AGEING FUTURES

TOWARDS COGNITIVELY INCLUSIVE DIGITAL MEDIA PRODUCTS

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Abstract

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This thesis is situated in a moment when the theory and practice of inclusive design appears to be significantly implicated in the social and economic response to demographic changes in Western Europe by addressing the need to reconnect older people with technology. In light of claims that cognitive ageing results in an increasing disconnection from novel digital media in old age, inclusive design is apparently trapped in a discourse in which digital media products and interfaces are designed as a response to a deterministic decline in abilities.

The thesis proceeds from this context to ask what intellectual moves are required within the discourses of inclusive design so that its community of theorists and practitioners can both comprehend and afford the enaction of cognitive experience in old age? Whilst influential design scholarship actively disregards reductionist cognitive explanations of human and technological relationships, it appears that inclusive design still requires an explanation of temporal changes to human cognition in later life. Whilst there is a burgeoning area of design related research dealing with this issue—an area this thesis defines as 'cognitively inclusive design'—the underlying assumptions and claims supporting this body of research suggests its theorists and practitioners are struggling to move beyond conceptualising older people as passive consumers suffering a deterioration in key cognitive abilities. The thesis argues that, by revisiting the cognitive sciences for alternative explanations for the basis of human cognition, it is possible to relieve this problem by opening up new spaces for designers to critically reflect upon the manner in which older people interact with digital media. In taking a position that design is required to support human cognitive enactment, the thesis develops a new approach to conceptualising temporal changes in human cognition, defined as 'senescent cognition'. From this new critical lens, the thesis provides an alternative 'senescentechnic' explanation of cognitive disconnections between older people and digital media that eschews reductionism and moves beyond a deterministic process of deterioration. In reassessing what ageing cognition means, new strategies for the future of inclusive design are proposed that emphasise the role of creating space for older people to actively explore, reflect upon and enact their own cognitive couplings with technology.

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I have been most fortunate to undertake my PhD at Transtechnology Research, a research group formed of the most unimaginably open-minded and generous individuals on both an intellectual and social level. For the past three years, I have attended the wonderfully inspiring yet challenging Transtechnology Research seminars, which have substantially influenced my thinking and opened my senses to ideas that I would never come into contact with if I had stayed in my home discipline. My thanks go to all those who have been a part of our research group and seminars, and my fellow PhD students within the School of Art and Media who have attended the monthly 'No Docs' clinics that have, thus far, successfully kept us off the streets at night. Whilst it is impossible to name everyone who has provided me with support over the past few years, I am particularly indebted to Dr. Brigitta Zics and Martyn Woodward, who as collaborators, peers and friends, have on many occasions inspired my work and nourished my mental well-being when times have been hard.

It is here also important for me to highlight how this research would not have been possible without the financial support of the Arts and Humanities Research Council, and both the Faculty of Arts and Faculty of Technology at the University of Plymouth. Without this support, I would have been unable to participate in the fantastic conferences I have attended across the world.

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Author's declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Graduate Committee.

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Lists of publications related to this thesis, relevant seminars and conferences attended are documented in Appendix 1 (section 9.1). A selection of full papers presented and published during the course of this research are documented in Appendix 2 (section 9.2).

Complementary information about art projects, publications, lectures and conferences is also available online at: www.johnvines.eu

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John Vines

Signed: ____________

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Introduction

Question: What intellectual moves are required within the inclusive design discipline so that its community of theorists and practitioners can both comprehend and afford the enaction of cognitive experience for older people interacting with digital media interfaces?

Contextual terminologies

To support the flow of reading this document, this short section provides contextualisation for the terminologies that are used most frequently throughout this thesis. This thesis is contextualised at the intersection of interaction design, gerontology and cognitive science, intervening upon design practice and theory that has made attempts to incorporate knowledge from the cognitive science of ageing into the design of digital media products. In particular, the thesis examines the manner in which different accounts of temporal change in human cognition are conceived have subsequent implications on the design of novel digital media products that are inclusive of older people.

Throughout the thesis, the use of the term **novel** is made in reference to digital media products and their associated interfaces that a person has no prior experience of. The thesis distinguishes **digital media** from **digital technologies**. Here, the term digital refers to media artefacts that are comprised of numerical representations.[1] As such, a digital technology comprises a combination of hardware and software components that enables the digital representation and manipulation of media. The notion of representation here is key, as it will be argued that the manner in which digital representations are conveyed in product interfaces are heavily implicated in a **cognitive disconnection** between older people and digital media.[2] Cognitive disconnection, as it is used here, is not to suggest a physical disconnection between older people and digital media[3], but that a combination of factors leads to an insufficient interaction between the cognition of older people and the design of the digital media product. As such, in line with the arguments of Manovich (2001, p.144) and Zics (2008), interaction

[1] Digital media, as it is described here, can be taken to be similar to Manovich's (2001) description of new media. Manovich (2001) defined that a 'new media object can be described formally (mathematically)' and that a 'new media object is subject to algorithmic manipulation' (Manovich, 2001, p.27).
[2] This argument will be expanded in chapter one of the thesis.
[3] This is not to suggest that there may not be a physical disconnection between older people and digital media as well. Primarily, however, this thesis examines the cognitive connections and disconnections between older people and digital media products, services and interfaces.

here is understood not purely in terms of a physical exchange between people and media, but also in terms of cognitive phenomena.[4] The thesis implicates that part of the problem that results in cognitive disconnection between older people and digital media lies in the prevailing understanding of **product**, which suggests a closed package designed to be consumed by users. Rather, in line with the arguments of Redström (2005), Punt (2000) and Thompson (2008), the thesis defines digital media products as open-ended and in a continuous dynamic flux with those *using* it, who are active participators in the construction of what they consume.[5]

Particularly relevant to this thesis is an area of design specialising in **inclusive design**, which, as defined in chapter one, is here understood as an informal community where designers come together to discuss issues related to older people being disconnected from the design of digital media products. Inclusive design is often considered as being a significant component of the social and economic response to the ageing population of many Western European nations (Coleman *et al*., 2007). As a consequence, this thesis deals with the issue of ageing and inclusive design in terms of a highly localised context. Therefore, such a discussion would not be relevant in nations where exclusion from digital technologies occurs on a widespread level.[6] Similarly, whilst this research acknowledges the economic and market-driven imperatives of inclusive design (as discussed by Coleman *et al*. (2007)), the thesis does not attend to these dimensions of design activity, except for moments where they are directly attached to the attended problematic.

For reasons of simplicity, the thesis makes use of the term **older people** throughout. This term and categorisation, however, is rather problematic. In some disciplines related to this thesis, such as gerontology and cognitive psychology, the term older people is used to identify the chronological age at which certain functions, abilities, or behaviours manifest or disappear. In line with this theme, further distinctions can be made between 'old old', 'frail

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[4] It is necessary to highlight that what may comprise cognitive phenomena is determined upon the ontological perspective of a particular research project. Although there may be many ways of describing what may or may not belong to the realm of the cognitive, this thesis refers to two main paradigms of cognitive science; cognitivism and the enactive, embodied cognitive sciences. These two differing ontological paradigms of conceiving of human cognition are used within the opposing accounts of cognitively inclusive design and senescentechnics, as defined in this section and throughout the thesis.

[5] Although this thesis understands products in terms of open-endedness, during chapter one, two and three, where contemporary arguments are explained, the prevailing understanding of a product as a finalised design output is used. The alternative understanding of digital media products, as presented here in the contextual terminologies, will be discussed in chapters seven, eight and in some of the examples presented in chapter nine.

[6] A study performed in 2007 highlighted how only approximately 19% of the Earth's population has access to a fixed telephone line, and 5 out of 100 African people were approximated to be users of the internet (International Telecoms Union, 2007). These statistics highlight profoundly how the issue of older people being disconnected from digital media is, in light of the wider worldly context, rather a Western-centric issue.

old', 'active old', 'third agers' and more.[7] As Stuart-Hamilton observes, however, 'there is no single point at which a person becomes 'old', and [...] chronological age is in any case an arbitrary and not very accurate measure, so the use of a single figure for the threshold would give a speciously objective status' (Stuart-Hamilton, 2006, p.25). A traditional people or user-centred approach to design requires a similar process of categorisation, identifying the particulars of the physical, social, emotional, behavioural, economic and political make-up of a certain group of older people. This thesis builds upon work that highlights the limitations of such design approaches (such as Redström (2005)), whilst also acknowledging the usefulness of having concrete reference points with which to bring together an intellectual community. As such, the thesis uses the term older people to aid the reading of the text and to give a reference point with which to conceive ideas, whilst also leaving this category open for future negotiation.[8]

Within this thesis, two fundamentally distinct, but potentially co-existive, approaches to conceptualising cognitive interactions between older people and digital media have been defined; **cognitively inclusive design** and **senescentechnics** (defined below). Both of these approaches have been defined in reference to, until now, disparate paradigms for conceiving of the **temporal changes** occurring to the **cognition** of older people. Temporal here refers to 'of or relating to time' (Hornby, 1995, p.1230). Cognition is defined as the mental activities of human beings that describe the 'acquisition, storage, transformation and use of knowledge' (Matlin, 2005, p.2). Therefore, through the diverging paradigms of cognitively inclusive design and senescentechnics, this thesis examines alternative explanations as to how, over the latter period of a person's life, the manner in which people acquire, store, transform and apply knowledge changes.

Cognitively inclusive design is defined within this thesis by bringing together under the same term a number of attempts to incorporate knowledge from the scientific study of **ageing** human **cognition** into design methods and tools that have, until now, been rather

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[7] This emphasises somewhat the disparate nature of the study of human ageing in a range of disciplines. Lesnoff-Caravaglia notes that '[r]esearchers have confounded their studies by dividing older persons into amorphous categories such as the "young old," "the old old," "the oldest old," "the frail elderly," "the well elderly," and "the long-living" [... whilst] others have facetiously referred to older age groups as "the slow go," "the no-go," and "the go-go;" or simply "the risky" and "the frisky"'(Lesnoff-Caravaglia, 2007, p.17). Highlighting the difficulty of categorising older people, especially based upon poorly informed assumption, Lesnoff-Caravaglia (2007) suggest categorising people into age-groups—an approach that is just as problematic (Stuart-Hamilton, 2006).

[8] For example, the older person that this thesis references might be somewhat categorised in terms of being contextualised within a Western European cultural setting, and being of a generation in a moment of discomfort between the digitally connected and the digitally disconnected.

loosely aligned.[9] Ageing, here, is understood as a multifaceted process of temporal change that occurs to human beings that results in a gradual deterioration in certain **cognitive functioning**. This cognitive functioning is reduced to a series of discrete information-processing capabilities, which are understood in isolation from the physiology and environment a person is interacting with. Cognitive functioning is understood to change significantly later in a person's life, wherein certain key functions deteriorate in such a manner that, it is argued, makes connecting with novel digital media products somewhat problematic.

Senescentechnics is a new term proposed by this thesis through a synthesis of a body of evidence from cognitive science and associated disciplines that are excluded from ageing discourse.[10] Senenscentechnics proceeds from an alternative understanding of ageing to that of cognitively inclusive design, distinguishing between ageing and **senescence** as a conceptual basis for understanding temporal changes to cognition. Although the term senescence is often used interchangeably with ageing within gerontology literature, it is also used in the biological sciences in reference to cellular changes to organisms that occur after a moment of maturity. Using senescence in terms of its biological definition is useful as it highlights the manner in which temporal changes to organisms, such as human beings, are in certain ways inseparable from the environments and technologies that are interacted with. This is used as inspiration within this thesis to develop an understanding of temporal changes to human cognition as part of an older person's ***Umwelt***. The term *Umwelt* is drawn from the work of the biologist Jakob von Uexküll (1957), and is used to highlight the mutuality and co-dependence of a particular agent and their experiential environment. The consequence of taking this approach is a subsequent emphasis within definitions of cognition of the notions of embodiment, ecology and enaction, which are defined in detail in chapter five. As such, senescentechnics develops an account of **cognitive experience** rather than cognitive functioning.

At moments, the thesis refers to the notion of a **human being**. The concept of a human being may appear to be so familiar within contemporary design literature that it requires little explanation. Thompson (2008) argues it may be the case that the unquestioned status of the human being, bounded by a physical skin that is described within design literature theory and practice, leads to an inability to deal with ideas that technology can be

[9] Cognitively inclusive design is developed through chapters one, two and three. Chapter four examines the inadequacies of cognitively inclusive design as a resolution to the cognitive disconnection between older people and digital media.

