study, and the insights they afford, provide food for thought for those who teach and learn drawing. Moving forward, it is my intention to apply and cultivate the understanding this project (and others like it) has enabled, through ongoing teaching interventions. Principally this will take place through the 'Thinking through Drawing' project, in which, together with Drs Angela Brew and Andrea Kantrowitz, I am developing a series of resources for teacher education that aim to embed core cognitive skills in drawing exercises. The project also aims to champion 'visual literacy' and to raise the educational profile of non-verbal modes of thinking and communication. While this initiative is still in its early stages, we are becoming aware of a growing interest in the use of drawing as a tool for thought, in the arts and beyond, as well as an international community of practice , and so we remain optimistic about the changing status of drawing practice in educational institutions.

References

Ahlström, K. G. (1961) *Transfer and communality: an experimental study of learning*. Sweden: Svenska bokförlaget, vol. 1

Alberge, D. (2005) 'Look how tickled Doddy is at being hung'. *The Times*. August 18th 2005

Alsop, W. (2002) 'Society's Inability to Draw is Destroying the Art of Looking'. *The Architect's Journal*, vol. 216, no. 13. Available from: http://www.architectsjournal.co.uk/home/societys-inability-to-draw-is-destroying-the-art-of-looking/177281.article [accessed 24/10/09]

Alvarez, G. A. & Cavanagh, P. (2004) 'The capacity of visual short term memory is set both by visual information load and by number of objects'. *Psychological Science*, vol. 15, pp. 106-111

Alvarez, G. A. & Oliva, A. (2008) 'The representation of simple ensemble visual features outside the focus of attention'. *Psychological Science*, vol. 19, pp. 392-398

Anderson, J. R. (1982) 'Acquisition of cognitive skill'. *Psychological Review*, vol. 89, pp. 369-406

Anderson, J. R. & Fincham, J. M. (1994) 'Acquisition of procedural skills from examples'. *Journal of Experimental Psychology: Learning, Memory and Cognition*, vol. 20, pp. 1322-1340

Andrade, J. (Ed.). (2002) *Working memory in perspective*. Psychology Press

Archer, L. B. (1997) 'Drawing as a tool for designers'. In: T. Moscovitch (ed.) *Proceedings of the Future of Drawing in Design Conference*. UK: Huddersfield Univ, pp. 39-42

Arnheim, R. (2004) Visual Thinking. Berkeley: University of California Press

Attneave, F. (1950) 'Dimensions of Similarity'. *The American Journal of Psychology*, vol. 63, no. 4, pp. 516-556

Awh, E. & Jonides, J. (2001) 'Overlapping mechanisms of attention and spatial working memory'. *Trends in Cognitive Sciences*, vol. 5, no. 3, pp. 119-126

Awh, E. & Pashler, H. (2000) 'Evidence for split attentional foci'. *Journal of Experimental Psychology: Human Perception & Performance*, vol. 26, pp. 834-846

Awh, E., Barton, B. & Vogel, E. K. (2007) 'Visual Working Memory Represents a Fixed Number of Items Regardless of Complexity'. *Psychological Science*, vol. 18, no. 7, pp. 622-628

Backer, G. & Mertsching, B. (2003) 'Two selection stages provide efficient object-based attentional control for dynamic vision'. In: *Proceedings of the International Workshop on Attention and Performance in Computer Vision*, pp. 9-16

Baddeley, A. (2000) 'The episodic buffer: a new component of working memory?' *Trends in Cognitive Sciences*, vol. 4, pp. 417-423

Baddeley, A. D. & Hitch, G. (1974) 'Working memory'. In: Bower, G. H. (ed.) *The psychology of learning and motivation*. New York: Academic Press. pp. 47-90

Baddeley, A. D. & Hitch, G. J. (1994) 'Development in the concept of working memory'. *Neuropsychology*, vol. 8, no. 4, pp. 485-493

Bailey, G. H. (1982) Drawing and the Drawing Activity: A Phenomenological Investigation. Doctoral dissertation. London: Institute of Education, University of London

Banks, W. P. (ed.) (2009) *Encyclopedia of Consciousness*, vol. 1/2. Academic Press

Barnett, R. (2004) *Engaging the Curriculum in Higher Education*. Open University Press

Barrett, E. & Bolt, B. (2007) *Practice as Research: Approaches to Creative Arts Enquiry*. London: IB Tauris & Co Ltd

Barrow, H. G. & Tenenbaum, J. M. (1978) 'Recovering intrinsic scene characteristics from images'. In: Hanson. A. & Riseman, E. (eds.) *Computer Vision Systems*. New York: Academic Press, pp. 3-26

Bayne, T., Cleeremans, A. & Wilken, P. (2009) *The Oxford Companion to Consciousness*. Oxford: Oxford University Press

Betts, S. (2011) 'The Bigger Picture of Drawing: A New Curriculum, A New Pedagogy'. In: Kantrowitz, A., Brew, A. & Fava, M. (eds.) Proceedings of *Thinking through Drawing: practice into knowledge*. New York: Teachers College, Columbia University, Art and Art Education Program, pp. 27-34

Biederman, I. (1987) 'Recognition-by-Components: A Theory of Human Image Understanding'. *Psychological Review*, vol. M, no. 2, pp. 115-147

Bilalić, M., McLeod, P. & Gobet, F. (2008) 'Why good thoughts block better ones: The mechanism of the pernicious Einstellung (set) effect'. *Cognition*, vol. 108, no. 3, pp. 652-661

Blackmore, S. (2010) *Consciousness: An Introduction*. 2nd ed. London: Hodder Education

Blakemore, C. (1973) 'The baffled brain'. In: Gregory, R. L. & Gombrich, E. H. (eds.) *Illusions in nature and art*. New York: Charles Scribner's Sons, pp. 9-48

Blakemore, C., Carpenter, R. H. S. & Georgeson, M. A. (1970) 'Lateral inhibition between orientation detectors in the human visual system'. *Nature*, vol. 228, pp. 37-39

Bliss, T. V. & Collingridge, G. L. (1993) A synaptic model of memory: long-term potentiation in the hippocampus. *Nature*, 361(6407), 31-39

Block, N. (1990) 'Consciousness and accessibility'. *Behavioral and Brain Sciences*, vol. 13, pp. 596-597

Block, N. (1995) 'On a confusion about a function of consciousness'. *Behavioral and brain sciences*, vol. 18, pp. 227

Block, N. (2007) ‘Consciousness, accessibility, and the mesh between psychology and neuroscience’. *Behavioural and Brain Sciences*, vol. 30, pp. 481-548

Bloor, M. J. & Wood, F. (2006) *Keywords in Qualitative Methods: a vocabulary of research concepts*. London: Sage

Bobek, E. (2011) *Visualizing the invisible: Generating explanations of scientific phenomena*. Dissertation. Columbia Teachers College

Bomberg, D. (1937) ‘The syllabus’. In Oxlade, R. (1977) *David Bomberg 1890-1957*, R.C.A. Papers No. 3. London: Royal College of Art

Brew, A. (2011) ‘Learning to pause’. In: Kantrowitz, A., Brew, A. & Fava, M. (eds.) *Proceedings of Thinking through Drawing: practice into knowledge*. New York: Teachers College, Columbia University, Art and Art Education Program, pp. 67-72

Brewer, A. A., Liu, J., Wade, A. R. & Wandell, B. A. (2005) ‘Visual field maps and stimulus selectivity in human ventral occipital cortex’. *Nature Neuroscience*, vol. 8, no. 8, pp. 1102-1109

Broadbent, D. E. (1958) *Perception and communication*. New York: Pergamon Press

Broderick, P. & Laszlo, J. L. (1989) ‘The copying of upright and tilted squares by Swazi children and adults’. *International Journal of Psychology*, vol. 24, pp. 333-350

Brogaard, B. (2011) ‘Are there unconscious perceptual processes?’ *Consciousness and cognition*, vol. 20, no. 2, pp. 449-463

Brown, C. & McLean, C. (2003) *Drawing from Life*. 3rd ed. Belmont, CA: Wadsworth Thomson

Brown, R. (2008) ‘The Neuroscience of Nothing’. UCtelevision. Series: "Voices" Show ID: 5947. Available from: http://www.youtube.com/watch?v=nUgb V0bijA&feature=related [accessed 21/02/2010]

Brown, T. H., Chapman, P. F., Kairiss, E. W. & Keenan, C. L. (1988) ‘Long-term synaptic potentiation’. *Science*, vol. 242, no. 4879, pp. 724-728

Burkhardt, F. & Bowers, F. (eds.) (1976) *The Works of William James: Essays in Radical Empiricism*. Harvard University Press

Bushara, K. O., Weeks, R. A., Ischii, K., Catalan, M, J., Tian, B., Rauschecker, J. P. & Hallett, M. (1999) ‘Modality-specific frontal and parietal areas for auditory and visual spatial localisation in humans’. *Nature Neuroscience*, vol. 2, pp. 759-765

Callaghan, T. C. (1984) ‘Dimensional interaction of hue and brightness in preattentive field segregation’. *Perception & Psychophysics*, vol. 36, pp. 25-34

Carpendale, S. & Walny, J. (in press) ‘Towards supporting interactive sketch based visualisations’. In: Fava, Brew & Kantrowitz (eds.) *Drawing in STEAM*. Special issue of

*TRACEY: Drawing and Visualisation Researc*h. Available from: http://www.lboro.ac.uk/departments/sota/tracey/

Carruthers, P. (no date) 'On central cognition'. *Philosophical Studies*

Cavanagh, P. & Leclerc, Y. G. (1989) 'Shape from Shadows'. *Journal of Experimental Psychology: Human Perception and Performance*, vol. 15, no. 1, pp. 3-27

Chandrasekaran, B. (2006) 'Multimodal Cognitive Architecture: Making Perception More Central to Intelligent Behavior'. *Proceedings of the AAAI National Conference on Artificial Intelligence*, pp. 1508-1512

Chandrasekaran, B. (2009) 'Problem solving methods and knowledge systems: A personal journey to perceptual images as knowledge'. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*, vol. 23, pp. 331-338

Charmaz, K. (2000). 'Grounded theory: Objectivist and constructivist methods'. In Den-Zin, N.K. & Lincoln, Y.S. (eds.) *Strategies of qualitative inquiry*, pp. 249-291. London: Sage

Charmaz, K. (1995) Grounded theory. In: Smith, J. A. Harre, R. & Van Langenhove, L. (eds) *Rethinking methods in psychology*. London: Sage, pp. 27-49

Charmaz, K. (2006) *Constructing Grounded Theory: a practical guide through qualitative analysis*. London: Sage

Cheng, P. W. & Pachella, R. G. (1984) 'A Psychophysical Approach to Dimensional Separability'. *Cognitive Psychology*, vol. 16, pp. 279-304

Chemero, A. (2009) *Radical Embodied Cognitive Science*. Cambridge, MA: MIT Press

Cherry, E. C. (1953) 'Some experiments on the recognition of speech, with one and two ears'. *Journal of the Acoustical Society of America*, vol. 25, pp. 975-979

Chong, S. C. & Treisman, A. (2003) 'Representation of statistical properties'. *Vision Research*, vol. 43, pp. 393-404

Chubb, C., Nam, J. H., Bindman, D. R. & Sperling, G. (2007) 'The three dimensions of human visual sensitivity to first-order contrast statistics'. *Vision Research*, vol. 47, no. 17, pp. 2237-2248

Chun, M. M., Golomb, J. D. & Turk-Browne, N. B. (2011) 'A taxonomy of external and internal attention'. *Annual Review of Psychology*, vol. 62, pp. 73-101

Cleeremans, A. (1997) 'Principles for Implicit Learning'. In: D. Berry (ed.) *How implicit is implicit learning?* Oxford: Oxford University Press, pp. 196-234

Cloutier, J., Kelley, W. M. & Heatherton, T. F. (2011) 'The influence of perceptual and knowledge-based familiarity on the neural substrates of face perception'. *Social neuroscience*, vol. 6 no.1, pp. 63-75

Coen-Cagli, R. (2011) ‘Visuomotor atoms of copy drawing’ In: Kantrowitz, A., Brew, A. & Fava, M. (eds.) *Proceedings of Thinking through Drawing: practice into knowledge*. New York: Teachers College, Columbia University, Art and Art Education Program, pp. 73-78

Cohen, D. J. & Bennet, S. (1997) ‘Why Can’t Most People Draw What They See?’ *Journal of Experimental Psychology: Human Perception and Performance*, vol. 23, no. 3, pp. 609-621

Cohen, D. J. & Jones, H. E. (2008) ‘How Shape Constancy Relates to Drawing Accuracy’. *Psychology of Aesthetics, Creativity and the Arts*, vol. 2, no. 1, pp. 8-19

Cohen, D. J. (2005) ‘Look little, look often: The influence of gaze frequency on drawing accuracy’. *Perception and Psychophysics*, vol. 67, no. 6, pp. 997-1009

Colman, A. M. (2009) *Oxford Dictionary of Psychology*. 3rd ed. Oxford: Oxford University Press

Connolly, A. (2010) ‘Anthony Connolly paintings & drawings’. Artist’s website. Available from: http://www.anthonyconnolly.co.uk/information.html [accessed 22/05/2013]

Cornette, L., Dupont, P., Salmon, E. & Orban, G. A. (2001) ‘The neural substrate of orientation working memory’. *Journal of Cognitive Neuroscience*, vol. 13, pp. 813-828

Corte-Real, E. (2009) ‘A Smooth Guide to Travel Drawing’. In: proceedings of *Thinking Through Drawing* Conference. 8th Oct 2009. London: Cochrane Theatre

Cowan, N. (2008) ‘What are the differences between long-term, short-term, and working memory?’ *Progressive Brain Research*, vol. 169, pp. 323-338

Cowan, N., Elliott, E. M., Saults, J. S., Morey, C. C., Mattox, S. M., Hismjatullina, A. & Conway, A. R. A. (2005) ‘On the capacity of attention: Its estimation and its role in working memory and cognitive aptitudes’. *Cognitive Psychology*, vol. 51, pp. 42-100

Craik, F. I. & Lockhart, R. S. (1972) ‘Levels of processing: A framework for memory research’. *Journal of verbal learning and verbal behavior*. vol. 11, no. 6, pp. 671-684

Crossman, E. R. (1959) ‘A Theory of acquisition of Speed Skill’. *Ergonomics*, vol. 2, pp. 153-166

Csikszentmihalyi, M. (1991) *Flow: the Psychology of optimal Experience*. New York: HarperCollins Publishers

Curtis, B. (2001) *Drawing from observation: an introduction to perceptual drawing*. London: McGraw-Hill

Curtis, C. E. & D'Esposito, M. (2003) ‘Persistent activity in the prefrontal cortex during working memory’. *Trends in cognitive sciences*, vol. 7, no. 9, pp. 415-423

Darlington, M. (2006) ‘Doing it Together: Collaborative Drawing as a Model of Peer Learning’. *Through the looking Glass*, vol. 3, 2008. UCLAN. Available from: http://www.academia.edu/210322/Doing_it_Together_Collaborative_Drawing_as_a_Model_of_Peer_Learning

Daugherty, J. & Mentzer, N. (2008) ‘Analogical reasoning in the Engineering Design Process and Technology Education Applications’. *Journal of Technology Education*, vol. 19, no. 2. Available from: http://scholar.lib.vt.edu/ejournals/JTE/v19m2/daugherty.html [accessed 30/04/2010]

Datson, L. & Galison, P. (2007). Objectivity. New York: Zone Books

Datson, L. (Ed.). (2004). *Things that talk: Object lessons from art and science*. MIT Press.

Denis. R. (2008)‘A Preliminary Survey of Drawing Manuals in Britain c. 1825-1975’ in Hickman, R. (2008) *Research in Art and Design Education: Issues and Exemplars*. Bristol: Intellect Books

Dehaene, S., Changeux, J. P., Naccache, L., Sackur, J. & Sergent, C. (2006) ‘Conscious, preconscious, and subliminal processing: a testable taxonomy’. *Trends in cognitive sciences*, vol. 10, no. 5, pp. 204-211.

Dehaene, S. & Naccache, L. (2001) ‘Towards a cognitive neuroscience of consciousness: basic evidence and a workspace framework’. *Cognition*, vol. 79, no. 1, pp. 1-37

Demeyere, N., Rzeskiewicz, A., Humphreys, K. A. & Humphreys, G. W. (2008) ‘Automatic statistical processing of visual properties in simultanagnosia’. *Neuropsychologia*, vol. 46, pp. 2861-2864

Dennett, D. (1991) *Consciousness Explained*. Little, Brown & Co. USA

Denzin, N. K. & Lincoln. Y. S. (eds.) (2003) *Strategies of Qualitative Enquiry*. 2nd ed. London: Sage

Denzin, N. K. & Lincoln. Y. S. (eds.) (2008) *The Landscape of Qualitative Research*. 3rd ed. London: Sage

Deregowski, J. B. (1973) ‘Illusion and culture’. In: Gregory, R. L. & Gombrich, E. H. (eds.) *Illusions in nature and art*. New York: Charles Scribner’s Sons, pp. 9-48

Desimone, R. & Duncan, J. (1995) ‘Neural Mechanisms of Selective Visual-Attention’. *Annual Review of Neuroscience*, vol. 18, pp. 193-222

Deubel, H. & Schneider, W. X. (1996) ‘Saccade target selection and object recognition: Evidence for a common attentional mechanism’. *Vision Research*, vol. 36, pp. 1827-1837

Dey, I. (1999) *Grounding grounded theory: guidelines for qualitative inquiry*. London: Academic Press

Driskell, J. E., Willis, R. P. & Copper, C. (1992) ‘Effect of overlearning on retention’. *Journal of Applied Psychology*, vol. 77, no. 5, pp. 615-622

Driver, J. & Baylis, G. C. (1998) 'Movement and visual attention: The spotlight metaphor breaks down'. *Journal of Experimental Psychology: Human Perception and Performance*, vol. 15, pp. 448-456

Driver, J. (2001) 'A selective review of selective attention research from the last century'. *British Journal of Psychology*, vol. 92, pp. 53-78

Dunbar, G. L. (2005) *Evaluating Research Methods in Psychology: a case study approach*. Oxford: Wiley Blackwell

Duncan, J. & Humphreys, G. W. (1989) 'Visual search and stimulus similarity'. *Psychological Review*, vol. 96, pp. 433-458

Duncan, J. (1980a) 'Demonstration of capacity limitation'. *Cognitive psychology*, vol. 12, pp. 75-96

Duncan, J. (1980b) 'The locus of interference in the perception of simultaneous stimuli'. *Psychological Review*, vol. 87, pp. 272-300

Duncan, J. (1984) 'Selective attention and the organization of visual information'. *Journal of Experimental Psychology: General*, vol. 113, pp. 501-517

Edwards, B. (2008 [1979]) *The New Drawing on the Right side of the Brain*. London: Harper Collins

Egly, R., Driver, J. & Rafal, R. D. (1994) 'Shifting visual attention between objects and locations: evidence from normal and parietal lesion subjects'. *Journal of Experimental Psychology: General*, vol. 123, pp. 161-177

Elkins, J. (2001) *Why Art Cannot Be Taught*. Urbana: University of Illinois Press

Eng, H. Y., Chen, D. & Jiang, Y. (2005) 'Visual working memory for simple and complex visual stimuli'. *Psychonomic Bulletin & Review*, vol. 12, pp. 1127-1133

Ericsson, K. A. & Crutcher, R. J. (1991) 'Introspection and verbal reports on cognitive processes – two approaches to the study of thought processes: A response to Howe'. *New Ideas in Psychology*, vol. 9, pp. 57-71

Ericsson, K. A. & Simon, H. A. (1993 [1980]) *Protocol Analysis: verbal reports as data*. Revised edition. London: MIT Press

Ericsson, K. A. (2006) 'Protocol analysis and expert thought: Concurrent verbalizations of thinking during experts' performance on representative tasks'. In: Ericsson, K. A., Charness, N., Hoffman, R. R. & Feltovitch, P. J. (eds.) *The Cambridge handbook of expertise and expert performance*, pp. 223-241

Eriksen, B. A. & Eriksen, C. W. (1974) 'Effects of noise-letters on identification of a target letter in a nonsearch task'. *Perception & Psychophysics*, vol. 16, pp. 143-149

Eriksen, C. W. & James, J. D. S. (1986) 'Visual attention within and around the field of focal attention: a zoom lens model'. *Perceptual Psychophysics*, vol. 40, no. 4, pp. 225-240

Evans, J. S. (2003) 'In Two Minds: Dual-process accounts of reasoning'. In: *Trends in Cognitive Science*, vol. 7, no. 10, pp. 454-459

Evans, J. S. B. T. & Over, D. E. (1996) *Rationality and reasoning*. Hove, U.K.: Psychology Press

Fairhall, S. L., Indovina, I., Driver, J. & Macaluso, E. (2009) 'The Brain Network Underlying Serial Visual Search: Comparing Overt and Covert Spatial Orienting, for Activations and for Effective Connectivity'. *Cerebral Cortex*, vol. 19, no. 12, pp. 2946-2958

Farah, M. J. (1984) 'The Neurological Basis of Mental Imagery: A componential Analysis'. *Cognition*, vol. 18, no. 1, pp. 245-272

Farah, M. J. (2000) *The Cognitive Neuroscience of Vision*. Oxford: Blackwell

Farah, M. J., Wong, A. B., Monheit, M. A. & Morrow, L. A. (1989) 'Parietal lobe mechanisms of spatial attention: modality specific or supramodal?' *Neuropsychologia*, vol. 27, pp. 461-470

Farthing, S. (2010) 'Crossing The Line: Interview with Stephen Farthing', in *Panoptikon: On Contemporary Visual Culture*. Available from: http://thepanoptikon.blogspot.com/2011/10/interview-with-stephen-farthing.html] [date accessed 23/05/2012]

Fava, M. (2010) 'What is the role of observational drawing in contemporary art and design curricula?' In: Norman, E. & Seery, N. *IDATER Online Conference: Graphicacy and Modelling, Loughborough*. Loughborough University Design Education Research Group, pp. 129-142

Fava, M., Brew, A. & Kantrowitz, A. (eds.) *Drawing in STEAM*. Special issue of *TRACEY: Drawing and Visualisation Researc*h. Available from: http://www.lboro.ac.uk/departments/sota/tracey/

Fayena-Tawil, F., Kozbelt, A. & Sitaras, L. (2011) 'Think global, act local: A protocol analysis comparison of artists' and nonartists' cognitions, metacognitions, and evaluations while drawing'. *Psychology of Aesthetics, Creativity, and the Arts*, vol. 5, no. 2, pp. 135-145

Fazl, A., Grossberg, S. & Mingolla, E. (2009) 'View-invariant object category learning, recognition, and search: how spatial and object attention are coordinated using surface-based attentional shrouds'. *Cognitive Psychology*, vol. 58, no. 1, pp. 1-48

Fellenz, W. & Hartmann, G. (1996) 'Preattentive grouping and attentive selection for early visual computation,' In: *Pattern Recognition, Proceedings of the 13th International Conference on Pattern Recognition, ICPR96*. IEEE, vol. 4, pp. 340-345

Findlay, J. M. (1997). 'Saccade target selection during visual search'. *Vision research*, vol. *37* no. 5, 617-631.

Findlay, J. M. (2009) 'Saccadic eye movement programming: sensory and attentional factors'. *Psychological Research*, vol. 73, pp. 127-135

Fish, J. & Scrivener, S. (1990) 'Amplifying the mind's eye: Sketching and Visual Cognition'. *Leonardo*, vol. 23, pp. 117-126

Fish, J. C. (1996) *How Sketches Work: A cognitive theory for improved system design*. PhD Thesis. Loughborough: Loughborough University of Technology

Fitts, P. M. (1964) 'Perceptual-motor skill learning'. In: A. W. Melton (ed.) *Categories of human learning*. New York: Academic Press

Fodor, J. A. (1983) *The modularity of mind: An essay on faculty psychology*. Massachusetts: MIT press

Fodor, J. & Pylyshyn, Z. (2002) 'How direct is visual perception?: Some reflections on Gibson's "Ecological Approach"' in Noe, A. & Thompson, E. (eds.) *Vision and Mind: Selected Writings in the Philosophy of Perception*, p. 167-228

Franconeri, S. L., Alvarez, G. A. & Enns, J. T. (2007) 'How many locations can be selected at once?' *Journal of Experimental Psychology: Human Perception and Performance*, vol. 33, pp. 1003-1012

Freeman, N. H. (1980) *Strategies of representation in young children: Analysis of spatial skills and drawing processes*. London: Academic Press

Frith, C. & Dolan, R. J. (1997) 'Brain Mechanisms Associated with Top-Down Processes in Perception'. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, vol. 352, no. 1358, pp. 1221-1230

Frith, C. & Law, J. (1995) 'Cognitive and Physiological Processes Underlying Drawing Skills'. *Leonardo*, vol. 28, no. 3, pp. 203-205

Fry, R. (1981 [1919]) *Vision and Design*. Minneola, New York: Dover

Fukuda, K., Awh, E. & Vogel, E. K. (2010) 'Discrete capacity limits in visual working Memory'. *Current Opinions in Neurobiology*, vol. 20, pp. 177-182

Fuster, J. M., Bauer, R. H. & Jervey, J. P. (1981) 'Effects of cooling inferotemporal cortex on performance of visual memory tasks'. *Experimental Neurology*, vol. 71, pp. 398-409

Gagné, R. M. & Smith Jr, E. C. (1962) 'A study of the effects of verbalization on problem solving'. *Journal of experimental psychology*, vol. 63, no. 1, pp. 12-18

Gallagher, S. & Sasma, M. (2003) 'Phenomenology and neurophenomenology: An Interview with Shaun Gallagher'. *Aluze: Revue pro literaturu, filozofii a jinè* (Czech Republic), vol. 2, pp. 92-102. Available from: http://pegasus.cc.ucf.edu/~gallaghr/GallINTERVIEW.htm [accessed 13/11/2010]

Gallese, V. (2007) 'The "conscious" dorsal stream: Embodied simulation and its role in space and action conscious awareness'. *Psyche*, vol 13, no. 1, pp. 1-20.

Galotti, K. M. (2008) *Cognitive Psychology: in and out of the laboratory*. 4th ed. Belmont, CA: Thomson Wadsworth

Garner, W. R. & Felfody, G. L. (1970) 'Integrality of stimulus dimensions in various types of information processing'. *Cognitive Psychology*, vol. 1, pp. 225-241

Garner, W. R. (1974) *The Processing of Information and Structure*. Potomac, MD: Erlbaum

Gentner, D. & Jeziorski, M. (1993) 'The shift from metaphor to analogy in western science'. In: Ortony (ed.) *Metaphor and Thought*. 2nd ed. Cambridge MA: Cambridge University Press, pp. 447-480

Gibbs, R. (2006) *Embodiment and cognitive science*. Cambridge: Cambridge University Press

Gibson, J. J. (1961). Ecological optics. *Vision research*, vol. 1, no. 3, pp. 253-262

Gibson, E. J. & Pick, A. D. (2000) *An Ecological Approach to Perceptual Learning and Development*, London: Open University Press

Glaser, B. G. (1998) *Doing Grounded Theory - Issues and Discussions*. Sociology Press

Glaser, M. (2009) *Drawing is Thinking*. Gerald Duckworth & Co. Available from: http://www.mad.co.uk/Main/Search/MadSearchResults/Articles/ca739ac9d4274cc8b1f616870fc09882/Glaser%27s-inner-artist.html) [accessed 12/10/09]

Goel, V. (1995) *Sketches of Thought*. Cambridge MA: MIT Press

Goldberg, D. (2009) 'Subjectivity, consciousness, and pain: The importance of thinking phenomenologically'. *The American Journal of Bioethics*, vol. 9, no. 9, pp. 14-16

Goldsmith, L., Simmons, S., Winner, E., Hetland, L., Hoyle, C. D. & Brooks, C. (in press) 'Geometric Reasoning and Drawing: Possible Interconnections Among STEM Subjects and Art'. In: Fava, Brew & Kantrowitz (eds.) *Drawing in STEAM*, special issue of *TRACEY: Drawing and Visualisation Research*. Available from: www.lboro.ac.uk/departments/sota/tracey/

Gombrich, E. H. (1960) *Art and Illusion*. Princeton, NJ: Princeton University Press

Gombrich, E. H. (1979) *The Sense of Order*. Oxford, UK: Phaidon

Gombrich, E. H. (1982) *The Image and the Eye*. Oxford, UK: Phaidon

Gordon, J. (2004) 'The 'wow' factors: the assessment of practical media and creative arts subjects'. *Art, Design and Communication in Higher Education*, vol. 3, no. 1, pp. 61-72

Goswami, U. (2008) *Cognitive Development: The Learning Brain*. New York: Psychology Press

Gottwald, R. L. & Garner, W. R. (1975) 'Filtering and condensation tasks with integral and separable stimuli'. *Perception & Psychophysics*, vol. 18, pp. 26-28

Gowen, E. & Miall, C. R. (2006) 'Eye-hand interactions in tracing and drawing tasks'. *Human Movement Science*, vol. 25, pp. 568-585

Green, M. (1991) 'Visual search, visual streams and visual architectures'. *Perception & Psychophysics*, vol. 50, pp. 388-403

Gregory, R. L. (1990) *Eye and Brain: The Psychology of Seeing*. 4th ed. Princeton: Princeton University Press

Gregory, R. L. (2005) 'The Medawar Lecture 2001 Knowledge for vision: vision for knowledge'. *Philosophical Transactions of the Royal Society London Biological Sciences*, vol. 360, no. 1458. pp. 1231-1251. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1569493/ [accessed 01/10/2012]

Gregory, R. L. (1998) 'Brainy Mind'. *British Medical Journal*, vol. 317, pp. 1693-1695

Griffin, I. C. & Nobre, A. C. (2003) 'Orienting attention to locations in internal representations'. *Journal of cognitive neuroscience*, vol. 15, no. 8, pp. 1176-1194

Grossberg, S. (2010) 'The link between brain learning attention, and consciousness'. In: Carsetti, A. (ed.) *Causality, Meaningful Complexity and Embodied Cognition*. Springer Netherlands, pp. 3-45

Guérin, F., Ska, B. & Belleville, S. (1999) 'Cognitive Processing of Drawing Abilities'. *Brain and Cognition*, vol. 40, pp. 464-478

Haberman, J. & Whitney, D. (2007) 'Rapid extraction of mean emotion and gender from sets of faces'. *Current Biology*, vol. 17, pp. R751-R753

Haberman, J. & Whitney, D. (2007) 'Saving face: Extracting summary statistics from a set of faces'. *Journal of Vision*, vol. 7, no. 9, pp. 885-885

Haig, B. D. (1995) 'Grounded theory as scientific method'. In: *Philosophy of Education 1995: Current issues*. Urbana, IL: University of Illinois Press, vol. 1, no. 11, pp. 281-290

Hale, R. B. (1989) *Drawing Lessons from the Great Masters*. New edition. New York: Watson-Guptill Publicaions

Haley, D. (2010) 'How do artists teachdrawing?' Thread, UK Drawing ResearchNetwork mailing list. 27 March 2010. Available e-mail:drawing-research@jiscmail.ac.uk

Haraway, D. (1991) *Simians, Cyborgs and Women: The Reinvention of Nature*. London: Free Association Books

Hayhoe, M. & Ballard, D. (2005) 'Eye movements in natural behavior'. *Trends in cognitive sciences*, vol. 9, no. 4, pp. 188-194

Head, H. (1920) *Studies in Neurology*, London: Frowde

Hetland, L. (2013) *Studio Thinking 2: The Real Benefits of Visual Arts Education*. Teachers College Press

Hewison, R. (1996) *Ruskin at Oxford: the art of education*. Oxford: Clarendon Press

Hickman, R. (2008) *Research in Art and Design Education: Issues and Exemplars*. Bristol: Intellect Books

Hirsh-Pasek, K. & Bruer, J. T. (2007) 'The brain/education barrier'. *Science*, vol. 317, no. 5843, pp. 1293-1293

Hodgson, D. (2004) 'Ways of Seeing: The Innocent Eye, Individual View and Visual Realism in Art'. *Journal of Consciousness Studies*, vol. 11, no. 12, pp. 3-16

Hoffman, H. S. (1989) *Vision and the art of drawing*. Englewood Cliffs, NJ: Prentice Hall

Hoffman, R. R. (1992) *The psychology of expertise*. New York: Springer

Hofstadter, D. R. (2001) 'Analogy as the core of cognition'. *The analogical mind: Perspectives from cognitive science*, pp. 499-538

Holyoak, K.J., Gentner, D. & Kokinov, B. N. (2001) 'Introduction: The place of analogy in cognition'. In: Gentner, D. Holyoak K. J. & Kokinov B. N. (eds.), *The analogical mind: Perspectives from cognitive science,* Cambridge, Massachusetts: MIT Press*,* pp. 1-19

Honey, P. & Mumford, A. (2000) *The learning styles helper's guide*. Maidenhead, UK: Peter Honey

Huang, L. & Pashler, H. (2007) 'A Boolean map theory of visual attention'. *Psychological review*, vol. 114, no. 3, pp. 599-631

Huang, L. (2010a) 'What Is the Unit of Visual Attention? Object for Selection, but Boolean Map for Access'. *Journal of Experimental Psychology*, vol. 139, no. 1, pp. 162-179

Huang, L. (2010b) 'Characterizing the nature of visual conscious access: The distinction between features and locations'. *Journal of Vision*, vol. 10, no. 24, pp. 1-17

Huang, L., Treisman, A. & Pashler, H. (2007) 'Characterizing the Limits of Human Visual Awareness'. *Science*, vol. 317, pp. 823-825

Hughes, J. & Parkes, S. (2003) 'Trends in the use of verbal protocol analysis in software engineering research'. *Behaviour & Information Technology*, vol 22, No. 2, pp. 127-140.