[10] The basis of senescentechnics is developed throughout chapter's five, six and seven.

incorporated into the enaction of cognitive experience. The thesis recognises this as a problem that is particularly evident within design theory and practice that acts as a response to scientific knowledge of human ageing, where the notion of the older person whose cognition expands beyond the skin of the body is somewhat ineffable. As such, senescentechnics is introduced in order to develop an account of older people interacting with digital media in such a manner that, both in moments of real-time and over the course of long term interactions, the artificial becomes embedded in the cognitive experience of the senescent human being. Returning to the biological understanding of senescence, the senescentechnic human is not so much bounded by their skin and cognitive functioning, but unbounded, restricted instead by the manner in which the designer has attended to the subtlety of senescent cognition in the design of digital media products.

To the reader

It is useful to alert the reader to some of the underlying narratives that inform this thesis. The research documented within this thesis emerged from questions arising from the author's past experience working on a number of design projects exploring the design of digital and computational media for, and with, groups of older people. These projects explored aspects of older people interacting with mobile communication devices, digital music players, digital photograph storage devices, and physical computing systems.[11] Through these various projects, the author observed that there appeared to be certain mental, psychological and cognitive issues that severely limited the ability for older people to understand the somewhat abstract interfaces of these digital media products. In particular, complex graphical interfaces, such as those found on personal computers and mobile communication devices, appeared to be highly problematic. It appeared that, for the most part, any discussion of cognition, or the 'mind', was ignored within design theory and practice as it related to human ageing. The result of the initial design projects was the development of a theoretical framework for the design of 'cognitively inclusive' digital media products; that is to say, they were designed in a manner to include the cognitive abilities of certain groups of users, in this case people between the age of 65 and 80.[12]

[11] These projects were documented by the author in a number of unpublished reports and a conference paper completed prior to this current research. See Vines (2007a) and Vines and Thompson (2007).
[12] Aspects of this later project, which was led by theoretically-informed practice, have been published in Vines and Thompson (2007).

The doctoral research set out to develop these earlier design projects, clarifying the theoretical underpinnings, ensuring the project met with the latest knowledge from the cognitive psychology of ageing. It was envisaged that useable design guidance for cognitive inclusion would be developed in the form of a series of guidelines, principles and tools, evidenced in the user-testing and in proofs of concepts and design prototypes. It was hoped, building upon the positives of the previous studies, that the doctoral research would add a small brick of knowledge into the wall of research attempting to resolve the problems of designing technologies in a period of a statistically-ageing population.

The thesis presented here, however, is rather different to the one imagined at the beginning of the PhD. The research proceeded with a greater examination of the cognitive psychology of ageing literature than that which formed the basis of the previous study. The cognitive psychology of ageing provided an abundant array of knowledge on changes to human cognition; a body of information accumulated over a period of more than 50 years. As the research developed, however, there was an increased awareness of the difficulties of incorporating knowledge from the cognitive psychology into digital media design practice. These issues have been highlighted by research within interaction design, where certain scholars have argued at length to marginalise cognitive psychology from the theory and practice of designing digital media systems. Whilst there has been an array of arguments for this discouragement, the most fundamental of all appeared to be the impoverishment of human agency, culture and meaning as a result of applying cognitive research straight to design.[13] The arguments from certain quarters of interaction design were profound and clear; cognitive psychology, formed upon a cognitivist philosophy of mind, was deeply problematic when applied both theoretically and practically in the design of digital media products and interfaces.

Just as problematic, however, was the inflexibility of the claims research cognitive psychology made about the functioning of the ageing cognitive system. Whilst the literature within cognitive psychology of ageing is useful in its disciplinary context, it becomes highly limiting once absorbed into design theory and practice. By using the cognitive psychology of ageing and associated concepts such as working memory within both the analysis of human-technological relationships, and, subsequently, altering the design of digital media products as a result, the designer immediately appeared to restrict the possibilities of action for the older individual. At its most severe, cognitive psychology research presents a situation where

[13] Arguments related to this issue will be unpacked in chapter four, where the thesis particularly draws upon the work of Suchman (1987; 2007), Dourish (2001) and Redström (2005).

older people cannot make sense of digital media, interfaces and products. Consequentially, any design response is automatically restricted, in some sense, to simplify and historicise novel products and interfaces. It appeared the thesis was now provided with a somewhat impossible question to answer without some obscure paradoxical reasoning; designing the novel for people who, it is claimed, cannot reason about the novel.

Just as cognitive psychology appeared to be highly questioned in design theory and practice, it was also noted that the claims of the cognitive psychology of ageing were becoming questioned by members of that discipline's research community.[14] Whilst cognitive psychology research suggests that people above certain ages would likely have significant losses in crucial cognitive functions, more critical members of the cognitive science community have questioned if this is so, as a great many older people appear to be perfectly cognitively capable and enjoy relatively active lives for their age. Although the case for a digital divide between younger and older people has resonance, and there might be a cognitive disconnection between older people and digital media, it appeared that the temporal changes occurring to human beings require a more subtle response from designers than those that currently prevail.

The manner in which this research started to question the cognitive psychology of ageing was further provoked by debates within cognitive science as to the fundamental basis of human cognition. Not only did cognitive psychology of ageing appear to lack applicability to experiential aspects of ageing, but the disciplines mode of study appeared to be founded upon an increasingly outmoded understanding of the human mind. Alternative models that examined the role of ecology, embodiment, neural dynamics, dynamic interactions and emergence were all revealing, yet somewhat distant from any sort of discussion about human ageing. There appeared to be usefulness in expanding these discussions into the realm of ageing in order to provoke an alternative perspective on the temporal changes to human cognition in later life; that of senescentechnics.

Historically, cognitive science and computer science have related well with one another. The disciplines had shared terminologies, methods, tools and a generally sympathetic mode of thinking about the world. Over the past two decades, many researchers, theorists, practitioners and scholars from human-computer interaction and interaction design have argued against this tight relationship with the cognitive sciences. Most of the arguments

[14] This refers to the emerging cognitive neuroscience research that is noting the highly plastic and reconfiguring physiology of the ageing human brain. This research, found in studies by Park *et al.* (Goh & Park, 2009; Park & Goh, 2009; Park & Reuter-Lorenz, 2009) and Cabeza (2002) is discussed in chapter six.

against the use of cognitive science research in the design of technological systems can be more specifically considered an argument against the older, cognitivist, models of cognition. Many areas of cognitive science have moved far beyond these models. Despite this, large areas of current interaction design ranges from the indifferent to the unfounded in their disregard for anything coming from cognitive science and its sub-disciplines. This thesis argues that issues emerging at the intersection of cognitive science, interaction design, and gerontology, would benefit from integrated conversation that transcends the boundaries of the individual disciplines and reintroduces aspects of cognitive science into theoretical and practical aspects of design research. In particular, a transdisciplinary[15] approach to this problem appears to profoundly highlight that one of the most commonly cited problems for designers of novel digital media products for older people—that of the failure of critical cognitive functions in old age—is rather false. Instead, it would seem the failure is that of designers of inclusive technologies who are 1) are not critical of the knowledge they draw upon from disciplines outside of their own and, 2) are unable to move beyond the traditions of the design disciplines and its tools and methods.

Why this thesis is important (and timely)

Building on the underlying narrative, this thesis provides a significant contribution of knowledge within an area of expertise that transcends the disciplines of inclusive design, interaction design, cognitive science and gerontology. The thesis brings together and synthesises knowledge from these disciplines in order to identify the underlying issues as to why design practitioners and theorists have struggled to connect older people to the design of digital media products and interfaces. Subsequently, the thesis opens the space for future

[15] Transdisciplinary is distinguished from multidisciplinary and interdisciplinary in this thesis through definitions provided by Basarab Nicolescu. Nicolescu states that '*Multidisciplinarity* concerns itself with studying a research topic in not just one discipline only, but in several at the same time. Any topic in question will ultimately be enriched by incorporating the perspectives of several disciplines. Multidisciplinarity brings a plus to the discipline in question, but this "plus" is always in the exclusive service of the home discipline. In other words, the multidisciplinary approach overflows disciplinary boundaries while its goal remains limited to the framework of disciplinary research. *Interdisciplinarity* has a different goal than multidisciplinarity. It concerns the transfer of methods from one discipline to another. Like multidisciplinarity, interdisciplinarity overflows the disciplines, but its goal still remains within the framework of disciplinary research. Interdisciplinarity has even the capacity of generating new disciplines, like quantum cosmology and chaos theory. *Transdisciplinarity* concerns that which is at once *between* the disciplines, *across* the different disciplines, and *beyond* all discipline. Its goal is the understanding of the present world, of which one of the imperatives is the unity of knowledge' (Nicolescu, 2006, p.145). Transdisciplinary is defined in greater detail in the following pages.

designers to develop resolutions to the problem through an alternative way of conceiving human cognitive interactions in old age.

The thesis is particularly important in its timeliness. The thesis is situated in a moment where the theory and practice of inclusive design appears to be significantly implicated in the social and economic response to demographic changes in various Westernised nations.[16] Inclusive designers, it appears, are thought to have some of the skills required to reconnect older people to digital media. At the same time, new ways of thinking about digital media technologies and human beings are being constructed that describes each as increasingly distributed, granular, dynamic and contingent. Problematically, inclusive design and critical conversations about human ageing are not just isolated from these debates but due to the theories, practices and assumptions underpinning ageing discourses, such radical discussions appear to be difficult to sustain.

The thesis provides an alternative interpretation of temporal cognitive change in order to open up new conversations about the problem of ageing human cognition and interactions with digital media products. This new way of thinking is argued to be necessary. Without it, inclusive design would continue to be trapped within a discourse that portrays the older people as requiring simplifications and nostalgic versions of digital media that, in normal circumstances, might be primarily designed for teenagers or middle-class white males. The thesis illustrates this by examining a contemporary strand of inclusive design—cognitively inclusive design—which can only respond to claims that older people are cognitively disconnected from digital media by constructing highly reduced models of their physical and cognitive abilities.

Beyond opening up a new perspective on human cognitive ageing, the thesis develops new synergies between the cognitive sciences and design fields. Although cognitive science and the design of technological systems has historically been a well-integrated field, in recent years design-orientated approaches to the development of technological systems have avoided entering discussions with those who scientifically study the human and artificial mind. This has most recently been evidenced in the growing issue of design scholarship actively eschewing the use of cognitive-esque models in design, instead reverting to traditional elements of designing.[17] This thesis does not oppose such critiques, but does

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[16] This is made in reference to the monumental evidence that populations in many westernised and industrialised nations are ageing, and that in many of these nations centres of design research and practice have been set up with a primary aim of developing products, services and goods that are better suited to this growing market.

[17] Some examples of such design research, usually contextualised within post-cognitivist theory and practice of interaction design, include (but are not limited to) Suchman (1987; 2007), Kaptelinin and Nardi (2006), Bannon

suggest that there is productivity in renewing the conversations between design (in particular inclusive design as it related to digital media) but not without a process of continual critical reflection upon the theories and practices of both disciplines. As this thesis suggests, design offers as much to cognitive science and the study of ageing cognition, as these fields offer insight to design.

Methodological approach

The methodological strategy of this thesis is that of transdisciplinarity, as defined by Nicolescu (2002; 2006). '*Transdisciplinarity* concerns that which *is* at once *between* the disciplines, *across* the different disciplines, and *beyond* all discipline. Its goal is *the understanding of the present world* , of which one of the imperatives is the unity of knowledge' (Nicolescu, 2002, p.44 - emphasis in the original). Nicolescu (2002) determined that a transdisciplinary approach to research requires the removal of boundaries between disciplines, with knowledge being understood in such a manner that it can manoeuvre fluidly from one discourse to the next. Nicolescu (2002) defined that transdisciplinarity was formed of three axioms.