Humphreys, G. W. (1999) *Case Studies in the Neuropsychology of Vision*. Hove, UK: Psychology Press Ltd

Humphreys, G. W., Olson, A., Romani, C. & Riddoch, M. J. (1996) 'Competitive mechanisms of selection by space and by object: A neuropsychological approach'. In: Kramer, A. F. Coles, M. G. H. &. Logan, G. D (eds.) *Convergent operations in the study of visual selective attention*. Washington, DC: APA Press

Husserl, E., Brough, J. B. (trans.) (1991 [1966]) *On the Phenomenology of the Consciousness of Internal Time* (1893-1917), Collected Works IV. London: Kluwer Academic Publishers

IDEAL project (2009) 'Intercultural Drawing for European Adult Learning'. *Life Long Learning Programme*, (on Drawing Spaces gallery website) GRUNTVIG. Available from: http://drawingspacesen.weebly.com/ideal-partnership---grundtvig.html [accessed 24/11/2009]

Ignatow, G. (2007) 'Theories of Embodied Knowledge: New Directions for Cultural and Cognitive Sociology?' *Journal for the Theory of Social Behavior*, vol. 37, no. 2, pp. 115-135

Imreh, R. C. G. (1997) '"Pulling teeth and torture": musical memory and problem solving'. *Thinking & Reasoning*, vol. 3, no. 4, pp. 315-336

Ione, A. (2000) 'Connecting the cerebral cortex with the artists' eyes, mind and culture'. *Journal of Consciousness Studies*, vol. 7, pp. 8-9

Irwin, D. E. (1992) 'Memory for position and identity across eye movements'. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, vol. 18, pp. 307-317

Itti, L. & Koch, C. (2001) 'Computational modeling of visual attention' *Nature Reviews Neuroscience*, vol. 2, no. 3, pp. 194-203

Jackendoff, R. (1996) 'How Language Helps Us Think'. *Pragmatics and Cognition*, vol. 4, pp. 1-34

Jackendoff, R. (2007) *Language, Consciousness, Culture: Essays on Mental Structure*. Cambridge MA: MIT Press

Jacob, P. & Jeannerod, M. (2003) *Ways of seeing: The scope and limits of visual cognition*. Oxford: Oxford University Press

James, R. A. & Arlinda, F. K. (1991) 'Discriminating artists from nonartists by their eye-fixation patterns'. *Perceptual and motor Skills*, vol. 73, no. 3, pp. 893-894

James, W. (2007 [1890]) *The Principles of Psychology*. New York: Cosimo

Jensen, E. (2001) *Arts with the Brain in Mind*. Alexandria, US: Association for Supervision and Curriculum Development

Johnson, M. (1988) 'Some Constraints on Embodied Analogical Understanding' In *Analogical Reasoning: Perspectives of Artificial Intelligence, Cognitive Science and Philosophy.* Helman, D. H. (ed)(1988) Dordrecht: Kluwer Academic Publishers, pp. 25-40

Johnson, M. (1990) *The Body in the Mind: the bodily basis of meaning, imagination, and reason*. Chicago: University of Chicago Press

Johnson, M. (2007) *The Meaning of the Body: aesthetics of human understanding*. Chicago: University of Chicago Press

Jolley, R. P. (2009) *Children and Pictures: Drawing and Understanding*. Oxford: Wiley Blackwell

Kahneman, D. & Frederick, S. (2002) ‘Representativeness revisited: attribute substitution in intuitive judgment’. In: Gilovich, T. et al. (eds.) *Heuristics and Biases: The Psychology of Intuitive Judgment*. Cambridge University Press, pp. 49-81

Kahneman, D. & Henik, A. (1981) ‘Perceptual organization and attention’. In: M. Kubovy & J. R. Pomerantz (eds.) *Perceptual organization*. Hillsdale, NJ: Erlbaum, pp. 181-211

Kahneman, D. (2003a) ‘A perspective on judgment and choice’. *American Psychologist*, vol. 58, pp. 697-720

Kahneman, D. (2003b) ‘Maps of Bounded Rationality: Psychology for Behavioral Economics’. *The American Economic Review*, vol. 93, no. 5, pp. 1449-1475

Kahneman, D. (2011) *Thinking, Fast and Slow*. New York: Farrar, Straus and Giroux

Kandel, E. (2012). *The age of insight: The quest to understand the unconscious in art, mind, and brain, from Vienna 1900 to the present*. London: Random House

Kandel, E. R. & Wurtz, R. H. (2000) ‘Constructing the visual image’. *Principles of neural science,* 4th ed., pp. 492-506

Kang, M. S., Hong, S. W., Blake, R. & Woodman, G. F. (2011) ‘Visual working memory contaminates perception’. *Psychonomic Bulletin & Review*, vol. 18, pp. 860-869

Kantrowitz, A. (2011) ‘Drawing: a matter of life and death?’ In: Kantrowitz, A., Brew, A. & Fava, M. (eds.) *Proceedings of Thinking through Drawing: practice into knowledge*. New York: Teachers College, Columbia University, Art and Art Education Program, pp. 119-122

Kantrowitz, A. (in press) *Cognitive interactions underlying contemporary artists drawing practices*. Dissertation. Columbia Teachers College

Kastner, S. (2004) ‘Attentional response modulation in the human visual system’. In: Posner, M. I. (ed.) *Cognitive Neuroscience of Attention*. New York: Guilford Press

Keil, F. C., Rozenblit, L. & Mills, C. M. (2004) ‘What Lies Beneath: Understanding the Limits of Understanding’. In: Levin, D. T. (ed.) *Thinking and Seeing: Visual Metacognition in Adults and Children*. Cambridge MA: MIT Press

Keogh, R. & Pearson, J. (2011) ‘Mental Imagery and Visual Working Memory’. Plos One, vol. 6, no. 12, document e29221. Available from: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0029221 [accessed 22/05/2012]

Koch. C. (1996) ‘Towards the neuronal substrate of visual consciousness’. In: Hameroff, S. R., Kaszniak, A. W. & Scott. A. C. (eds.) *Towards a Science of Consciousness: The First Tucson Discussions and Debates*. Cambridge MA: MIT Press

Koch, C. & Tsuchiya, N. (2012). Attention and consciousness: related yet different. *Trends in cognitive sciences*, vol. 16, no. 2, pp. 103-105

Koch, C. & Ullman, S. (1987) ‘Shifts in selective visual attention: towards the underlying neural circuitry’. In Veiner, L. M. (ed.) *Matters of Intelligence,* vol. 188, Springer Netherlands. pp. 115-141

Kolb, D. A. (1984) *Experiential learning: Experience as the source of learning and development* (vol. 1). Englewood Cliffs, NJ: Prentice-Hall

Kosslyn, S. M. (1980) *Image and Mind*. Cambridge, MA: Harvard University Press

Kosslyn, S. M. (1996) *Image and Brain: the resolution of the imagery debate*. MA: MIT Press

Kosslyn, S. M. & Koenig, O. (1992) *Wet mind: The new cognitive neuroscience*. New York: Simon and Schuster

Kosslyn, S. M., Thompson, W. L., Kim, I. J. & Alpert, N. M. (1995) ‘Topographical representations of mental images in primary visual cortex’. *Nature*, vol. 378, pp. 496-498

Kosslyn, S. M., Upert, N. M., Thompson, F. V. L., Maljkoric, V., Weise, S. B., Chabris, C. F., Hamilton. S. E., Rauch, S. I. & Buonanno, F. S. (1999) ‘Visual Mental Imagery Activates Topographically Organized Visual Cortex: PET Investigations’. *Journal of Cognitive Neuroscience*, pp. 263-287

Kowler, E. (2011) ‘Eye movements: The past 25 years’. *Vision research*, vol. 51, no. 13, pp. 1457-1483

Kowler, E., Anderson, E., Dosher, B. & Blaser, E. (1995) ‘The role of attention in the programming of saccades’. *Vision Research*, vol. 35, pp. 1897-1916

Kozbelt, A. & Seeley, W. P. (2007) ‘Integrating art historical, psychological, and neuroscientific explanations of artists' advantages in drawing and perception’. *Psychology of Aesthetics, Creativity, and the Arts*, vol. 1, no. 2, pp. 80-90

Kozbelt, A. (2001) ‘Artists as experts in visual cognition’. *Visual Cognition*, vol. 8, no. 6, pp. 705-723

Kozbelt, A. (2008) ‘Gombrich, Galenson, and beyond: Integrating case study and typological frameworks in the study of creative individuals’. *Empirical Studies of the Arts*, vol. 26 no. 1, pp. 51-68

Kozbelt, A., Seidel, A. ElBassiouny, A., Mark, Y. & Owen, D. R. (2010) ‘Visual Selection Contributes to Artists’ Advantages in Realistic Drawing’. *Psychology of Aesthetics, Creativity and the Arts*, vol. 4, no. 2, pp. 93-102

Kramer, A. F. & Hahn, S. (1995) ‘Splitting the beam: Distribution of attention over non-contiguous regions of the visual field’. *Psychological Science*, vol. 6, pp. 381-386

Kramer, A. F., Wiegmann, D. A. & Kirlik, A. (2007) *Attention: from theory to practice*. Oxford: Oxford University Press

Krippendorff, K. (2004) *Content Analysis: An Introduction to Its Methodology*. 2nd ed. London: Sage

Kvale, S. & Brinkmann, S. (2009) *InterViews: Learning the craft of qualitative research interviewing*. 2nd ed. London: Sage

Kvale, S. (1996) *Interviews: an introduction to qualitative research interviewing*. London: Sage

Lakoff, G. & Johnson, M. (1980) *Metaphors We Live By*. Chicago: University of Chicago Press

Lakoff, G. & Johnson, M. (1999) *Philosophy in the Flesh: The Embodied Mind and its Challenge to Western Thought*. University of California, Berkeley / University of Oregon. New York: Basic Books

Land, M. F. (2006) 'Eye movements and the control of actions in everyday life'. *Progress in retinal and eye research*, vol. 25, no. 3, pp. 296-324

Langer, E. J. & Imber, L. G. (1979) 'When practice makes imperfect: debilitating effects of overlearning'. *Journal of personality and social psychology*, vol. 37 no. 11, 2014

LaSpina, J. A. (1998) *The Visual Turn and the Transformation of the Textbook*. New Jersey: Lawrence Erlbaum Associates

Lathrop. S. D. (2008) *Extending cognitive architectures with spatial and visual imagery mechanisms*. PhD thesis. University of Michigan

Latour, B. & Woolgar, S. (1979) *Laboratory life: The social construction of scientific facts*. Princeton University Press

Latour, B. (1999) *Pandora's Hope: Essays on the Reality of Science Studies*. London: Harvard University Press

Latto, R. (1995) 'The brain of the beholder'. In: R. L. Gregory, J. Harris, P. Heard & D. Rose (eds.) *The Artful Eye*. Oxford: Oxford University Press

Laughton, B. (1986) *The Euston Road School*. London: Scholar Press

Law, J. (2004) *After Method: Mess in social science research*. London: Routledge

Lawrence, M. A. & Klein, R. M. (2013) 'Isolating exogenous and endogenous modes of temporal attention'. *Journal of Experimental Psychology*. vol. 142, no. 2, pp. 560-572

Lee, M. (1989) 'When is an object not an object? The effect of "meaning" upon the copying of line drawings'. *British Journal of Psychology*, vol. 80, pp. 15-37

Lockhart, R. S. & Craik, F. I. (1990) 'Levels of processing: a retrospective commentary on a framework for memory research'. *Canadian Journal of Psychology/Revue canadienne de psychologie*, vol. 44, no. 1, pp. 87-112

Luck, S. J. & Vogel, E. K. (1997) 'The capacity of visual working memory for features and conjunctions'. *Nature*, vol. 390, pp. 279-281

Luquet, G. H. (1927) *Le Dessin Enfantin*. Paris: Alcan

Lynch, M. A. (2004) 'Long-term potentiation and memory'. *Physiological reviews*, vol. 84 no.1, pp. 87-136

Lyons, L. (2012) 'drawing your way into understanding' *TRACEY Drawing Knowledge* Available online: http://www.lboro.ac.uk/microsites/sota/tracey/journal/edu/2012/lyons.html [accessed 12/04/2013]

Macleod, K. & Holdridge, L. (eds.) (2006) *Thinking Through Art: reflections on art as research*. New York: Routledge

Maffei. L. & Fiorentini. A. (1973) 'The visual cortex as a spatial frequency analyzer'. *Vision Research*, vol. 13, pp. 1255-1267

Magnussen, S. (2000) 'Low-level memory processes in vision'. *Trends in neurosciences*, vol. 23, pp. 247-251

Malcolm, G. L. & Henderson, J. M. (2009) 'The effects of target template specificity on visual search in real-world scenes: Evidence from eye movements'. *Journal of Vision*, vol. 9, no. 11, pp. 1-13

Marr, D. (1982) *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information*. New York: Freeman

Marr, D. & Nishihara, H. K. (1978) 'Representation and recognition of the spatial organization of three-dimensional shapes'. *Proceedings of the Royal Society of London*. Series B. Biological Sciences, vol. 200, no. 1140, pp. 269-294

Marshall, J. C. & Halligan, P. W. (1988) 'Blindsight and insight in visuo-spatial neglect'. *Nature*, vol. 336, pp. 766-767

Martin, S. J., Grimwood, P. D. & Morris, R. G. M. (2000) Synaptic plasticity and memory: an evaluation of the hypothesis. *Annual review of neuroscience*, 23(1), 649-711

Marzio, P. C. (1976) *The Art Crusade: An Analysis of Nineteenth Century American Drawing Manuals, Chiefly 1820-1860*. Smithsonian Institution Press

McDermott, J. J. (ed.) (1977) *The writings of William James: a comprehensive edition*. Chicago: University of Chicago Press

McGraw, T. M. (1997) *The effects of Two-dimensional and Three-dimensional Stimuli on Spatial Recognition in Drawings*. PhD Thesis. Virginia, USA: Virginia Polytechnic Institute and State University

McLuhan, M. & Fiore, Q. (1967) *The medium is the message*. New York, 123, 126-128

McLuhan, M. (2008) 'The medium is the message'. *Communication theory*, pp. 390-402

McMahon, J. A. (2002) ‘An explanation for normal and anomalous drawing ability and some implications for research on perception and imagery’. *Visual Arts Research*, pp. 38-52

Mehler, J. & Dupoux, E. (1994) *What Infants Know: The New Science of Early Cognitive Development*. London: Blackwell

Melcher, D. & Kowler, E. (1999) ‘Shapes, surfaces and saccades’. *Vision Research*, vol. 39, pp. 2929-2946

Miall, C., Gowen, E. & Tchalenko, J. (2009) ‘Drawing cartoon faces – a functional imaging study of the cognitive neuroscience of drawing’. *Cortex*, vol. 45, pp. 394-406

Miall, R. C. & Tchalenko, J. (2001) ‘A Painter's Eye Movements: A Study of Eye and Hand Movement during Portrait Drawing’. *Leonardo*, vol. 34, no. 1. Cambridge, MA: MIT Press, pp. 35-40

Micklewright, K. (2005) *Drawing: mastering the language of visual expression*. London: Lawrence King

Miller, S. & Fredericks, M. (1999) ‘How does grounded theory explain?’ *Qualitative Inquiry*, vol. 9, pp. 538-551

Milner, A. D. & Goodale, M. A. (2008) ‘Two visual systems re-viewed’. *Neuropsychologia*, vol. 46, pp. 774-785

Mishkin, M. & Petri, H. L. (1984) ‘Memories and habits: some implications for the analysis of learning and retention’. *Neuropsychology of memory*, pp. 287-296

Mitchell, P., Ropar, D. & Ackroyd, K. (2005) ‘How Perception impacts drawing’. *Journal of Experimental Psychology: Human Perception and Performance*, vol. 31, pp. 996-1003

Miyashita, Y. (1988) ‘Neuronal correlate of visual associative long-term memory in the primate temporal cortex’. *Nature*, vol. 335 no.6193, pp. 817-820

Monahan, J. S. & Lockhead, G. R. (1977) ‘Identification of integral stimuli’. *Journal of Experimental Psychology: General*, vol. 106, pp. 94-110

Montarou, C. (2013) Mindfulness: The holy grail of design education? Proceedings of DRS CUMULUS, 2nd international Conference for Design Education Researchers. Oslo, May 2013

Montgomery-Whicher, R. (1997) *Drawing from Observation: A phenomenological enquiry*. Doctoral dissertation. Canada: University of Alberta

Moore, C. M. & Wolfe, J. M. (2001) ‘Getting beyond the serial/parallel debate in visual search: a hybrid approach’. In: Shapiro, K. (ed.) *The Limits of Attention: Temporal Constraints on Human Information Processing*. Oxford University Press, pp. 178-198

Neider, M. B. & Zelinsky, G. J. (2006) ‘Scene context guides eye movements during visual search’. *Vision Research*, vol. 46, pp. 614-621

Neisser, U. (1963) ‘Decision time without reaction time: Experiments in visual scanning’. *American Journal of Psychology*, vol. 76, no. 3, pp. 376-385

Neisser, U. (1967) *Cognitive psychology*. New York: Appleton Century Crofts.

Neisser, U. (1976) *Cognition and reality: Principles and Implications of Cognitive Psychology*. San Francisco: Freeman

Nelson, T. O., Leonesio, J., Shimamura, A. P., Landwehr, R. F. & Narens, L. (1982) ‘Overlearning and the feeling of knowing’. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, vol. 8, no. 4, pp. 279-288

Nicolaides, K. (2008 [1941]) *The Natural Way to Draw*. London: Souvenir Press

Nielsen, S. G. (1999) ‘Learning strategies in instrumental music practice’. *British Journal of Music Education*, vol. 16, no. 3, pp. 275-291

Nisbett, R. E. & Wilson, T. D. (1977) ‘Telling more than we can know: Verbal reports on mental processes’. *Psychological review*, vol. 84, no. 3, pp. 231-259

Noë, A. & Thompson, E. (eds.) (2002) *Vision and mind: selected readings in the philosophy of perception*. Cambridge MA: MIT Press

Norman, F. (2001) ‘Towards a paperless studio’. In: *Proceedings of The ARCC Spring Research Meeting Architectural Research Centers Consortium*

Novick, L. R. (1988) ‘Analogical transfer, problem similarity, and expertise’. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, vol. 14, no. 3, pp. 510-520

Novick, L. R. (1988) ‘Analogical Transfer: processes and individual differences’. In: Helman, D. H. (ed.) *Analogical Reasoning: Perspectives of Artificial Intelligence, Cognitive Science and Philosophy*. Dordrecht: Kluwer Academic Publishers

Novick, L. R. (1988a) ‘Analogical Transfer’. In: D. H. (ed.) *Analogical Reasoning*. Dordrecht: Kluwer Academic Publishers

O’Craven, K. M. & Kanwisher, N. (2000) ‘Mental Imagery of Faces and Places Activates Corresponding Stimulus-Specific Brain Regions’. *Journal of Cognitive Neuroscience*, vol. 12, no. 6, pp. 1013-1023

O’Regan, J. K. & Noë, A. (2001) ‘A sensorimotor account of vision and visual consciousness’. *Behavioral and Brain Sciences*, vol. 25, no. 4, pp. 883-975

Oh, S. W. & Kim, M. S. (2004) ‘The role of spatial working memory in visual search efficiency’. *Psychonomic Bulletin & Review*, vol. 11, no. 2, pp. 275-281

Op de Beeck, H., Baker, C., DiCarlo, J. & Kanwisher, N. (2006) ‘Discrimination Training Alters Object Representations in Human Extrastriate Cortex’. *Journal of Neuroscience*, vol. 26, pp. 13025-13036

Osgood, C. E. (1949) 'The similarity paradox in human learning; a resolution'. *Psychological review*, vol. 56, no. 3, pp. 132-143

Oxford English Dictionary (OED) (2012) *The definitive record of the English Lanuage.* Oxford University Press. Available from: http://oxforddictionaries.com/ [accessed 07/05/2012]

Paas, F., Renkl, A. & Sweller, J. (2003) 'Cognitive Load Theory and Instructional Design: Recent Developments'. In: Corno, L. & Winne, P. H. (eds.) *Cognitive Load Theory: A Special Issue of Educational Psychologist*, vol. 38, no. 1. London: Lawrence Erlbaum Associates

Packer, M. J. (1985) 'Hermeneutic inquiry in the study of human conduct'. *American Psychologist*, vol. 40, no. 10, pp. 1081-1093

Parkes, L., Lund, J., Angelucci, A., Solomon, J. A. & Morgan, M. (2001) 'Compulsory averaging of crowded orientation signals in human vision'. *Nature Neuroscience*, vol. 4, no. 7, pp. 739-744

Pashler, H. (1988) 'Familiarity and visual change detection'. *Perception & Psychophysics*, vol. 44, pp. 369-378

Pearson, J., Clifford, C. W. G. & Tong, F. (2008) 'The functional impact of mental imagery on conscious perception'. *Current Biology*, vol. 18, pp. 982-986

Peller, L. E. (1966) 'Freud's Contribution to Language Theory'. *The Psychoanalytical Study of the Child*, vol. 21, pp. 448-467

Perkins, D. N. & Salomon, G. (1988) 'Teaching for Transfer'. *Educational Leadership*, vol. 46, no. 1, pp. 22-32

Perry, R. J. & Zeki, S. (2000) 'The neurology of saccades and covert shifts in spatial attentionAn event-related fMRI study'. *Brain*, vol. 123, no. 11, pp. 2273-2288

Petersen, S. E., Van Mier, H., Fiez, J. A. & Raichle, M. E. (1998) 'The effects of practice on the functional anatomy of task performance'. *Proceedings of the National Academy of Sciences*, vol. 95, no. 3, pp. 853-860

Petherbridge, D. (1996) 'Drawing backwards into the future: Formulating an agenda'. In: Hetherington, P. (ed.) *Issues in Art and Education. Aspects of the Fine Art Curriculum*. London: Wimbledon School of Art/Tate Gallery, pp. 57-62

Petherbridge, D. (2008) 'Nailing the Liminal: The Difficulties of Defining Drawing' in Steve Garner (ed.) *Writing on Drawing, Essays on Drawing Practice and Research*. Bristol and Chicago: Intellect

Petherbridge, D. (2008) 'Nailing the Liminal: The Difficulties of Defining Drawing'. In: Steve Garner (ed.) *Writing on Drawing, Essays on Drawing Practice and Research*. Bristol and Chicago: Intellect

Petherbridge, D. (2010) *The Primacy of Drawing*. London: Yale University Press

Phillips, W. A., Hobbs, S. B. & Pratt, F. R. (1978) 'Intellectual realism in children's drawings of cubes'. *Cognition*, vol. 6, pp. 15-33

Piaget, J. & Inhelder, B. (1967 [1948]) *A Child's Conception of Space*. Translated by F. J. Langdon & J. L. Lunzer, Trans. New York: Norton

Piaget, J. (1926) *The Language and Thought of the Child*. London: Routledge and Kegan Paul

Picon, A. & Ponte, A. (2003) *Architecture and the Sciences: exchanging metaphors*. New York: Princeton Architectural Press

Pierrot-Deseilligny, C., Milea, D. & Müri, R. M. (2004) 'Eye movement control by the cerebral cortex'. *Current opinion in neurology*, vol. 17, no. 1, pp. 17-25

Pinker, S. (1990) 'A theory of graph comprehension'. In: Freedle, R. (ed.) *Artificial intelligence and the future of testing*. Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 73-126

Põder, E. (2001) 'Size-based selection in rapid serial visual presentation'. *Vision research*, vol. 41, no. 17, pp. 2221-2234

Polanyi, M. (1966) *The Tacit Dimension*. London: Routledge & Kegan Paul Ltd.

Popper, K. & Eccles, J. C. (1977) *The Self and Its Brain*. London: Springer Verlag

Posner, M. I. (1980) 'Orienting of Attention'. *Quarterly Journal of Experimental Psychology*, vol. 32, pp. 3-25

Posner, M. I. (ed.) (2011) *Cognitive Neuroscience of Attention*. 2nd ed. New York: Guilford Press

Posner, M. J. & Peterson, S. E. (1990) 'The attention system of the human brain'. *Annual Review Neuroscience*, vol. 13, pp. 25-42

Prats, M., Lim, S., Jowers, I., Garner, S. W. & Chase, S. (2009) 'Transforming shape in design: observations from studies of sketching'. *Design Studies*, vol. 30, no. 5, pp. 503-520

Pylyshyn, Z. (2003) *Seeing and Visualizing: It's Not What You Think*. Cambridge, MA: MIT Press

Pylyshyn, Z. W. (1973) 'What the mind's eye tells the mind's brain: A critique of mental imagery'. *Psychological Bulletin*, vol. 80, no. 1, pp. 1-24

Pylyshyn, Z. W. (1984) *Computation and Cognition*. Cambridge, MA: MIT press

Pylyshyn, Z., Burkell, J., Fisher, B., Sears, C., Schmidt, W. & Trick, L. (1994) 'Multiple parallel access in visual attention'. *Canadian Journal of Experimental Psychology*, vol. 48, no. 2, pp. 260-283

Quinlan, P. T. (2003) 'Visual feature integration theory: past, present, and future'. *Psychological bulletin*, vol. 129, no. 5, pp. 643-673

Ramachandran, V. S. & Hirstein, W. (1999) ‘The Science of Art: A Neurological Theory of Aesthetic Experience’. *Journal of Consciousness Studies*, vol. 6, no. 6-7, pp. 15-51

Reber, A. S. (1989) ‘Implicit Learning and Tacit Knowledge’. *Journal of Experimental Psychology: General*, vol. 118, no. 3, pp. 219-235

Recanzone, G. H. & Cohen, Y. E. (2010) ‘Serial and parallel processing in the primate auditory cortex revisited’. *Behavioural brain research*, vol. 206, no. 1, pp. 1-7

Reif, F. (2008) *Applying Cognitive Science to Education*. London: MIT Press

Rensink, R. A. (2009) ‘Attention: Change Blindness and Inattentional Blindness’. *Encyclopedia of Consciousness*, vol. 5, pp. 47-59

Repp, B. H. & Doggett, R. (2007) ‘Tapping to a very slow beat: a comparison of musicians and nonmusicians’, *Music Perception: An Interdisciplinary Journal*, vol. 24, No. 4, pp. 367-376

Ress, D., Backus, B. T. & Heeger, D. J. (2000) ‘Activity in primary visual cortex predicts performance in a visual detection task’. *Nature Neuroscience*, vol. 3, pp. 940-945

Revonsuo, A. & Newman, J. (1999) ‘Binding and Consciousness’. *Consciousness and Cognition*, vol. 8, pp. 123-127

Richardson, J. T. E. (1996) *Handbook of Qualitative Research Methods for Psychology and the Social Sciences*. Leicester: PBS Books

Riley, B. (2009) ‘At the End of My Pencil’. *London Review of Books*, vol. 31, no. 19. pp. 20-21. Available from: http://www.lrb.co.uk/v31/n19/bridget-riley/at-the-end-of-my-pencil [accessed 01/10/2012]

Riley, H. (2000) ‘Drawing and Culturally-Conditioned Perception’. In: *Tracey-Drawing and Visualisation Research* (online journal) Loughborough University. Issue Sept. 1997 Available from: http://www.lboro.ac.uk/departments/ac/tracey/thin/riley.html [accessed 06/09/09]

Riley, H. (2001) *The Intelligence of Seeing*. PhD thesis. Swansea: University of Wales

Riley, H. (2008) ‘Drawing: Towards an Intelligence of Seeing’. In: Garner, S. (ed.) *Writing on Drawing*. Bristol: Intellect/University of Chicago Press, pp. 153-167

Rizzolatti, G., Riggio, L., Dascola, I. & Umiltá, C. (1987) ‘Reorienting attention across the horizontal and vertical meridians: evidence in favor of a premotor theory of attention’. *Neuropsychologia*, vol. 25, no. 1, pp. 31-40

Roberts, A. C., Robbins, T. W. & Weiskrantz, L. E. (1998) *The prefrontal cortex: Executive and cognitive functions*. Oxford University Press

Rodrigues, A. L. (2007) *Ensaios nas Margens do Futuro, Sentidos e Significações* [Essays at the margins of the Future, Senses and Significations]. Lisbon: Estampa

Rohrer, D; Taylor, K., Pashler, H., Wixted, J. T. & Cepeda, N. J. (2004) 'The Effect of Overlearning on Long-Term Retention'. *Applied Cognitive Psychology* vol. 19, pp. 361-374

Rose, C. (ed) (2004) *Neurology of the Arts*. London: Imperial College Press.