> i. The ontological axiom: There are, in Nature and in our knowledge of Nature, different levels of Reality and, correspondingly, different levels of perception.
>
> ii. The logical axiom: The passage from one level of Reality to another is insured by the logic of the included middle.
>
> iii. The complexity axiom: The structure of the totality of levels of Reality or perception is a complex structure: every level is what it is because all the levels exist at the same time. (Nicolescu, 2006, p.148)

The implication of Nicolescu's axioms is that the distinguishing of clear boundaries between disciplines, ideas and sources of knowing are only temporary. Therefore, in trying to understand a particular problem, it is not always sufficient to centralise one's study with a particular mode of thought or, as Nicolescu terms it, reality. There are many ways to describe similar phenomena—similarly, very different phenomena can be described as one and the

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(1991), Bannon and Bødker (1991), Gaver (2009), Dourish (2001), and McCarthy and Wright (2004). Some of these authors offer critiques of cognitive-esque models of human being interacting with digital media system, whilst others provide alternative models and conceptions that are considered to afford more agency to the user. Rather than considering this thesis as a critique of these works, the argument developed to inform senescentechnics should be considered somewhat extending and developing the arguments provided by these numerous authors.

same. Different perspectives on related problems can exist alongside one-another and be navigated by a researcher sensitive to the differing ontological and epistemological contexts that inform certain research trajectories. This is emphasised by Nowotny *et al.* (2003, p.186), who propose that transdisciplinary means the:

> mobilization of a range of theoretical perspectives and practical methodologies to solve problems. But, unlike inter- or multi-disciplinarity, it is not necessarily derived from pre-existing disciplines, nor does it always contribute to the formation of new disciplines. The creative act lies just as much in the capacity to mobilize and manage these perspectives and methodologies, their 'external' orchestration, as in the development of new theories or conceptualisations, or the refinement of research methods, the 'internal' dynamics of scientific creativity. In other words, [transdisciplinary] knowledge is embodied in the expertise of individual researchers and research teams as much as, or possibly more than, it is encoded in conventional research products such as journal articles or patents.

Drawing upon the proposals of Nicolescu (2002; 2006) and Nowotny *et al.* (2003) perspectives, a transdisciplinary perspective on the problem of the cognitive disconnect between older people and digital media, therefore, provides a rather different mode of knowledge output to research that would be fully situated within a design discipline. In terms of this thesis, using a lens developed through research with cognitive science, philosophy of mind, and gerontology, as well as design, provides a basis with which new questions are raised for future design practice and theory to reflect upon.

Although used as a strategy for completing this research, the basis of transdisciplinary also appears to be sympathetic to the problems that have emerged as this study has progressed. As will become clear throughout the text, an increasing discontent is developing within areas of design research, the cognitive sciences and associated disciplines with approaches that focus on closure.[18] Although this discontent is becoming increasingly wide-spread and holistic and fluid discussions are opening up within these disciplines, rationalistic, dualistic and linear frameworks and models can still be found in much contemporary literature. This is particular evident within areas of design that have dealt with the co-development of knowledge between inclusive design and the cognitive psychology of ageing. As this research has developed, it became increasingly clear that the boundaries between disciplines are frequently a point of friction in the development of explanations of problems. In terms of the interactions between inclusive design and cognitive psychology, it often appears that designers misinterpret, simplify or are critically unaware of the implications of

[18] This will be discussed at various points throughout chapters five, six, seven and eight.

the knowledge they transfer from the sciences, or the cognitive scientists' attempt to become the designer. Rather than attempting to attain the closure that both the contemporary methods these fields appear to employ, this thesis argues that openness is useful both in terms of creative approaches to the design of novel digital media products and as a way of conceiving the temporal changes to the cognition of older people.

Rather than attempting to locate this thesis' analysis in terms of primarily design or cognitive science, this research navigates a middle-way between the two, whilst also not discounting connections to related ideas and discourses. Literature has been surveyed as a result of its relevance to the problems inclusive design practitioners and theorists encounter when dealing with the issues of ageing human cognition, and also for its relevance to providing a possible route out of the problem. Most of the literature used within this thesis can be concretely situated within the broad design discipline, gerontology or the cognitive sciences. Literature and ideas from other disciplines are integrated into the conversation in order to add depth and support transactions from one moment to the next.

The study has operated in terms of a continuous reflective and creative practice (Moon, 2004) in which theories and practices are surveyed and analysed in reference to the situational moment of the study in order to provide insight and add to or take away from the conversation developed thus far. With each development in this conversation, questions are answered and new questions emerge that require the continuation of the narrative. Therefore, this thesis is not an intervention directly into design, although it is possible to read it as one.[19] Building upon Nicolescu's framing, this thesis is equally an intervention in gerontology, cognitive science and the philosophy of mind, situated in a nexus between these traditions and design. Consequentially, the response to the issue of human cognitive ageing and the design of digital media products within this thesis is distant in its form to a thesis within which the intervention is completely situated in design, cognitive science or gerontology.

As noted in the previous section, this thesis was initially considered a more traditional design doctoral thesis. The problem had been identified; the literature surrounding this problem context had been surveyed; a possible theoretical route out had been identified. All that was necessary was the execution of the practice element of the study, which was to

[19] Although this thesis argues in favour of openness and interpretation, at the same time it is a doctoral thesis embedded within the institutional framework of a western European academic system founded upon the English language. There are certain points where closure and concrete terms, in relation to the argument documented in this thesis, are required. In the final chapter the thesis more specifically focuses upon the relevancy of the theory developed in this research to the wider inclusive design community, suggesting a study intervening solely on this subject area. Whilst this thesis intervenes specifically within a small area of inclusive design, it is important to highlight how the understanding of cognition, interaction and ageing developed throughout is always an interactive process between relevant disciplines.

explore the theoretical framework through an iterative process of designing technological prototypes. Although the thesis presented here is rather different to this earlier iteration, the manner in which it is structured resembles on some levels what may be expected of a practice-based design thesis, albeit with the word-count requirements of a theoretical endeavour. As documented in this thesis, chapters one, two and three can be read as what would typically constitute the contextualisation of the problem domain and a review of literature within the identified relevant fields and an examination of practices that have gone before. At this point, this thesis diverges from what might constitute a traditional practice-based design thesis. In terms of a traditional thesis, chapter four might explain the methodological approach of the following practice, whilst any following chapters might be documentations of this practice, its successes, its failures, and its conclusions, and a short final chapter may summarise the overall conclusions and provisions for future research. This thesis diverges from this tradition having outlined the problem domain. Instead, chapter four provides a critical reflection upon the contemporary research within the interacting disciplines of inclusive design and cognitive psychology to highlight how what is often assumed to be a problem is instead an inevitable flaw in the knowledge base and methodologies of contemporary inclusive design and cognitive practice. The chapters that follow this open up new discussions for future designers, cognitive scientists and gerontologists—or those from a transdisciplinary in-between—to build upon.

The thesis in outline

This thesis is divided into eight chapters with an appendix. Within the main text each chapter is introduced through a question and brief summaries of the component sub-sections.

Chapter one contextualises the thesis within Western European society where inclusive approaches to design are implicated as part of a strategic response to claims that older people are somewhat disconnected from the adoption of digital media products. Whilst many older people are apparently willing to engage with digital media, the methods and processes of inclusive design are limited in providing a thorough account as to why this disconnection continues to exist. Chapter one explains how designers of digital media products are drawn to scientific analyses of human ageing as it relates to technology. A significant corpus of knowledge that examines the problems older people appear to have when interacting with digital media products and interfaces is provided by the field of human factors. Human factors studies have been useful for designers of digital media in providing evidence of the problems older people have connecting with particular types of computing technology and associated media, along with explanations as to why these problems occur as a result of age-related changes to human beings. Chapter one concludes by explaining how human factors studies often repeat the significance of temporal changes to cognition occurring in old age in the inability on the part of older people to connect to digital media products and interfaces.

Chapter two brings together a number of loosely affiliated research projects into an approach that is defined within this thesis as cognitively inclusive design. Cognitively inclusive design specialises in providing a response to the claims that temporal changes to cognition make it difficult for older people to connect with digital media. Returning to the human factors literature, the chapter explains how attempts have been made to provide assistance to designers in the form of guidelines, specifications, methods and tools in order to alter complex digital media products and interfaces to be better suited to ageing cognitive functions. Although the advice provided by the human factors literature is concrete and robustly evidenced, the thesis argues that this approach is lacking in regards to designing completely novel digital media products. The limitations of the human factors literature is reflected in four design-orientated projects dealing with the issue of designing cognitively inclusive digital media. The recurring theme within the four discussed projects is that in order to ameliorate the cognitive disconnection between older people and novel digital media, it is necessary to reference historical forms of interaction. The examples of recent design research are used to highlight the problems designers appear to have in developing responses to cognitive ageing that do not focus upon harnessing past models of interaction. These four examples provide a number of concepts, tools and methods that exploit the principle that older people are a storehouse of long term memories, which can be harnessed to compensate for the deteriorations in working memory and fluid intelligence. Chapter two concludes by summarising the key principles of cognitively inclusive design through an example of the authors past digital media design practice.

Chapter three examines in more detail what the term 'cognition' refers to in contemporary cognitively inclusive design literature. The chapter begins by providing a historical context for the cognitive psychology of ageing research that is used within cognitively inclusive design. The chapter establishes how much of this research applied in cognitively inclusive design is founded upon the cognitivist philosophy of mind. Cognitivism became the dominant theory of mind during the formative years of the cognitive sciences in the mid-twentieth century. Cognitivism, which developed in a virtuous circularity with early computational science and artificial intelligence research, is based upon the primary principle that the human mind is a processor of information. Therefore, much of cognitivist psychology has historically focused upon identifying, defining and elaborating the functional systems of cognition where certain processing is performed. The study of human memory is used as a key example of how an information processing perspective on the mind leads to the reduction of cognition into modular, discrete sub-systems. The cognitive study of human memory is particularly important in informing the claims that older people are disconnected from novel digital media. The prevailing claims of the cognitive psychology of ageing suggest that functional systems such as working memory and fluid intelligence—which are instrumental to the encoding and retrieval of complex memories, and are required to transform short-term memories—reduce in efficiency in old age. Chapter three concludes by arguing that the prevailing claims of the cognitive psychology of ageing present a situation where older people, in general, are understood to be poor processors of novel information; they are, however, powerful storehouses of long term knowledge. Reflecting upon the findings in chapter two and three, it appears that reductionist cognitivist philosophy underlying some of the work within the cognitive psychology of ageing are absorbed verbatim into cognitively inclusive design.

Chapter four examines cognitively inclusive design in light of the broader context of research on interactions between people and complex digital media systems. The thesis argues that a central theme of cognitively inclusive design is a process of predicting the (cognitive) behaviours of older people, inscribing these predictions into a designed outcome, and subsequently concretely prescribing how an older user interacts with a digital system. The process of prediction, inscription and prescription is problematic within the context of interaction design at both a practical and pragmatic level. Observations of digital media systems in-use appear to highlight how prescriptions made by designers based upon cognitive modelling of people fail to account for the emergent, contingent and situated nature of the everyday use of technologies. These practical failings are often a result of the philosophical stance of the designer, who has traditionally been considered as a manager of the couplings between people and technology in an *a priori* fashion. The fascination with prediction, inscription and prescription within cognitively inclusive design is established to be a result of a broader fascination in design to construct models of users in order to generate design outcomes. In the design process these constructions of the user become somewhat fixed, which reduces the agency of the user to objective properties to be designed for. The history of digital media, however, overwhelmingly suggests that individuals and communities of people are dynamic agents, appropriating and reforming technologies in ways that are unpredictable and surprising to experts such as designers. The inability of cognitively inclusive design to move beyond concrete constructions of older people is interpreted to be the result of designers requiring fixed points of reference with which to resolve the issue of cognitive disconnection. Temporal changes to cognition, however, require a response from design that is sensitive to the provisional and transient nature of human cognition in later life; in this context, fixed points of reference are highly problematic. As it stands, cognitively inclusive design struggles to deal with the limitations identified in this chapter as a result of drawing heavily from the cognitive psychology of ageing, which is the dominant domain of knowledge on changes to the ageing mind. Chapter four closes by defining five statements with which to begin exploring an alternative to cognitively inclusive design that moves beyond a discourse of cognitive deterioration and the impoverishment of the agency of older users of technology, an approach that is coined senescentechnics by this thesis and developed in the following chapters.