Rose, G. (2007) *Visual Methodologies: An Introduction to the Interpretation of Visual Materials*. 2nd ed. London: Sage

Rose, S. E., Jolley, R. P. & Burkitt, E. (2006) 'A Review of Children's, Teachers'. *and Parents' Influences on Children's Drawing Experience'. JADE. London: NSEAD/Blackwell Publishing*, vol. 25, no. 3, pp. 341-349

Ruskin, J. (1991 [1857]) *The Elements of Drawing*. Illustrated edition. London: The Herbert Press

Ryle, C. & Dennet, D. (2002) *The Concept of Mind*. Chicago: University of Chicago Press

Salama, A. M. & Wilkinson, N. (2007) 'Introduction: Digital Technologies and the Studio'. In: Wilkinson, N. (ed.) *Design Studio Pedagogy: Horizons for the Future*. ARTI-ARCH, pp. 41-46

Schacter, D. L., Addis, D. R. & Buckner, R. L. (2007) 'Remembering the past to imagine the future: the prospective brain'. *Nature Reviews Neuroscience*, vol. 8, pp. 657-661

Scheidemann, N. V. (1939) 'Die Fliegenden Blatter'. In: *Experiments in General Psychology*. Enlarged ed. Chicago, fig. 21, p. 67

Schiferl, E. (2002) 'Eye on the brain: Connecting Egyptian and Medieval spatial representation to brain scan research'. In: a paper presented at *The Meeting of the College Art Association*. Philadelphia

Schiferl, E. (2007) 'Bridging the two cultures: Disciplinary divides and educational reward systems'. *Forum on Public Policy*. Special Issue on Art and Science, vol. 1 23. Available from: http://www.forumonpublicpolicy.com [Accessed 20/05/2010]

Schiferl, E. I. (2008) 'Both sides now: Visualizing and drawing with the right and left hemispheres of the brain'. *Studies in Art Education*, vol. 50, no. 1, pp. 67-82

Schleser, R., Meyers, A. W. & Cohen, R. (1981) 'Generalization of self-instructions: Effects of general versus specific content, active rehearsal, and cognitive level'. *Child Development*, vol. 52, pp. 335-340

Schneider, W. X. & Deubel, H. (2002) 'Selection-for-perception and selection-for-spatial motor-action are coupled by visual attention: a review of recent findings and new evidence from stimulus-driven saccade control'. In: W. Prinz & B. Hommel (eds.) *Attention and Performance XIX: common mechanisms in perception and action*. Oxford: Oxford University Press, pp. 609-627

Scholl, B. J., Pylyshyn, Z. W. & Feldman, J. (2001) 'What is a visual object? Evidence from target merging in multiple object tracking'. *Cognition*, vol. 80, no. 1, pp. 159-177

Schön, D. A. (1983) *The Reflective Practitioner: how professionals think in action*. London: Basic Books

Schön, D. A. (1987) *Educating the reflective practitioner.* San Francisco: Jossey-Bass

Schwartz, S., Maquet, P. & Frith, C. (2002) 'Neural correlates of perceptual learning: A functional MRI study of visual texture discrimination'. *Proceedings of the National Academy of Sciences of the United States of America*, vol. 99, no. 26, pp. 17137-17142

Schwartz, T. (1989) 'The Art of The Mind'. *New York Magazine*, vol. 22, no. 49, pp. 42-59

Scrivener, S. (1997) 'Structure of sketching behavior'. In: *Tracey-Drawing and Visualisation Research*, (online journal) Loughborough University. Issue Sept. 1997. Available from: http://www.lboro.ac.uk/departments/ac/tracey/thin/scriven.html [accessed 03/10/09]

Seago, A. & Dunne, A. (1999) 'New Methodologies in Art and Design Research: The Object as Discourse'. *Design Issues*, vol. 15, no. 2, pp. 11-17

Seeley, W. P. & Kozbelt, A. (2008) 'Art, artists, and perception: A model for premotor contributions to perceptual analysis and form recognition'. *Philosophical Psychology*, vol. 21, pp. 149-171

Shapley, R., Caelli, T., Grossberg, S., Morgan, M. & Rentschler, I. (1990) 'Computational theories of visual perception'. In: L. Spillmann & J. S. Werner (eds.) *Visual Perception: The Neurophysiological Foundations*. San Diego: Academic Press, pp. 417-448

Sheliga, B. M., Riggio, L., Rizzolatti, G. (1995) 'Spatial attention and eye movements'. *Experimental Brain Research*, vol. 105, pp. 261-275

Shepard, R. N. (1964) 'Attention and the metric structure of the stimulus space'. *Journal of Mathematical Psychology*, vol. 1, pp. 54-87

Shih, S. I. & Sperling, G. (1996) 'Is there feature-based attentional selection in visual search?' *Journal of Experimental Psychology: Human Perception and Performance*, vol. 22, no. 3, pp. 758-779

Shipp, S. (2004) 'The brain circuitry of attention'. *Trends in Cognitive Sciences*, vol. 8, no. 5, pp. 223-230

Simon, H. A. (1967) 'Motivational and Emotional Controls of Cognition'. *Psychological Review*, vol. 74, no. 1, pp. 29-39

Sinha, P. (2003) *Vision: Challenges and Prospects*. Online Lecture. MIT world. Available from: http://mitworld.mit.edu/video/154 [accessed 12/01/2010]

Sligte, I. G., Scholte, H. S. & Lamme, V. A. F. (2008) 'Are there multiple visual short-term memory stores?' *Plos One*, vol. 3, no. 2, pp. 1-9

Sloman, S. A. (1996) 'The empirical case for two systems of reasoning'. In: *Psychology Bulletin*, vol. 119, pp. 3-22

Smith, D. T. & Schenk, T. (2012) 'The Premotor theory of attention: Time to move on?' *Neuropsychologia*, vol. 50, no. 6, pp. 1104-1114

Smith, E. E. & Jonides, J. (1999) 'Storage and executive processes in the frontal lobes'. *Science*, vol. 283, pp. 1657-1661

Smith, J. A. (2008) *Qualitative Psychology: a practical guide to research methods*. 2nd ed. London: Sage.

Smith, P. & Kemler, D. G. (1978) 'Levels of experienced dimensionality in children and adults'. *Cognitive Psychology*, vol. 10, pp. 502-532

Solso, R. L. (1996) *Cognition and the Visual Arts*. Cambridge, MA: MIT Press

Solso, R. L. (2001) 'Brain Activities in a Skilled versus a Novice Artist: An fMRI Study'. *Leonardo*, vol. 34, no. 1, pp. 31-34

Speed, H. (2012 [1913]) *The practice and science of drawing*. Courier Dover Publications.

Spence, C. & Driver, J. (1996) 'Audiovisual links in endogenous covert spatial attention'. *Journal of Experimental Psychology: Human Perception & Performance*, vol. 22, pp. 1005-1030

Spence, C., Pavani, F. & Driver, J. (2000) 'Crossmodal links bettween vision and touch in covert endogenous spatial attention'. *Journal of Experimental Psychology, Human Perception and Performance*, vol. 26, pp. 1298-1319

Sperling, G. (1960) 'The information available in brief visual presentations'. *Psychological Monographs: General and Applied*, vol. 74, no. 1, pp. 1-29

Sperry, R. W. (1967) 'Split-Brain Approach to Learning Problems'. In: Quarton, C. G., Melnechuk, T. & Schmitt, F. O. (eds.) *The Neurosciences, A Study Programme*. New York: Rockefeller University Press

Stanovich, K. E. & West, R. F. (2000) 'Individual differences in reasoning: Implications for the rationality debate'. *Behavioral and Brain Science*, vol. 39, pp. 645-726

Stanyer, P. & Rosenberg, T. (1999) *A Foundation Course in Drawing*. London: Watson-Guptil Publications

Steinberg, L. (1972 [1953]) 'The Eye is a Part of the Mind'. In: Steinberg, L. (1972) *Other Criteria: Confrontations with Twentieth-Century Art*. Oxford University Press: London, pp. 289-306

Studio in a School, official website (2012) Available from: http://www.studioinaschool.org/ [accessed 12/06/2012]

Supèr, H., Spekreijse, H. & Lamme, V. A. F. (2001) 'Contextual modulation in primary visual cortex as a neuronal substrate for working memory'. *Journal of Vision*, vol. 1, no. 3, pp. 345-345

Supèr, H., Spekreijse, H. & Lamme, V. A. F. (2001a) 'A neural correlate of working memory in the monkey primary visual cortex'. *Science*, vol. 293, pp. 120-124

Sutton, P. J. & Rose, D. H. (1998) 'The Role of Strategic Visual Attention in Children's Drawing Development'. *Journal of Experimental Child Psychology*, vol. 68, no. 2, pp. 87-107

Suwa, M. & Tversky, B. (1997) 'How do designers shift their focus of attention in their own sketches?' *Reasoning with Diagrammatic Representations: Papers from the 1997 AAAI Spring, Technical Report FS9703*, pp. 102-108

Suwa, M. & Tversky, B. (2003). Constructive perception: A metacognitive skill for coordinating perception and conception. In *Proceedings of the Annual Conference of the Cognitive Science Society, Boston*. Pp. 1140-1145

Suwa, M., Tversky, B., Gero, J. S. & Purcell, A. T. (2001) 'Seeing into sketches: Regrouping parts encourages new interpretations'. In: J. S. Gero, B. Tversky & T. Purcell (eds.) *Visual and Spatial Reasoning in Design II*. Sydney: Key Centre of Design Computing and Cognition, University of Sydney, pp. 207-219

Sweller, J., Ayres, P. & Kalyuga, S. (2011) *Cognitive load theory*. New York: Springer

Tchalenko, J. & Miall, R. C. (2009) 'Eye–hand strategies in copying complex lines'. *Cortex*, vol. 45, no. 3, pp. 368-376

Tchalenko, J. & Miall, R. C. (2012) 'Blind Drawing and Accuracy in Observational Drawing'(unpublished)

Tchalenko, J. (2007) 'Eye movements in drawing simple lines'. *Perception*, vol. 36, no. 8, pp. 1152-1167

Tchalenko, J. (2009a) 'Henri Matisse Drawing: An Eye-Hand Interaction Study Based on Archival Film'. *Leonardo*, vol. 42, no. 5, pp. 433-438

Tchalenko, J. (2009b) 'Segmentation and accuracy in copying and drawing: Experts and beginners'. *Vision research*, vol. 49, no. 8, pp. 791-800

Thackwray, D., Meyers, A., Schleser, R. & Cohen, R. (1985) 'Achieving generalization with general versus specific self-instructions: Effects on academically deficient children'. *Cognitive Therapy and Research,* vol. 9, pp. 297-308

Thistlewood, D. (1981) *A Continuing Process*. London: ICA

Thomas, G. & James, D. (2006) 'Reinventing grounded theory: some questions about theory, ground and discovery'. *British Educational Research Journal*, vol. 32, no. 6, pp. 767-795

Thornton, T. L. & Gilden, D. L. (2007) 'Parallel and serial processes in visual search'. *Psychological. Review*, vol. 114, pp. 71-103

Titchner, E. B. (1912) 'Description vs. statement of meaning'. *American Journal of Psychology*, vol. 23, pp. 165-182

Tootell, R. B., Silverman, M. S., Switkes, E. & De Valois, R. L. (1982) 'Deoxyglucose analysis of retinotopic organization in primate striate cortex'. *Science*, vol. 218, no. 4575, pp. 902-904

Tormey, J. (1997) 'Foundation course drawing'. In: *Tracey-Drawing and Visualisation Research* (online journal) Loughborough University. Issue Sept. 1997. Available from: http://www.lboro.ac.uk/departments/ac/tracey/edu/tormey.html [accessed 03/10/09]

Tormey, J. (2008) 'Dialogues Inter-disciplines'. Conference presentation at *Interrogations*. Loughborough University, January 21, 2008. Available from: http://www.interrogations.org.uk/papers.htm [accessed 28/03/2010]

Treisman, A. & Gelade, G. (1980) 'A feature-integration theory of attention'. *Cognitive Psychology*, vol. 12, pp. 97-136

Treisman, A. & Gormican, S. (1988) 'Feature analysis in early vision: evidence from search asymmetries'. *Psychological review*, vol. 95, No. 1, pp. 15-48

Treisman, A. (1964) 'Selective attention in man'. *British Medical Bulletin*, vol. 20, pp. 12-16

Treisman, A. (1977) 'Focused attention in the perception and retrieval of multidimensional stimuli'. *Perception & Psychophysics*, vol. 22, pp. 1-11

Treisman, A. (1982) 'Perceptual grouping and attention in visual search for features and for objects'. *Journal of Experimental Psychology: Human Perception and Performance*, vol 8 no. 2, 194-214

Treisman, A. (1985) 'Preattentive processing in vision'. *Computer Vision, Graphics, and Image Processing*, vol. 31, pp. 156-177

Treisman, A. (1996) 'The binding problem'. *Current Opinion in Neurobiology*, vol. 6, pp. 171-178

Treisman, A. M. & Gelade, G. (1980) 'A feature-integration theory of attention'. *Cognitive Psychology*, vol. 12, pp. 97-136

Turvey, M. T., Shaw, R. E., Reed, E. S. & Mace, W. M. (1981) 'Ecological laws of perceiving and acting: In reply to Fodor and Pylyshyn'. *Cognition*, vol. 9, pp. 237-304

Tversky, B. & Lee, P. U. (1998) 'How space structures language'. In: Freksa, C., Habel, C. & Wender, K. F. (eds.) *Spatial Cognition: An interdisciplinary approach to representation and processing of spatial knowledge*. Berlin: Springer-Verlag, pp. 157-175

Tversky, B. & Lee, P. U. (1999) 'Pictorial and verbal tools for conveying routes'. In: Freksa, C. & Mark, D. M. (eds.) *Spatial information theory: cognitive and computational foundations of geographic information science*. Berlin: Springer-Verlag, pp. 51-64

Tversky, B. (1995) 'Cognitive origins of graphic conventions'. In: Marchese, F. T. (ed.) *Understanding Images*. New York: Springer-Verlag, pp. 29-53

Tversky, B. (2001) 'Spatial schemas in depictions'. In: M. Gattis (ed.) *Spatial schemas and abstract thought*. Cambridge: MIT Press, pp. 79-111

Tversky, B. (2002) 'What do sketches say about thinking?' In: Stahovic, T., Landay, J. & Davis, R. (eds.) *Proceedings of AAAI spring symposium on sketch understanding*. Menlo Park, CA: AAAI Press.

Tversky, B. (2011) 'Obsessed by Lines' In: Kantrowitz, A., Brew, A. & Fava, M. (eds.) *Proceedings of Thinking through Drawing: practice into knowledge*. New York: Teachers College, Columbia University, Art and Art Education Program, pp. 15-18

Van Essen, D. C. & Gallant, J. L. (1994) 'Neural mechanisms of form and motion processing in the primate visual system'. *Neuron*, vol. 13, pp. 1-10

Van Essen, D. C., Maunsel, J. H. R. & Bixby, J. L. (1981) 'Organization of the extrastriate visual areas in the macaque monkey'. In: Woolsey, C. N. (ed.) *Cortical sensory organization: Multiple visual areas*. Clifton, New Jersey: Humana Press, vol. 2, pp. 157-170

Van Kleef, J., Berry, R. & Stange, G. (2008) 'Directional Selectivity in the Simple Eye of an Insect'. *The Journal of Neuroscience*, vol. 28, no. 11, pp. 2845-2855

Van Sommers, P. (1984) 'The impact of meaning on executive strategies'. In: *Drawing and Cognition*. Cambridge University Press

Van Sommers, P. (1984) *Drawing and Cognition: Descriptive and experimental studies of graphic production processes*. Cambridge: Cambridge University Press

Van Sommers, P. (1989) 'A system for drawing and drawing-related neuropsychology'. *Cognitive Neuropsychology*, vol. 6, no. 2, pp. 117-164

Van Sommers, P. (1995) 'Observational, experimental and neuropsychological studies of drawing'. In: Lange-Küttner, C. & Thomas, G. V. (eds.) *Drawing & Looking*. New York: Harvester Wheatsheaf, pp. 44-61

Vanrullen, R. (2009) 'Binding hardwired versus on-demand feature conjunctions'. *Visual Cognition*, vol. 17, pp. 103-119

Varela, F. & Shear, J. (eds.) (1999) *The View from Within: First-person Approaches to the Study of Consciousness*. London: Imprint Academic

Varela, F. (1999) 'The Specious Present: A Neurophenomenology of Time Consciousness'. In Petitot, J., Varela, F.J., Pacoud, B. & Roy, J. (eds.) *Naturalizing Phenomenology*. Stanford University Press

Vartanian, O. & Mandel, D. R. (eds.) (2011) *Neuroscience of decision making*. Psychology Press

Velmans, M. & Schneider, S. (eds.) (2007) *The Blackwell Companion to Consciousness*. Malden, MA: Blackwell

Verghese, P. (2001) 'Visual search and attention: a signal detection theory approach'. *Neuron*, vol. 31, pp. 523-535

Verstegen, I. (2004) ‘Arnheim and Gombrich in social scientific perspective’. *Journal for the Theory of Social Behavior*, vol. 34, pp. 91-102

Viviani, P. (1990) Chapter 8. In: Kowler, E. (ed.) *Eye movements and their role in visual and cognitive processes*. Amsterdam: Elsevier Science

Vogel, E. K., Woodman, G. F. & Luck, S. J. (2001) ‘Storage of features, conjunctions and objects in visual working memory’. *Journal of Experimental Psychology: Human Perception and Performance*, vol. 27, pp. 92-114

Walter, W. G. (1953) *The Living Brain*. New York: Vail-Ballou Press

Wandell, B. A., Brewer, A. & Dougherty, R. F. (2005) ‘Visual field map clusters in human cortex’. *Philosophical Transactions of the Royal Society*, vol. 360, no. 1456, pp. 693-707

Watson, S. E. & Kramer, A. F. (1999) ‘Object-based visual selective attention and perceptual organization’. *Perception & Psychophysics*, vol. 61, no. 1, pp. 31-49

Weisberg, D. S., Keil, F. C., Goodstein, J., Rawson, E. & Gray, J. R. (2008) ‘The Seductive Allure of Neuroscience Explanations’. *Journal of Cognitive Neuroscience*, vol. 20, no. 3, pp. 470-477

Whale, G. (2006) *An Investigation of Spatial Strategy in Observational Drawing*. PhD thesis. Loughborough: Loughborough University

Whiteley, L. (2012) ‘Resisting the revelatory scanner & quest; Critical engagements with fMRI in popular media’. BioSocieties. vol. 7, pp. 245-272

Wickens, C. D. (1984) ‘Processing resources in attention’. In: Parasuraman, R. & Davies, R. (eds.) *Varieties of attention*, pp. 63-101

Willats, J. (1977) ‘How children learn to draw realistic pictures’. *Quarterly journal of experimental psychology*, vol. 29, pp. 367-382

Willats, J. (2005) *Making Sense of Children’s Drawings*. New Jersey: Lawrence Erlbaum.
Williams, D. W. & Sekuler, R. (1984) ‘Coherent global motion percepts from stochastic local motions’. *Vision Research*, vol. 24, pp. 55-62

Williams, R. F. (2008) ‘Gesture as a conceptual mapping tool’. In: Cienki, A. & Mueller, C. (eds.) *Metaphor and Gesture*. Gesture Studies 3, pp. 55-92

Willingham, D. T. (2009) ‘Three problems in the marriage of neuroscience and education’. *Cortex*, vol. 45, no. 4, pp. 544-545

Willingham, D.T. & Lloyd, J.W. (2007) ‘How Educational Theories Can Use Neuroscientific Data’. *Mind, Brain, and Education*, vol. 1, pp. 140-149

Winner, E. & Hetland, L. (2008) ‘Art for our sake: school arts classes matter more than ever - but not for the reasons you think’. *Arts education policy review*, vol. 109, no. 5, pp. 29-32

Winner, E., Hetland, L., Veenema, S., Sheridan, K., Palmer, P., Locher, I. P., ... & Leontiev, D. (2006) ‘Studio thinking: how visual arts teaching can promote disciplined habits of mind’.

New directions in aesthetics, creativity, and the arts. Amityville, New York: Baywood Publishing Company, pp. 189-205

Wolfe, J. (1994) 'Guided search 2.0: A revised model of visual search'. *Psychonomic Bulletin and Review*, vol. 1, no. 2, pp. 202-238

Wolfe, J. M., Cave, K. R. & Franzel, S. L. (1989) 'Guided Search: An alternative to the feature integration model for visual search'. *Journal of Experimental Psychology: Human Perception and Performance*, vol. 15, pp. 419-433

Wolfe, J. M., Vo, M. L. H., Evans, K. K. & Greene, M. R. (2011) 'Visual search in scenes involves selective and non-selective pathways'. *Trends in Cognitive Science*, vol. 15, no. 2, pp. 77-84

Wolfe. J. M. (2003) 'Moving towards solutions to some enduring controversies in visual search'. *Trends in Cognitive Neuroscience*, vol. 7, pp. 70-76

Woods, D. L., Alho, K. & Algazi, A. (1992) 'Intermodal selective attention 1: Effects on event-related potentials to lateralized auditory and visual stimuli'. *Electroencephalography and Clinical Neurophysiology*, vol. 82, pp. 341-344

Woodworth, R. S. & Thorndike, E. L. (1901) 'The influence of improvement in one mental function upon the efficiency of other functions'. *Psychological Review 8: Part I*, vol. 8, no. 3, pp. 247-261

Wundt, W. M. (1969 [1904]) *Principles of physiological psychology*, vol. 1, translated by E. Titchner. New York: S. Sonnenschein & Co.

Wurtz, R. H. & Kandel, E. R. (2000) 'Constructing the visual image'. In Kandel, E. R., Schwartz, J. H. & Jessell, T. M. (eds.) *Principles of neural science.* 4th Ed. New York: McGraw-Hill. pp. 492-506

Yoon, S. Y. & D'Souza, N. (2009) 'Different visual cognitive styles, different problem solving styles'. In *Proceedings of the International Association of Societies of Design Research 2009 Conference* pp. 2341-2352

Yarbus, A. L. (1967) *Eye movements and vision*. New York: Plenum Press

Zalta, E. N. (ed.) (2011) *The Stanford Encyclopedia of Philosophy*. The Metaphysics Research Lab, Stanford University. Available from: http://plato.stanford.edu/ [accessed 13/03/2012]

Zeki, S. (1978) 'Functional specialization in the visual cortex of the rhesus monkey'. *Nature*, vol. 284, pp. 412-428

Zeki, S. (1992) 'The visual image in mind and brain'. *Scientific American*, vol. 267, no. 3, pp. 69-76

Zeki, S. (1997) 'The Woodhull Lecture: Visual Art and the Visual Brain'. In Proceedings: *Royal Institution of Great Britain*. Oxford: Oxford University Press, vol. 68 (October), pp. 29-64

Zeki, S. (1998) 'Art and the brain'. *Daedalus*, vol. 127, no. 2, pp. 71-103

Zeki, S. (1999) *Inner Vision: An exploration of Art and the Brain*. Oxford: Oxford University Press

Zeki, S. (2004) 'The neurology of ambiguity'. *Consciousness and cognition*, vol. 13, no. 1, pp. 173-196

Zull, J. E. (2002) *The art of changing the brain: Enriching teaching by exploring the biology of learning*. Sterling, Virginia: Stylus Publishing

Appendix A

Coded verbal report transcripts

Concurrent report were transcribed from trials the artists identified as their most apt attempts at verbalising their process while drawing in their ususal manner. The dual coding scheme described in chapter 3 is applied here in the two columns on the right.

Retrospective reports were cued by video footage also chosen by the artist, immediately after the initial drawings were made.

1. Angela Brew, concurrent report transcript, 11 Jan 2011, (final coding)

	Strategic	Visual attentive
Ok, I'm looking at the, what I'd call the bottom corner of my eye,	Describing action	point Individual feature
and I'm gonna follow, I am, Yeah I'm just about to actually,	Describing action	
I'm gonna follow the line of the edge of the skin,	Subgoal	Line
and I'm now following it,	Describing action	
and I'm just looking at my eye,	Describing action	Individual feature
I'm not looking at the paper.	Describing action	
And then I've got to the little change of angle	Input only	Relative orientation
and I'm gonna	misc	
Yeah, I just glanced at the paper	Describing action	
and now I'm carrying on with the line at a slightly different angle,	Subgoal	Relative orientation
now I've just noticed a nice thing that, how that line connects to the line of my eyebrow	Meta description	Configuration of lines Individual feature
and my feeling was that I didn't want to lose the contact with my, with my eye looking at my eye,	Meta plan	Individual feature
so I didn't wanna look at the paper	Meta plan	
so I glanced really quickly just to see where the pencil was.	Meta evaluation	
Now I'm keeping my pencil on the paper	Describing action	
and I'm going, making a provisional line for, a bit of my eyebrow,	Subgoal	Individual feature
but it's all a bit of shade	Input only	Tonal shape
and then I'm carrying on that line over	Describing action	
which is the line (chuckles), I drew first.	Meta description	
and then, this line is interesting, to connecting that to another line,	Meta description	Configuration of lines
and then I'm drawing a line that slopes down	Describing action	Orientation
and then I'm looking at how that connects to the first line I drew.	Describing action	Configuration of lines

and I'm drawing quite lightly there the other corner of my eye	Describing action	Point
		Individual feature
Just to get it mapped in	Subgoal	
then I'm gonna draw, I'm gonna connect this this line where my eyelashes are up to this other point here	Subgoal	Configuration of lines
		Individual feature
		Point
and then I'm gonna shade it.	Subgoal	Tone
It's all quite provisional,	Meta evaluation	
I'm just seeing how it looks.	Meta evaluation	
so I'm shading in a bit of my eyebrow	Describing action	Tone
		Individual feature
and then I'm going across here	Describing action	
and I'm gonna shade in little bit of shade above my eyelid	Subgoal	Tone
		Individual feature
and a bit of, bit more shade on the eyelid,	Input only	Tone
		Individual feature
I'm looking at the sort of, I've noticed a highlight on one bit of my eyelid and	Meta description	
		Tone
then I'm drawing the edge of my eyeball	Describing action	Line
and lining it up with the highest point of this line here	Sub goal	Configuration of lines
I'm looking at how much of my, the edge of my eyeball I can see and where it intersects with the skin of my eyelid	Meta description	line
then I just noticed a shadow that comes down here so	Meta description	Relationship between constructed shapes
		Individual feature
		Tonal shape
I'm gonna shade that in	Subgoal	
badadubum	Misc	
and then I'm gonna draw my pupil	Subgoal	Individual feature
and there's no light reflecting in that	Input only	tone
so I'm just drawing it completely dark	Meta description	tone
and then I'm looking at where the … few bits of reflected light in my iris	Meta description	Tonal shape
		Individual feature
and I'm outlining them	Describing action	Tonal shape
and then I'm shading in ……………..	Describing action	Tone

the iris		Individual feature
and then I'm gonna look at....	misc	
I'm shading those. I'm shading these in	Describing action	Tone
so that the, only the highlight bits show. Ar, blabla, as the lightest bits of the drawing.	Subgoal	relative tonal value
um	misc	
an I'm looking at one of my eyelashes	Describing action	Individual feature
can be seen, just a slight fuzziness for the line there	Input only	Textural detail line
and then I'm noticing another bit of shadow down here,	Input only	Tonal shape
and I'm gonna draw that	Subgoal	
and then I'm gonna draw a little bit of shadow I can see here under my eyelid.	Subgoal	Tone Individual feature
and a bit of a line and a few wrinkles	Input only	Line Individual feature
shall I stop now?	Misc	

2. Angela Brew. Retrospective report. 11 Jan 2011.

AB: Angela Brew
MF: Michelle Fava

AB: Orientation - getting sense of my position. Warming up eye and hand. Locating everything - all elements ready. Attending to future. Potential. What I expect to happen. Based on experience.
If I could see hand movements more clearly - I may say that I was planning where to start - attending to first point on eye and where pencil will start
don't know

Attending to line I was looking at - and aware of hand movement. "Consciously trying to sync eye and hand". Trying to sense a match of speed and orientation - draw the same line with eye on mirror and pencil on paper. V sure I was attending to keeping eye on my eye, and syncing eye and hand. Attending to whether they are making the same movement. Watching out for going wrong - aware of harder bits. Perhaps taking those bits slower? not sure. Probably watching pencil stop.

Same as above. Trying to sync eye and hand. Noticed a relationship – "responding to movement along line, and topology of the area" - aware that the external situation will provide information – "feels like my eye is travelling along, and arrives at interesting junction - does feel like a decision point - only at that point do I have any awareness of where next line will go"- navigation - contingency. Responding to external info not guided by a plan. Decided which way to go next - feels like am building up a spatial awareness as if my eye is a little person in a big space. And my hand is another little person trying to walk exactly the same path, by copying person A's movements.

felt like i had to drag my attention away from person A - torn. That person B needed my attention - SUPPORT is better word - I think I use word attention to please you! Because that is what you asked for - but concerned that breaking contact with person A may be bad. Feels like Person A needs most support. From what? DOES feel like my eye is watching the little person on the end a stalk coming out from my eye! MY hand is a bit more controllable as it actually is on a stalk and I can SEE the path it is taking. maybe because my eye isn't actually doing what I am imagining - it is important for me to feel that my eye is moving smoothly. If my eye path was visible, it would be jittery, but maybe v interesting to have an actual line emerging as I drew.

Anchor points. I think I tried to quickly jump back to where I was on eye - before I lost awareness of where I was. Not sure whether is awareness in a labelled way i.e. I chose a turning point, so was easy to return to, and that I jumped back along the same line I travelled to the paper on....knowing that if I returned soon enough I would physically remember my path - in which case anchor point don't necessarily need to be visually significant - e.g. change of angle, intersection of lines - are they?

Assessed that no clear line for me, analogue of clear footpath - so tried one. In this case I am aware that I am going to check it with original for a match.

Trying to get sense of where I am - am I lost? Triangulating - or will do soon - q re 1.56 - any significance in terms of matching?

Check to see if I double checked by going back up provisional path - how do I check the lines?

Seems much more like the contingency method of navigation - locating myself at each moment in relation to lines around me.

Attending to feeling of down-ness - my way to know that eye and hand doing the same in this case relies on feeling of going down. I think I told you how important I think our sense of gravity is. Learn to use automatic existing skills to help us to draw. Sensori-motor knowledge.
Going down, following line. Hand in sync.
Watching end of drawing that line.

Checking match. Distance measured with pencil in air and eye movement between 2 corners of eye, and horizontal alignment observed / checked. A point where it feels anchored - have gone on journey to other side of eye without checking back to start point - am now looking at e.g. my pole star - is it still in the right position? judging distance and direction.
makes sense that this orientation takes quite long - is very important moment.

I remember light drawing was a trying out, provisional 'Lets see'…line - trial. A hmm type moment. Feeling relaxed and assured, as am in the right place. Can experiment a bit. Not worried about getting it wrong. Can correct. Small section of line - not thinking about length of line as much as shape of small section - getting the angle right.
at this point I am that am in right place - but move attention to detail of the corner - shape of the tight arc. Trying to get accurate impression of it to begin with.

Felt an easy line - lots to anchor it - short distances between it and lower line, easy to observe and to check line. End point clear. A target - a point on an existing line.

Relying on lines drawn already to bound area of shading - easy to compare with original. Easy to see if wrong.

I think I remember NOT trying to look carefully before I drew - again, is anchored and I tried something out and compared with original

I sense by now that I know where I am. Bit like running around in a playground, feeling like I know the space and am safe to experiment -

Highlight motivated me to look at it from wider view - compared areas of tone and noticed 2 that were the lightest. So yes at this point attending to tonal balance of the whole (planned drawing)

Locating line on original and drawing - matching. Confident that my existing drawn line matches original well enough for this to be possible - nb. Using drawing for info about the original. Relying on it.