Chapter five returns to the cognitive sciences in order to identify alternatives to the cognitivist information processing paradigm that are useful in developing an account of senescent cognition. This chapter begins by arguing that it is possible to conceive of human cognition as inseparable from the human body and environment, encompassed within a particular individual's *Umwelt* (von Uexküll, 1957). In considering the inseparability of these systems, cognition comes to be understood as an experiential component of the pragmatic interactions of the human body within ecology. James Gibson's ecological psychology and theory of affordances is introduced as an influential alternative to cognitivist information processing that emphasises the dialogical nature of human perception and action with the environment. Although the theory of affordances has been used at length within design theory and practice, it is argued that these discussions are unhelpful as a consequence of its distance from Gibson's original ideas. Following this, it is proposed that it is useful to develop these concepts from their original definitions rather than as it is popularised by design literature. The chapter goes on to use Gibson's concepts as an entry point to understanding robotics and artificial intelligence research, which exemplifies how there is a necessity for coherence within the *Umwelt* in order for an economy of cognitive functioning to emerge. The arguments made by a number of robotics researchers are best understood in terms of an enactive approach to understanding human cognition. Enactivism, as developed by Varela *et al.* (1991), defines cognition as a dynamic capacity of human beings to bring forth a world based upon a historical network of structural couplings between brain, body and world. The enactivist perspective places new demands on Gibson's original definition of affordances and the manner in which it is applied in design literature. As a consequence of this discussion, the chapter draws upon recent developments of the theory of affordances that proposes affordances to be dynamic, relational, and primarily experiential aspects of human cognition that are in continual flux. The chapter concludes by arguing that whilst the dynamic account of human cognition appears to offer a useful alternative to traditional cognitivist accounts, it is still necessary to examine how this understanding relates to moments when the *Umwelt* is not coherently enacted, and the relevancy this has to the cognitive disconnections older people appear to encounter with digital media, which is attended to in chapter six.

Chapter six introduces the concept of senescent cognition, which is used to provide an alternative description of the cognitive disconnections between older people and digital media through a dynamic and enactive account of temporal changes to cognition. The chapter opens by discussing phenomenological accounts of individuals encountering moments of disruption in their embodied abilities to coherently enact their *Umwelt*. Through the work of Shaun Gallagher and Alva Noë, this chapter shows how subtle changes to the structure of human embodiment have subsequently subtle, yet significant, consequences on the manner in which the dynamics of brain, body and world are integrated. Gallagher and Noë's research highlight the fragile nature of the integrative systems of human cognition, which might normally be considered as rather robust, and provide a basis for understanding cognitive disconnections in a senescent account of cognition. The critical lens provided by Gallagher and Noë is used as an entry point to reinterpreting more traditional cognitive psychology research that has examined the interconnections between cognitive, sensory and physical ageing. These studies, still influenced by the cognitivist tradition, have attempted to identify the components of the ageing body and brain that deteriorate and how other components compensate for this. If understood in terms of what this thesis defines as senescent cognition, however, the observations made by these studies highlight how one consequence of human senescence is the sudden decoupling of previously highly integrated and dynamic systems that bring coherence to cognitive experience. This alternative explanation maintains that older people, when understood in terms of senescence, enter a process of subtle yet continual experiential blindness in terms of how experience is cognized. The thesis acknowledges that it is difficult to take this argument seriously as a result of the dominant prevailing claims that the ageing human being, and their brain, is in a state of sudden and continual deterioration. This assumption, however, has been questioned by emerging neuroscience research, which has observed that the brain and central nervous system actively reorganises itself as a result of perturbations to its system—even in old age. Chapter six closes by providing an example of a senescentechnic explanation of cognitive disconnection that highlights the limitations of the contemporary cognitively inclusive design approach defined in chapter two. Rather than dwelling on limitations to information processing functions and harnessing storehouse metaphors of long term memory, senescent cognition requires a response from designers that harnesses the agency and potential abilities of the embodied and enacting older person.

Chapter seven examines the implications that a senescent account of cognition has on the stance of the designer and how affordances are conceived in a design process. It is argued that, as a result of the discussion in the previous two chapters, the concept of affordances when used in reference to senescent cognition requires the eschewing of closure, as far as it is feasible, in the design outcome. If designers are to afford the reintegration of cognitive experience—to afford the continued enactment of a coherent *Umwelt*—then it is necessary to move away from design activities that focus upon the construction of concrete users interacting with concrete products. Instead, designers must explore the broader and dynamic spaces that affordances emerge and disappear in, passing certain questions about the details of usage to the user. Chapter seven proceeds to explain four broad spaces for the design of future digital media products that allow older users to explore localised affordances that support the continued enaction of senescent cognition; affordances of self-perception, affordances of ongoing co-design, affordances of balanced self-efficacy, and affordances of self-(re)organisation. The chapter closes by arguing that senescentechnics requires designers to have a sensitivity to the agency of older people as having intentional control over both their embodiment and interactions with digital media products; designers must consider the ongoing process of wear between people and technology, and how digital media wears with older people rather than treating older people as wearing out.

Chapter eight reflects upon the argument of the thesis within the broader context of inclusive design and design research. The chapter touches upon how the problems identified within cognitively inclusive design are replicated on a meta-level within the practice and theory of the broader discipline of inclusive design. It is noted how inclusive design, although considering more experiential models of the use of technology, continues to be restricted to constructing a fit between people and technological media. The chapter goes on to briefly touch upon examples of current design research that support bridging the gap between current inclusive design practice and theory, and the senescentechnics approach developed within the thesis. Following this, the thesis is concluded by reflecting upon these negotiations in light of the senescentechnic approach to understanding the problem of the cognitive disconnection between older people and digital media products, highlighting the relevancy of transdisciplinary investigations to examining design-related problems, and providing speculation for the direction of future research.

An appendix is provided comprising papers presented and published during the period in which this research was performed.

Chapter 1

Ageing, digital media and the cognitive disconnect

Question: Is there evidence of a disconnection between older people and novel digital media products and interfaces, and, if there is a disconnection, how might a designer proceed?

1.1. Although laden with contradictions, there is research suggesting that older people appear to be somewhat disconnected from the adoption of novel digital media-based products and services, despite showing a willingness to engage with them.

1.2. Inclusive design can be understood as an informal community for designers to discuss issues related to older people being disconnected from the design of digital media products, yet is limited in providing a resolution to the problem.

1.3. Beyond traditional design disciplines, the human factors community appears to be particularly useful to designers of digital media technologies due to providing evidence as to both the problems older people have connecting with technology and why these occur.

1.4. Temporal changes to human cognitive functioning appear to be significantly implicated within the problems older people are observed as having connecting to digital media products and interfaces.

1.1. Human ageing and disconnection from digital media

Although laden with contradictions, there is research suggesting that older people appear to be somewhat disconnected from the adoption of novel digital media-based products and services, despite showing a willingness to engage with them.

Whether there is a relationship between human ageing and a disconnection with digital media appears to be a rather polemical discussion. On the one hand, there is evidence that digital media is increasingly used and interacted with by groups of older people; on the other hand, there is research suggesting a digital divide between young and old in many Westernised nations. For example, recent government statistics within the United Kingdom have documented that between 2008 and 2009, 'the largest increase in the proportion of those accessing the Internet was in the oldest age group' (National Statistics, 2009). This view is repeated by a study performed by Microsoft in the United States, suggesting that the use of digital media technologies in old age is the result of generational population characteristics.

> People who range from 55 to 64 years old today currently use computers in the workplace at a higher rate than people in their 60s and 70s did at earlier ages. As current 55- to 64-year-olds mature into their 60s and 70s, they will continue to use computers. Therefore, in 10 years, there will be 2.5 times as many adults who range from 65 to 74 years old using computers as there are today. (Microsoft, 2003)

The above argument prevails in the earliest studies of the adoption of digital media and technologies, such as personal computers[20], by older people in the United States. Adler observed that although there were significant differences in the numbers of middle-aged and older people adopting computing technologies, it was predicted that 'within a few years, penetration of PCs among older adults will be virtually indistinguishable from that in the general population' (Adler, 1996). The view prevailing in studies such as these is that although there is an apparent disconnection, or digital divide, between older people and digital media, it is a generational characteristic. As such, the problem of disconnection from digital media in old age no longer manifests once the problematic generation cease to be.

One of the limitations of this generational perspective appears to be the lack of consideration of current generations of older people as active participators with both well-established and novel digital media technologies. The generational perspective is contended by Fisk *et al.* (2009, p.241) who argue that:

> [o]lder adults are active users of technology, and designers should think of them as a viable user group. [...] Older adults are willing users of technologies if [...] the benefits are clear to them, [...] they receive adequate instruction about how to use the system, and [...] the system itself is easy to use.

Fisk *et al.* (2009) argue that not only are older people active users of digital media but they are active learners of technologies they have not previously experienced. Fisk *et al.* concede, however, that there are significant barriers for an older person attempting to incorporate

[20] Many of the studies discussed in this chapter focus upon the use and adoption of personal computers and by older people. These studies are particularly important in terms of understanding some of the issues related to human ageing and the disconnection from digital media products. Personal computers and networked information and communication technologies (ICT) are useful to this thesis due to their prevalence as an object of study and their complex, representational, design. At the same time, it is important to highlight how this thesis is not focusing primarily on personal computing and associated technological infrastructures (such as broadband internet and wireless networking) or media (such as email clients or digital media players).

digital media into their everyday activities.[21] 'There is always going to be new technology and there are always going to be age-related changes' to human beings beyond huge medical breakthroughs (Fisk *et al.*, 2009, p.245). 'Even future older adult cohorts will be faced with learning to use new technologies because it is not possible to foresee what the future will bring in terms of technology changes in the next few decades', whilst the '[e]xperience with today's technology may not transfer at all to the use of tomorrow's technology' (Fisk *et al.*, 2009, p.245).

A perspective on the disconnection between older people and technology based upon generational determinism is difficult to take forward if older people are to be understood as active participators with technology, and technology itself is conceived of in terms of a continuously altering state. This is not to argue that there is no relationship between human ageing and technological disconnection. As Fisk *et al.* (2009) allude to, there appears to be a relationship with certain processes of ageing that makes connections between older people and digital media somewhat complicated. Some of these complications are highlighted by the comments of older users of personal computers in a study performed by Goodman *et al.* (2003).

> Sometimes I get into difficulties such as not understanding certain terms or which buttons to touch. [...] I dislike the amount of information you need to digest in order to do quite simple things. [...] I find it now too complicated. [...] Little support for older person like me to gain help. My son is fed up with me phoning for help, so I try not to bother him. (Goodman *et al.*, 2003, p.3)

Goodman *et al.* (2003, p.3) noted that the problems detailed above were seemingly related to the complexity of the computer applications people used, a problem heightened by the use of 'too much jargon and inadequate support, both during learning and on-going use'. For Goodman *et al.* (2003) the confusion resulting from complexity of digital media provided a significant barrier to successfully incorporating the computer interface into everyday activities.[22]

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[21] Although Fisk *et al.* (2009) refer to technologies during their text, they specifically focus upon the role of information and computing technologies, highlighting some of the implications of older people interacting with digital media.

[22] The observations made by Goodman *et al.* (2003) have been noted by many. For example, Fairweather (2008) observed that older people had a tendency to get lost in more complex websites when attempting to find specific information than younger people. Fairweather suggested that part of this issue was the result of an inability to track the hyperlinks they had entered during their time on the website. Similar observations were made by Neerincx *et al.* (2001), whom noted older people were more likely to become disoriented by complex navigations on internet browsers. Zajicek (2007) and Chadwick-Dias *et al.* (2007) suggest that digital media

Despite some of the earlier predictions that older people being disconnected from the uptake and use of digital media would erode over time, more recent studies have highlighted how there still appears to be a digital divide between young and old—for example, accessing broadband internet from home (Ipsos MORI, 2009; Jones & Fox, 2009). It has also been noted that older people that do use digital media and technologies tend to restrict their participation to relatively basic activities, such as simple web-searches and sending emails (Hanson *et al.*, 2010; Jones & Fox, 2009). Although the literature examining the relationship between human ageing and digital media is polemic, there appears to be weight to the claims that some processes associated with ageing are related to a disconnection between older people and digital media products. Before attempting to reconnect older people with digital media, designers may find it useful to understand more fully the underlying reasons for this disconnect. The polemic nature of the evidence, however, makes it complicated for designers to proceed. Opportunistically, however, design communities have developed over the previous decade that attempt to provide the tools and methods for designers to reconnect older people and technology.

1.2. Inclusive design communities

Inclusive design can be understood as an informal community for designers to discuss issues related to older people being disconnected from the design of digital media products, yet is limited in providing a resolution to the problem.

A designer attempting to examine the reasons why contemporary digital media products appear to be disconnected from older people may initially look towards their own discipline's corpus of knowledge in order to find an explanation. Over the past ten years, design practitioners and theorists have come together to form a community referred to as inclusive design.[23] This community, in terms of design sub-disciplines it serves, is highly broad; the conference series and web resources[24] that support this community comprise of product design, graphic design and visual communication, architecture, interaction design and

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delivered through dynamic web technologies and web 2.0 may increase the problems older people have navigating and coming to terms with complex web interfaces.

[23] Inclusive design is the common name for this philosophical approach to designing in the United Kingdom. In continental Europe and the United States the same approach is often called universal design, whilst the term design-for-all is also used (tiresias.org, 2009).

[24] Although the inclusive design community is not particularly formalised, conferences such as the biennial Include conferences (Helen Hamlyn Centre, 2010a), web resources such as the inclusive design toolkit (www.inclusivedesigntoolkit.com) and organisations such as the Helen Hamlyn Centre (Royal College of Art, London, UK) and The Centre for Universal Design (NC State University, Raleigh, NC) provide points where this community of designers becomes more grounded.

human-computer interaction, fashion design, and more.[25] The ideas underpinning inclusive design have become increasingly popularised in recent years within design literature as a way of avoiding the exclusion of older people in the decisions made in the design process.

In order to more fully understand inclusive design it is necessary to recognise what it is an intellectual response to. Central to inclusive design is an approach known as people-centred design.[26] People-centred design is founded upon understanding the individuals that are intended to experience the designed product or service on a regular basis (Department of Trade and Industry, 2004). The people-centred approach is not a design method as such but a critical move to ensure that the needs and requirements of people are considered from the start of the design process, rather than being an afterthought of technological innovation and styling (Department of Trade and Industry, 2004).

The people-centred approach to design is not a novel approach; for example, Redström (2005) suggests that the shift towards focusing on aspects of the user in the design of consumer products is most dramatic in early modernism, whilst Krippendorff (2006) characterises that the design discipline, in general, has evolved with an increased attentiveness to human rather than technological concerns. It is often the work of Henry Dreyfuss, however, that is used as evidence of a point of departure in industrial design history where people became centralised as the focal point of design. It appeared that, before Dreyfuss, people were an incidental component of interactions with designed technologies (Miller *et al.*, 2004). For Dreyfuss (1955 [2003]), the key component of all his design activities was that they were to be used by people; cars are driven, radios are listened to, buildings are walked around.

> If the point of contact between the product and the people becomes a point of friction, then the industrial designer has failed. If, on the other hand, people are made safer, more comfortable, more eager to purchase, more efficient – or just plain happier – the designer has succeeded. (Dreyfuss, 1955 [2003], pp.22-23)

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[25] This list could continue as long as there are fragmented design disciplines to note down. It is suggested within literature that inclusive design is not yet another fragmentation of design but rather a meta-perspective that should be incorporated into any specific design approach (Coleman *et al.*, 2007a).

[26] An examination of the Helen Hamlyn Centre website provides numerous references to people-centred design as the key component to an inclusive philosophy to designing. Within their literature, however, people-centred design is never explicitly defined. Problematically, people-centred design is sometimes referred to in literature (but not by the Helen Hamlyn Centre) as human-centred and user-centred design. In some cases, the distinction is merely semantic. As Buchanan (2001) highlights, however, there are crucial differences between design for people, humans, or users. This issue is complicated further by there being a myriad of possible definitions of people, humans and users.

Dreyfuss' (1955 [2003]) introduced Joe and Josephine as typifications of the male and female human body to be considered in the design of any industrial product to be used by people. Dreyfuss (1955 [2003]) signalled a move towards constructing representations and models of what constitutes human beings, with the design process acting in response to this knowledge. In understanding the constituting elements of human beings, it was suggested that designers can develop products and interfaces to be less intrusive and provide greater support to what it is to be human.[27]

In terms of the philosophy of inclusive design, however, the values that Joe and Josephine appear to represent are problematic. As Miller *et al.* illustrate:

> [t]he way they created Joe and Josephine was to make thousands of measurements of Americans and then simply come up with an average figure for everything from size to reach, strength to agility. At the time this was a great leap forward – actually designing objects around people was a novelty, with most machines designed by engineers more interested in what was easy to make rather than what was easy to use. But the process of designing for the middle, the average person, has driven mass marketing and mass consumerism ever since. (Miller *et al.*, 2004, pp.55-56)

As such, Dreyfuss' archetypes appear to 'imply that people come in standard sizes and proportions and are all healthy and able-bodied' (Porter *et al.*, 2004, p.250). Human beings, however, do not come in standard forms, and the discourse surrounding inclusive design is an attempt at broadening this perspective beyond the typical white, middle-class user of a technology. Miller *et al.* (2004) recall a discussion with then Helen Hamlyn Centre co-director Jeremy Myerson, who explains the concept of inclusive design.

> He draws two circles – one inside the other – in his notebook. 'Instead of designing products for this tiny group of people who are "average",' he points to the smaller circle in the middle, 'you design them for everyone.' He moves his pen out and taps it on the far larger circle. (Miller *et al.*, 2004, p.54)

[27] Somewhat problematically, the concept that designers can somewhat design for human beings requires a specific understanding of what it might mean to use the word 'human'. This is highlight by Richard Buchanan's (2001) alternative interpretation of user/human/people-centred design. Buchanan (2001) argues that designers should not centre the human as the focal point of their design in terms of usage or experiences, but instead in terms of human dignity. Buchanan's argument highlights how it is possible to design in response to knowledge about human beings without necessarily improving the lives of those who may use or interact with the resulting products and services. Using the example of Robben Island, Buchanan notes how designing based upon data about people may be critically and ethically flawed if not grounded in a primary principle that heightens awareness to the necessity to improve the dignity of people. Although this thesis does not specifically develop Buchanan's account, it will be highlighted in chapter four how although some designers developing inclusive digital interfaces may be improving certain aspects of usability for older users of digital media, a broader perspective highlights how the dignity of the user is lacking any consideration.

Although people-centred design may be a key theme of inclusive design, the philosophy of inclusivity appears to reach beyond reductions to specific types of users. A more formal definition of this attribute of inclusive design is found on the Helen Hamlyn website:

> Design of mainstream products and/or services that are accessible to, and usable by, people with the widest range of abilities within the widest range of situations without the need for special adaptation or design. (Helen Hamlyn Centre, 2010b)

This research focus of the Helen Hamlyn Centre has lead to the development of a British Standard for inclusive design in 2005, which 'provides a strategic framework and associated processes by which business executives and design practitioners can understand and respond to the needs of diverse users without stigma or limitations'[28] (British Standards Institute, 2005). This standard has been augmented by the provision in the public domain of an 'inclusive design toolkit' to support designers in the development of inclusive products and services.[29] The broader philosophy of inclusive design, then, is that designers are required to construct a broader picture of the type of people they are designing for and ensure that their designs are as usable to as many people as feasibly possible.

How might such an inclusive approach be implemented? Within the inclusive design toolkit, it is suggested that the designer may proceed from the identification of a perceived need resulting from a 'newly identified market opportunity', the 'availability of a new technology' or a 'requirement to update or repackage an existing product or service' (i~design, 2008a). From this, the designer can go through a series of phases in order to accomplish an inclusive design. These are laid out as four key stages:

> Discover: The systematic exploration of the perceived need to ensure the right design challenge is addressed, with due consideration of all stakeholders; leading to the first output, an understanding of the real need
>
> Translate: The conversion of this understanding into a categorised, complete and well defined description of the design intent; leading to the second output, a requirements specification
>
> Create: The creation of preliminary concepts that are evaluated against the requirements; leading to the third output, concepts.
>
> *Develop: The detailed design of the final product or service, ready to be manufactured* or implemented; leading to the final output, solutions. (i~design, 2008b)[30]

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[28] Bristish Standard code BS 7000-6:2005.

[29] The full inclusive design toolkit, cited also within the text, can be found at www.inclusivedesigntoolkit.com.

[30] This is just a brief explanation of the inclusive design process. The inclusive design toolkit webpage provides a more detailed, step-by-step guide to this process.

The above quotation portrays inclusive design as a cohesive and systematic approach to developing design solutions to the needs of large groups of people. It appears, however, that in actual examples of inclusive design projects this portrayal of a cohesive methodology for inclusive design is somewhat false. An examination of the proceedings of the biennial Include conferences suggests that inclusive design can be observed instead as an informal network of individually specialised research projects. Rather than focusing upon inclusive projects that consider as many stakeholders as is feasibly possible, inclusive design publications are characterised by focusing mostly upon issues related to older people or certain groups with disabilities (Donahue & Gheerawo, 2009). As such, inclusive design, as it is practiced and documented, has a tendency to be rather un-inclusive. Donahue and Gheerawo (2009) note how in the cases where designers have examined more closely older or disabled users, standardised images of all people from that group are still formed and translated into the designer's solution.

Figure 1 BT Big Button 100 Phone © 2006 British Telecom

The British Telecom Big Button phone (Figure 1) is an often referred to example of good inclusive design practice. The large buttons mean it is easier to dial a number; the red light visually alerts someone when it is ringing, rather than relying purely on audible perception; the larger buttons lead to larger printed numbers with high contrast, making them easier to read. If we take inclusive design as a response to Joe and Josephine, however, the Big Button phone is just as problematic. The phone is the designed response to an averaged account of the tactile, visual and aural competencies of a certain group of older or physically impaired people. In a rather tautological manner, the inclusive designer attempts to resolve the problems of traditional people-centred design through the very same process of designing; in their attempt to distance their practice from the heritage of Joe and Josephine, the designer commits to the same reductions.

Thompson (2008) highlights how design communities form in order to bring a level of solidity to a shared problem that may actually be somewhat uncertain. Whilst the inclusive design community acknowledges a shared problem in developing products and services for people of differing levels of ability, its individual members appear to struggle in managing the chasm between the generality of inclusive design and the idiosyncrasies of projects emphasising the needs, requirements, and abilities of specific groups of people. One would expect to find that the individualised nature of inclusive design projects presents opportunities for a designer to understand why older people appear to be disconnected from digital media products. An examination of this literature, however, appears to be lacking any critical conversation on this matter. As a community, inclusive design is useful to this thesis since it brings attention to the issue of designing for groups of people, such as older people, who may normally be neglected by designers. At the same time, inclusive design is limited in providing knowledge as well as tools to greater interrogate the disconnection between older people and digital media. As highlighted within the inclusive design toolkit, many designers often assume:

> that the perceived need accurately represents the true problem. However, experience shows this is not always the case, it being easy to provide a solution to meet the wrong need. A thorough exploration of the design context will ultimately lead to the identification of the real need. (i~design, 2008a)

Whilst the inclusive design toolkit suggests that designers often jump to conclusions regarding the identification of problems to be resolved, it may be that the tools and methods of inclusive design are somewhat restrictive in providing a fuller examination of the disconnection between older people and digital media. One way to interpret inclusive design is as a hysterical reaction to the changing social milieu of Westernised nations. Rather than examining the underlying reasons for disconnections between marginalised groups of people and the design of digital media products, inclusive design reaffirms a common process of designing. The inability of the inclusive design community to provide a comprehensive account of human ageing and the disconnection with digital media has led designers of digital media products to look elsewhere for instruction. In particular, some designers have proceeded to draw upon examinations of the points of friction between older people and digital media interfaces, somewhat continuing the legacy of Dreyfuss' (1955 [2003]) Joe and Josephine.

1.3. The human factors of ageing and digital media

Beyond traditional design disciplines, the human factors community appears to be particularly useful to designers of digital media technologies due to providing evidence as to both the problems older people have connecting with technology and why these occur.