The just noticed statements fit so well with my sense of finding out as I go, and responding - not pre planned, to large extent. Seems like Andrea's artists- set yourself a problem and try to solve it. The jigsaw - actually is like sudoku - can discover you went wrong somewhere right at the very end when a line doesn't fit - and then search back for the error - often hard to find - when i do sudoku i write all the numbers I am sure about in pen, the provisional ones in pencil - then if i go wrong I rub out all the pencil ones so get back to the point when I was confident. Exactly like my drawing - back tracking. Have had this happen with students - they don’t want to rub out but we have worked out where error/s are by comparing original and drawing.

Just doing it - no need to look at eye again. Made decision. Simple shape.

Not too concerned re getting exactly right - I know that it will look like light in eye even if shape not entirely accurate! Sometimes I do draw it more accurately - sometimes just want to give impression of shining eye.

Ditto. Easy shape. Monitoring that I stick within line and maybe watching the tone. Attending to shading within lines. And creating tonal balance to match original

One! I think not!

Again, once I had decided I didn’t need to check original again then noticing…this is my favourite bit!

Attended to lines first, then noticed shadows and tonal balance

"i'm gonna' versus 'just noticed'.

3. Amanda Roberts, concurrent report transcript, 17 March 2011 (final coding)

Statement	Strategic	Visual attentive
Ok. So that's the sort of compositional size that I want the head to fill.	Evaluation (against subgoal)	Compositional size
That's the sort of space I'm gonna use on the page.	Decision	Overall composition
Ok. The problem there is I've just gone too long.	Evaluation (of part)	Global view
		Relative length
So I just need to reassess	Decision	
the shape of the nose, the chin and the mouth in relation to the eyes,	Subgoal	Shape
		Features
		Configuration of points
so it's that sort of triangle bit (gestures) in the centre of the head.	Input only	Constructed shape
		Global view
I've changed the angle slightly cause I've lifted my head,	Meta-goal	Direction/ orientation
		Global view
and I'm gonna go for a slightly more tilted head angle there,	Decision	Direction/ orientation
so just rearrange the angle of that,	Subgoal	Direction/ orientation
it's gonna mean redrawing in relation to that,	Decision	
so what I'm gonna do is, because of that,	Rationalisation	
I'm just gonna take, I'm not gonna get rid of these lines I'm gonna just take them down a little bit	Decision	
so that I can remind myself what was there before,	Rationalisation	
but I won't feel too inhibited, when I change the diagonal line of the drawing.	Rationalisation	
Fix the neck a minute,	Evaluation	Individual feature
to make sure I've got the head sitting in the neck convincingly.	Subgoal	Partial view
This'll be useful in the drawing because it's quite defined, that bit there is,	Rationalisation	
and the angle of that'll give me something to hang the rest of it on.	Rationalisation	Direction
Ooh,arm's aching.	Misc	
Um, I'm gonna take that down a bit again,	Decision	
just a little bit too defined here.	Evaluation (of part)	Partial view
I think things are coming,	Evaluation (of whole)	
I'm happy about the general structure of the head now.	Evaluation (of whole)	Structure
Oh, I've defined that line too much,	Evaluation (of	Partial view

	part)	
get rid of that.	Decision	
That's better.	Evaluation (of part)	
I'm just gonna ignore the bit I've taken down a minute,	Decision	
so I can look at it afresh in a second, concentrate on this bit up here instead.	Meta plan	
I'm gonna use a darker tone now,	Decision	Tone
to help try and sort of pin down what I've got a little bit	Subgoal	
Yeah, I'm happier with the way that's working now, with the structure of it.	Evaluation (of whole)	Structure
I'm gonna go back in and just keep defining some darker areas of tone, the darkest areas.	Decision	Tone
Sorry, how long have I had, I've lost track again.	Misc	
now I've got things where they should be I don't mind stopping,	Evaluation (of whole)	
I'm not that interested in producing finished drawings for this.	Meta goal	
I've got my structure now,	Evaluation	Structure
I'm happy with the angle of it.	Evaluation	Direction
Obviously there's things, you know I could just, I can just keep going,	Meta goal	
that would just need a little bit of reassessment,	Meta evaluation	
the mouth probably needs to go a bit lower,	Evaluation (of part)	Partial view
		Individual feature
the nose would need defining.	Evaluation (of part)	Individual feature
it's it's sort of all over the shop, um, but, the sort of (gestures vertically from high up)	Meta evaluation	
the structure of it, is sort of there now	Evaluation (of whole)	Structure

4. Amanda Roberts, retrospective report transcript, 17 March 2011

AR: Amanda Roberts
MF: Michelle Fava

MF: […] as much as you can, just describe what you think was going on as you were doing the drawing, and so just describe the process, so we'll look at it a few times, and so that I'm not leading you too much, I won't ask too many questions the first time. Don't worry if there's a period of silence, or if you don't say anything at all, just kind of, if anything strikes you about it.
AR: Yeah, I think it'll be much easier to talk about this cause I'm not drawing, it's fine.
MF: so we can hear what we were saying the first time.
Amanda: So I'm moving my head even before I start drawing and sort of looking at the sort of angle I want it at, and where I want it to be on the page, that was all that head tilting was about, I've got my head quite static now I've started to draw.
MF: if you want to pause at any point by the way just say…
AR: I'm actually keeping my head much more static than I thought I was when I was drawing, felt like it was moving around much more than that.
MF: what between looking and drawing.
AR: yeah, it's surprising how static I'm holding my head. Felt like it was, you know, the angle was changing more. Ooh, it's hard to see what I'm actually drawing isn't it?
MF: it gets darker.
AR: You can see me sort of, forming the shapes and stuff though, just looking.
MF: It's almost like they're emerging as you go…. Sorry, I wasn't going to talk through this one.
AR: Yeah, the eye squinting's funny, I had to stop myself doing that when I was drawing my eyes, it was like, sort of squint, sort of try and see, try and make the shapes a bit more basic, to sort of blur them out a bit, so you've got an idea of um, you're not seeing details. So you're seeing it more as blocks. (laughs) I'm doing it loads.
MF: Blocks of tone?
AR: yeah, it just sort of gets rid of all detail, and just makes you see it a bit more um, out of focus so you can see the shapes more generalised, yeah? And again it stops that sort of descriptive thing going on. Um,
MF: so it's like the opposite of what was happening when you were saying words, when you were naming things (referring to 1st attempt at concurrent verbalisation)
AR: Yeah, yeah exactly, cause you're having to focus aint you? Whereas the ideas is you actually, the initial stages you're sort of blurring your focus out a little bit.
MF: Does it surprise you to see how often you're doing that?
AR: It would surprise me later on if I was doing it as much but in the initial stages no, that would make sense, yeah. What I have done is done the head much more, it seems more tilted here than the drawing I'm doing, I wonder if I changed my head..
MF: No it's the angel of the camera, so it's not going to look the same here as there…
AR: Oh that's good, I was gonna say cause I'm completely fabricating that! (laughs)
MF: but this is just so that I can see where your eyes are looking and I think if I slow it down I can even see, are you looking at more than one place in the mirror before you then look back at the drawing.
AR: Yeah.
MF: So I can make guesses about the amount of detail you're carrying across with each glance.
AR: So I've stopped, I stopped then. [04:20]

MF: so that's the first time you stop to evaluate there isn't it, pretty much?
AR: Yeah yeah.
It's nice watching myself draw, it's so familiar. (laughs) I can understand exactly what I'm doing, you know, it's quite weird that is. It's funny, it's not like watching somebody else draw at all. I never watched myself drawing.
MF: is there anything about it…
AR: I wanna correct it, Yeah, I wanna (draws) that, but again, the head, it' a different angle so. Yeah, I feel like going 'No! the angle's like this' (laughs).
MF: yeah if it was a student, but I think this is what happens with students sometimes, that you think, oh no that's different, but you are just seeing it form a different angle.
AR: I always try, I make a point of never drawing on a students drawing, I really try not to draw on a students drawing, um I mean, we had a lecturer when I was in college, he didn't do it to me to be fair, but if somebody was really struggling with drawing, he would draw it for them and one of my friends drawings, he basically re did it for her and at the end of the class he was like, you know this is a good drawing now, and she was like no that's your drawing, that's not my fucking drawing. So I really try not to. If it's an angle problem, I'll hold my pencil for them and say 'look no it needs to be more like (gestures) that', so they can see it like that or I'll get them to re measure it when I'm with them, so I'll say re-measure that, do a plumb line, check it against yours and do it that way, and really make an effort, you know it's much quicker and easier to just take your pencil and draw a line, but I don't think it's fair.
MF: it doesn't help really does it?
AR: it's not fair, all it shows is that they couldn't see something and you've seen it, it makes them feel as though they've failed in what they're doing I think. And it stops them taking that pride in their work if they do something good because they see it as being somebody else's.
MF: Yeah, sometimes I'll just come and say yep, just re-measure this bit with me, and then, if they're not really doing it, then I'll get them like come on, get your pencil up and we'll do it together. Sometimes I'll have a sketchbook and I'll draw, and say come on we'll do it together and I draw and they draw, so I am drawing it for them but..
AR: Yeah, I'll have a bit of scrap paper, and I'll, especially for something more general, say the way the head is sitting on the neck, instead of having it balancing on top, you need it resting into it, something like that.
MF: Is there anything about seeing yourself drawing that's surprising?
AR: No, like I said it just seems very familiar, yeah, really familiar. It's funny seeing how much of a struggle it is, because seeing that figure there, you could transfer it so easily because it's a film, because it's been flattened because it's 2 dimensional so, you do sort of think, well why are you struggling, it's just like this, because it's because the figure's flattened out on the screen, but no it's quite comforting actually it's quite a nice thing to watch, yeah.
I think I'm taking it, I'm actually taking the drawing down, I'm doing a much quicker drawing than I would normally do, I don't normally do 5 minute drawings, so even working in this sort of way, I'd be much slower about defining these areas normally. Maybe there's be more layers under this I think.
MF: you mean, would you move the pencil slower…
AR: no, just take more time. Id rub it out, I'm rubbing it out less than I would normally. But If I was given 5 minutes to do drawing, this is how I would, I'd do it like this.
[…]
It looks more confident than you feel, when you're doing it, that surprised me. You look more assured of the outcome when you're watching it than when you're actually doing it.

MF: sometimes it comes across in the quality of line, how certain you are, doesn't it? Like the first lines are very feint, and then sometimes you'll go 'right that's there' and really block it in, especially if it's a dark thing. That's what it looks like anyway.
AR: But you only do the dark bit when it's been mapped up from underneath. And even then I might rub it out.
I am looking at myself more than…. I'm back to the squinting thing now look cause it's shadow areas,
MF: that's pretty much the end now isn't it… we'll have another look if that's alright?
AR: That was the last one wasn't it? Yeah.
MF: I chose that one because I felt like it was the most natural, or the most representative of the way that you were talking about … or comfortable…
AR: The most natural one to do, I must admit, was the first one, Bizarrely, because I hadn't started thinking about what I was doing.
MF: do you want to have a look at that one instead?
AR: yeah, lets have a look at that one. Because once I started talking about it, and then even when, when I, by the time I got to the third one I had the baggage of
the other three behind me, the other things we'd been doing, so it wasn't …
[looking at film no. 4]
MF: so this is the first one, that was without talking.
AR: I'd be quite interested to see that actually, especially in relation to having seen that last one now as well.
MF: so we'll have a look at this, and just tell me what you notice about what you were doing, and then we'll look at it again and Ill ask more specific questions.
AR: Yeah I had my head sorted quicker that one. My head was already in position before the video came on. It's really static. It's really similar to the other one, it's really similar actually.
MF: so those initial glances are just kind of getting the structure?
AR: Yeah, it's just sort of, I think I'm a bit random with it actually I'm sort of looking all over, it's not like starting in one part and working your way down, just, um, it's literally just sort of moving your eye over the whole sort of head area and just trying to map it in, just to get in the space that you're gonna, that the head is gonna fit on your paper. And doing that in rough and then refining it and refining it, and redefining it where everything's gonna be.
MF: and that's what you did in the slower one wasn't it except more…
AR: Yeah! It's it's ,it's a different way of doing the same thing, do you know what I mean? You're just constantly, you do it, you get it down to start with, and then I think on the other one, you do your measurements, you do some basic measurements first, and then you're working within this framework. With this one you're not doing measurements you're just getting it down. But with both of them, once you've got those initial marks down, you're drawing, reassessing, changing, drawing reassessing, changing, drawing, reassessing, changing. And that's what I'm doing here, I'm drawing and I'm looking back in the mirror and reassessing what I've done, and I'm going back and I'm changing it accordingly.
MF: And sometimes you change it, without rubbing into it, do you?
AR: Oh yeah.
MF: it's kind of several lines, and then later on you can kind of go back and think well, which one was it?
AR: Yeah I'll keep drawing on top of the lines regardless, so yeah once I know, yeah, I've got about three lines in the same place there so I was quite confident that that was, if I'm re-drawing something it's alright isn't it?
MF: I'd be really interested to look at when you go back more confidently over a line that's already there, if you're, how much you're looking at the mirror compared to the first time you drew it.

AR: I was quite confident but I recon I'm going to rub this down again aren't I? Cause it's not right, around that side of it. I'm gonna notice that in a minute. I'm doing those lines quite firm there, but I think I'm happy with that structure there. Because I've got that structure there it's easier to map, to be more confident mapping that area then. Because, I've defined that to that sort of set, that line there is working, so I can be more confident where that's gonna go because, you've got this sort of area here. (pointing)
MF: So would you say that once this is quite certain, once you say right, that's where that is…
AR: And this is important as well, it's that bit that I've got going there, and that, the mouth, has to come from there then doesn't it. That sort of make sense, that sort of, it's grounded. That's where that's gonna be. Now that could change, I could decide that that is actually in the wrong place, I could decide to rub that out, redraw that and the whole thing will shift, [04:55] if it doesn't, if when the rest of the drawing, everything else is there, I don't know, it just makes, because this is quite firm, because of the negative shapes, that's gonna fit there. But it's not just that line, its these bits that are really important (drawing). It's those bits.
MF: and do you see this as a shape, like you think, ok that..
AR: yes, I've drawn that as a shape,
MF: you're not just thinking about the relationship of that angle? That's kind of that becomes a 2 dimensional shape once it's there, does it?
AR: Um, yeah, it's also a hollow as well mind. Cause it's hollower there than there isn't it. So that will effect the type of line that you draw as well, because you want it to dip in there, from out here. And the same here, those lines there, because it's sort of pulling in slightly. So I don't think it's a 2 dimensional shape, it's a 3 dimensional shape you're seeing, it's not flat. [I pause video]
And it's keeping, yeah the connections between everything. So I did the eye, and I was quite happy with the eye, but then you've got to go back and make sure that this eye is connecting to this bit properly. And it's the same with that it's pointless just having that and then doing the lines. It's got to be structurally connected. If that makes sense, it's quite hard to describe.
MF: So, it's like you block in this bit, and then you think about where this begins in relation to it (pointing to left corner of mouth).
AR: No, I block in that, [07:02] and then what happens, that's like that, and then that joins to that. You can't have that and then that,
MF: there has to be something in between?
AR: There doesn't have to be, it could be a negative space, d'you know what I mean? Yeah, but there'd be something there, it's not just floating in empty space is it.
MF: and so that was the same up here as well, you're kind of defining some shape and then using that to pinpoint
AR: Yeah, I mean, I did this bit, and that linked to that shadow there and that links to the eyebrow there. So that's giving you that shape as well and that shape. And it gives you this shape, that's got your eyebrow which is quite dark, things sit on top of other things. Um, and again this is a mistake that people who are beginning to draw will do, they might say right, side of the chin, neck and they'll try and put that mouth in, floating in space. Whereas if you think of the face as a structural form with everything, almost like a jigsaw, like a 3 dimensional jigsaw with everything fitting in and the anatomy underneath it as well, because you've got your bones and that structure and skin on top of that. Everything has got a purpose, has got a reason for being where it is, so yeah it's shape.
MF: There has to be a shape here,
AR: Yeah, there would have to be, and what is that shape, and what that shape is, is gonna differ form person to person. It differs depending on the individual face that you're drawing. Because we have different bone structures and different muscle structures and different

ages, and different ways that our flesh sits, and yeah that's why drawing people is so lovely, it's never the same. Your basic structure might be the same, but it's not it's really different.
MF: And if I asked you, would you be able to say, um, like you know you said there's this shape, and then there's this other shape here and they kind of overlap, but. would you be able to define where they are, would you need to see yourself drawing it? Or could you say kind of yeah, I looked at that as a shape and then that as another shape,
AR: You can sort of, yeah that's what I'm doing when I'm drawing I suppose, but you don't define to yourself that's what you're doing, you just do it?
MF: Now can you?

AR: Yeah, but that's only part of what's going on as well. It's only like a little bit of it. Because as well as that, you're thinking how,

- how strong is it,
- is it something that's peripheral,
- is it sitting back in the drawing,
- is it coming out, Is it coming out in space, is it receding in space,
- what sort of line do you need to define what that is, um,
- is this the right size for what's going on over here,
- is it the right angle.

Do you know what I mean, it's just like there's like loads and loads of layers to what's sort of going on in a really short space of time.
Like language, like verbal language, yeah, when we say something, when you have a conversation it's like loads of layers on what's being said, what isn't being said, what emphasises that are being used, um, and I think drawing is a language in the same way it's just visual. So as you can't say, yeah, I'm doing this I'm doing this, because actually you're doing several things simultaneously.
MF: And you feel like, um, so all of these things like looking at a shape, feeling how strong the line is, whether it's receding or coming out
AR: And also the texture of it, what would it feel like? Is it, is it, you know, is it soft, is it hard, is it textured? Is it, you know, cause the sort of line that I was doing for the tone on the shadow on the head there, wouldn't be the sort of kind of line I would use on the eye, even though tonally they might have the same tonal quality to them, the same darkness, texturally they would be very different.
MF: So each time you're making a line, you're making a decision about all of these things?
AR: Yeah, but not consciously,
MF: yeah, exactly, and it feels like it's happening simultaneously, is that what you said?
AR: I suppose, yeah,
MF: so you're not thinking serially about what was the shape is it…
AR: No you're not thinking sequentially or linearly about it. It might not be all of them at the same time even, you might have one, I dunno, you concentrate on one thing and you come back and realise you've missed something else about it. Which is why it needs to be constantly redefined and checked.
MF: and is it possible to think about like, one aspect, so say we were gonna look at it, look at one playback and just think about the shapes, would you be able to re-draw just the shapes
AR: I think it would make, you'd probably make a much flatter drawing there, make a much less interesting
MF: I mean not…
Amanda. Cause we just did that now didn't we, we just, by mapping out these, you can see the shapes we've done, there's one there look, and there's I can't remember that one I don't

think that one was drawn like that I think that one was drawn form the shadow instead actually.
MF: let's look at it from the beginning, and then we'll be able to look at. …
[restart footage from beginning]
AR: You can see that even going on there. Sort of mark that you make are just, can you rewind? […] just really like first, the first that you were making was, it was looking at blocked shape, d'you know what I mean.
MF: A blocked shape as in, the whole thing?
AR: Yeah, No. It was um, behind, [..]
So I've drawn the line down the middle, and then I'm doing that bit there, so you're thinking, it's feature based there isn't it, there you are, that bit there [13:48].
It's hard looking at it. Can see the how everything's linking together thing going on,
MF: and most of the lines you go over a few time, but it has to do with the relationship as well. Between the line and the previous line?
AR: Yes, because I'm using so many lines, if I just did one line it's just gonna get lost isn't it. If I go over a couple of times it's usually the ones I'm more confident of. Or the ones I want to, uh, to ground. You know to sort of, set a bit more firmly in the drawing.
Yeah, there are some shapes going on there, there's that sort of… It is hard thinking about it in terms of just one thing though! I don't know what I was thinking at the time. Cause you don't separate it in your head as you're actually drawing it. I'm looking for clues for it, but I can't actually say, yeah that's what I was thinking, because you don't consciously separate it like that. I suppose Ideally you'd get someone to describe it as they were drawing it, but I found that really difficult.
MF: So it's like, I'm gonna do this with my left hand so it might be wrong, like that (I draw a line) [15:47] , stop me if this is wrong, it seems like that's a shape, and then you have this central line,
AR: Yeah
MF: maybe this central line has less to do with shape and more to do …
AR: central line is just finding the um, finding the angle coming down the centre of the head. It links to those models that they use, as we were saying, you know as long as the body […] as the head, and then you have the centre line coming down centre of the face and then you have the line coming in with the angle of the eyes, I actually find that quite useful, especially when I'm not using a measurement system.
MF: and so that was a shape..
AR: That isn't an observed shape, see that's an angle shape that is. And to be honest this initial head shape isn't really an observed shape, it's just like a rough sort of 'where's the head gonna be in the paper'.
MF: it's more lines than shape. So maybe in that instance we could say that in that moment, you were just mainly looking at size, and not really thinking about the sort of line, or..
AR: oh yeah, absolutely, for those initial marks, yeah. Absolutely. The more the drawing develops, the more things come into play. The more complicated the type of lines that you are making become. Definitely
MF: the more different facets…
AR: yeah
MF: that's interesting cause it's like each line you kind of draw it a number of times and it gets richer and more complex in all of these dimensions doesn't it?
AR: I was taught specifically not to do that as well. We were always taught that doing that or a line (draws [17:39]) when you could do that was absolutely wrong. And I've sort of gone against that now. Yeah.
MF: But you're not feathering it as much as looking many times at it,

AR: That's it! Yeah, yeah it's not… yeah at the moment the ear has got a line there, and its got a line there and it's got one in the middle in between yeah.
MF: it's quite honest in a way, because a line can be ' oh I'm not sure, could be there, could be there'
AR: Yeah, cause one of the things I read about people who have been drawing a lot is that they deliberately introduce ambiguity into their drawings, I don't do that. I don't think, I'm not deliberately making things ambiguous, or deliberately trying to make my lines not relate directly to what's there' do you know what I mean? I suppose, there is ambiguity in that you're not trying to join the dots, if you like. You're happy to leave gaps.
MF: Those people might say that when you rub it back, that is maybe what's going on, but..
AR: well that's just rubbing it out though really isn't it, but if you rub it out completely, there's nothing to stop you drawing the same lines all over again. (laugh s) Whereas if you leave a shadow of the lines, and I love them, I do like the quality it gives, but from a practical level, if you rub that out, what's to stop you redoing it.
MF: bit I'm sure you know that if you just do it for an effect then it will be. It will feel false,
AR: it would look awful. It would be awful yeah, I'd hate it.
MF: seems like, you go around the chin and then,
AR: that was a shape, that's a shape bit [19:25]. Cause look at the shapes there.
MF: draw it.
AR: there's that bit there and there's that bit there, and those were sort of tonal block shapes those were. Bit it was tonal block, it was all structure, it was looking at how the neck is working on the head. And again, there's one there,
MF: and when you blocked that bit of tone in a few seconds ago…
AR: that bit down there?
MF: does that have a shape?
AR: Yeah, when I do tone, it will tend to be within a defined shape,
MF: and do you, do you outline it first and then block it, or do you just kind of know what the shape is?
AR: with a pencil, I don't know.
MF: (reviewing footage) it's hard, it happened so fat,
AR: I would imagine that I outline it first, but I don't know if it's as structured as that. In my head I'm outlining it, whether I actually physically have to outline it I don't know. Half and half.
MF: it's one line, you draw one of the lines..
Amanda. Yeah, just as a sort of guideline,
MF: but then maybe the other one,… I've outlined it here look, I've outlined that bit. Then I don't outline that bit.
MF: so it's like you draw that line, and then, sorry I made that too long there
AR: I did, I drew that line, like that, I went like that like that [21:07] and then I toned in that bit. Cause that, probably cause that was a simpler one.
MF: and the other edge of that bit of tone where it's stops, does that line already exist?
AR: very hard to register it.. … No
MF: it doesn't, does it.
AR: straight down isn't it. You can see
MF: maybe there's a really feint line,
AR: there's a lot of lines on it aren't there.
MF: we've run out of batteries that's what's happened… […]
AR: I do think of tone in quite a planey way though. If you think of Cezanne's planes, to make 3 dimensional shapes, I will deal with tone in that way. Um,
MF: So it's more planes than 3 dimensional shapes, cause this one…
AR: Well it's the planes that make the 3 dimensional shapes isn't it?

MF: This one you were kind of thinking of as a shape, but then you were aware that it was concave at the same time weren't you.
AR: but it's still that sense of plane,
MF: So it has a curvature, and a shape, but its it not like it's, Cezanne kind of…
AR: it's not as straight edged as the way that he would have worked it's not fragmented up in that way.
MF: And his later drawings were quite, like he'd look at 3 dimensional shapes, in terms of finding a cylinder or..
AR: Yeah, no.
MF: it's more like planes, but then they have a 3 dimensional aspect to them isn't it?
[…]

Beginning film again. [25:46]
MF: that first central line gets in quite early.
AR: It has to doesn't it. I hold my pencil, I noticed I hold my pencil quite far back. Does that change working into the more detailed bits?
MF: sometimes you were holding it more like you were writing, more at a right angle. Earlier on it seemed to be further down.
AR: Yeah, I've just moved it.
MF: I wonder if that was significant with the way you were looking at things. (laughs)
AR: (laughs) no I think all it is, is that initially, you've gotta see the whole thing haven't you. So you've got to keep the gap to your pencil just so you can see what you've been doing.
MF: It's like taking a step back mentally, almost isn't it. Rather than actually getting up and…
AR: and you haven't got to have control over those first marks, because you don't know where they're going anyway yet. You don't know where you're gonna sort of move them to, so,
MF: so would it be fair to say that, like of this list we made earlier, this probably isn't exhaustive, but it seems like the emphasis shifts, like, this is just what I'm kind of…
AR: Oh yeah, the emphasis shifts as the drawing progresses, absolutely.
MF: First it seems like it's more about size,
AR: and shapes, size and shape.
MF: size and then shape?
AR: And angles. Yes.
MF: So we can maybe number these, would size be 1?
AR: Size would have to be the first one cause that's your composition isn't it.
MF: I'm not listing..
[tape ends – batteries run out.]

[the list ended like this

1. size / scale /composition
2. Angles & plumb lines
3. Shapes
4. Receding or coming out
5. Contour
6. Tone
7. Strength of line
8. Sort of line /quality of line /texture
9. Texture

1, 2, 3, (4) = structure/scaffolding]

5. David Cobley, concurrent report transcript, 05 June 2011 (final coding)

	Strategic	Visual attentive
Ok, well, um, what I'm drawing,	Describing action	
what I'm trying to do initially is to,	Describing action	
um, draw the whole head all at the same time,	Describing action	Global view
so, um I'm going around in a very sketchy fashion,	Describing action	
so I'm trying to mark out, not points exactly, but areas, um,	Subgoal	Point
or um areas of the head that are important,		Global view
so even by now I've got the basic shape of the head	Evaluation (against subgoal)	Global view
and something of the features indicated in the first sort of 30 seconds.	Evaluation (against subgoal)	Global view
Um, it's a pretty moveable feast really,	Meta plan	
because, um, there is some movement between drawing and looking,	Misc	
um, I noticed that when I was doing the first drawing I wasn't even sure where I was, where my head was going to be,	Meta description	
but now somehow, the head's settled into position,	Meta description	
so that makes it kind of easier.	Meta plan	
Um, and uh, you know I'm aware of the skull underneath, you know,	Input only	Internal structure
I'm aware of the light it's not a terribly good light, for drawing in a way	Misc	
because, um, there's a number of different light sources,	Misc	
and sometimes it's much easier if you've just got one light source, or two light sources, a main source and then another one. Less obvious one.	Misc	
So anyway, I've got the basic shape of the head.	Evaluation (of whole)	Global view
It's all over the place,	Evaluation (of whole)	
but it means I can, I've got most of it there,	Evaluation (against subgoal)	
before I get into any kind of detail I want to, um,	Meta plan	
I'm just searching it out really,	Describing action	
finding out where all these things are.	Subgoal	
They're not immediately obvious.	Meta description	
That's why it's, I'm working in this kind of way, not, um with definite lines.	Rationalisation	
Because I'm trying to draw it all at once if	Rationalisation	

that makes sense,		
I'm not starting at the top and working down,	Meta plan	
I'm in this kind of sketchy way,	Meta description	
um, helps me do that I think.	Misc	
The eyes the nose the mouth, thinking about the distances between chin, mouth.	Input only	Individual feature Distance between points
Of course as soon as you, as soon as I put one line in it affects all the other lines that I've put in.	Meta description	
So um, I'm changing things as I go along,	Describing action	
cos each new line effects what I've already got down there.	Rationalisation	
So that's part of what's going on.	Misc	
I notice that if I'm trying to talk, I can't draw as well and my face is moving.	Misc	
MF: if it slows you down, that's ok, if you feel you need to pause.		
DC: Ok. Thank you.		
I might do that, because as I'm talking I'm responding to what I'm saying,	Misc	
and my face is moving,	Misc	Global view
so I'll just concentrate on drawing for a minute.	Decision	
As I'm sure of where things are, I can make darker lines, definite lines.	Meta description	
And talking about drawing the head,	Misc	
I often talk about the relationship between the head the neck and the shoulders.	Meta plan	Global view
And I'm aware of that as I'm drawing my own head.	Meta description	
Trying,	Misc	
form.	Input only	Form
Part of what, a large part of what I'm trying to do is describe the form that I'm seeing.	Meta goal	Form
A three dimensional form on a two dimensional surface.	Meta goal	
Aware that I'm looking up at myself, so it's not a straight on view.	Meta description	Symmetricality
I'm looking up and away.	Description	Direction of gaze
My head's moving backwards and forwards.	Description	Global view Movement
Sometimes I can see more ear, of the right ear.	Meta description	Individual feature
I can see more of the right hand side of my face.	Description	Symmetricality

I've got too much of the top of my head here.	Evaluation (of whole)	Global view
The glasses. There's the bridge over the nose.	Input only	Individual feature
The two side pieces that are more obvious than the glass, they help also describe the angle of the head.	Input only	Individual feature Direction
Quite good for me at this point to um, get back from the drawing and see it from a distance.	Meta plan	
I'm aware that it's possibly not possible, or a good idea at this stage, so I'll just carry on.	Meta evaluation	
Squinting helps, just seeing it through one eye,	Meta description	
helps see it from a distance without actually moving away from the canvas, moving away from the paper.	Meta description	Global view
Trying to think in terms of planes , and uh, how one plane moves away into another, very subtly.	Meta description	Plane
I'm aware of how scribbly the drawing looks.	Evaluation (of whole)	Global view
It's not um, it's because it's a way I don't normally work.	Rationalisation	
I normally work smaller or larger, or with a different tool.	Rationalisation	
Shadow caused by the glasses there.	Input only	tone
I'm beginning to look like artists often do in their own self-portraits. Rather suspicious, of themselves.	Input only	Mood
I think that it's as a result of looking out of the corner of your eye at something.	Rationalisation	
I am also rather suspicious of myself, but that's another story.	Misc	
I'll call this self-portrait with mouth open.	Misc	Mood
MF: you've had about ten minutes, so when you feel it's finished.		
DC: oh, it'll never be finished. But uh, for the purpose of the exercise I can stop now.	Misc	
With all of these drawings I want to carry on.	Meta evaluation	
I've only just started. But that's the constraints we're working with.	Misc	

6. David Cobley, Retrospective report transcript, 05 June 2011

DC: David Cobley
MF: Michelle Fava

MF: How did you feel like talking was affecting the drawing, you said it was …
DC: Yeah, at some points it was affecting, I think it was affecting it all the way through, um. One wants to be concentrated entirely on the drawing cos that's hard enough. Trying to talk about it at the same time makes it more difficult.
MF: Do you think it's possible to say only the things that kind of enter your mind anyway as you're drawing, and sort of describe, because I noticed at a few points, you kind of describe what you're doing, but then, kind of qualifying why you were doing that, or explaining why. Which was great, but I felt that normally you probably wouldn't say that to yourself as you were drawing.
DC: No, I was sort of talking about, I was kind of reminded about teaching situations, so I was talking about things that I might talk to a student about. But that's something you'd rather not have is it? You'd rather just me talking about what I'm..
MF: well, we'll have another look at the footage and we'll talk about it again. And we can go into more depth, um, if you want to explain strategies, but I feel like that kind of explanation is really distracting from doing the drawing. Do you know what I mean? But maybe there are certain kinds of talking which are less distracting. Like, if it's um, more plainly, just saying what you're doing in each moment. In a more... Does that make sense?
DC: Yes, I guess, I guess it does. I don't know. Until I start to do it again whether it has made sense until I do it again.
MF: SO what we'll do, we'll have another look at this footage, and then we'll do another one.