An established body of research that designers refer to when dealing with the disconnection of older people from digital media is the discipline of human factors. Rogers and Fisk (2003, p.2) state that '[h]uman factors researchers aim to match the demands of a system to the capabilities of the user' (illustrated in schematic form in Figure 2).[31] Rogers and Fisk continue to comment that:

> The system imposes certain demands on the user as a function of the characteristics of the hardware, software, and instructional support that is provided for it. The operator of the system has certain sensory/perceptual, cognitive, and psychomotor capabilities. The degree of fit between the demands of the system and the capabilities of the user will determine performance on the system as well as attitudes, acceptance, usage of the system, and self-efficacy beliefs about one's own capabilities to use that system. (Rogers & Fisk, 2003, p.2)

Human factors research provides an abundant body of knowledge of key issues related to the relationships between older people and digital media. Human factors researchers investigate the underlying issues that cause the difficulties certain groups of older people are observed as having interacting with digital media products and interfaces. Frank Schieber (2003, p.42) notes that human factors research often means understanding, among others, the 'anthropometry, biomechanics, sensory process, and cognitive psychology' of the specific user group.[32] The human factors approach to understanding ageing and technology has

[31] A large contributor to the human factors study of older people is the research performed at the Center for Research on Aging and Technology Enhancement (CREATE). CREATE is formed through a consortium formed by the University of Miami, Florida State University, and the Georgia Institute of Technology.
[32] Human factors approaches to discussing the problems older people encounter when interacting with digital media are, typically, communicated in a manner that is more focused upon the scientific basis from which

specific methods of identifying the limitations in the 'person-environment interaction' (Schieber, 2003, p.42). In Dreyfuss' terminology, the human factors approach proceeds from a claim that there are certain points of friction between people and certain technologies that lead to disconnections between the two systems. By understanding how the properties of the technology cause friction with the human user, it is possible to redesign technology to be better suited to specific groups of people. Rooted in the heritage of Dreyfuss' Joe and Josephine, here technology is conceived as implicitly antagonistic to the people who have to use it, and can be amended to closer fit human capabilities.

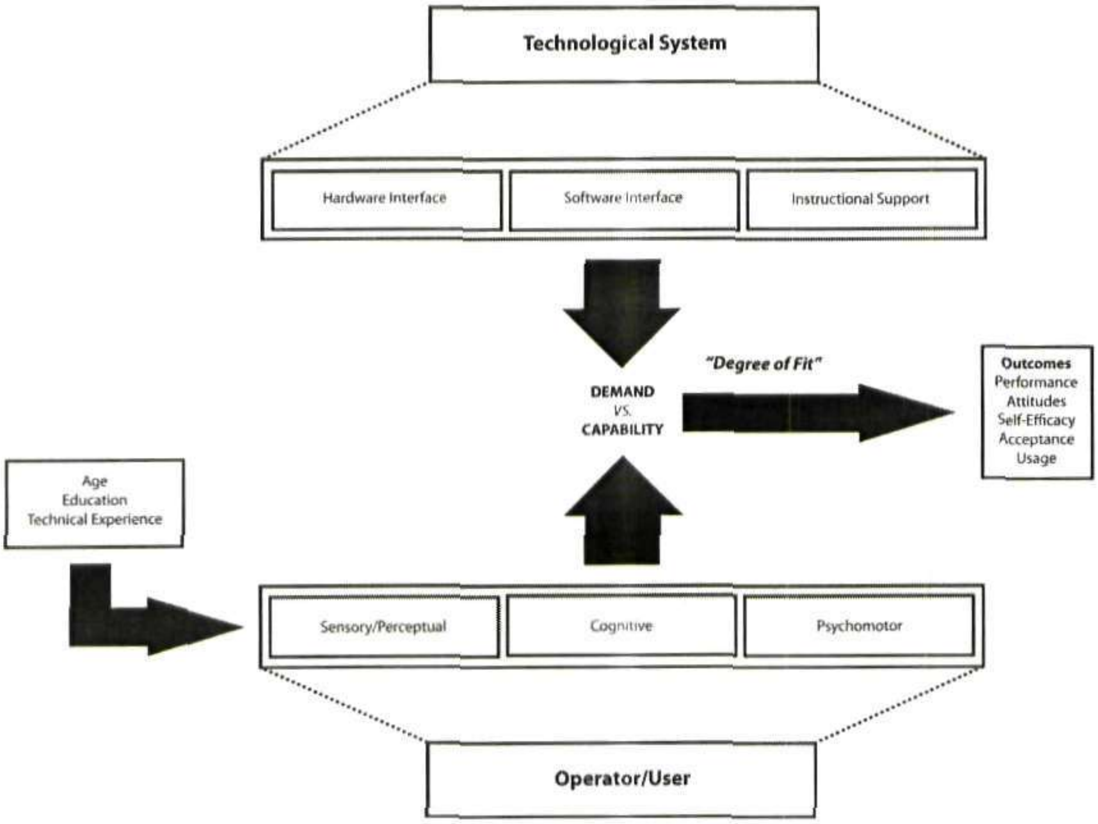

Figure 2 Schematic diagram of the human factors approach to understanding human - technological interactions.© Adapted from Rogers and Fisk (2003).

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certain knowledge is drawn. *Within the inclusive design literature, however, it is common to only provide very* brief and concise references to how certain changes to people as they age have implications to the design of new products and services. For example, Roberts and Warburton (2009, pp.4-5) state that '[b]etween the ages of 60 and 90 there is a vast range of cognitive and physical ability, interests and attitudes to life' but fail to explain in more detail what these may be formed of, although it is suggested the effects of such changes include 'navigation difficulties, hand movement problems, comprehending and conceptualisation difficulties'. It can be stated, therefore, that designers of digital media interfaces that are inclusive of older users may be inclined to draw upon human factors studies in order to more fully engage with understanding age-related issues for older people interacting with digital media, whilst avoiding having to read and interrogate the primary scientific literature.

Rogers and Fisk (2003) determine three main approaches that are central to understanding the problems older people have with digital media products and associated interfaces; task analysis, user observations and design manipulations. Before discussing the insights human factors research provides regarding the possible reasons for disconnections between older people and digital media, it is worth explaining these three methods.

Task analysis is used both as a way of predicting the problems and errors people will have with a specific interface, and also as a way of prescribing interventions to reduce such problems and errors (Rogers & Fisk, 2003). Task analysis does not require the observation of users but rather the researcher identifies the stage-by-stage manoeuvres a user of a specific digital system needs to perform in order to complete a set task (Rogers & Fisk, 2003). The usefulness of task analysis appears to be in identifying those products which, whilst appearing to be rather simplistic, have unnecessary complications and stages the user has to go through to complete a specific task. Rogers and Fisk (2003) use the specific example in which the analysis of a blood glucose meter, advertised as being as "easy to use as 1, 2, 3", highlighted how it in fact required up to 52 sub-stages to complete one task.[33]

User observations take task analysis one stage further by incorporating potential users into the analysis of the interaction observation process. As Rogers and Fisk (2003, p.5) note, the 'observation of users interacting with an existing system provides valuable information about how to improve (i.e., redesign) that system and how to develop future systems.' In the context of studying older people interacting with digital media, it is useful to compare the observations of the older user to younger users and analyse the differences between one group to another[34] (Rogers & Fisk, 2003). For example, a consistent observation made by human factors researchers is that older people learning a novel interface take longer to establish interactions that appear to be fluent in their manner. Czaja and Sharit (1998) compared groups of younger (20-39 years of age), middle-aged (40-59) and older (60-75)

[33] This refers to a study performed by Rogers *et al.* (2001, p.6) on a blood glucose meter that was advertised as: 'It's as easy as 1, 2, 3 [...] Simply set up the meter, check the system, and test your blood'. In performing an analysis of this simple task, however, Rogers *et al.* counted as many as 52 individual components of the task that the user had to perform before completing the operation. In the case of this device, as is the process of much human factors research, the team analysed each component of the task in relation to the capabilities (physically and cognitively) of the typical user, and established where potential problems may occur for the user. As is documented by Rogers *et al.* (2001), this leads to a subsequent list of usability improvements for the analysed device.

[34] Although this approach is logical in trying to observe the differences that occur with age, taking small cross-sections of age groups to compare abilities with one another is a problematic method. This is highlighted in the field of experimental psychology by Stuart-Hamilton but is of equal relevance in the study of ageing and technology. '[I]f the researcher finds an age group difference, he or she cannot be sure how much of an age group difference is down to age *per se*, and how much is due to the effects of different educational and socio-economic backgrounds. [...] a difference due to generational differences in background and upbringing rather than ageing per se is called a cohort effect' (Stuart-Hamilton, 2006, p.53).

adults in their performance on a simulated computer data entry task. The older age group produced significantly less work during the three day period that the study was performed and took longer to improve their performance on the task compared to the younger age groups (Czaja & Sharit, 1998). Despite the slower time it took to learn the task and increase speed, the older group still displayed an ability to comprehend and complete the set task, albeit at a slower pace than the younger groups (Czaja & Sharit, 1998). Other studies have also identified that older people take longer to learn the fundamentals of new workplace technologies they are not familiar with, for example word processing (such as Elias *et al.* (1987)).

The third human factors method of analysing the problems takes user observation a stage further by comparing the differences between similar groups of users in performing operations on different interface or training designs (Rogers & Fisk, 2003). Examples of the use of this method can be observed in the various studies performed by human factors researchers in attempting to identify whether there are training methods and techniques that are particularly useful to older people in comparison to younger people. Rather than redesigning the interface, it is proposed instead that it is possible to provide instruction and tuition in such a way that older people are able to learn the interface in a manner that is more suitable to their particular abilities. Many of the studies performed in this area compare groups of young and old against each other using different forms of training or different levels of instructional support built into the technological system (Czaja (2001) and Charness and Czaja (2005) provide a useful overview of these training studies).[35]

Although the above methods of analysing interactions between people and technology are central to the human factors approach, such methods are always performed in reference to a corpus of scientific knowledge on the capabilities of human beings. In the context of

[35] Human factors researchers have gone to great lengths to compare different training techniques between older and younger people to see what may be more beneficial for the older user of a technology. For example, Gist *et al.* (1988) compared a step-by-step interactive tutorial loaded from a diskette, where the trainees had to complete certain tasks in order to proceed with the session, to a method involving the trainees observing a videotape with a model demonstrating the computer program through describing it verbally and then enacting each procedure himself. In comparing young and old using these different techniques, however, Gist *et al.* (1998) noted that although there were improvements for all using the second method, the older group still had much slower performance and made more errors. Westerman and Davies (2000) argue that studies such as Gist *et al.* (1988) are problematic in that they imply that the types of skills used in one training method (such as procedural, systematic, conceptual) for a particular technology (word-processing, ATM machines, drawing packages) are comparable with one another across scenarios. In simple terms, what might work in one situation may not be the case for another. Westerman and Davies (2000, p.480) argue that by looking at the evidence there is little to suggest that the 'pattern of performance disadvantage for older adults can be modified substantially by the adoption of specific training regimes'. This has not stopped human factors researchers providing guidelines and principles for the design of instruction material for novel digital media products, services and interfaces specifically for older people, as described at length in Fisk *et al.* (Fisk *et al.*, 2009).

designing for older people, task analysis, user observations and comparisons between different age groups and system types are augmented by scientific understandings of human ageing. Through combining these methods and the associated knowledge, human factors researchers identify certain points of friction between certain properties of the interface and certain properties of specific groups of people. As will be highlighted in chapter two, for a designer dealing with the issues of the disconnection between older people and digital media products, human factors research appears to be particularly useful in providing concrete guidance. More specifically, however, human factors studies have repeatedly identified that there is a relationship between temporal changes to the human mind later in life and the complexity of interacting with digital technologies; an area often overlooked by the inclusive design community.

1.4. Cognition, human ageing and disconnection with digital media

Temporal changes to human cognitive functioning appear to be significantly implicated within the problems older people are observed as having connecting to digital media products and interfaces.

An inspection of the human factors literature from the initial study of older people using early computer technologies in the 1980s, through to more recent discussions, highlights how there is growing support of claims that limitations on the part of the mental capabilities of older people are key factors resulting in disconnections with digital media. For example, Rogers and Fisk (2003, p.7) suggest that '[o]lder adults exhibit declines in abilities shown to be important for learning and skill acquisition' and highlight cognitive systems such as working memory and fluid intelligence for specific attention.[36] Similarly, Sara Czaja (2001, p.556) argues that 'declines in working memory may make it difficult for older adults to learn new concepts, such as those associated with computer technologies, or recall complex and/or uncommon operational procedures'. More recently, Fisk *et al.* (2009) suggest that cognitive declines with age significantly influence an older person's ability to interact with digital media; again highlighting working memory for particular attention.

> One of the most common and pervasive changes is a decline in working memory – the ability to keep information active and available for processing. Working memory is an important component of many activities; hence, declines in working memory lead to a wide range of performance difficulties. (Fisk *et al.*, 2009, p.242)

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[36] Definitions of working memory and fluid intelligence will be provided in chapter two, which focuses upon the prevailing understanding of ageing cognition from the discipline of cognitive psychology of ageing.