[video begins]

MF: So we'll watch it a few times, and the first time, um, I would like you to just mention anything you feel you could have said but didn't, and anything that surprises you about it, and just your general reactions. I won't ask you too many questions, but then we'll look at it again and I'll ask you a few more specific things that I made a note of. But we'll do that the second time.
DC: No sound?
MF: We can have sound. It might be better if we don't have sound actually, cos then, on the second footage..
DC: Which one of the three is this?
MF: This is the last one of the three.
DC: there's all these funny facial expressions I'm not aware of. Pulling funny faces, that's always funny to watch. Um. I'm not aware of all of those. [..] all this adjustment, all this fiddling about.
I won't be able to comment on thing's I haven't said cos I won't hear what I'm saying.
MF: Uh, ok. Just turn the sound up. Can you hear that?
DC: Just about. (03:12 on 6 retro)
Trying to think of something that surprises me, but there's nothing.
MF: Don't worry if there's nothing. I mean, that's also interesting. If we watch it through and don't think of anything to say, that's ok too.
Lots of people are surprised by how fast they draw.
DC: That's been pointed out to me before, I'm aware of that.

[…]
I'm sorry I haven't said anything about being surprised, or things I haven't said. I think I was very conscious of what I was saying and very conscious of what I was doing.
MF: because of talking?
DC: No, because I'm conscious of what I'm doing. Um, and um, I don't think the camera, having the camera there and having you there made much difference to that.
MF: You feel that you're very aware of your working method and the way that you go about…
DC: Yeah. (08:44) Very aware of it yeah.
MF: Good, because now I'm going to ask you some very specific questions. […] So to begin with, you are positioning things and you have a look at the paper, and then you take a look in the mirror a quite long look in the mirror, and I was just wondering…
DC: What I was doing when I was taking that long look. I suppose what I was doing is um, because I didn't talk about it at all, but I think what I was doing was, placing that visibly on the paper. So I had finished the drawing before I started in in a way. In terms of having it on the paper.
MF: You said something about having it sight size,
DC: No no no, I said that afterwards. They're all positioned quite well on the paper. It's just that if I make a mark there, at the top of the head, that there'll be enough room for that button when I start. I think that was what I was doing. I mean, who knows. But there's also this matter of starting something isn't there. Starting something, you're putting yourself, getting yourself in the frame of mind to start. From stillness to actually,
MF: I think I do that as well. Steady myself, quiet myself.
DC: yeah.
MF: and then when you make the first few marks you mentioned about the size or the general.. let's have a look at what you said…
So you plan size, and then you mark it out roughly, and you said, you're trying to draw the whole head.
DC: all at once
MF: all at once. You mentioned features and I was wondering, when you do this process, would it usually be the same kinds of features you pick out, to make that initial structure
DC: yes.
MF: and would it vary with lighting, or?
DC: Yes it would. If we had a different lighting, it would affect it, but I think I'm still looking for basically the same things. The shape of the skull, where those main features are, on the skull, because that's what makes each person different.
MF: What would you say the main features are, could you name them?
DC: Um. OK, I'm not sure this is in order, but um, talking about features, I talked about the shape of the skull, I think that's critical, the length of the, (13.20) skull, the shape of the skull. But the features on the head are the eyes ears, nose, mouth, um, yeah.
MF: And you seemed to be looking at things like, um, where the eyes nose and mouth sit, in relation to the shape that you've drawn, in relation to the shape of the head. Do you think it's possible to describe a little bit more how you go about that, I mean, are you using a grid system, or…
DC: I imagine I am, I imagine I am cause, um that's what I say to students when I'm talking, when I'm teaching, to have that in their mind, so I imagine I probably do have that. I've got a vertical and a horizontal or a series of verticals and a series of horizontals, and I'm measuring, when I'm putting in an eye, I'm looking at that distance between there and there, and comparing it (14.27 points to places on drawing) comparing it with the distance between there and there, so I am doing that in the process of drawing, I didn't talk about it but I am definitely doing that (still pointing) Soon as I've put my pencil there, I'm aware of

distance between there and there, there and there, there and there, and I think that's, that goes on throughout (still pointing 14.54). It's relationships between one mark and the next, one area and other areas in the drawing.
MF: And, in relation to each other, would you ever would you ever think about a diagonal measurement?
DC: No! actually no, I don't think I think much about diagonals, they kind of take care of themselves. Um, no, I think it's mainly verticals and horizontals.
MF: That's really interesting. And the negative spaces between the eyes and the mouth, it seems like they don't exist yet, you've just kind of...
DC: The negative spaces between the eyes and mouth? What do you mean by that?
MF: I mean, rather than thinking there's a shape here, the shape of the cheek (15.47)
DC: Ah
MF: I would use the shape of the cheek to determine how far the eye is from the mouth, but you seem to be able to have these floating independently, and still be accurate, without having ..
DC: Right. I can't see it. I,
MF: Do you know what I mean?
DC: Yeah, but I can't see a shape of a cheek, in the mirror, I can't see, (looking at face in the mirror 16:15) well I can see (pointing) but where does the cheek start and end? You know. That doesn't help me at all. What's the cheek?
MF: It just strikes me as a different strategy from other people that I've filmed who seem to reply more on finding something that's happening between those two points to be certain of what's happening in their relationship. (16.39)
DC: Ok. No, I think one two three four five six. I mean, one two, three four, five six, seven eight, nine, ten. I suppose. I haven't done that before, but, one two three, one two three, four five, six seven eight nine ten eleven. Something like that. Twelve. (now pointing at paper 17.02) one two three four, the height of the head, from top to chin. Length of neck, width of head and then
MF: Can we draw it on?
DC: So, height of head, length of neck, one two, three four. With of head, five six, and then, ears, eyes, nose, mouth, neck. Ok, on two three… there's about a dozen things I'm looking for I suppose. I am also thinking about, I mean very much thinking about, this form in space, so it's a kind of cylindrical shape, sitting in a rounded…
MF: And you do draw a mark, I think I spotted it, it was kind of like this (I draw on paper (18.00)
DC: Right.
MF: Something, it might be there already actually, yeah you can see it better on this screen. It's a mark that just goes across the forehead. Around, where the eyebrows would be.
DC: Hm, is it my glasses, I don't know. I don't remember doing that.
MF: Could be glasses.
DC: And, uh, I hope I didn't do that, I hope
MF: You hope you didn't do that?
DC: Well, because I'm looking up.
MF: Wait, it's not that one…
DC: The one underneath.
MF: This line here.
DC: So there is you're right, what's that then? What's that then.
MF: It went on quite early on I think.
DC: Did it really, goodness me. Look how observant you are. I don't know what that is at all.
MF: It could be a number of things, I mean it could just be, that was the path your pencil took moving from one location to another,

DC: Possibly.
MF: But some people do that because they're thinking about the roundness.
DC: That's why I said I hope I didn't do that because I'm looking up, so, it would be more like that (19.04) so, like that wouldn't it.
MF: yeah, the angle would be different. It seems to make sense in that..
DC: Nah, to me that's, that's um, I'm surprised. Ok, we found something I'm surprised about at last. At last, I'm surprised by that. I don't know why I've done it.
MF: It continues across, uh, to at least there I think.
DC: Yep. Dunno what I was looking at or thinking about.
MF: ok. Um, and this might be an awkward question, but when you draw the eye, or when you make this mark 'that's the eye', how aware of you that it is an eye, in the sense that it's something that might be looking at you? Or, or are you just purely thinking about position of the darkest point in a formal sense.
DC: While I'm drawing I just thinking that that is a point on the face, or a, not a point exactly, but it's an area on the face. I'm very aware that I have eyes and that they're taking in all this information, but while I'm drawing it, I haven't got time to think about stuff like that.
MF: Good. So, um, let's have a little look at the next bit. Oh yeah, so when you say, it's moveable, and then later on you say something like, that you can put darker marks on when you're more certain,
DC: Uh huh.
MF: um, but things do seem to stay more or less, where you put them.
DC: Uh huh.
MF: Um, (20.57) would you say there's a process of re-evaluation, or, how would..
DC: All the time.
MF: How would that go?
DC: Yeah, re-evaluation is a good word, I'm constantly re-evaluating. So these initial marks help set it on the paper, but then I'm constantly changing it, especially down this, I found this side of the face especially difficult, particularly because I was moving I think. Largely because I was moving. Uh, there's always, when something's turned away from you, you've got to think about, the tendency is to draw something as if it's facing you so you tend to make, this the side that's turning away from you larger than it ought to be. I think I'm conscious of that. But Yeah, the whole process, drawing, painting process, is one of constant re-evaluation and not accepting that the mark you've already made is necessarily the, in the right place, or does what you want it to do.
MF: SO you're aware of tendencies which might normally lead to errors like, there's a tendency to make things more symmetrical than they really are..
DC: Yes, I am. And I'm aware of them because I've done some teaching and I can see that happens in other people and I think it's also, probably also a tendency in me, although I've been doing It for such a long time that perhaps it's not a tendency any more, like perhaps it's something I don't need to be so conscious of, but, um,
MF: Bit it's maybe something that you're sub-conscious of,
DC: Yes
MF: Or, because you're aware that that's a danger you know to avoid it perhaps
DC: Yes. Yes.
MF: There are many aren't there, like this distance, um, between, in a profile view, how far back the ear sits that's often wrong, or, I've noticed things like, um, table tops, um, people always want to make them more um, up
DC: Why is that do you know, why is that?
[Discussion about drawing errors]

MF: I guess that's why I was asking you about this and about how much you were aware of the difference between this distance (pointing 28.54) and this distance and the symmetricality of it.
D Very aware, I wasn't uh verbalising it, but very aware.
MF: I was going to ask you…
DC: Yeah, sorry while we're on the subject you know, I'm conscious that I was pr… if I was teaching I'd probably say things like you know, look for that line, (draws)this midline between the face, of course if the head is straight on, then its there, but if the head is where we've got it here, um, or like that, then that moves over with it. I'd probably be talking about doing, putting those lines on as well.
So I think I'm, I know I'm aware of things as I'm doing them, but I'm not, these things, in the time frame you think probably… you see points are more important. These are only rough guides actually, you know that does describe the head doesn't it. Describes it differently to the way I see it.
MF: When you were learning, when you were much younger would you have thought more about this sort of thing, I guess as you were being taught.
DC: Yes,
MF: They may have drummed it into you, but would you have relied more on that kind of scaffold?
DC: Probably. Probably, I don't know, it would be nice to… It would be nice to, I've got some drawings from when I was smaller, when I was younger, um, and I was always drawing, I remember people telling me, my mother and my brother say I was always drawing. I do remember drawing and drawing a lot. I don't remember meeting this kind of thing until much later (points to diagram of central line drawn on top right of page). So I developed a way of drawing without that. But that helped, there's no doubt about that. Made me think more about the form and space. Much more sculpturally.
MF: Ok. And I think, there are a few points when I could probably hazard a guess as to when you're probably making an evaluation, but there's probably many more, like later on, there's appoint and you say..
DC: I mention about getting back from the drawing, is that it,
MF: Yeah. About standing back, and squinting, um
DC: I shut my left eye and squint. Go slightly cross eyed that also helps.
MF: And there's a bit where you say, 'oh, there's too much top of the head,
DC: M hm.
MF: And so, the moment when you say that I can probably pinpoint more or less the moment when you looked at it and realised that, because there would have been, probably would have looked a couple of times and thought, yeah this is wrong, uh, so we'll have a little look at that in a bit..
[discussion about lighting]
DC: I was just looking at these lines, not the ones that I'm drawing there, the ones I drew afterwards. It's not a bad likeness!
MF: So it seems like, uh, there are different phases in the process, so initially… stop me at any point this becomes wrong, initially you are looking at things like the compositional size, the general shape, um, where the features sit in relation to that, uh,
DC: Yep.
MF: and then, possibly there's a point where, you say, I'm not sure exactly what you said but it was something like,' I'm happy with the shape', and then it seems like that's a new phase where you start to work into more detail.
DC: Yeah, you could say there's a slight change of phase I suppose, I feel I can, not exactly relax, but let's say relax once I've got those things in place uh, still constantly evaluating, but I can think possibly more in terms of, well I'm always thinking in terms of form, but of light

and shade. Yeah. I don't think about those things much to begin with. I think, it's fair to say, in terms of those points, and then I think in terms of form, light, dark, light dark.
MF: And when you say you're always evaluating, do you think that you evaluate each time you glance back from the paper, or are there moments when you stop…
DC: Yeah. There are. Uh. And if the drawing continued as I'd have liked or until I felt it had finished or I got to the point where I wanted to stop, which would probably have been at least an hour. There would have been times when I just stopped and looked.
MF: And stood back?
DC: Yes, and stood over there, and looked at it form a distance, and then I would have just compared, without doing any drawing at all for about 20 seconds or so.
MF: And then afterwards maybe re-drawing or re…
DC: Yeah. (flicking though drawings) I might do some rubbing out, um. Don't know if there would be any re-measuring. There might be some serious re-measuring if I stood up and thought 'it's all completely wrong' I might do quite a lot of re-measuring. But it seems to me that most of these, I mean, the first is definitely the weakest.
MF: I'm not suggesting that the measuring's wrong, I'm just wondering,
DC: No. I know you're not but um, I don't think there needs to be any serious re-measuring.
MF: But even when there doesn't need to be, you might still go through that um, process of asking yourself if there needs to be. I'm quite interested in that. For example in the few minutes where you say 'oh there's too much top of the head', um, when you looked and evaluated, were you, or do you think that you were, um, looking at the drawing and thinking, 'does it look like me'?
DC: No.
MF: Were you just thinking does it look weird? Or were you simply looking at the shapes and making an objective comparison of the planes, you talk at one point about where planes meet each other.
DC: Right.
MF: I mean, maybe evaluation can take place on all of those levels. Um..
DC: I think it does, I think there are… Do I think ,'oh, does it look like me?' um, yes. I think I must have thought that. Um. Does it look like me. I suppose when I got to, ah, where was I in the process, Fairly near the end I suppose I was thinking does it look like me.
MF: We can have a look and then see. So at this point you weren't really thinking about that at all. (39.11)
DC: Does it look like me, no, no no. no. I think to think that early on is too early. It will look like, of course it will look like me if the marks are in the right place. It's a natural consequence of drawing that it will look like me. As an apple looks like an apple or a desk like a desk. But I suppose because you know your own face so well, or you think you do, you're more aware of whether the drawing is quote a 'good' drawing or not, because you're highly aware of your own appearance. Whereas you may not be if you're drawing say a space rocket, or a tank or a chaffinch or something. In a way it's easy to judge whether it's like what you're drawing, because you're aware of your own face, but then it's less easy because, um, you have all these pre-conceived ideas about the way you look. Your appearance is constantly changing, the ageing process, um, affects it.
MF: SO during this phase, if we can call it a phase,
DC: yeah, yeah.
MF: I mean once you've established where the main features are going to be, you mentioned, form. You're looking at form. Where light and dark things are. Light and darks. And then a little bit after that you mention planes, how planes meet each other. When you look at dark bits, uh, do they have a shape? Um,
DC: Yeah (hesitates), they have a shape. They have a, they sort of have a shape, they have a… If something is very strongly lit, if they have a strong directed light, and the rest is

shadow, then those shapes definitely have a very clear shape. Those darks have a very clear shape, the lights have a clear shape. With this, it's much less obvious because, light there, light there, light there, and then all this ambient light as well so, it's very complicated. So, you know, none of these… That's a shape. That's a shape, but that, It starts there, and then it peters out.
MF: So you might think of it in terms of having an edge and then a gradient sometimes? Or…
DC: Yes, yes.
MF: Or sometimes it might be enclosed, like this, this patch (43.09) of hair, when you drew that did you first think, oh, it's going to be that shape and then hatch it
DC: A little bit yes,
MF: Or, did you think, oh, there's this edge, and then start drawing the hair, and then where does it end?
DC: Yeah, all of those things, I don't know in which order, or if there was an order. I'm conscious of there being a sort of shape there, made up of many many individual hairs, so it's not an exact shape, I'm never going to be able to draw it exactly, unless I spend the next day or two drawing each individual hair, but, um, thinking about it, yes it does have an overall shape, it's pretty amorphous.
MF: Looking at the footage it seems like you return to it a few times,
DC: This area, yeah.
MF: uh, (scrolling through video)so now it's hot a couple more lines, but they just have to do with refining the shape, and now there's a few more, can you see them?
DC: uh huh.
MF: Now there's a few more, and then after another 30 seconds or so… oh yeah, so it was like, it looked like this: 'yeah, that ends there, (44.41) and then this is hair, it kind of ends, but it doesn't end as abruptly as it did there'
DC: M hm, yeah.
MF: and then draw, that line, so. So yeah, it seems like there was a moment where you were looking at the edge of, on one side, but not on the other side.
DC: M Hm.
MF: But then those bits of tone, you don't draw line. The bits of tone down the centre of the face seem to be more, more just sketchy, not confined. I've been looking at Cezanne's [...] sketches and he seems to have this technique of uh, outlining a patch, and then hatching it.
DC: Right.
MF: And then I realised that's kind of what I do, often, uh, at least when it's possible and I look for shapes, and I think what I do is, first I look at the shape, then I assess its tonal value, taking another look, and then I assess its tonal value and hatch it, and that allows me to think about it twice instead of once, and
DC: Yes. I think I'm doing that to a degree.
MF: and these bits, here. So there's the glasses, the angle of the glasses, that's an edge, that's a bit of tone, and drawing two patches of hair, tone, and then there's, those two bits you don't really give them any, you don't draw any boundary.
DC: where?
MF: the bits, you draw this (47.40) and it's kind of like, 'oh, yeah that's eyebrow', and then you sort of seem to outline it a bit, and then you do some stuff over here, and then you hatch there, and there, and then that's a line.
DC: Yes.
MF: But that's not a line that gives a boundary to the patch of tone, it's a line that's just there.
DC: Yes.
MF: Um, and so this tone is without, uh, I mean maybe in your mind it has boundaries.
DC: Yeah.

MF: But you don't draw them on.
DC: They weren't ever so obvious to me. Those boundaries, I think it was too early to define them. I think, talking about tone. Um, when I'm doing a drawing I want to use, I want to use this implement to make that kind of tone at some point, but it would take me quite a while before I was able to use it with that ferocity. Um, but, you know I see tones, when I'm drawing, as dark as that. So I want to go back to the drawing and emphasise lots of areas as I go along. As I say it would take certainly an hour or two to get to that point. And I'd use a rubber more until I got to the point when I felt the drawing was more finished.
MF: So you'd return to those patches of tone and darken them.
DC: Yes I would.
MF: And at that point you'd look again at…
DC: I couldn't see it as clearly as I can here (pointing to video 49:17) but like that little area. I could see it a bit, but I wouldn't come back to that, define it as much as that until later on in the process.
I think the other thing I emphasise, whether I'm actually doing it or not, I don't know, but what I say to students, you know, if you're working on one eye, you know because there is this symmetry, always work in pairs. So, when you do something there, immediately go to the other. So there and there, there and there, that ear that ear, you know, that that. I think I probably am doing that. I think I hadn't been looking at it in those sort of terms, but I do say that when I'm teaching.
MF: You do it just then yeah. I never thought of that.
DC: So I've brought the hand across. Whether that indicates I was looking at the other ear. It probably does.
MF: It implies you were looking
DC: It does.
MF: Checking if there was anything equivalent on that side.
DC: That's right yes. So difficult to see yourself objectively isn't it. To see this person working. To see what they're doing. You can see it better than I can probably. (51.45)
MF: I don't know, I'm probably more likely to just, imagine that you're doing what I might do, and I might misinterpret.
DC: Yeah, ok. I took may hand away there, I think. I made that mark and I just wanted to just look across. Just check, and work.
MF: What do you mean by work? What might you have been checking for?
DC: Well, to see if it was in the right place. (52:26) I'd made that mark, and made that mark there, and I took my hand away, and I think my is, that's the other thing you're not doing […] is have a camera looking at one of my eyes,
MF: I can see what your eyes are doing in the mirror.
DC: That's something in the analysis you'll be looking at?
MF: Yeah. I can; see in too much detail, unless we have, if I have the eye tracker on I can tell things like, how many different things you're looking for.
DC: Ah, that's what the eye tracker is, right.
MF: So you might look at three fixations here, and then three on the drawing, and I'll be able to know how much information, or how much …
DC: What is an eye tracker exactly?
[…]
DC: I thought of something I missed, and that's again something I've said when I'm talking about painting and drawing, what I'm trying to do, in the past. That I very much feel that I'm feeling things with the tip of the implement I'm using. I feel as if I'm just pressing it with my fingertips as it were.
[…]

DC: Um, because I draw a lot, because I draw people a lot, faces a lot and I like drawing, I've been doing it for a very long time, when I'm not drawing and talking to somebody I'm um, what is it, I'm slightly, sometimes more than slightly conscious of looking at them as if I'm drawing them. Do you know what I mean?
MF: Yeah I do.
DC: And I think oh no, they must think that I'm looking at them too carefully or in too much detail.
MF: Looking at their teeth and things like that, sometimes people are like, oh have I got something…
DC: And also I start to think that people are looking at me that way and they're not. Because a lot of people, most people don't draw, of course they're looking for visual information aren't they, what does this person mean when they saying this by their expression and all that, they're maybe not looking in the same way as somebody who does a lot of drawing, they're maybe not.
MF: Yeah. They're not. There's been eye tracking studies that compare that, some really nice ones with Humphrey Ocean and John Tchalenko, and normally people will look just mostly at the eyes maybe at the mouth if somebody's talking more
DC: See I'm looking at your eyes now…
MF: Most of the looking is just concentrated here and then…Sometimes they get really nice bits of data from the eye tracker which actually shows the path that the eye takes around the face being similar to the pencil, so it's almost as though you're really drawing it, like you can really draw… one of the things I want to do is actually try and draw with the eye tracker.
DC: D using the eye to draw, bypassing the hand.
MF: Just for fun really, not as part of the PhD.
DC: The technology's there? You can draw people directly with the eye?
MF: You look at people as though you're drawing them, but what do you look at, because, one thing I realised that I didn't know, I wasn't aware of, was that you think that your eye can smoothly trace something
[…]
(07:08)
MF: And so that's really clear to see there that you're reassessing the,
DC: Yes, this, side of the face, too much of that.
MF: Yeah so it was kind of here
DC: yeah
MF: And made up with lots of marks, and now it's there,
DC: Yes
MF: And so I might hazard speculation, I'm aware that this is just me speculating, but maybe you looked at it roughly during the first phase' oh, it's probably there' and then once you were happy with the whole you looked again in more detail, at things like, the curvature and the segments, like perhaps the relative lengths of each segment,
DC: I was looking at these distances we said before, looking at that again and thinking it's too far over (08:15) so it's always too far over, um. The head wasn't, you know, there was that movement between, you know where am I actually, where am I holding my head, and that became more fixed over time, especially over the three drawings, I was clearer about where my head was, in relation to, well, not the background so much cause I hadn't drawn anything here, but more conscious of where it was in the mirror and the angle I was holding my head, yeah.
MF: And then once you'd decided, you made a decision that that's the position your head was gonna return to
DC: Then that helps, you always need a mark, to work off don't you, to work against to react to. You need something, something there. Well I do anyway. I can't uh, well I could, of

course, if I'm drawing a lot and I'm drawing in pen I can draw very fluidly, like almost, like I've tried drawing a single line and not adjusting it, and over time if I'm drawing for hours and hours every day, I get to a point where I can almost get it right first time .
MF: When you try that sort of 'getting it right first time' drawing, like when you're using the ink, uh, would you take a different strategy of constructing, you know that's probably there, that's probably there, or would you start from a point and work your way out from the point, or…
DC: Probably yes, I think what happens is that uh, you become so fluid that while you're drawing, let's say the whole figure, while you're drawing the head, you you're able to assess where the rest of the body is while you're drawing it. You know, if you were doing that figure from life, you get to such a degree of confidence that while you're making that mark there you know that the left side is there, so you can do that with confidence, but I haven't been drawing enough to do that with you today.
MF: Sure, people I've filmed who draw like that, or aspire to draw like that, their looking is very different, the way they look backwards and forwards. I'll show you after this…
[…]
MF: OK we've got so far, we're happy that there have been kind of two phases. The first one in which you decide the size it's gonna be on the paper, and the general shape and you use a grid system to map the features, where they are in relation to each other and themselves vertically and horizontally. And there's a bit of evaluation going on. You decide you're happy and then you can look at things in more detail like tone, um, sometimes tone has a shape sometimes it doesn't, sometimes it has a gradient, and form and then later on, um.. because I'd like to be able to describe quite exhaustively how the kinds of things that you look for progresses into greater detail and complexity and so, at the moment we're kind of in the middle and we're looking at re-evaluating contour. Would that be an adequate word?
DC: Yeah, re-evaluating contours, Yeah, yeah that would be a good word, yeah.
MF: We can certainly say that's what happened on that edge.
DC: Yes.
Wasn't happy with that mark. Too dark. Soon as I put it in. I thought oh I'll carry on anyway (14:47) that was too dark too. I thought 'oh, I'll carry on it'll all come out in the wash. '
MF: so, this bit, you, um, […] put loads of big patches of tone. And when you did that, um make a conscious decision to map in lots of big areas of tone or did you look and think oh, the neck's all dark, and then look again and think there are other patches I can include that have an equivalent, like this big patch..
DC: Um, I think I felt, dunno really, I think I thought of them both at the same time. I thought, 'now I'm gonna put some tone in', because I'm trying to draw the whole thing all at once, as soon as I've put tone in there I've got to put tone in everywhere else. But yeah, I'm looking for tones that are equivalent. They're sort of mid-tones but in the drawing they're not even mid-tones, they're much, ..everything's mid-tones at this stage, nothing's dark enough to say it's anything beyond a , well a mid-tone. In reality, all of this is quite a lot darker, but I thought I'll make a start.
MF: I suppose earlier on you look for things that are quite a lot darker, like the line of the mouth
DC: Yes.
MF: And the pupils and the shadow
DC: Yes.
MF: Things like that.
DC: I am looking for equivalencies there's no doubt about that. If I'm putting that darkness in, I'm aware of you know the points of darkness that are of equal or similar darkness. (17.59)

MF: yeah, great. And then when you …. So that's a shadow there, and that's boud by lines that you've already defined
DC: Yeah,
MF: so you don't really have to think about the shape, at all
DC: No. That's right. I do either ..
MF: Except this one, on the cheek, because I don't think there was a line there. I don't think there was a line here, was there, you just, this was already …
DC: Yeah, they're not all constructed. Like that, there's nothing there and I'm starting to put some sort of shape in there with the tone. Is that what you mean?
MF: Yeah. I was just wondering when you look at this you can think 'yeah, that's a mid-tone', and then you also think this is also a mid-tone so I'll map it in, but you must also be thinking about its boundary.
DC: M hm.
MF: at the same time. This boundary's already drawn but this one wasn't. So, maybe you're just thinking it's just rough, but maybe you're aware that it stops at this, uh, do you know what I mean?
DC: Yeah, I do I think. (moving paper aside to see reflection) Oh, it's al changed now cause we've got sunlight coming through.
MF: I mean maybe there is or isn't a line but I guess what I'm interested in is are you thinking of two things at once, are you thinking about the tone and the shape of that patch of tone..
DC: Yes. Yes I am yeah.
MF: Ok. Excellent. Uh, and then you pick out a couple of others, on the forehead.
DC: I guess when I'm drawing I try to think of everything at once. Tone, shape, form, contour, line. Well there aren't lines. There are few distinct lines in nature, so […] we might cover, really.
MF: When you say you're aware of how scribbly it looks, that shows that you're also evaluating the drawing as a whole.
DC: M hm. Yep.
MF: I mean that might happen very quickly, but it's going on at certain points. And I can pinpoint that to certain things you say, like 'too much top of the head' , 'it looks scribbly' um and then also stuff that you do with lines when you re-assess, when you re-draw lines with more accuracy. That's evaluating on a smaller scale isn't it?
DC: Yeah. Again when I, think, I'm hopping back and forwards from one eyebrow to the other. Oh good. I'm following my own advice.
I try to do this as un-self-consciously as possible. He says..(laughs) But you have to try when you're on camera with another person in the room. If you're on your own you don't have to think about it. About being… you are unconscious, or, un-self-conscious I should say.
MF: I suppose. Are you saying you had to think more about being un-self-conscious? Because I was watching?
DC: I think there has to be some sort of effort made, don't you?
MF: I find, I try to draw people that don't know I'm drawing them. And that's much easier, if someone's sitting for me, that scrambles my signals because I'm too, uh, I become much more critical I draw a couple of lines and think, 'oh no it's rubbish! What are they gonna think, and… '
DC: Right, yeah, I think I've got beyond that but, sorry I'm not trying to say I'm ahead of you
MF: I think you spend much more time
DC: I do spend more time doing it probably.
[…]
MF: So we might even have entered a third phase in which you are refining things that you've already drawn.

DC: Yes, looks like it.
MF: Putting more detail into tonal differences.
DC: M hm
MF: Oh that was a shape
DC: Yeah, I thought you'd like that (31,09) Good. Well done David, left then right, that's good.
MF: And so this refining phase..
DC: See my head went back then to try and see it from a distance (31.41)
MF: Oh, oh that was me turning the projector on. So if you did carry on, would it be more,
DC: of the same
MF: continuing this process of evaluating,
DC: Yes it would
MF: adding detail
DC: yes.
MF: Um, and maybe at this point, what sorts of evaluation would you say you would be doing? If that's an adequate question, I mean don't speculate..
DC: Particularly with the tone I think, I want to have a drawing with tones as dark as that pencil, that graphite will make. So I'll be working it up to a point where there were tones like that. And constantly re-evaluating re-defining. Uh, the pupils would be that sort of blackness, although that's not black it's grey. Yeah just continuing to model it to make it more 3 dimensional, appear more 3 dimensional . Maybe even thinking about what's going on around it.
MF: and at that point, we were talking earlier about recognising and maybe sometimes you might glance and recognise it as yourself. And you said that maybe that would happen later on in the process only.
DC: Uh, well we're getting there probably now aren't we. Um, we're towards the end, how far have we got? 2 thirds in?
MF: It's about another minute to go.
DC: Well. Yeah. I'm sitting back. What am I doing there, I'm probably thinking 'is that like me'. Um, but I'm reasonably happy, yeah it's almost finished now, I'm reasonably happy that that's a good likeness.
MF: Yeah, that's the end isn't it. So, there's this last. Let's look again at this last minute. I hope that wasn't me putting words in your mouth, asking me if you were recognising it in that moment.
DC: No, I don't think it was, I'm thinking, it's a consideration pretty well on. Well pretty, you know when I'm making these marks, at the very beginning, these twelve marks, or whatever, it's got to be like me then, um. It's got to be like me all the way through. But it only starts to really, really look like me when it's got, you know eyes that are better defined and a mouth that's better, and a nose that's better defined. But the proportions look like me and as I said, when I'm teaching I say that you know you can recognise a friend, from across the park, you know by the way they walk or you recognise their face from a very long way off, because there's something about the tilt of the head, or the position of the, the relations between the eyes and the nose and the length and so on. All of those things.
MF: Yeah. There have been some interesting studies about how little information you can recognise people from . […] Sometimes people report evaluating by not by necessarily recognising it as themselves but they'll just ask something like 'does it look weird?' and then if they think it looks weird somehow, then drilling down and thinking about why. So that last person I interviewed, she reported saying that yeah. She would just look at it and think, does it look weird? Yes, what's weird about it? Something about the eye, then shell look at the eye and compare that to the mirror and then try to pinpoint spatially or In terms of the mark that she's made, what exactly is it about the eye before she's re-drawn it. So rather

than asking herself 'does it look like me?' she's just feeling it more like 'does it feel right?' Or, um..
DC: Uh huh.
MF: and some people claim only to look at things on a purely formal basis. But I'm not sure I believe them.
DC: No, You can't do that. I don't think you can do that. Maybe you can. Um, I don't know. I was looking at tat little drawing I did before you got here, and I was looking at the eyes, after I'd got quite a long way along with it and I thought 'no that one eye is too far over' and I rubbed it out and shifted it, only about a millimetre to the left, but that made all the difference. Seeing that the eyes were too close together. Um, I'd have seen that, I'd hopefully have seen that if it was somebody I was drawing for the first time or were drawing for the first time, but it does take time to get to know a face, and drawings. When I draw somebody, I was drawing Quentin Rinney, really struggling to draw Quentin um, because I wasn't familiar with the way his face was constructed and I think that does take time. You can't expect to do your best drawing the first time you meet someone. You need time, your brain needs time to recognise the relationships.
MF: is that different for people that you know well, or is it a question of how much you've drawn that person, to recognise the shapes.
DC: Uhh, it's both I think. If it's somebody you know well and haven't drawn […] you have a memory don't you of what they look like.
MF: I tend to be much more critical of myself if I'm drawing somebody that I know because it's often, there's a little voice that's saying 'it doesn't look like them, it doesn't look like them' or maybe it's easier to be critical, I don't know it just comes more naturally that if I'm drawing somebody that's just on a train or something, often I don't really care how good a likeness it is, um I mean obviously I want it to be a good likeness, but um, but because I do it so fast, there isn't really time to rub it out and start again, so I'm more concerned about the spontaneity of the line, the quality of line that I'm making. Not necessarily that I'm making a nice drawing, but that my line is an accurate record of my looking, and that's all I can ask of it really it's not a sustained..
DC: Yes. I have to say that because you're filming it, um, along with the fact that I also want to make a good drawing because I want to make a good drawing, that I want to make a good drawing because you're filming it. Um, and um, because it's being recorded and I'm supposed to be quite good at this, that has a bearing on, I am thinking about drawing..
MF: Creates a pressure sometimes?
DC: I can't stop, I don't put a lot of emphasis on it but that is a thought that has occurred to me in the process of drawing.

7. Anthony Connolly, concurrent report transcript, 27 June 2011 (final coding)

	Strategic	Visual attentive
Um, So that's I do wonder why I start with that particular eye,	Meta plan	
the sort of left hand eye or my right eye, the left hand eye in the picture	Input	Individual feature
but it is a place that I begin from.	Meta plan	
And I do, find when I look in the mirror it's the first thing I see	Rationalisation	
in a sense, the thing I see most clearly.	Rationalisation	
I wonder if that's because I know I'm going to start drawing there,	Meta plan	
or if I start drawing there because it's the thing I see most clearly.	Rationalisation	
Um, and I suppose as I'm drawing, as I start to draw,	Describing Action	
I'm literally transcribing the **dark** of the pupil for instance,	Describing action	Tone
		Individual feature
and then some of the **shade** in the iris.	Input only	Tone
		Individual feature
I'm trying to draw the **soft grey** that's in the iris and then ...	Subgoal	Tone
I'm trying to I suppose, I'm, I quite like to see the **roundness** of the eyeball. I like to see the **bally-ness** of it,	Meta plan	Geon (ball)
		Individual feature
and as I draw the flesh around the eyeball that can become quite flat quite easily,	Meta evaluation	Individual feature
and as I'm putting lids to the flesh I do feel like I'm **resting the flesh on top of the ball of the eye**,	action	Individual feature
		Weight
		Individual feature
and then there's quite nice **shadow** on the iris which puts it underneath the lid.	Evaluation (part)	Tone
		Individual feature
		Individual feature
		Configuration of geons
(03.34) and similarly now, I'm, I'm quite conscious of **the skull, the bone beneath the brow**.	Meta description	Internal structure
And I feel handicapped by the fact that I've got hardly any eyebrows.	Meta evaluation	Individual features
Some of these lines that wrap around I feel like they're wrapping themselves **round the skull**	Input only	Curvature
		Internal structure

bone.		
Similarly there on the cheekbone.	Input only	Curvature Internal structure
Um, there's quite a soft line between the lid and the eyeball.	Input only	Tone Line Individual feature Individual feature
You can know that one is in front of the other, but it doesn't look as if that's the case.	Meta description	Structure
And the white of the eye is very, I always think it's kind of, it's a misnomer it's not white it's always greyish or …	Meta description	Tone
I'm still right in the middle of the eye.	Description	
Just trying to coax it into something that I like.	Meta evaluation	
And I quite like every once in a while just to kind of stand back, although I won't do it now, I find it useful just to walk away and kind of look back at it.	Meta evaluation	
Having said that I don't want to do it now.	Meta plan	
Um, this bit here is, it's just shadow,	Input only	Tone
but you could sort of stick a thumb in there,		Form (hollow)
and I quite like to feel as if, when I make the drawing, that the drawing would tell you you could stick a thumb in there as well,	Meta plan	
a big hole in your, not a hole but a dint in the side of your face, down the side of the nose.	Input only	Form
And then there's a sort of fleshy bit of the bags underneath your eyes.	Input only	Tactile quality Individual feature
(08:49) Um, the fle… As the flesh comes down from the bag, this kind of baggy part of the eye,	Input only	Direction Individual feature
and it meets, the sort of, the top lip,	Input only	Configuration of shapes Individual feature
the, of your nostril part of your nose, the flesh kind of folds down,	Input only	Individual feature Form
so those contour, those kind of lines coming down,	Input only	Line Direction
they sort of describe the way the flesh…	Goal	
I suppose what I'm doing I'm not really drawing as much what I see there, but just, as what I know	Meta plan	
the flesh is coming down.	Input only	Individual feature Direction
Yeah, and it's falling, hanging rather	Input only	Weight,
so you're describing the kind of. In like a diagrammatic way the flesh comes down		

but it's sort of, I feel as if it tells the truth I suppose,	Meta plan	
it's kinda, It's …	Misc	
And similarly the way this crease comes down here, the flesh folds under it,	Input only	Form Direction Form
and then it comes out again to this part to the bottom of the nose.	Input only	Form Configuration of shapes Individual feature
And a um, if you sort of squint at it	Describing action	Tone
you can sort of see the shadow under the nose,	Meta description	Individual feature
so that's what I'm putting on there.	Describing action	
And then dropping, I'm dropping a line from that bit there where the cheek meets the nose,	Describing action	Configuration of points (along an imagined vertical line)
I'm dropping […] I'm thinking where does the nostril start and it's about there.	Describing action	Individual feature Configuration of points
I'm looking at the line that your nostril makes it comes down the bottom of your nose.	Input only	Configuration of lines Individual feature
I quite like this, sort of a seagull shape here	Evaluation (part)	Complex line
which it's not symmetrical at all, it's more this side than that.	Input	Symmetricality
It's that line that describes the front of your nose, but, sometimes, I,	Misc	
I quite like the rubber because you overstate things and then you take them back a bit and you restate them (11:33)	Meta plan	
I quite like, I quite like being able to accrue corrections.	Meta plan	
(sighs) And this fleshy part here, I'm kind of conscious of the fact that it kind of wraps itself across the top of the Jaw.	Input	Tactile quality Internal structure
I think this is the part, I think, drawing the head I find this is the part I find most taxing. Is putting the mouth in.	Meta plan	Individual feature
Not what the mouth looks like but putting it in the right place.	Meta plan	Configuration of shapes
And it's something that I, kind of, will re-draw quite a lot. Quite often.	Meta plan	
Now, that's the shadow. That's the shadow on the top part, on the top part of my bottom lip.	Input	Tone Configuration of shapes Individual feature

But again it's sort of … (rubs out). […]	(Evaluation)	
I suppose now, what I'm looking at is kind of the way that the nose which should hang straight down your face is not,	Input only	Familiarity with faces
it's not going down like that it's kind of going across like that.	Input	Direction
I sort of know that's the case.	Meta description	

8. Retrospective report resncript, 27 June 2011

AC: Anthony Connolly
MF: Michelle Fava

MF: We've had about fifteen minutes.
AC: Is that enough?
MF: I think so, I mean how um, how much would you say that your process would change over the course of the rest of the drawing, would it be a question of just continuing with the same process of..
AC: Yeah it would.
MF: Observing and just work your way around.
AC: Yeah, and re-visiting. Yeah,
MF: In relation to the original point where you started?
AC: I suppose, it changes in a way that... for instance I was down here drawing this (the mouth)(16:19) and what, I noticed is that there kind of is a black in the eye that I haven't drawn. So you go back over and kind of, put it in. But it only becomes black, only becomes, it kind of just becomes visible or necessary when you start to kind of give it that much context you know. As the thing grows out then you have to keep… As you accumulate more, more drawing, then it seems to me you have to create the drawing you've already done, or make it work with, it has to kind of, it's no good to say that's correct. I can't just say that's correct and then do the rest of the drawing. I just, it's a kind of um, a kind of anxiety I suppose. You just, you do it, and then you think it's ok and you go somewhere else and you come back to it because it becomes not ok.
MF: And is that mainly a tonal thing, you go forwards and re-evaluate and say 'oh now it has to be darker'
AC: Yeah very often.
MF: Would you often also move the location of it, even of the first thing that you drew?
AC: Yep. Absolutely yeah.
MF: Hm .
AC: Although, actually having said that I probably wouldn't move the eye necessarily, I'd probably move the other bits in relation to it. And use it as a kind of, you know it's kind of, it's the thing that that's where it is. You know um, but I might change the shape of it, if I noticed that the lid droops more, or whatever, so I'd kind of, I'd look again at it yeah. But it probably wouldn't be the thing that would change. If I was looking at this eye (the one not drawn yet) If I put this in tentatively there and then I looked at that, that kind of triangle across there, I'd kind of quite happily move it. And I suppose that'd be the one I'd move around. Um and I'm quite likely to move, to put the mouth in and then take it out again.

(video starts)

AC: The things that occur to me are the most curious things. It's actually that you're thinking about distance you're, you're […] your face here, but actually the distance between my nose and my cheek is huge. (moving finger back and forth towards the drawing) Really, you need to articulate that in a drawing. You really need to find a way of bringing the nose forward
MF: This is a different angle. This is the angle from which the camera was seeing you.
AC: Yes, I realise that. I'm looking at that, but actually what's there as well is that, from the bag underneath my eye to the bridge of my nose is actually quite a long way.
MF: Seems to be um, relatively few lines that you draw while you're looking at the mirror. This is just my initial reaction, but it seems like when you're looking in the mirror

AC: I'm not drawing
MF: You're not really drawing but maybe repositioning the pencil, and when you make the mark itself you kind of watch yourself make it. Not always. Would that be consistent with what you would expect that you would do?
AC: Yeah I would think so. I don't very often draw, blind as it were, I'm not very often doing that. That would surprise me to see that I was doing that. Um, It's quite difficult to get beyond the consciousness of, I don't think I'm particularly conscious of it, but I am conscious of being filmed. And I think it makes you ..
[…]
MF: Actually I think this is the third drawing and not the fourth one that we're looking at. But that's fine […]
AC: I think my drawing's quite sensitive. It's not uh,
Are you going to be measuring the saccades, what to you call it, the saccades?
[…]
MF: M hm. When we use the eye tracker I can measure things like, when you look from one place to the other, how many fixations are you making and for how long.
AC: And will it tell you exactly what I'm looking at?
MF: Depends on how accurately we can calibrate it. The system we have is quite old and if the person wearing it moves around a lot it does throw it out of kilter a little bit. But I've been getting some reasonably accurate readings from it.
AC: What else is it used for then […]
I'm not sure what I'd say about it as I'm watching it. It's interesting because im looking at myself and that interests me. But beyond that I'm not sure what
MF: Sure. How does it feel watching it and it's you drawing?
AC: Oh I love it (laughs). No, actually, I'd be, it would be false modesty to say I don't like , I am interested in my own head. Yeah. So yeah it interests me. And it interests me because it's not something you do very often. Looking at yourself doing what you do.
MF: And this is nice because it allows you to think about how you're drawing in a way that's, you've already done the drawing so it's allowing you more room to watch what's going on and see how the drawing…
AC: I suppose the other incentive to actually doing this, to kind of responding to the email that came from you, is actually it, it's just quite interesting to look at what you do and have a different perspective on the thing that you just do. I mean you call it practice, which, and I've got, that's a kind of, in a way it's a word people don't, when I was at art school people didn't have a 'practice' they just did stuff. And I suppose it's an opportunity to think about your practice, reflect on it, so it is inherently interesting to me.
And I think I'm doing what I would normally do in the sense that I wouldn't know how to do anything else.
Will you do any work about people drawing from photographs?
[…]
MF: So that was the third one, let's have a look at… (the concurrent report drawing) (11:30)
[…]
AC: Even seeing your own hands is quite…
MF: Actually I noticed that you were holding the pencil and holding the rubber in your left hand during the third one, and each time you were looking, turning it over with your thumb
AC: Really!
MF: I wasn't filming it but I was noticing that you weren't aware that you were doing it.
I might pause it sometimes to ask you things.
AC: One thing that does occur to me is that when you're drawing yourself, it's very, because it's something I do I draw myself, and, I'm in a slight danger of kind of drawing, using a template if you like, I kind of know. I mean I'm not conscious of doing that, I'm conscious of

looking but I'm … One of the problems about drawing yourself is that, I would say if you do it frequently, that um, you can end up repeating the same drawing, because the looking element recedes and the knowing element becomes more dominant.
MF: Would you see that as a negative thing.
AC: Yeah. Um, in the sense that uh, I'm more interested in trying to find out. I'm more interested in trying to mark what I see than rely on what I know, or what I think I know. Cause, you don't want to repeat the same, um. I suppose. One of the things that Arika said, about him changing from becoming, he was quite a successful abstract painter. One of the reasons he stopped was he said he kept repeating the same forms. Because his head only had, you know, his imagination only contained a limited repertoire. And whatever he did making abstract paintings he was actually using that repertoire, and actually to some degree repeating the same forms. And actually he went back to drawing from life, because you can't control what's out there.
MF: But I think you can control the way you look at it and I think that's… the … repertoire, that's an interesting word, and I wonder if there's a sort of, a repertoire of sorts going on, like here the first thing that you mention that you look at is the roundness, you're drawing the pupil and you say something about the roundness of and the balliness of it. And a lot of the descriptive terms that you use have to do with the three dimensional form, and so it was as you were very much attending to the sculptural quality of it, to the three dimensional quality of the things that you were looking at and I had the sense that the direction of the lines was very important,
AC: Yep
MF: in relation to that. And so you begin by saying… yeah, that you're aware that you draw that eye first, then you mention about the shape, the form of it.
AC: I suppose the drawings I like, do very often have a, a real appreciation of the third dimension in the sense that, I like the feeling that you could put your hand behind something. That you, you know, you can't there, but I like the feeling that you could actually hold the thing. The three dimensional illusion is kind of, it's actually almost not illusory. It's almost… You're so conscious of it becomes a three dimensional reality even though it's just on a flat surface, it's the consciousness of it…
MF: That's lost when you work from a photograph isn't it. Sorry I interrupted you.
AC: No, no. I think it is. But I think it's something else that's lost as well. I've got a feeling that you lose that because your eye is not having to disentangle three dimensions it's kind of, that's done for you. But I think you also acquire the characteristics of the photographs as well.
MF: You're making a drawing of the photograph really not of the, not of the subject. So I'd like to try and list things you look for, different as the drawing progresses. Ok? And think, is there an order that you tend to think about those things.
Some people have a set routine, like first they might think about the size, and then they might think about the contour then tone, or that kind of routine, but yours seems very different from that, it's not that. It's like, the first characteristic you mention is the roundness. Um, I mean prior to that you must have located it.
AC: I think,
MF: What would you say the first thing is?
AC: Well, I think, I was saying that I quite like to work something up to a point where it seems to be more or less ok. And I think I do that because I think what determines where I go next it's the drawing. And I think when the drawing starts to work, it's a dialogue with the drawing. So I don't have a scheme, I don't say, I'm, you know I need to get the tone right across the thing, or I need… I kind of… The drawing starts to say to me ' Oh', … I mean for instance when I was down here I went back up to the eye, and I don't know why I did that, apart from the fact that the eye, when I started to draw here, it seemed to me that the eye,

that actually just flashing across, that the eye had these much dense, dark places in it, much denser darker spots than I had recorded. And I only knew that when I had started to create a distance, but I only knew that when I had started to sort of create a distance and you, but you only, but the drawing , it's as if you started a conversation with the drawing, and the drawing is saying to you, um, you know,' I'm a bit washed out here', or 'if you pronounce, you know, I'm starting to get a shadow under the nose there, and it is starting to throw the nose forward and that kind of thing I would like .That would be, you know if I could make the nose come out of the paper, that would appeal to me. And so, I respond to the drawing I suppose. And if that began to work, it's beginning to work there, I might then think, well I'll just see what happens when I start to indicate where the other eye might be, and then when I get up there, it might occur to me that actually you look really sort of forlorn or something , and that's not actually what I'm seeing, so you might go back to the mouth and look at that again. There is, you know that kind of, forlorn look, that kind of lost bewildered look in the drawing, might not correspond to what I'm seeing, so I might re-visit that, and say, you know, where does that…
MF: So there would be a point in which you look at he mirror and the drawing and recognise the emotive or the mood,
AC: Yep.
MF: and would that be in an evaluative way perhaps? Or, would you be kind of recognising yourself and the mood and questioning it?
AC: Do you know, in a funny way, I just think when you're drawing, when you're really drawing well you're trying to climb into the thing that you're drawing. And you're trying to, you know, you're trying to scratch away at it to hold it. And so I'm flashing back and forth from the mirror to the drawing, mirror to the drawing, and it is, you become aware that, you know, remains superficial. And so you go back and look at something. It might be the mouth, or it might be the eye again, or it might be the nose, or it might be the cheekbone. It, it, you start to look at something harder. And you go back and you work the drawing more. And I think there's something about interiority, there's something about trying to get inside the thing that you're looking at. Um, and it's um,
MF: In what sense inside? In terms of mood or…
AC: It's more essential than that. It's not… Mood, mood is one of those things, you could offer me a word and I'd say it's not that, but it's something to do with presence, or being, or… and you think it's to some degree the likeness, to some degree the intensity of the looking. You know if you … Sometimes you feel as if you're looking at the thing hard enough for the thing to kind of... It's just sort of, uh, it's something that you know retrospectively, as well I think. You know, you know after the event. Rather, I don't feel I can go to a drawing with an agenda, and fulfil that agenda. You go to a drawing and you're like a beggar. You go to a drawing and you start, and you start that that kind of dialogue, that kind of back and forth with the drawing with any luck, You know if that doesn't happen the work's kind of really lost, you start that kind of conversation with the drawing, and if it works that conversation's become sort of .. it sounds, this is all kind of mystical isn't it, but it's kind of, it sort of becomes sufficiently resonant that you actually feel that there is, that you are holding something of that matter, that moment, in the drawing. It might be just the slightest thing. But if it's there at all, that, for me I value the drawing.
MF: would you say that's something you recognise that you're doing? Or, what am I getting at, How often would you say that you look at the drawing in that way? Like sometimes you might just be thinking about the roundness of the eye, like you said initially, but then sometimes you're looking at it in this way, you're trying to get a feeling of the presence of it and how, how often and how soon along in a drawing would you say that you do that.
AC: What I suspect is that the kind of latter, the more reflective kind of looking at the entirety of the thing, I would say, I wonder if that's just an accumulation of looking at the

eyeball, looking at the, you know the skull underneath, you know thinking that the skin there is really thin. I wonder if it's an accumulation of looking at details which you get enough of them together then you can start reflecting on whether it has a… whether it holds something a little bit more than the sum of the parts. I don't know
MF: That would imply that it happens more later on, as the drawing progresses, that that kind of looking might happen more. Whether it's an awareness that builds up of many looks or whether it's not…
AC: In that sense, it's something that happens two thirds of the way into the drawing, I would guess. And not before that. And certainly not immediately. And I think this is kind of, it's almost like, um, you know when you get putty, and its cold, it's quite hard, you have to warm it in your hands for it to become malleable. I think drawing is a bit like that in that, in a sense, you have to start this looking process, and you kind of warm up the thing you're looking at in the drawing. And then If it gets sufficiently warm it becomes malleable and then it becomes more interesting. You know, it kind of, then you begin to feel as if you've got something. Sometimes (laughs).
I say this, this is not… I think it does happen. I think it's not an everyday occurrence, that you actually make something you really feel is kind of… And sometime sit might be only me that thinks it because it might be a drawing of one of my children. And it may not particularly, it may not even be a particularly good likeness, it's just, I just feel something. Because you have an intimate relationship with that person, and, and you just take hold of something which belongs to something that you know viscerally, rather than..
MF: If it was a stranger, that would be a different experience wouldn't it, because you wouldn't necessarily know what it was, what quality you were..
AC: And even, I suspect even if you found it you wouldn't know that you'd found it, necessarily.
MF: Or you might stumble across something else.
AC: Yeah.
MF: that may or may not be accidental. Yeah. So, um, so far,
AC: I'll just say, I feel I'm being very vague and wooly.
MF: No, no, I feel like we're making some progress actually.
AC: Can I show you, that's a drawing of one of my sons. […] Because I, basically we've grown up together this boy and I, and I feel there is definitely something, I just feel there is something uh, there's something of the quality that I'm trying to talk about and not succeeding very well there.
MF: Not succeeding?
AC: Not succeeding in talking about it very well,
MF: But in this drawing you did succeeded.
AC: In that drawing (29:05) there is something of, there is something worthwhile there. Yeah.
MF: Yeah. I can see that. I think there's perhaps, at least when I draw I think the danger is that I fall into that way of looking too soon and I need to get more of the groundwork done before I can start thinking on that level, but..
AC: You know, I'm not even sure I think about it. I mean, you're obliging me to think about it now,
MF: Sure,
AC: uh, and I think, a lot of the time,
MF: You're not aware that you have a strategy for doing it?
AC: […] But if you ask me what I want I'm not sure what it is I want. I just want to get a good drawing and that's what, I'm now being obliged to think about what I mean by 'a good drawing' and I can show you what I think, as far as I'm concerned is a better drawing than others. And so I look for some of the qualities in there, um. I just, perhaps it is ineffable,

perhaps it's just, perhaps there are some things that actually you can only adequately describe with a pencil.
MF: Absolutely. One of the questions I'm thinking about is, uh, what is it that you're able to say as you were doing the drawing, and what is it that you are able to say on reflection, as we think about the drawing. So you know, maybe you weren't explicitly aware that you had a strategy for looking at it in this way, sometimes looking at the roundness of the eye and sometimes thinking about the presence of the, the essence of it, or however we can describe it, the essence of the thing or, how did you describe it? The likeness or the feeling of it? And, but now that we're looking at it, we can maybe think about, perhaps even identifying moments, like saying yeah, in this, during this glance you might have been thinking only about the fact that this part here, you can fit your thumb here, and then other times your thinking more about the likeness.
AC: See, I think that is likeness. I actually think, when I commented about the fact that the distance between, the bridge of the nose and the eye is quite deep, I was struck by it. When I look at this I think it's quite deep because I think I wanna put my thumb in there, I'd actually, I didn't realise how deep it was until you see yourself in profile and you think actually it really is deep, I mean you know you really could, put your thumb right into that, you know, in there. And lose it more or less. And it's that, um, it's, it's about the physicality of it. And those are the things that I'm conscious of thinking about when I'm making the drawing. The other things about, whatever it is, essence of presence, is, that I can think about more easily now that I'm not making the drawing. And I'm kind of reflecting on the whole business. Whereas actually making the drawing, you tend not, I wouldn't be reflecting like that I'd be much more concerned with the physicality, actually put things in the right place. Not just look, it has to feel right.
MF: You mentioned that sometimes you would step back and look. Um, how does that figure in this kind of dichotomy of looking perhaps at the three dimensionality of it and then sometimes thinking about how it feels, if it feels right, I mean when you step back, what are you thinking about, what are you looking at?
AC: I tell you what I think stepping back does for me, uh, is, I think it gives me somebody else's perspective. Because I'm here, I'm looking quite closely and trying to get things right, and that is this kind of you have this intimate kind of thing going on. And you walk away and turn around and you look at it and it's as if you're looking at somebody else's drawing, momentarily. It's as if you know you just happen to walk into another studio and you look at a piece of work. And it doesn't stay like that for long, but momentarily it's like that, and it's that detachment and you think actually that drawing looks rubbish, or the nose is all wrong, and it just kind of, it's momentarily somebody else's perception.
MF: So would it be fair to say that that allows you perhaps, to look at the whole and evaluate, and think if there's something weird or wrong,
AC: Yeah, I would say that. And the other thing which I haven't done which if I'm drawing, if I had a model in the chair and I was drawing, I would use a mirror to look at the drawing […] to look at the drawing and the sitter, and that has the same effect. And I don't know about the mechanics of it, but it's um, …
MF: So you're just seeing the same thing but reversed.
AC: yeah. And I mean I suppose sometimes I could use that mirror down there, but I just have this little hand mirror. And that will also give me a certain kind of distance. Detachment from what I'm doing. It just, it just confuses you rather. I find if I have a tendency to draw to the left, or the drawing grows of to the right in a funny way. If you look at it in the mirror you'll see it straight away. And then, what I'll typically do is look at the sitter, and if the sitter is similarly looping off, you know, kind of if the face is distorted, if in the mirror it is and in the drawing it is, if it corresponds in both that's fine, if it's just in my drawing and not, not in

what I'm seeing in the mirror then I'll go back to it again. But those are kind of, those are, that is physical that's the pragmatics of it. I think it's um, it's a mechanical aid really.
MF: To help you evaluate,
AC: Yep.
MF: By giving some distance.
I'm just gonna take this back to the beginning. (36.39) So, uh, you say things like, I'm right in the middle of the eye, that was interesting to me because you didn't say, my pencil is right in the middle of the eye or I'm looking right, you said 'I am in the middle of the eye' as if the moment your pencil was there, that's where you were as if all of your attention was ..
AC: I think it is it's like, uh, yeah, it's as if you're trying to take, it's as if your eye is this long stick and you're looking for something with this long stick and you're going from there, taking an impression to there. Almost as if it's kind of um, I don't know if it's like that at all, but I wonder if it's like you know, um, I'm drawing that box and I'm there and, that bit of the box, I'm taking an impression of it from there, and putting it there, on, does that kind of make sense in a strange sort of way. It as if, on some level that's what you're trying to do you're trying to take it, whatever it is, your eye is holding and you're kind of flicking across and trying to put it, you know put it onto the paper. (38.53)
MF: And you do that, that's clearly what you're doing and it seems also like you take many glances at the same thing, so if we look again at you drawing the eye, for example, it starts off, it seems as though uh, you look many times, even at the same location so it's like you're trying to take this and put it here, I would wonder, um, it's not like you're taking a snapshot and remembering what it looks like. This will be my interpretation, I mean, stop me at any point if you think this is wrong, but I feel like, I felt like when I was watching, that you would look at the round, you would look at the centre of it, ok, so that's where it is, and I think that's when you said ok I'm in the centre of the eye, and then you were kind of looking at this the roundness of the, iris, and the pupil and you looked at a bit of shade, and then you were thinking more again about the roundness of the eyeball itself, and, and you were talking about the quality of the skin, the thickness of the skin. And it felt like each time you looked you were taking in a different detail about that thing. So whether it's the thickness of the skin or the roundness of the eye, or the circular-ness of the pupil0 or the tonal value of the pupil in relation to what's around it, or the shape of that patch, because you change the shape of it a number of times, sometimes you think oh there's a bit of shade here. You mention at one point that the white of the eye isn't actually white it's grey. Uh, and then, maybe, we can look at things like this more accurately with the eye tracker, but things like how often you are referring back to that central point when you measure the locations, like when you think about where stuff is, that would be something I'd be interested in looking at.
AC: Two observations I'm afraid, Last one first really, I clearly am measuring because you know I'm trying to make an accurate representation, but I'm not, it's more like kind of, I'm looking at what they call the eyes and I'm flicking back and forth just to kind of make a mark and locate it, and it's less, it's more touchy feely than measuring. In the sense that I'm not, I mean I do, but not very often I run my finger up and down the pencil, and do that, but I clearly am measuring. That's, it's more tactile I think than measuring. The other thing is, just an observation that occurs to me, I sometimes wonder when I'm painting people of drawing people, I wonder if they can feel which part of their head I'm drawing or painting, because it feels to me as if they should be able to feel it. And I'm thinking, be curious to know if you asked somebody. Ok, so what am I drawing, just to think, could they. It kind of wouldn't surprise me if they could feel…
MF: When I was drawing David he was drawing his nose and then scratching his nose. […] if it feels as though you should that in itself is interesting.
AC: You're touching with your eye, and but I think then the reality is that intensity, you don't get that intensity frequently and it's difficult to sustain. But I do wonder or it has occurred to

me if there could be a physical kind of connection between, you know. And you know, some people do say they felt someone's eyes were on them.
MF:[…]
AC: I just wonder if the fact that I'm looking at you is a palpable, is a, I don't know. It's fanciful, but I do sometimes wonder if people are aware, that, you know, that I'm doing it.
MF: Just to back track a minute, when you said you were measuring you were pointing here and saying about measuring
AC: yeah
MF: I think you pointed like maybe to here and here, and to here. And you said it's not exactly measuring in this sense, it's more, feeling where things are. Uh, would you say that it might still be possible to think, that you might still be thinking about where things are in relation to each other,
AC: definitely yes, I would say that's definitely the case, in the sense that it's not measuring as much as, it's sort of, that shape there between the edge of the iris and the corner of the eye, I'd be conscious of actually making that shape, correspond. So in that sense it is measuring.
MF: So it's not only the circularness of this, but also the shape of this triangle, that also has a shape, I've just drawn it completely wrong, but that has a shape,
AC: That's exactly what I mean yeah.
MF: and then there must be other shapes, what else (46.20) can we identify as a shape?
AC: Well in a way, I use that kind of shapeyness a lot, for instance if, um, like the shape of that […] they um, the shape of that, the sort of , the ridge of the nose coming down, and I might visualise what it's like in relation to the you know, the kind of, the bit where the eye disappears, into the head, the little dark bit there, And I'd look at that sort of shape that that makes. And, similarly, I might look at the kind of the shape of the bag I suppose is another one.
MF: If I put this forward, we can scribble on the other paper and that might, be… if we can see it well enough. It's moved a bit.
[…]
So, so that's uh, not exactly a shape but curve, and then there's this,
AC: Yeah, I just, I would look at the bag of the eye when it comes down there, and I'd look at how that falls in relation to the bridge of the nose, I don't know if that is the bridge of the nose… and I'd look at those two parts and, just a general, cause there's this kind of tract of shadow coming up here, and I'd kind of try and abstract that kind of shape coming across from the edge of my eyebrow down to the, that kind of bony part of my nose. And I'd look at that shape and see if it corresponds. So I do isolate bits all the time, as you do when you're drawing I guess. And then, look at that (49.23) that corner and then look again at that one and does that kind of triangle shape correspond. I think people do that all the time as their laying on correspondences and shapes. And, in a way, I feel the more you can abstract the shape put to make the correspondence, probably the sounder the drawing is going to be. The more accurate.
MF: Yeah, and that's a separate kind of looking than when you're looking for the essence of it. It happens in a different moment?
AC: It is, it's separate in that I don't think you can do the two things at once, but I don't think you can separate them. I suspect they belong to each other. I suspect that what I call essence is in fact an accumulation of good observation. It could be, the presence could be something really mundane, like just getting the thing right, could be what I mean by presence.
MF: And when you say you abstract the shapes and that there's a bit of tone here. Does the patch of tone have a shape?