The human factors literature alludes to the relative incompatibility of contemporary digital media interfaces and the cognitive functioning of most older people. There are inherent features of modern interfaces that require greater cognitive excursion on the part of the user. This may be an issue for younger people, but their relatively capable cognitive abilities possibly mean they can work through these problems. For older people, however, the abstract representations and complex layering of modern graphic interfaces are too much for their cognitive abilities to handle.

The human factors research provides a substantial body of evidence that supports the importance of understanding how cognition changes on a temporal level when designing digital media products to be inclusive of older people. If the role of cognitive capabilities in the acquisition of certain technological skills is of great importance, then it appears to be useful for the designer of such technologies to have a solid understanding of what cognitive abilities alter with age. Primarily, the human factors community refers to the abundance of cognitive psychology of ageing literature in order to define the specific functions of the ageing mind that are problematic in interactions with digital media. Therefore, it is seemingly useful for designers to more fully explore the claims and knowledge emanating from this discipline in order to better understand the causes of the cognitive disconnections with novel digital media, whilst also identifying strategies to redesign technological systems to be more cognitively inclusive. Although it is unwise to suggest designers can develop digital media products for older people based purely on an understanding of cognition[37], based upon the claims of the human factors community it is possible to suggest a deeper understanding of cognition in later life may allow designers to make novel technologies more inclusive of this group of people.

It is the above logic that prevails within many contemporary accounts examining the relationship between human ageing and the design of digital media products and interfaces. The potential usefulness of designing in reference to the limitations of the ageing mind has not gone unnoticed, with various attempts having been made to redesign contemporary digital

[37] Although designing purely based upon knowledge of human cognition may be unwise, approaches have been developed by both cognitive and computer scientists in the past that have used cognitive models of human beings as both a way of analysing human-computer interactions and, subsequently, as a tool for the redesign. A prominent example of such an approach is that of Card *et al.* (1983). Card *et al.*'s (1983) approach has been heavily criticised within literature surrounding human-computer interaction and information technology (see, for example, Suchman (1987; 2007), Coyne (1995) and Agre (1997)). Despite these arguments, the methods described by Card *et al.* appear to still influence contemporary areas of inclusive design as it relates to developing digital media products for older people, which will be discussed at length in chapters two and three. Chapter four will present some of the problems of approaches that appear to be rooted to the Card *et al.* as it relates to the issue of cognitive disconnections between older people and digital media.

products based upon the observations of the shared knowledge of the human factors community and the cognitive psychology of ageing. Perhaps unsurprisingly, much of the design guidance and development of new design strategies has been developed by the very human factors researchers who initially identified the problems related to ageing cognition. For example, Fisk *et al.* (2009) provide a chapter-length, although still rather brief, taxonomy of the cognitive changes that occur with age and the manner in which designers may avoid the subsequent limitations on cognitive capabilities. Fisk *et al.*'s (2009) commentary on these issues, plus attempts by designers to implement such insights into the design process will be discussed in the following chapter.

Chapter 2

Designing for cognitive inclusion

Question: How have inclusive designers dealt with the claims of cognitive disconnections between older people and digital media products and interfaces?

2.1. Human factors researchers have provided guidelines to designers of digital media products, suggesting older people require interactive systems that present less information and harness long term memories.

2.2. Recent digital media design research has examined the relationship between an older person's lifetime experience of technologies and their cognitive disconnection with current interface styles.

2.3. It is possible to design intuitive digital media products that are inclusive of groups of older people by going through an iterative process of identifying the metaphors of prior experiences that can be mapped onto new digital products, reducing the effects of cognitive dysfunction in later life.

2.4. It is possible to remove cognitive friction from digital media products through a process of cognitively inclusive design.

2.1. Removing cognitive friction from digital media

Human factors researchers have provided guidelines to designers of digital media products, suggesting older people require interactive systems that present less information and harness long term memories.

This chapter will examine in more detail what moves have been made within research related to the design of digital media to deal with those changes occurring to the ageing human mind. This chapter will weave together a number of loosely aligned design-oriented research projects into an approach that this thesis has defined as cognitively inclusive design. In chapter one the thesis introduced how human factors studies of older people interacting with computing systems have frequently observed that cognitive limitations related to human ageing were a significant cause of the disconnection between older people and digital media. To begin with, this chapter will continue discussing the human factors literature, identifying the guidance this community provides for designing cognitively inclusive digital media products.

In analysing the properties of the digital systems in relation to the properties of older people, human factors researchers not only attempt to provide insight into the problems older people have with interacting with digital media, but also provide information for designers to help ameliorate these difficulties. One popular way of communicating this information to the design community has been in the form of guidelines. For example, in a chapter titled 'Compensating for Age-Related Deficits in Memory', Frank Schieber (2003, pp.70-71) provides guidelines for designers of digital interfaces that can be implemented to attune the products interface to better fit ageing memory. For example:

> 1. Minimize the need to manipulate or transform information in short-term memory. Age-related decrements in the capacity of working memory increase dramatically when "in-line" transformations are required. Tasks can be redesigned or augmented via technology interfaces to off-load such demands. [...] 3. Leverage recognition memory, which is relatively robust in old age, to redesign tasks that rely upon recall memory. [...] 8. Avoid (or control) stimulus "pacing" effects, which can interfere with encoding and response selection during both the acquisition and retrieval phases of memory operations. Technological interfaces need to be carefully designed to algorithmically optimize the rate of stimulus presentation or implement user-paced input/output strategies. [...] 9. Explore the potential of multisensory/multimedia presentation formats for improving the encoding and retention of to-be-remembered information. (Schieber, 2003, pp.70-71)

The above guidelines provided by Schieber's (2003) are formed after an extensive review of cognitive psychology of ageing literature (the general claims of which will be discussed in detail in chapter three) and outlines the various changes that occur to human memory in later life. A key theme argued by Schieber is that designers of digital media systems need to take into account of the significant limitation on an older person's working memory abilities by presenting 'visual information in smaller "chunks"'[38] both in terms of the amount of information and its spatial distribution (2003, p.61). Therefore, as little irrelevant 'clutter' should be presented as possible, and information should be removed from interfaces 'as soon as its usefulness has expired' (2003, pp.61-62). The point made by Schieber is that designers can make digital information systems more comprehendible to the cognitive functions of older people by feeding information slowly, in smaller chunks, in such a manner that it can be suitably processed.

[38] This is a direct reference to studies discussed in the following chapter that have identified older people as less efficient at 'chunking' information compared to younger people.

The guidelines Schieber (2003) provides can be difficult to realise in the design of a novel digital media product. The guidelines are somewhat rooted within the technical language of cognitive psychology and concepts of different types of memory are conflated and ill-defined for the uninitiated reader (for example, Schieber (2003) interchangeably uses recognition and recall memory in design guidelines, despite defining them as distinct types of memory earlier in the text). Certain guidelines, instance 'leverage intact automatic memory processes (such as semantic priming) to support or off-load volitional memory processes' (Schieber, 2003, p.71), whilst potentially relatively simple to realise on a practical level, are difficult to translate into design due to being layered in the terminology of the cognitive psychologist. There is little reference to designing; the closest references being the occasional detailed discussion of interaction troubles resulting from the cognitive study of a human information-processor who is sat at a computer in a psychology laboratory. As such, beyond broad references to 'multisensory/multimedia presentation formats' and '[t]he growing pervasiveness of *embedded computer systems*', (Schieber, 2003, p.71) the guidelines only specifically relate to the traditional desktop computer which is likely to be found in the cognitive psychologists/human factors laboratory.

Fisk *et al.* (2009) observe that such guidelines are difficult to translate into effective designs and have made attempts to integrate such guidelines into information that is more easily interpretable by designers and traditional design methods. In a similar vein to Schieber (2003), Fisk *et al.* (2009) provide an overview of the main findings from the cognitive psychology of ageing, again identifying the significant role of deteriorations in working memory, but discuss these observations in language less grounded in cognitive psychology. An often repeated and broad suggestion based upon a summary of these observations is that 'it is important that design limits demands on working memory and attention. One should also design to make use of previous experience' (Fisk *et al.*, 2009, pp.26-27). Fisk *et al.* elaborate upon this as:

> [g]enerally, people perceive and respond rapidly to things that they expect on the basis of past experience. People generally respond much more slowly to those things that are unexpected compared to things that are expected. One of the roles of the designer is to understand, predict, and capitalize on what people will expect. Another role of the designer is to understand that when people are faced with using a novel product or experiencing a new environment, they will try to make their task manageable by relating what is new to what they already know. If design does not capitalize on relevant semantic memory, problems can and often do arise. (Fisk *et al.*, 2009, p.27)

What Fisk *et al.* (2009) proposes is a direct transferral of the cognitive psychology of ageing research into the design of digital media products. All design, in Fisk *et al.*'s (2009) definition, works in the realm of making sense of the novel in terms of what has gone before. In the context of older people and their cognitive functions, this feature of designing is elaborated further due to the greater reliance on long term memory than the dynamic sense-making transformations of working memory. Whilst Fisk *et al.*'s (2009) guidance does not focus primarily upon cognitive ageing—they are interested in a great variety of factors that alter with age—many of the guidelines appear to incorporate the theme of harnessing past experience in the design of the new. For example, in the case of designing interfaces for novel digital media products, Fisk *et al.* suggest two key themes that appear to emphasise the prevailing cognitivist understanding of ageing cognition.

> (1) capitalize on the knowledge and capabilities of the user group, and (2) provide environmental support for the limitations of the user group. [...] Understanding the labels that users have for functions, the ways in which they organize information, their expectations about how systems work, and their experience with similar systems will all contribute to the development of systems that are usable by that user group. [...] Environmental support involves providing information such as cues, reminders, or system tools to support the intended action of the user. This notion is analogous to the idea of putting the needed information for a task in the world, rather than requiring the information to be in the head of the user. (Fisk *et al.*, 2009, p.87)

Fisk *et al.*'s response to the observations of cognitive ageing focus upon exploring the experiences of older people accumulated over their lifetime. If past experiences are implemented in the design of novel digital media products, as argued by Fisk *et al.* (2009), there is a lowered requirement for intensive cognitive information processing and the use of working memory. For interactive tasks that still require the older user to process large amounts of information, Fisk *et al.* suggest the designer externalises or distributes this information into the environment or around the interface of the product.

As was highlighted in chapter one, Fisk *et al.*'s (2009) approach, and that of human factors studies in general, is based upon the designer understanding the task that an older person is engaging in when interacting with a specific product or service. In understanding the task, the designer can proceed with analysing the procedures that an older person will be going through in order to complete certain goals. Fisk *et al.* (2009) extend the analysis of the task to incorporate a method of human-computer analysis known as Goals, Operators, Methods, and Selection Rules (GOMS). The GOMS approach, introduced by Card *et al.* (1983), was originally introduced as a practical extension of cognitivist information-processing psychology to the design of computer interfaces. In the original, and then influential, text, Card *et al.* (1983, p.24) provided an exemplar of 'the model human processor', which could be described as a synthesis of the information processing literature of the time into an idealised model of the human information processor (Figure 9).

> The Model Human Processor [...] can be described by (1) a set of memories and processors together with (2) a set of principles, hereafter called the "principles of operation." [...] The Model Human Processor can be divided into three interacting subsystems: (1) the *perceptual system*, (2) the *motor system*, and (3) the *cognitive system*, each with its own memories and processors. (Card *et al.*, 1983, p.24)

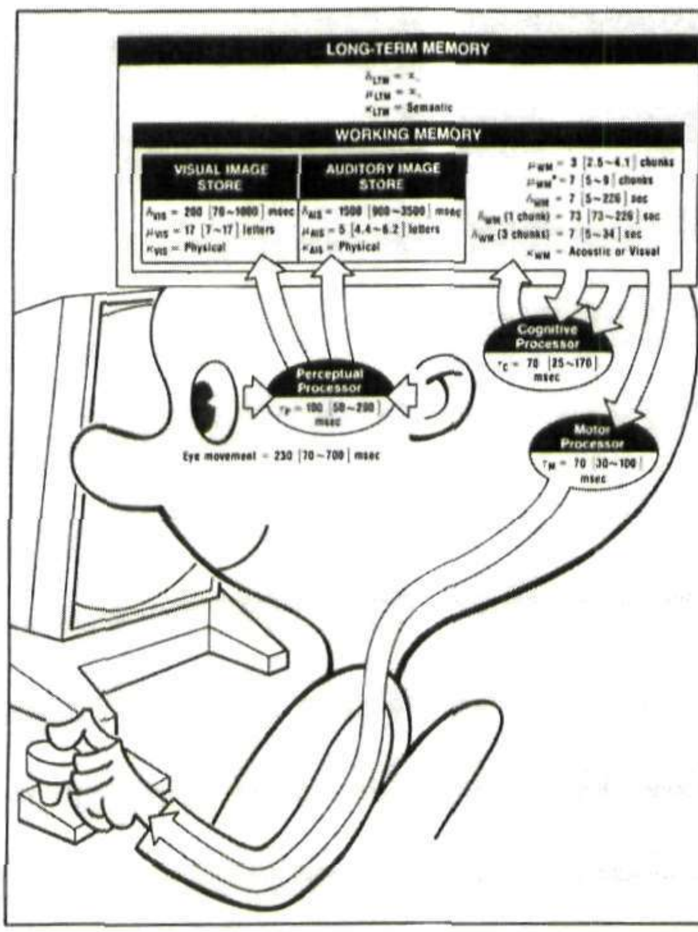

Figure 3 The Model Human Processor, taken from Card *et al.* (1983, p.26).