AC: Yeah it's the shape of the tone, and then you look at the quality of the tone itself. So, I would say it's the overall shape, and then within that shape, is it modulated within that shape?
MF: Do you mean like a gradient?
AC: Yeah. And then quite often I would then, in on top of that I might put contour lines on top of that to say that there's the shape, but there's also the way the bridge of the nose rolls round into it.
MF: So the direction of the lines that you use to put the shade in also has an aspect that you need to look for. And so really that's a lot of information that you're taking in with one glance. Potentially, the shape, the tonal value the gradient in the tone, the curvature, that's at least four different kinds of thing you might be ascertaining with a single glance, But then it's possible that you might look twice, although it didn't seem like that's what you were doing. It seemed as though you'd look and draw and look and draw, and it seemed as though each bit of drawing that you did corresponded to a single glance. It didn't happen very often, I mean from the first time I've looked at it, it didn't happen very often that you looked twice and then draw. I don't think you did anyway I can look more at that.
AC:I mean, I am conscious of looking twice and drawing, that is something I would do, especially if, if I'm going out and I'm trying to find where the corner of my mouth is, for instance, that is something I would look at, several times, before I made a commitment, which then I might amend anyway.
MF: Sure. Let's just look at the last few minutes and then we can have a look at that.
You did a bit of blind drawing then.
AC: I'm drawing blind? The pencil's going and I'm looking somewhere else?
MF: Just for a moment, but then this, this part of tone you were drawing and then looking, and then continued drawing it a bit. I think it was this part here.
AC: Do you know the drawings of a guy called Claude Heath? He draws, he will kind of blindfold himself, put his hand on your head
MF: Ah, yeah I have seen those, they all start from the top and then the lines come down, from the top. They've got some of those in the British Museum. In the drawing room, they're lovely.
Yeah that's interesting in relation to what you were saying in that it feels like feeling something it's tactile, when you look it's tactile.
MF: This part here, when you draw this, line you put quite a lot of information into the drawing without even looking back at the mirror, maybe, I guess you started drawing it, and then you
AC: I suppose when I talk about abstracting shapes, one of the thinks I'm conscious of abstracting is that, I think I referred to it as a kind of seagull and it's that kind of line that goes across and it actually describes both nostrils and the bottom of the nose.
MF: I was aware that that was a slower look than usual. (55.27) Why did you rub it out there? Yeah I was aware that that was slower, normally you look backwards and forwards quite fast but when you drew that bit you had quite a long, it was quite a long look at the paper.
Sometimes you seem to, you put a shape and you give it a boundary, like this shape, I think it was about here, there's a feint line defining where these lines will stop perhaps.
And that's when you decide that needs to be darker. (58:02)
AC: yeah. The only thing there is that, it clearly wasn't apparent to me that it needed to be darker when I was drawing it, it only became apparent to me when the drawing had kind of rolled out sufficiently,
MF: You know that It's darker than this. So, that suggests you weren't only looking here you were maybe also looking at the whole and comparing one part to the other.
AC: It's very difficult to quantify all this isn't it.

MF: Yeah, we'll be able to find out more things when we look at, when we use the eye tracker cause that will be able to tell us, we could ask it, ok, did you look at the eye? Or did you just kind of take a single glance or were you looking around, when you decided that, when you decided this needs to be darker. What, was your looking behaviour different because you were evaluating than if you were taking a piece, an abstracted shape, and transferring it onto the paper. That's, we can identify a different kind of looking that corresponds to you evaluating it, maybe. That might be possible. But then it might not be that you looked here and then here, you might be looking at the whole. And so where your eye falls or seems to fall, so using the tracker might not always
AC: Correspond with, yeah.
MF: correspond with that because you might be taking the whole. Like, not, you said that you step back, but it's also possible to do that in your mind
AC: Oh yeah. Yeah.
MF: To look at the whole rather than a part even though you're still stood in the same spot. More difficult but I think you can do it can't you.
How are we for time?

Appendix B

Quantitative data analysis results – timing of co-occurrence of looking and drawing activities in verbalised and non-verbalised trials

These tables show the results of the quantitative analysis which were used to generate the graphs in chapter 3. Video footage of verbalised and non-verbalised drawings (trials) were segmented into 'state events' (non-overlapping periods) during which the artist's eyes were directed at the mirror and the paper. The drawing activities taking place during those periods were also segmented, allowing analysis of the co-occurrence of those activities.

Columns here refer to the mean duration of each behaviour (listed in column 2), the total duration (of the drawing trial), rate per minute (mean number of times per minute each behaviour occurred), total number (of instances the behaviour occurred), percentage of the total duration, and the percentage of the analysed duration (the portion of the drawing spent looking at the mirror or paper).

1. **Angel Brew, verbalised trial**

	Behaviours						
		Mean duration (hh:mm:ss.ms)	**Total duration**	**Rate per minute (observation)**	**Total number**	**Percentage (observation)**	**Percentage (analysed duration)**
mirror	**<Initial Looking behaviour>**	0	0	0	0	0	0
	paper	0	0	0	0	0	0
		00:00:02.162	00:02:37.816	13.98	73	50.36	100
	<Initial Drawing Behaviour>	0	0	0	0	0	0
	drawing	0	0	0	0	0	0
	pausing	00:00:02.850	00:00:25.653	1.72	9	8.19	16.26
	not drawing	00:00:01.482	00:00:05.930	0.77	4	1.89	3.76
	rubbing out	0	0	0	0	0	0
	drawing rough lines	0	0	0	0	0	0
	drawing scaffold marks	00:00:01.647	00:00:08.237	0.96	5	2.63	5.22
	drawing contour	00:00:03.771	00:00:56.571	2.87	15	18.05	35.85
	drawing tone	00:00:01.336	00:00:37.410	5.36	28	11.94	23.7
	other mark making	00:00:00.948	00:00:18.963	3.83	20	6.05	12.02
	defining patch	00:00:00.561	00:00:05.052	1.72	9	1.61	3.2
	hovering	0	0	0	0	0	0
	<Initial verbal behaviour>	0	0	0	0	0	0
	verbalising	00:00:02.054	00:02:27.877	13.78	72	47.18	93.7
	not talking	0	0	0	0	0	0
	chatting	0	0	0	0	0	0
	rationalising	00:00:03.313	00:00:09.939	0.57	3	3.17	6.3
paper	**<Initial Looking behaviour>**	0	0	0	0	0	0
		00:00:02.125	00:02:35.148	13.98	73	49.51	100
	mirror	0	0	0	0	0	0

	<Initial Drawing Behaviour>	0	0	0	0	0	0
	drawing	0	0	0	0	0	0
	pausing	00:00:03.416	00:00:30.742	1.72	9	9.81	19.81
	not drawing	00:00:01.898	00:00:07.592	0.77	4	2.42	4.89
	rubbing out	0	0	0	0	0	0
	drawing rough lines	0	0	0	0	0	0
	drawing scaffold marks	00:00:01.195	00:00:05.974	0.96	5	1.91	3.85
	drawing contour	00:00:01.467	00:00:20.540	2.68	14	6.55	13.24
	drawing tone	00:00:01.725	00:00:51.765	5.74	30	16.52	33.36
	other mark making	00:00:01.268	00:00:24.092	3.64	19	7.69	15.53
	defining patch	00:00:01.605	00:00:14.443	1.72	9	4.61	9.31
	hovering	0	0	0	0	0	0
	<Initial verbal behaviour>	0	0	0	0	0	0
	verbalising	00:00:02.103	00:02:31.442	13.78	72	48.32	97.61
	not talking	00:00:01.318	00:00:01.318	0.19	1	0.42	0.85
	chatting	0	0	0	0	0	0
	rationalising	00:00:01.194	00:00:02.389	0.38	2	0.76	1.54

2. Angela Brew, non-verbalised

	Behaviours						
		Mean duration (hh:mm:ss.ms)	**Total duration**	**Rate per minute (observation)**	**Total number**	**Percentage (observation)**	**Percentage (analysed duration)**
mirror	**<Initial Looking behaviour>**	0	0	0	0	0	0
	paper	0	0	0	0	0	0
		00:00:01.375	00:03:20.771	16.29	146	37.35	100
	<Initial Drawing Behaviour>	0	0	0	0	0	0
	drawing	00:00:04.027	00:00:12.081	0.33	3	2.25	6.02
	pausing	00:00:00.928	00:00:20.417	2.46	22	3.8	10.17
	not drawing	00:00:00.921	00:00:52.496	6.36	57	9.76	26.15
	rubbing out	00:00:00.729	00:00:00.729	0.11	1	0.14	0.36
	drawing rough lines	0	0	0	0	0	0
	drawing scaffold marks	0	0	0	0	0	0
	drawing contour	00:00:00.982	00:00:50.077	5.69	51	9.31	24.94
	drawing tone	00:00:01.025	00:01:02.495	6.81	61	11.62	31.13
	other mark making	0	0	0	0	0	0
	defining patch	00:00:00.826	00:00:02.477	0.33	3	0.46	1.23
	hovering	0	0	0	0	0	0
	<Initial verbal behaviour>	0	0	0	0	0	0
	verbalising	0	0	0	0	0	0
	not talking	00:00:01.379	00:03:15.857	15.85	142	36.43	97.55
	chatting	00:00:00.983	00:00:04.914	0.56	5	0.91	2.45
	rationalising	0	0	0	0	0	0
paper	**<Initial Looking behaviour>**	0	0	0	0	0	0
		00:00:02.106	00:05:15.895	16.74	150	58.76	100
	mirror	0	0	0	0	0	0
	<Initial Drawing Behaviour>	0	0	0	0	0	0
	drawing	00:00:00.692	00:00:02.076	0.33	3	0.39	0.66
	pausing	00:00:00.716	00:00:12.897	2.01	18	2.4	4.08
	not drawing	00:00:01.142	00:01:25.641	8.37	75	15.93	27.11
	rubbing out	00:00:02.740	00:00:13.701	0.56	5	2.55	4.34
	drawing rough lines	0	0	0	0	0	0
	drawing scaffold marks	0	0	0	0	0	0
	drawing						
		00:00:01.384	00:01:00.884	4.91	44	11.33	19.27

	contour						
	drawing tone	00:00:01.845	00:02:12.873	8.04	72	24.72	42.06
	other mark making	0	0	0	0	0	0
	defining patch	00:00:01.118	00:00:07.823	0.78	7	1.46	2.48
	hovering	0	0	0	0	0	0
	<Initial verbal behaviour>	0	0	0	0	0	0
	verbalising	0	0	0	0	0	0
	not talking	00:00:01.993	00:04:46.936	16.07	144	53.37	90.83
	chatting	00:00:05.792	00:00:28.960	0.56	5	5.39	9.17
	rationalising	0	0	0	0	0	0

3. Amanda Roberts, verbalised trial

	Behaviours						
		Mean duration (hh:mm:ss.ms)	**Total duration**	**Rate per minute (observation)**	**Total number**	**Percentage (observation)**	**Percentage (analysed duration)**
mirror	**<Initial Looking behaviour>**	0	0	0	0	0	0
	paper	0	0	0	0	0	0
		00:00:00.604	00:03:42.295	32.02	368	32.24	100
	<Initial Drawing Behaviour>	0	0	0	0	0	0
	drawing	0	0	0	0	0	0
	pausing	00:00:00.334	00:00:00.334	0.09	1	0.05	0.15
	not drawing	00:00:00.786	00:00:55.808	6.18	71	8.09	25.11
	rubbing out	00:00:00.300	00:00:00.600	0.17	2	0.09	0.27
	drawing rough lines	00:00:00.559	00:00:42.509	6.61	76	6.17	19.12
	drawing scaffold marks	00:00:00.357	00:00:03.574	0.87	10	0.52	1.61
	drawing contour	00:00:00.494	00:01:12.087	12.71	146	10.46	32.43
	drawing tone	00:00:00.514	00:00:35.981	6.09	70	5.22	16.19
	other mark making	00:00:00.516	00:00:02.579	0.44	5	0.37	1.16
	defining patch	00:00:00.464	00:00:08.823	1.65	19	1.28	3.97
	hovering	0	0	0	0	0	0
	<Initial verbal behaviour>	0	0	0	0	0	0
	verbalising	00:00:00.653	00:00:35.932	4.79	55	5.21	16.16
	not talking	00:00:00.586	00:02:48.750	25.06	288	24.48	75.91
	chatting	00:00:00.509	00:00:05.085	0.87	10	0.74	2.29
	rationalising	00:00:00.482	00:00:12.528	2.26	26	1.82	5.64
paper	**<Initial Looking behaviour>**	0	0	0	0	0	0
		00:00:01.211	00:07:33.996	32.63	375	65.85	100
	mirror	0	0	0	0	0	0
	<Initial Drawing Behaviour>	0	0	0	0	0	0
	drawing	0	0	0	0	0	0
	pausing	00:00:00.154	00:00:00.154	0.09	1	0.02	0.03
	not drawing	00:00:00.992	00:01:42.135	8.96	103	14.81	22.5
	rubbing out	00:00:02.722	00:00:24.495	0.78	9	3.55	5.4
	drawing rough lines	00:00:00.839	00:01:04.620	6.7	77	9.37	14.23
	drawing scaffold marks	00:00:01.319	00:00:10.554	0.7	8	1.53	2.32

	drawing contour	00:00:00.967	00:02:30.801	13.58	156	21.87	33.22
	drawing tone	00:00:00.926	00:01:19.627	7.48	86	11.55	17.54
	other mark making	00:00:00.599	00:00:02.994	0.44	5	0.43	0.66
	defining patch	00:00:00.716	00:00:18.616	2.26	26	2.7	4.1
	hovering	0	0	0	0	0	0
	<Initial verbal behaviour>	0	0	0	0	0	0
	verbalising	00:00:01.084	00:01:05.020	5.22	60	9.43	14.32
	not talking	00:00:01.123	00:05:24.527	25.15	289	47.07	71.48
	chatting	00:00:01.810	00:00:18.098	0.87	10	2.62	3.99
	rationalising	00:00:01.495	00:00:46.352	2.7	31	6.72	10.21

4. Amanda Roberts, non-verbalised trial

	Behaviours						
		Mean duration (hh:mm:ss.ms)	Total duration	Rate per minute (observation)	Total number	Percentage (observation)	Percentage (analysed duration)
mirror	<Initial Looking behaviour>	0	0	0	0	0	0
	paper	0	0	0	0	0	0
		00:00:00.590	00:02:19.903	40.14	237	39.49	100
	<Initial Drawing Behaviour>	00:00:01.039	00:00:02.077	0.34	2	0.59	1.48
	drawing	0	0	0	0	0	0
	pausing	0	0	0	0	0	0
	not drawing	00:00:00.670	00:00:04.021	1.02	6	1.14	2.87
	rubbing out	00:00:00.395	00:00:01.184	0.51	3	0.33	0.85
	drawing rough lines	00:00:00.645	00:00:39.345	10.33	61	11.11	28.12
	drawing scaffold marks	00:00:00.341	00:00:01.706	0.85	5	0.48	1.22
	drawing contour	00:00:00.539	00:01:09.524	21.85	129	19.63	49.69
	drawing tone	00:00:00.556	00:00:15.007	4.57	27	4.24	10.73
	other mark making	00:00:00.466	00:00:03.731	1.36	8	1.05	2.67
	defining patch	00:00:00.414	00:00:03.308	1.36	8	0.93	2.36
	hovering	0	0	0	0	0	0
	<Initial verbal behaviour>	0	0	0	0	0	0
	verbalising	0	0	0	0	0	0
	not talking	00:00:00.598	00:02:00.828	34.21	202	34.11	86.37
	chatting	00:00:00.516	00:00:19.075	6.27	37	5.38	13.63
	rationalising	0	0	0	0	0	0
paper	<Initial Looking behaviour>	0	0	0	0	0	0
		00:00:00.835	00:03:22.090	40.99	242	57.05	100
	mirror	0	0	0	0	0	0
	<Initial Drawing Behaviour>	00:00:01.496	00:00:01.496	0.17	1	0.42	0.74
	drawing	0	0	0	0	0	0
	pausing	0	0	0	0	0	0
	not drawing	00:00:00.811	00:00:09.737	2.03	12	2.75	4.82
	rubbing out	00:00:01.427	00:00:05.708	0.68	4	1.61	2.82
	drawing rough lines	00:00:00.596	00:00:36.344	10.33	61	10.26	17.98
	drawing scaffold marks	00:00:01.199	00:00:05.995	0.85	5	1.69	2.97

	drawing contour	00:00:00.844	00:01:49.769	22.02	130	30.99	54.32
	drawing tone	00:00:00.857	00:00:24.841	4.91	29	7.01	12.29
	other mark making	00:00:00.524	00:00:04.720	1.52	9	1.33	2.34
	defining patch	00:00:00.580	00:00:03.480	1.02	6	0.98	1.72
	hovering	0	0	0	0	0	0
	<Initial verbal behaviour>	0	0	0	0	0	0
	verbalising	0	0	0	0	0	0
	not talking	00:00:00.829	00:02:49.892	34.72	205	47.96	84.07
	chatting	00:00:00.847	00:00:32.198	6.44	38	9.09	15.93
	rationalising	0	0	0	0	0	0

5. David Cobley, verbalised trial

	Behaviours						
		Mean duration (hh:mm:ss.ms)	Total duration	Rate per minute (observation)	Total number	Percentage (observation)	Percentage (analysed duration)
mirror	<Initial Looking behaviour>	0	0	0	0	0	0
	paper	0	0	0	0	0	0
		00:00:00.556	00:01:42.325	34.96	184	32.4	100
	<Initial Drawing Behaviour>	00:00:06.132	00:00:12.263	0.38	2	3.88	11.98
	drawing	0	0	0	0	0	0
	pausing	0	0	0	0	0	0
	not drawing	00:00:00.259	00:00:01.551	1.14	6	0.49	1.52
	rubbing out	0	0	0	0	0	0
	drawing rough lines	00:00:00.400	00:00:15.213	7.22	38	4.82	14.87
	drawing scaffold marks	0	0	0	0	0	0
	drawing contour	00:00:00.459	00:00:11.023	4.56	24	3.49	10.77
	drawing tone	00:00:00.522	00:00:52.704	19.19	101	16.69	51.51
	other mark making	00:00:00.399	00:00:07.572	3.61	19	2.4	7.4
	defining patch	0	0	0	0	0	0
	hovering	00:00:00.499	00:00:01.998	0.76	4	0.63	1.95
	<Initial verbal behaviour>	00:00:04.119	00:00:12.358	0.57	3	3.91	12.08
	verbalising	00:00:00.449	00:00:13.028	5.51	29	4.12	12.73
	not talking	00:00:00.546	00:00:21.291	7.41	39	6.74	20.81
	chatting	00:00:00.587	00:00:05.872	1.9	10	1.86	5.74
	rationalising	00:00:00.474	00:00:49.776	19.95	105	15.76	48.65
paper	<Initial Looking behaviour>	0	0	0	0	0	0
		00:00:01.131	00:03:28.050	34.96	184	65.87	100
	mirror	0	0	0	0	0	0
	<Initial Drawing Behaviour>	00:00:00.389	00:00:00.389	0.19	1	0.12	0.19
	drawing	0	0	0	0	0	0
	pausing	0	0	0	0	0	0
	not drawing	00:00:01.095	00:00:08.759	1.52	8	2.77	4.21
	rubbing out	0	0	0	0	0	0
	drawing rough lines	00:00:00.912	00:00:34.639	7.22	38	10.97	16.65

	drawing scaffold marks	0	0	0	0	0	0
	drawing contour	00:00:00.833	00:00:21.646	4.94	26	6.85	10.4
	drawing tone	00:00:01.168	00:02:00.332	19.57	103	38.1	57.84
	other mark making	00:00:01.123	00:00:19.092	3.23	17	6.04	9.18
	defining patch	0	0	0	0	0	0
	hovering	00:00:00.532	00:00:03.193	1.14	6	1.01	1.53
	<Initial verbal behaviour>	00:00:00.947	00:00:00.947	0.19	1	0.3	0.46
	verbalising	00:00:01.033	00:00:30.980	5.7	30	9.81	14.89
	not talking	00:00:01.340	00:00:52.268	7.41	39	16.55	25.12
	chatting	00:00:01.138	00:00:11.385	1.9	10	3.6	5.47
	rationalising	00:00:01.041	00:01:52.471	20.52	108	35.61	54.06

6. David Cobley, non-verbalised trial

	Behaviours						
		Mean duration (hh:mm:ss.ms)	Total duration	Rate per minute (observation)	Total number	Percentage (observation)	Percentage (analysed duration)
mirror	<Initial Looking behaviour>	0	0	0	0	0	0
	paper	0	0	0	0	0	0
		00:00:00.558	00:01:44.971	36.21	188	33.69	100
	<Initial Drawing Behaviour>	0	0	0	0	0	0
	drawing	0	0	0	0	0	0
	pausing	0	0	0	0	0	0
	not drawing	00:00:00.656	00:00:02.623	0.77	4	0.84	2.5
	rubbing out	00:00:00.302	00:00:00.605	0.39	2	0.19	0.58
	drawing rough lines	00:00:00.446	00:00:11.589	5.01	26	3.72	11.04
	drawing scaffold marks	0	0	0	0	0	0
	drawing contour	00:00:00.489	00:00:18.573	7.32	38	5.96	17.69
	drawing tone	00:00:00.631	00:00:44.194	13.48	70	14.19	42.1
	other mark making	00:00:00.498	00:00:25.873	10.01	52	8.3	24.65
	defining patch	00:00:00.189	00:00:00.758	0.77	4	0.24	0.72
	hovering	00:00:00.378	00:00:00.756	0.39	2	0.24	0.72
	<Initial verbal behaviour>	00:00:00.561	00:01:44.971	36.01	187	33.69	100
	verbalising	0	0	0	0	0	0
	not talking	0	0	0	0	0	0
	chatting	0	0	0	0	0	0
	rationalising	0	0	0	0	0	0
paper	<Initial Looking behaviour>	0	0	0	0	0	0
		00:00:01.097	00:03:25.129	36.01	187	65.84	100
	mirror	0	0	0	0	0	0
	<Initial Drawing Behaviour>	0	0	0	0	0	0
	drawing	0	0	0	0	0	0
	pausing	0	0	0	0	0	0
	not drawing	00:00:00.960	00:00:08.639	1.73	9	2.77	4.21
	rubbing out	00:00:03.762	00:00:15.048	0.77	4	4.83	7.34
	drawing rough lines	00:00:00.878	00:00:22.838	5.01	26	7.33	11.13
	drawing scaffold marks	0	0	0	0	0	0

	drawing contour	00:00:00.750	00:00:28.514	7.32	38	9.15	13.9
	drawing tone	00:00:01.020	00:01:14.436	14.06	73	23.89	36.29
	other mark making	00:00:00.977	00:00:51.757	10.21	53	16.61	25.23
	defining patch	00:00:00.997	00:00:02.992	0.58	3	0.96	1.46
	hovering	00:00:00.302	00:00:00.905	0.58	3	0.29	0.44
	<Initial verbal behaviour>	00:00:01.097	00:03:25.129	36.01	187	65.84	100
	verbalising	0	0	0	0	0	0
	not talking	0	0	0	0	0	0
	chatting	0	0	0	0	0	0
	rationalising	0	0	0	0	0	0

7. Anthony Connolly, verbalised trial

	Behaviours						
		Mean duration (hh:mm:ss.ms)	**Total duration**	**Rate per minute (observation)**	**Total number**	**Percentage (observation)**	**Percentage (analysed duration)**
mirror	**<Initial Looking behaviour>**	0	0	0	0	0	0
	paper	0	0	0	0	0	0
		00:00:01.853	00:02:20.793	14.96	76	46.19	100
	<Initial Drawing Behaviour>	00:00:00.470	00:00:00.470	0.2	1	0.15	0.33
	drawing	0	0	0	0	0	0
	pausing	0	0	0	0	0	0
	not drawing	00:00:00.375	00:00:00.375	0.2	1	0.12	0.27
	rubbing out	0	0	0	0	0	0
	drawing rough lines	0	0	0	0	0	0
	drawing scaffold marks	0	0	0	0	0	0
	drawing contour	00:00:03.133	00:00:06.266	0.39	2	2.06	4.45
	drawing tone	00:00:00.896	00:00:11.648	2.56	13	3.82	8.27
	other mark making	0	0	0	0	0	0
	defining patch	00:00:00.123	00:00:00.246	0.39	2	0.08	0.17
	hovering	00:00:01.715	00:02:01.788	13.98	71	39.95	86.5
	<Initial verbal behaviour>	0	0	0	0	0	0
	verbalising	00:00:01.643	00:01:22.145	9.84	50	26.95	58.34
	not talking	00:00:00.999	00:00:22.987	4.53	23	7.54	16.33
	chatting	00:00:00.813	00:00:01.626	0.39	2	0.53	1.16
	rationalising	00:00:04.254	00:00:34.035	1.57	8	11.17	24.17
paper	**<Initial Looking behaviour>**	0	0	0	0	0	0
		00:00:01.993	00:02:29.495	14.76	75	49.04	100
	mirror	0	0	0	0	0	0
	<Initial Drawing Behaviour>	0	0	0	0	0	0
	drawing	0	0	0	0	0	0
	pausing	00:00:01.144	00:00:01.144	0.2	1	0.38	0.77
	not drawing	00:00:01.096	00:00:01.096	0.2	1	0.36	0.73
	rubbing out	0	0	0	0	0	0
	drawing rough lines	0	0	0	0	0	0
	drawing scaffold marks	0	0	0	0	0	0

	drawing contour	00:00:00.931	00:00:16.756	3.54	18	5.5	11.21
	drawing tone	00:00:01.317	00:01:08.506	10.24	52	22.47	45.83
	other mark making	0	0	0	0	0	0
	defining patch	00:00:00.995	00:00:05.970	1.18	6	1.96	3.99
	hovering	00:00:00.452	00:00:56.023	24.41	124	18.38	37.47
	<Initial verbal behaviour>	0	0	0	0	0	0
	verbalising	00:00:01.780	00:01:29.008	9.84	50	29.2	59.54
	not talking	00:00:01.968	00:00:41.320	4.13	21	13.56	27.64
	chatting	00:00:03.111	00:00:03.111	0.2	1	1.02	2.08
	rationalising	00:00:02.294	00:00:16.056	1.38	7	5.27	10.74

7. Anthony Connolly, non-verbalised trial

	Behaviours						
		Mean duration (hh:mm:ss.ms)	Total duration	Rate per minute (observation)	Total number	Percentage (observation)	Percentage (analysed duration)
mirror	<Initial Looking behaviour>	0	0	0	0	0	0
	paper	0	0	0	0	0	0
		00:00:01.133	00:01:49.859	19.33	97	36.49	100
	<Initial Drawing Behaviour>	00:00:03.238	00:00:06.477	0.4	2	2.15	5.9
	drawing	0	0	0	0	0	0
	pausing	00:00:00.761	00:00:01.522	0.4	2	0.51	1.39
	not drawing	00:00:01.409	00:00:09.861	1.39	7	3.28	8.98
	rubbing out	0	0	0	0	0	0
	drawing rough lines	0	0	0	0	0	0
	drawing scaffold marks	0	0	0	0	0	0
	drawing contour	00:00:00.160	00:00:02.246	2.79	14	0.75	2.04
	drawing tone	00:00:00.354	00:00:03.184	1.79	9	1.06	2.9
	other mark making	0	0	0	0	0	0
	defining patch	00:00:00.196	00:00:00.782	0.8	4	0.26	0.71
	hovering	00:00:00.943	00:01:25.785	18.13	91	28.49	78.09
	<Initial verbal behaviour>	00:00:03.238	00:00:06.477	0.4	2	2.15	5.9
	verbalising	0	0	0	0	0	0
	not talking	00:00:01.100	00:01:43.382	18.73	94	34.34	94.11
	chatting	0	0	0	0	0	0
	rationalising	0	0	0	0	0	0
paper	<Initial Looking behaviour>	0	0	0	0	0	0
		00:00:01.858	00:02:54.608	18.73	94	57.99	100
	mirror	0	0	0	0	0	0
	<Initial Drawing Behaviour>	00:00:00.353	00:00:00.353	0.2	1	0.12	0.2
	drawing	0	0	0	0	0	0
	pausing	00:00:00.299	00:00:00.597	0.4	2	0.2	0.34
	not drawing	00:00:00.602	00:00:07.824	2.59	13	2.6	4.48
	rubbing out	00:00:01.954	00:00:01.954	0.2	1	0.65	1.12
	drawing rough lines	0	0	0	0	0	0
	drawing scaffold marks	0	0	0	0	0	0

	drawing contour	00:00:00.728	00:00:21.117	5.78	29	7.01	12.09
	drawing tone	00:00:01.171	00:01:06.774	11.36	57	22.18	38.24
	other mark making	00:00:00.508	00:00:00.508	0.2	1	0.17	0.29
	defining patch	00:00:00.877	00:00:06.141	1.39	7	2.04	3.52
	hovering	00:00:00.462	00:01:09.341	29.89	150	23.03	39.71
	<Initial verbal behaviour>	00:00:00.353	00:00:00.353	0.2	1	0.12	0.2
	verbalising	0	0	0	0	0	0
	not talking	00:00:01.874	00:02:54.255	18.53	93	57.87	99.8
	chatting	0	0	0	0	0	0
	rationalising	0	0	0	0	0	0

Appendix C

Quantitative data analysis results: time based sampling

These tables show the results of the quantitative analysis which were used to generate the graphs in chapter 3. Video footage of non-verbalised drawings (trials) were segmented into 30 second intervals. The drawing and talking activities taking place during those periods were also segmented, allowing analysis of the frequency and duration of those activities in each 30 second period.

Columns here refer to the mean duration of each behaviour (listed in column 2), the total duration (of the drawing trial), rate per minute (mean number of times per minute each behaviour occurred), total number (of instances the behaviour occurred), percentage of the total duration, and the percentage of the analysed duration (the portion of the drawing spent looking at the mirror or paper).

1. Angela Brew

	Behaviours						
Time (s/m)		**Mean duration (hh:mm:ss.ms)**	**Total duration**	**Rate per minute (observation)**	**Total number**	**Percentage (observation)**	**Percentage (analysed duration)**
0-30	**<Initial Looking behaviour>**	00:00:04.412	00:00:08.824	0.22	2	1.64	29.41
	paper	00:00:01.158	00:00:05.789	0.56	5	1.08	19.3
	mirror	00:00:03.847	00:00:15.387	0.45	4	2.86	51.29
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	00:00:07.149	00:00:07.149	0.11	1	1.33	23.83
	pausing	00:00:01.594	00:00:01.594	0.11	1	0.3	5.31
	not drawing	00:00:17.222	00:00:17.222	0.11	1	3.2	57.41
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:04.035	00:00:04.035	0.11	1	0.75	13.45
	drawing tone	-	-	-	-	-	-
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.11	1	5.58	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
30_1	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:01.647	00:00:14.821	1	9	2.76	49.4
	mirror	00:00:01.687	00:00:15.179	1	9	2.82	50.6
	<Initial Drawing Behaviour>	-	-	-	-	-	-

	drawing	00:00:07.007	00:00:07.007	0.11	1	1.3	23.36
	pausing	00:00:01.926	00:00:09.628	0.56	5	1.79	32.09
	not drawing	00:00:01.976	00:00:03.953	0.22	2	0.74	13.18
	rubbing out	00:00:04.692	00:00:04.692	0.11	1	0.87	15.64
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:01.573	00:00:04.719	0.33	3	0.88	15.73
	drawing tone	-	-	-	-	-	-
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.11	1	5.58	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
1_130	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:01.288	00:00:15.454	1.34	12	2.87	51.51
	mirror	00:00:01.322	00:00:14.546	1.23	11	2.71	48.49
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	00:00:01.638	00:00:06.553	0.45	4	1.22	21.84
	not drawing	00:00:02.660	00:00:05.320	0.22	2	0.99	17.73
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:03.625	00:00:18.127	0.56	5	3.37	60.42
	drawing tone	-	-	-	-	-	-
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.11	1	5.58	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
130_2	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:01.825	00:00:18.246	1.12	10	3.39	60.82
	mirror	00:00:01.175	00:00:11.754	1.12	10	2.19	39.18
	<Initial Drawing	-	-	-	-	-	-

	Behaviour>						
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:04.412	00:00:04.412	0.11	1	0.82	14.71
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:12.794	00:00:25.588	0.22	2	4.76	85.29
	drawing tone	-	-	-	-	-	-
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.11	1	5.58	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
2_230	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:01.542	00:00:16.967	1.23	11	3.16	56.56
	mirror	00:00:01.185	00:00:13.033	1.23	11	2.42	43.44
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	00:00:00.739	00:00:02.216	0.33	3	0.41	7.39
	not drawing	00:00:01.562	00:00:07.809	0.56	5	1.45	26.03
	rubbing out	00:00:02.410	00:00:02.410	0.11	1	0.45	8.03
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:02.927	00:00:17.565	0.67	6	3.27	58.55
	drawing tone	-	-	-	-	-	-
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.11	1	5.58	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
230_3	**<Initial Looking behaviour>**	00:00:00.862	00:00:00.862	0.11	1	0.16	2.87
	paper	00:00:01.885	00:00:18.852	1.12	10	3.51	62.84
	mirror	00:00:01.143	00:00:10.286	1	9	1.91	34.29

	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	00:00:01.347	00:00:06.737	0.56	5	1.25	22.46
	not drawing	00:00:01.398	00:00:05.594	0.45	4	1.04	18.65
	rubbing out	00:00:04.492	00:00:04.492	0.11	1	0.84	14.97
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:02.635	00:00:13.177	0.56	5	2.45	43.92
	drawing tone	-	-	-	-	-	-
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.11	1	5.58	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
3_330	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:01.239	00:00:13.630	1.23	11	2.54	45.43
	mirror	00:00:01.488	00:00:16.370	1.23	11	3.04	54.57
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	00:00:02.188	00:00:04.377	0.22	2	0.81	14.59
	not drawing	00:00:02.845	00:00:08.535	0.33	3	1.59	28.45
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:04.272	00:00:17.088	0.45	4	3.18	56.96
	drawing tone	-	-	-	-	-	-
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.11	1	5.58	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
330_4	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:02.147	00:00:17.172	0.89	8	3.19	57.24

	mirror	00:00:01.833	00:00:12.828	0.78	7	2.39	42.76
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	00:00:00.674	00:00:00.674	0.11	1	0.13	2.25
	not drawing	00:00:02.194	00:00:06.582	0.33	3	1.22	21.94
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:04.177	00:00:08.354	0.22	2	1.55	27.85
	drawing tone	00:00:07.195	00:00:14.390	0.22	2	2.68	47.97
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.11	1	5.58	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
4_430	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:01.432	00:00:17.180	1.34	12	3.2	57.27
	mirror	00:00:01.165	00:00:12.820	1.23	11	2.38	42.73
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:02.700	00:00:08.099	0.33	3	1.51	27
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	-	-	-	-	-	-
	drawing tone	00:00:05.475	00:00:21.901	0.45	4	4.07	73
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.11	1	5.58	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
430_5	**<Initial Looking behaviour>**	00:00:00.629	00:00:00.629	0.11	1	0.12	2.1

	paper	00:00:01.734	00:00:19.074	1.23	11	3.55	63.58
	mirror	00:00:01.144	00:00:10.297	1	9	1.92	34.32
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:04.569	00:00:09.138	0.22	2	1.7	30.46
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	-	-	-	-	-	-
	drawing tone	00:00:06.954	00:00:20.862	0.33	3	3.88	69.54
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.11	1	5.58	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-

2. Amanda Roberts

	Behaviours						
		Mean duration (hh:mm:ss.ms)	**Total duration**	**Rate per minute (observation)**	**Total number**	**Percentage (observation)**	**Percentage (analysed duration)**
Results	**<Initial Looking behaviour>**	00:00:09.925	00:00:09.925	0.17	1	2.8	33.08
	paper	00:00:00.499	00:00:07.484	2.54	15	2.11	24.95
	mirror	00:00:00.839	00:00:12.591	2.54	15	3.55	41.97
	<Initial Drawing Behaviour>	00:00:13.498	00:00:13.498	0.17	1	3.81	44.99
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	00:00:16.502	00:00:16.502	0.17	1	4.66	55.01
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	-	-	-	-	-	-
	drawing tone	-	-	-	-	-	-
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:13.504	00:00:27.008	0.34	2	7.62	90.03
	chatting	00:00:02.992	00:00:02.992	0.17	1	0.84	9.97
	rationalising	-	-	-	-	-	-
30_1	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:00.572	00:00:13.729	4.07	24	3.88	45.76
	mirror	00:00:00.651	00:00:16.271	4.23	25	4.59	54.24
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	00:00:30.000	00:00:30.000	0.17	1	8.47	100
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	-	-	-	-	-	-
	drawing tone	-	-	-	-	-	-
	other mark making	-	-	-	-	-	-

	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.17	1	8.47	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
1_130	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:00.815	00:00:17.927	3.73	22	5.06	59.76
	mirror	00:00:00.525	00:00:12.073	3.9	23	3.41	40.24
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:01.461	00:00:01.461	0.17	1	0.41	4.87
	rubbing out	-	-	-	-	-	-
	drawing rough lines	00:00:15.911	00:00:15.911	0.17	1	4.49	53.04
	drawing scaffold marks	00:00:07.701	00:00:07.701	0.17	1	2.17	25.67
	drawing contour	00:00:00.221	00:00:00.221	0.17	1	0.06	0.74
	drawing tone	-	-	-	-	-	-
	other mark making	00:00:04.706	00:00:04.706	0.17	1	1.33	15.69
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.17	1	8.47	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
130_2	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:00.797	00:00:17.540	3.73	22	4.95	58.47
	mirror	00:00:00.542	00:00:12.460	3.9	23	3.52	41.53
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:30.000	00:00:30.000	0.17	1	8.47	100
	drawing tone	-	-	-	-	-	-
	other mark	-	-	-	-	-	-

	making						
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.17	1	8.47	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
2_230	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:00.852	00:00:18.736	3.73	22	5.29	62.45
	mirror	00:00:00.512	00:00:11.264	3.73	22	3.18	37.55
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:30.000	00:00:30.000	0.17	1	8.47	100
	drawing tone	-	-	-	-	-	-
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:19.186	00:00:19.186	0.17	1	5.42	63.95
	chatting	00:00:05.407	00:00:10.814	0.34	2	3.05	36.05
	rationalising	-	-	-	-	-	-
230_3	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:00.927	00:00:19.463	3.56	21	5.49	64.88
	mirror	00:00:00.527	00:00:10.537	3.39	20	2.97	35.12
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:01.718	00:00:01.718	0.17	1	0.48	5.73
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:07.178	00:00:21.533	0.51	3	6.08	71.78
	drawing tone	00:00:04.665	00:00:04.665	0.17	1	1.32	15.55

	other mark making	00:00:02.084	00:00:02.084	0.17	1	0.59	6.95
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:00.681	00:00:00.681	0.17	1	0.19	2.27
	chatting	00:00:29.319	00:00:29.319	0.17	1	8.28	97.73
	rationalising	-	-	-	-	-	-
3_330	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:00.689	00:00:17.227	4.23	25	4.86	57.42
	mirror	00:00:00.532	00:00:12.773	4.07	24	3.61	42.58
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:01.193	00:00:01.193	0.17	1	0.34	3.98
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:28.807	00:00:28.807	0.17	1	8.13	96.02
	drawing tone	-	-	-	-	-	-
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:15.000	00:00:30.000	0.34	2	8.47	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
330_4	**<Initial Looking behaviour>**	00:00:01.163	00:00:02.325	0.34	2	0.66	7.75
	paper	00:00:01.188	00:00:19.010	2.71	16	5.37	63.37
	mirror	00:00:00.542	00:00:08.665	2.71	16	2.45	28.88
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:02.755	00:00:05.509	0.34	2	1.56	18.36
	rubbing out	00:00:03.080	00:00:06.159	0.34	2	1.74	20.53
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:07.433	00:00:14.866	0.34	2	4.2	49.55

	drawing tone	-	-	-	-	-	-
	other mark making	-	-	-	-	-	-
	defining patch	00:00:03.466	00:00:03.466	0.17	1	0.98	11.55
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:12.996	00:00:25.991	0.34	2	7.34	86.64
	chatting	00:00:04.009	00:00:04.009	0.17	1	1.13	13.36
	rationalising	-	-	-	-	-	-
4_430	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:00.819	00:00:18.013	3.73	22	5.08	60.04
	mirror	00:00:00.599	00:00:11.987	3.39	20	3.38	39.96
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	00:00:00.733	00:00:00.733	0.17	1	0.21	2.44
	drawing rough lines	00:00:07.132	00:00:07.132	0.17	1	2.01	23.77
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:06.840	00:00:13.679	0.34	2	3.86	45.6
	drawing tone	00:00:05.134	00:00:05.134	0.17	1	1.45	17.11
	other mark making	-	-	-	-	-	-
	defining patch	00:00:03.322	00:00:03.322	0.17	1	0.94	11.07
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.17	1	8.47	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
430_5	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:00.700	00:00:16.802	4.07	24	4.74	56.01
	mirror	00:00:00.550	00:00:13.198	4.07	24	3.73	43.99
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	00:00:06.144	00:00:06.144	0.17	1	1.73	20.48
	drawing scaffold marks	-	-	-	-	-	-
	drawing						
		00:00:06.033	00:00:12.065	0.34	2	3.41	40.22

	contour						
	drawing tone	00:00:05.065	00:00:10.130	0.34	2	2.86	33.77
	other mark making	00:00:01.661	00:00:01.661	0.17	1	0.47	5.54
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:12.567	00:00:25.133	0.34	2	7.09	83.78
	chatting	00:00:04.867	00:00:04.867	0.17	1	1.37	16.22
	rationalising	-	-	-	-	-	-

3. David Cobley

	Behaviours						
		Mean	**Total duration**	**Rate per minute (observation)**	**Total number**	**Percentage (observation)**	**Percentage (analysed duration)**
Results	**<Initial Looking behaviour>**	00:00:00.543	00:00:00.543	0.19	1	0.17	1.81
	paper	00:00:00.813	00:00:18.695	4.43	23	6	62.32
	mirror	00:00:00.448	00:00:10.762	4.62	24	3.45	35.87
	<Initial Drawing Behaviour>	00:00:00.349	00:00:00.349	0.19	1	0.11	1.16
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	00:00:12.340	00:00:24.680	0.39	2	7.92	82.27
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	-	-	-	-	-	-
	drawing tone	-	-	-	-	-	-
	other mark making	00:00:04.220	00:00:04.220	0.19	1	1.35	14.07
	defining patch	-	-	-	-	-	-
	hovering	00:00:00.752	00:00:00.752	0.19	1	0.24	2.51
	<Initial verbal behaviour>	00:00:30.000	00:00:30.000	0.19	1	9.63	100
	verbalising	-	-	-	-	-	-
	not talking	-	-	-	-	-	-
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
30_1	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:01.116	00:00:21.199	3.66	19	6.8	70.66
	mirror	00:00:00.463	00:00:08.801	3.66	19	2.82	29.34
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	00:00:09.748	00:00:09.748	0.19	1	3.13	32.49
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	-	-	-	-	-	-
	drawing tone	-	-	-	-	-	-
	other mark making	00:00:20.252	00:00:20.252	0.19	1	6.5	67.51

	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	00:00:30.000	00:00:30.000	0.19	1	9.63	100
	verbalising	-	-	-	-	-	-
	not talking	-	-	-	-	-	-
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
1_130	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:00.959	00:00:20.148	4.04	21	6.47	67.16
	mirror	00:00:00.493	00:00:09.852	3.85	20	3.16	32.84
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:00.960	00:00:00.960	0.19	1	0.31	3.2
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:06.911	00:00:06.911	0.19	1	2.22	23.04
	drawing tone	00:00:04.193	00:00:08.386	0.39	2	2.69	27.95
	other mark making	00:00:02.498	00:00:09.994	0.77	4	3.21	33.31
	defining patch	00:00:01.875	00:00:03.750	0.39	2	1.2	12.5
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	00:00:30.000	00:00:30.000	0.19	1	9.63	100
	verbalising	-	-	-	-	-	-
	not talking	-	-	-	-	-	-
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
130_2	**<Initial Looking behaviour>**	00:00:00.906	00:00:00.906	0.19	1	0.29	3.02
	paper	00:00:00.948	00:00:19.912	4.04	21	6.39	66.37
	mirror	00:00:00.483	00:00:09.182	3.66	19	2.95	30.61
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:04.113	00:00:04.113	0.19	1	1.32	13.71
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:06.629	00:00:06.629	0.19	1	2.13	22.1
	drawing tone	-	-	-	-	-	-
	other mark	00:00:09.629	00:00:19.257	0.39	2	6.18	64.19

	making						
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	00:00:30.000	00:00:30.000	0.19	1	9.63	100
	verbalising	-	-	-	-	-	-
	not talking	-	-	-	-	-	-
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
2_230	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:00.967	00:00:19.341	3.85	20	6.21	64.47
	mirror	00:00:00.533	00:00:10.659	3.85	20	3.42	35.53
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:10.841	00:00:10.841	0.19	1	3.48	36.14
	drawing tone	-	-	-	-	-	-
	other mark making	00:00:19.159	00:00:19.159	0.19	1	6.15	63.86
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	00:00:30.000	00:00:30.000	0.19	1	9.63	100
	verbalising	-	-	-	-	-	-
	not talking	-	-	-	-	-	-
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
230_3	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:00.780	00:00:17.156	4.24	22	5.51	57.19
	mirror	00:00:00.584	00:00:12.844	4.24	22	4.12	42.81
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:00.695	00:00:00.695	0.19	1	0.22	2.32
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:09.689	00:00:19.377	0.39	2	6.22	64.59
	drawing tone	00:00:02.589	00:00:05.179	0.39	2	1.66	17.26

	other mark making	00:00:04.749	00:00:04.749	0.19	1	1.52	15.83
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	00:00:30.000	00:00:30.000	0.19	1	9.63	100
	verbalising	-	-	-	-	-	-
	not talking	-	-	-	-	-	-
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
3_330	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:00.910	00:00:18.194	3.85	20	5.84	60.65
	mirror	00:00:00.621	00:00:11.806	3.66	19	3.79	39.35
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	-	-	-	-	-	-
	drawing tone	00:00:30.000	00:00:30.000	0.19	1	9.63	100
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	00:00:30.000	00:00:30.000	0.19	1	9.63	100
	verbalising	-	-	-	-	-	-
	not talking	-	-	-	-	-	-
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
330_4	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:01.831	00:00:20.141	2.12	11	6.46	67.14
	mirror	00:00:00.822	00:00:09.859	2.31	12	3.16	32.86
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:02.022	00:00:04.043	0.39	2	1.3	13.48
	rubbing out	00:00:05.627	00:00:05.627	0.19	1	1.81	18.76
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	-	-	-	-	-	-

	drawing tone	00:00:10.165	00:00:20.329	0.39	2	6.53	67.76
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	00:00:30.000	00:00:30.000	0.19	1	9.63	100
	verbalising	-	-	-	-	-	-
	not talking	-	-	-	-	-	-
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
4_430	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:01.290	00:00:20.647	3.08	16	6.63	68.82
	mirror	00:00:00.585	00:00:09.353	3.08	16	3	31.18
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:03.328	00:00:03.328	0.19	1	1.07	11.09
	drawing tone	00:00:12.785	00:00:25.569	0.39	2	8.21	85.23
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	00:00:01.103	00:00:01.103	0.19	1	0.35	3.68
	<Initial verbal behaviour>	00:00:30.000	00:00:30.000	0.19	1	9.63	100
	verbalising	-	-	-	-	-	-
	not talking	-	-	-	-	-	-
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
430_5	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:01.191	00:00:20.255	3.27	17	6.5	67.52
	mirror	00:00:00.609	00:00:09.745	3.08	16	3.13	32.48
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	00:00:04.559	00:00:04.559	0.19	1	1.46	15.2
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing	-	-	-	-	-	-

	contour						
	drawing tone	00:00:25.441	00:00:25.441	0.19	1	8.17	84.8
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	00:00:30.000	00:00:30.000	0.19	1	9.63	100
	verbalising	-	-	-	-	-	-
	not talking	-	-	-	-	-	-
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-

4. Anthonty Connolly

	Behaviours						
		Mean	**Total duration**	**Rate per minute (observation)**	**Total number**	**Percentage (observation)**	**Percentage (analysed duration)**
0_30	**<Initial Looking behaviour>**	00:00:05.083	00:00:10.166	0.4	2	3.38	33.89
	paper	00:00:01.562	00:00:07.811	1	5	2.59	26.04
	mirror	00:00:02.004	00:00:12.023	1.2	6	3.99	40.08
	<Initial Drawing Behaviour>	00:00:16.099	00:00:16.099	0.2	1	5.35	53.66
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:02.926	00:00:11.705	0.8	4	3.89	39.02
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:00.563	00:00:01.688	0.6	3	0.56	5.63
	drawing tone	-	-	-	-	-	-
	other mark making	00:00:00.508	00:00:00.508	0.2	1	0.17	1.69
	defining patch	-	-	-	-	-	-
	hovering	-	-	-	-	-	-
	<Initial verbal behaviour>	00:00:09.028	00:00:09.028	0.2	1	3	30.09
	verbalising	-	-	-	-	-	-
	not talking	00:00:14.130	00:00:14.130	0.2	1	4.69	47.1
	chatting	00:00:06.842	00:00:06.842	0.2	1	2.27	22.81
	rationalising	-	-	-	-	-	-
30_1	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:02.112	00:00:21.122	1.99	10	7.02	70.41
	mirror	00:00:00.888	00:00:08.878	1.99	10	2.95	29.59
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:00.415	00:00:00.415	0.2	1	0.14	1.38
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing						
		00:00:01.1	00:00:03.5	0.6	3	1.18	11.88

	contour	88	65				
	drawing tone	00:00:01.663	00:00:11.640	1.39	7	3.87	38.8
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	00:00:01.438	00:00:14.380	1.99	10	4.78	47.93
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.2	1	9.96	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
1_130	<Initial Looking behaviour>	00:00:05.741	00:00:05.741	0.2	1	1.91	19.14
	paper	00:00:01.480	00:00:11.842	1.59	8	3.93	39.47
	mirror	00:00:01.380	00:00:12.417	1.79	9	4.12	41.39
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	00:00:01.053	00:00:01.053	0.2	1	0.35	3.51
	not drawing	00:00:05.201	00:00:10.403	0.4	2	3.46	34.68
	rubbing out	00:00:01.954	00:00:01.954	0.2	1	0.65	6.51
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:00.502	00:00:02.010	0.8	4	0.67	6.7
	drawing tone	00:00:00.852	00:00:02.557	0.6	3	0.85	8.52
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	00:00:01.503	00:00:12.023	1.59	8	3.99	40.08
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.2	1	9.96	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
130_2	<Initial Looking behaviour>	-	-	-	-	-	-
	paper	00:00:01.639	00:00:18.034	2.19	11	5.99	60.11
	mirror	00:00:01.088	00:00:11.966	2.19	11	3.97	39.89
	<Initial Drawing	-	-	-	-	-	-

	Behaviour>						
	drawing	-	-	-	-	-	-
	pausing	00:00:00.355	00:00:01.065	0.6	3	0.35	3.55
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:00.900	00:00:07.197	1.59	8	2.39	23.99
	drawing tone	00:00:01.797	00:00:07.187	0.8	4	2.39	23.96
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	00:00:01.455	00:00:14.551	1.99	10	4.83	48.5
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.2	1	9.96	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
2_230	<Initial Looking behaviour>	-	-	-	-	-	-
	paper	00:00:01.711	00:00:17.105	1.99	10	5.68	57.02
	mirror	00:00:01.289	00:00:12.895	1.99	10	4.28	42.98
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:00.616	00:00:03.078	1	5	1.02	10.26
	drawing tone	00:00:01.234	00:00:04.937	0.8	4	1.64	16.46
	other mark making	-	-	-	-	-	-
	defining patch	00:00:01.189	00:00:02.378	0.4	2	0.79	7.93
	hovering	00:00:01.782	00:00:19.607	2.19	11	6.51	65.36
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.2	1	9.96	100

	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
230_3	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:01.739	00:00:19.130	2.19	11	6.35	63.77
	mirror	00:00:00.906	00:00:10.870	2.39	12	3.61	36.23
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:00.825	00:00:01.651	0.4	2	0.55	5.5
	drawing tone	00:00:01.002	00:00:08.012	1.59	8	2.66	26.71
	other mark making	-	-	-	-	-	-
	defining patch	-	-	-	-	-	-
	hovering	00:00:01.849	00:00:20.337	2.19	11	6.75	67.79
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.2	1	9.96	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
3_330	**<Initial Looking behaviour>**	-	-	-	-	-	-
	paper	00:00:01.884	00:00:18.842	1.99	10	6.26	62.81
	mirror	00:00:01.116	00:00:11.158	1.99	10	3.71	37.19
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:01.200	00:00:01.200	0.2	1	0.4	4
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	-	-	-	-	-	-
	drawing tone	00:00:01.502	00:00:12.017	1.59	8	3.99	40.06
	other mark making	-	-	-	-	-	-
	defining patch						
		00:00:00.8	00:00:00.8	0.2	1	0.29	2.86

		59	59				
	hovering	00:00:01.448	00:00:15.924	2.19	11	5.29	53.08
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.2	1	9.96	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
330_4	<Initial Looking behaviour>	-	-	-	-	-	-
	paper	00:00:01.913	00:00:21.039	2.19	11	6.99	70.13
	mirror	00:00:00.815	00:00:08.961	2.19	11	2.98	29.87
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	-	-	-	-	-	-
	drawing tone	00:00:00.826	00:00:08.260	1.99	10	2.74	27.53
	other mark making	-	-	-	-	-	-
	defining patch	00:00:01.124	00:00:01.124	0.2	1	0.37	3.75
	hovering	00:00:01.718	00:00:20.617	2.39	12	6.85	68.72
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.2	1	9.96	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
4_430	<Initial Looking behaviour>	-	-	-	-	-	-
	paper	00:00:02.154	00:00:21.538	1.99	10	7.15	71.79
	mirror	00:00:00.769	00:00:08.462	2.19	11	2.81	28.21
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	00:00:00.601	00:00:00.601	0.2	1	0.2	2
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-

	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:00.828	00:00:03.312	0.8	4	1.1	11.04
	drawing tone	00:00:01.244	00:00:07.463	1.2	6	2.48	24.88
	other mark making	-	-	-	-	-	-
	defining patch	00:00:00.940	00:00:01.880	0.4	2	0.62	6.27
	hovering	00:00:01.395	00:00:16.745	2.39	12	5.56	55.82
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.2	1	9.96	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-
430_5	**<Initial Looking behaviour>**	00:00:00.718	00:00:00.718	0.2	1	0.24	2.39
	paper	00:00:01.616	00:00:17.778	2.19	11	5.9	59.26
	mirror	00:00:00.959	00:00:11.505	2.39	12	3.82	38.35
	<Initial Drawing Behaviour>	-	-	-	-	-	-
	drawing	-	-	-	-	-	-
	pausing	-	-	-	-	-	-
	not drawing	-	-	-	-	-	-
	rubbing out	-	-	-	-	-	-
	drawing rough lines	-	-	-	-	-	-
	drawing scaffold marks	-	-	-	-	-	-
	drawing contour	00:00:00.431	00:00:00.862	0.4	2	0.29	2.87
	drawing tone	00:00:00.876	00:00:07.885	1.79	9	2.62	26.28
	other mark making	-	-	-	-	-	-
	defining patch	00:00:00.684	00:00:00.684	0.2	1	0.23	2.28
	hovering	00:00:01.582	00:00:20.569	2.59	13	6.83	68.56
	<Initial verbal behaviour>	-	-	-	-	-	-
	verbalising	-	-	-	-	-	-
	not talking	00:00:30.000	00:00:30.000	0.2	1	9.96	100
	chatting	-	-	-	-	-	-
	rationalising	-	-	-	-	-	-

Appendix D. Glossary of terms

Access consciousness	A distinction introduced by philosopher Ned Block, to refer to a category of consciousness that is 'poised', available for controlled processing.
Accessibility	The possibility of attentional access (sensory or conscious) or retrieval of memory.
Attentional priming	Conditioning of attention by way of contextual cues to facilitate or inhibit a response.
Attentional selection	The act of retrieving memory from LTM.
Binding problem	A term used in both philosophy and cognitive science to indicate the question of how sensory information is combined to form a coherent experience.
Boolean map	A notional pre-attentive representation, similar to a saliency map, but that can.
Bottom-up processing	Information processing that proceeds in sequential stages, determined by input.
Chunking	The conglomeration of memory components, associated with schema construction.
Cognitive load	'Load' related to executive control of Working Memory. Usually described as constituting maximum of 7 components, plus or minus two, after the work of GA Miller in the 1950s.
Computational theory of mind	A view of the human mind as similar to an information-processing system reducible to the use of algorithms.
Concurrent report	A verbal report given during a task.
Declarative memory	Verbalisable factual knowledge.
Depth of Processing	The extent to which incoming information is contextualised by association with prior knowledge.
Embodied cognitive paradigm	The standpoint that all aspects of cognition are influenced or shaped by aspects of the body or sensory experience.
Episodic memory	Knowledge relating to experienced events.

Eye-tracking	The use of technologies to monitor and measure eye movements.
Feature conjunction	Two or more visual features, combined by attention to appear as a single thing.
Feature value	A specific example of one feature type, e.g. a particular colour.
fixation	In relation to eye-movements, to train ones eyes on a point in the visual field. In the present study, parameters were set at >50ms duration.
Functional-anatomical	A physical anatomical location or sub-division (used here with reference to the brain) that coincides with a functional division.
Gaze-cycle	The period (during drawing) during which the eyes move from the subject to the paper and back again.
Hemispheric lateralisation	Processing associated with a specific task or function that is weighted towards one side of the brain.
High-Level vision	Object recognition and other complex, context-dependant visual processing associated with higher order processing (see also 'order of processing').
Internal imagery	Visualisation in the 'mind's eye'
Internal representation	An explanatory tool used in computational accounts of perception and cognition to account for pre-attentive mechanisms
Low level vision	Perception of piecemeal and abstracted visual information, associated with lower order processing (see also 'order of processing')
Modality	Used here with reference to *sensory* modality- relating to relatively independent sensory systems, and sub-divisions within them, but also to modularity of *mind* which includes top-down modular distinctions such as propositional and executive thought.
Order of processing	Relating to the sequence in which information is processed in the brain.
Pre-attentive processing	Processing that occurs automatically, prior to attention but involved in attentional processes.
Pre-striate cortex	Visual areas of the brain adjacent to striate cortex, including areas V2, V3, V4 and V5.
Proceduralisation	When a routine for completing a task is committed to procedural memory, as distinct from declarative memory.
Radical embodied cognition	A theory espoused by A. Chemero, in which explanations of cognition do not rely on internal 'representations' (or information processing models), but instead employs dynamical systems theory.

Retinotopic	Topological similarity to the retinal field (in higher-order visual areas).
Retrospective report	A verbal report given immediately after a task.
Saccade	Rapid movement of the eye between two fixations.
Salience	Conspicuousness or prominence of a feature.
Saliency map	A notional pre-attentive representation that maps relative salience of visual features and contributes to pre-attentive processing.
Scan-path	The journey taken by the eye.
Schema	A mental representation based on prior experience (plural schemata).
Semantic memory	Knowledge relating to the meaning or significance of things (e.g. words), aiding interpretation. Necessary for the use of language.
Striate cortex	The area at the back of the brain involved with visual processing, otherwise known as V1 or 'primary visual cortex'.
Synaptic-potentiation	Enhanced signal detection between brain cells, as a result of repeated simultaneous stimulation.
Top-down processing	Processing that proceeds from information already stored in memory.
Type-one verbalisation	Thinking that is directly vocalised.
Type-two verbalisation	Thinking that requires some degree of translation before vocalisation can occur.
Visual feature	An attribute of a visual stimulus, e.g. colour, shape, tonal value, etc.

Acronyms

BMT: Boolean Map Theory	A theory offering a unified interpretation of visual phenomena, with regard to the recent work of L Huang and H. Pashler.
FIT: Feature Integration Theory	A theory of vision first presented in 1977 by Anne Treisman "according to which features of a stimulus such as colour and shape are analysed separately and only later intedgrated in the process of perception" (Colman 2001: 279).
LTM: Long-Term Memory	Information and experienced stored for long periods (anything over 30 seconds). Often divided into memory types: procedural, semantic, perceptual, declarative, episodic.
STM: Short-Tem Memory	A memory system capable of holding a limited amount for 20 or 30 seconds, but which can be refreshed indefinitely.
VWM: Visual Working Memory	The visual component of WM, which includes other modality-specific subsystems.
WM: Working Memory	A temporary 'buffer' for recently and presently activated processing. Involved with executive mental operations (as distinct from STM which is only a store).
MRT: Mulltiple Resource Theory	A theory presented by Wickens in 1984, in which WM is comprised of multiple stages, modes and types of input.
fMRI: functional Magnetic Resonance Imaging	A brain-imaging technique in which neural activation is inferred by the magnetic measurement of blood-flow in the brain.