The GOMS method proceeds to suggest that the various components of the human cognitive system can be attributed with certain variables, and that these variables can be linked to certain aspects of a digital media interface. Fisk *et al.* (2009) highlight that the GOMS approach is more useful to situations where procedures are repeated and well-learnt, such as workplaces, rather than the learning of a novel digital interface. They argue, however, that it is possible to use GOMS analysis as a way to simulate how efficient individuals will interact with an interface designed in a certain way. GOMS and task analysis, as key features of the human factors approach to designing, are essentially procedures of predicting digital interface use by a specific group of people. In understanding how a task will be approached by an older person and their cognitive functioning, Fisk *et al.* (2009) argue that it is possible to predict how the features of specific tasks (and the media that comprise them) may result in cognitive disconnection. In this model of human-technological interaction, both systems are considered to be information processors operating on different levels of symbolic representations. In order to attune the interaction for a better exchange of information (as the human information processor is somewhat flawed, especially so in the case of older people) the digital interface can be designed to send information in less intensive ways.

Some human factors research, as it relates to ageing, is complicated for designers to implement as a result of being layered with the language of cognitive psychology and, at best, computer science. Fisk *et al.* (2009) provide an attempt to bridge the gap between the human factors of ageing and inclusive design by providing more general advice, but do so without moving beyond the traditional methods and tools of human factors. The themes that dominate the guidance provided by the human factors literature, however, appears to be illustrative of the claims emerging from design-oriented research examining the relationship between ageing cognition and the development of methods and tools for designers to use in response; an area of design research that is here defined as 'cognitively inclusive design'. The following section brings together a number of these loosely affiliated design research projects.

2.2. Cognitive disconnect as a symptom of the history of technology and generational experience

Recent digital media design research has examined the relationship between an older person's lifetime experience of technologies and their cognitive disconnection with current interface styles.

A number of post-human factors, design-orientated research projects have emerged during the past decade that have explored similar themes to that of Schieber (2003) and Fisk *et al.* (2009). Although these design-orientated projects do not belong to the human factors approach to designing digital media products and interfaces, they are rather synergetic in their overall argument. As will be highlighted throughout the remainder of this chapter, the influence of cognitive psychology and human factors analysis of ageing can be observed in these projects common portrayal of the necessity to remove stimulus and to-be-processed information from digital media interfaces and to harness the long term memory of older people.

One of the central findings of the cognitive psychology of ageing is that as people age aspects of long term memory (such as semantic and procedural memory, see chapter three) are apparently not affected by the process of human ageing. What this suggests is that there are certain aspects of long term memory related to language, concepts and technical knowledge that older people can bring to bear in their interactions with people and environments. This is evidenced within the guidance for designers developed by the human factors researchers discussed above, where it is agreed across much of the literature that emphasising aspects of prior experiences of older people is a useful strategy to offset the deterioration in the capacity to develop new knowledge and memories in old age. This theme is developed further by Milli Docampo Rama (2001), whose doctoral thesis investigates the importance of examining prior experience in order to reduce technological complexity. Whilst Docampo Rama's (2001) thesis is not a fully published work, and she has not developed her work in an academic context since, her argument appears to resonate in more recent works and is therefore significant to this study.[39]

The crux of Docampo Rama's (2001) argument was in the development of a theoretical framework for designers termed 'Technology Generations'. She questioned whether the reasonable observation that interfaces from the early to mid 20th century have little in common with the interfaces of the latter 20th century was a significant factor in older people struggling to learn novel digital media products. Based upon an interrogation of cognitive psychology and sociological literature, Docampo Rama argued that all people go through a formative period between the ages of 10 and 25, during which time many of the values and experiences appear to inform the rest of an individual's life.[40] From this, it was argued that:

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[39] Although this thesis refers to her doctoral thesis in the main text, Docampo Rama's research was disseminated in a number of articles (such as Docampo Rama and van der Kaaden (1998) and Docampo Rama (1997)). Docampo Rama's (2001) thesis was part of a project entitles 'Technology Generations' commissioned by Philips Design. Although the research has not been furthered by the original authors in an academic context, it is plausible to assume that the research has had some impact within the decisions made in the design process of Philips' consumer products.

[40] Docampo Rama (2001) makes a useful connection between literature within cognitive psychology of ageing, (such as Rubin *et al.* (1998)) that highlights how older people tend to recollect experiences from an early adulthood most reliably, and sociological literature (such as Sroufe and Cooper (1988) and Glenn (1974)) that suggests the period between the ages of 10 and 25 is the most significant in the development of norms, values and skills that they take forward for the remainder of their lives. Although this connection is insightful, it is also problematic as it suggests the cognitive literature and the sociological literature are co-extensive and describe

> [u]ser interface developments imply that users need to constantly adapt to new user interfaces and learn to operate them; after their formative period too. Therefore, it might be the case that technology generations can be distinguished based on the type of user interface experience during the formative period. Technology generations that did not grow up with present-day user interfaces are expected to have most difficulties dealing with present-day devices. They need to learn to understand new procedures of present-day user interfaces, which might be much more difficult to manage after the formative period. (Docampo Rama, 2001, p.5)

Docampo Rama (2001) examined material related to the design of telephones, televisions and video cassette recorders from throughout the 20th century in order to identify profound shifts in the interface style of these products. Through this analysis, three types of interface style were categorised in her study; electro-mechanical style (between 1930 and 1980), display style (between 1980 and 1990) and the menu style (1990 onwards). Further analysis of diffusion data allowed Docampo Rama to claim that by 1955 the majority of the Dutch population would have experienced types of electro-mechanical style interfaces, by 1985 for the display style and 1995 for the menu style.[41]

Based upon these findings, Docampo Rama devised a model with which to classify the population into specific technology generations that could aid designers of novel digital media products and interfaces (see Figure 10). The electro-mechanical generation was identified as being born between 1930 and 1960, the display generation 1961 and 1970, and the menu generation 1971 and beyond. Docampo Rama also identified an earlier generation she called the mechanical generation, whom would have been ages beyond their formative period before the proliferation of electro-mechanical devices such as the telephone. Although on the surface she appears to suggest rather concrete dates and boundaries between the diffusion of novel interface styles and the correlating technology generation, Docampo Rama (2001, p.16) notes that 'the introduction of the new style can only be expressed in terms of fuzzy periods'.

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similar phenomena. This is not to argue that both arguments are not coextensive however; after all, this thesis' approach is one of identifying the synergies between knowledge from normally disparate disciplines. Problematically, however, Docampo Rama does not explicitly discuss how the knowledge from these two fields relates to one another, apart from the occasional sentence throughout the text.

[41] Docampo Rama realised that the time at which a certain product or interface style went to market did not necessarily accurately represent the moment when people experienced these products for the first time. Although Docampo Rama (2001) goes to great lengths to make a detailed account of product distribution and adoption in The Netherlands, her statistical data on certain types of interfaces adoption are still limited. It is also problematic that her studies focused upon primarily functional components and properties of the technological interfaces, disassociating the function from the form and content of the devices. These limitations of Docampo Rama's (2001) specific studies are not attended to in this thesis, but form part of the critique of the cognitively inclusive design approach that is developed in the latter part of the thesis.

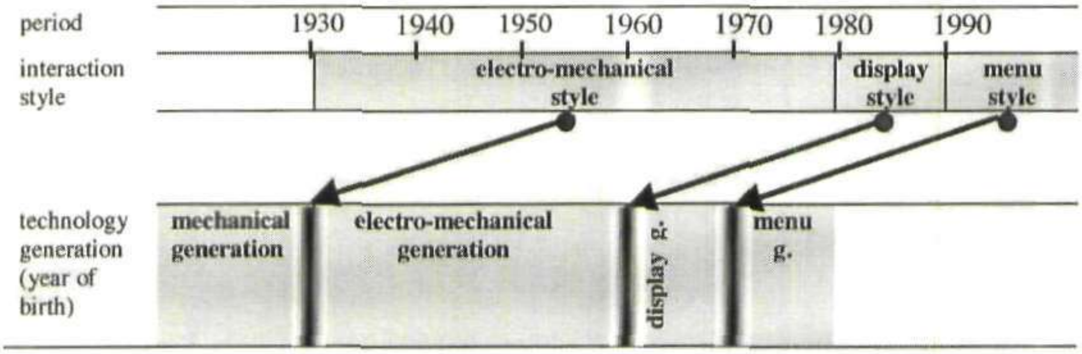

Figure 4 'Overview of interaction styles and technology generations. The dot at the tail-end of the arrow depicts at which point in time it is hypothesized that the diffusion of an interaction style has reached the 20 percent diffusion rate. The arrow indicates when a new technology generation starts. The vertical band between two technology generations indicates the fuzzy generational boundary.' (Docampo Rama, 2001 p.18)

Docampo Rama's (2001) further analysis of the use of new interaction styles in a particular cohort's formative years led to the reduction of these four generations into two; the electro-mechanical and menu style generations. She differentiates between electro-mechanical and menu style interfaces around the notion of layering within the design of the interface. It appeared from her study of product interfaces over the 20th century that the earlier style 'was organized in breadth, such that all functionality was directly visible to the user, whereas the latter style is hierarchically organized, and temporarily less relevant functionality is often hidden' (Docampo Rama, 2001, p.27). She added that 'most input and output devices of multi-layered consumer products have many functions depending on their mode, and have been implemented without providing direct feedback about their state' (Docampo Rama, 2001, p.27). It is at this stage that Docampo Rama links these important differences in the interaction of electro-mechanical and software technologies to the observed changes in the cognitive study of older people.

Much of Docampo Rama's (2001) thesis was a series of usability studies set at a single workstation. These studies explored the effects of various ranges of visuo-cognitive abilities and an individual's technological generation on their use of digital media interfaces of varying levels of complexity and layering. Having established a division between those potential users who were of the 'electro-mechanical' and 'software' generation, she observed that the strategies used by individuals from different technology generations differed greatly when trying to learn a novel interface. It appeared that as a result of their fundamentally different formative experience with technological interfaces, older people brought to bear conceptual knowledge of interactions with technologies that was incompatible with the design of contemporary interface styles. Docampo Rama (2001) did not necessarily suggest that the disconnection between older people and digital media is purely generational—she is seemingly aware that current generations of older people are capable of learning digital media products—however, she recognises that this can take considerably more cognitive effort. This increased cognitive effort is made all the more difficult for many older people as a result of the claimed limitations in their working memory and information processing capabilities (discussed in chapter three). Designers, Docampo Rama (2001) claims, can make life easier for older people learning to use digital media products by ensuring that interfaces better relate to their technological generation. This requires that the designer adapts contemporary and novel interfaces to reflect the history of technological interactions for a particular age group.

Docampo Rama (2001) did not further these ideas. It is notable that even though her thesis was entitled 'Technology Generations handling complex user interfaces', by the end there was little reference as to how to apply technological generations in practice. In the conclusion, it is suggested that:

> [e]ase-of-use software style devices could be improved by re-introduction of electro-mechanical style concepts such as the one-to-one relation between function and button, understandable direct-feedback about the state of the device and increase of affordance (i.e. the user's perception about the applicability of the device) [...] for a straightforward interaction. (Docampo Rama, 2001, p.108)

The fleeting references to concepts such as affordance (this concept will be explained in more detail in chapter five) and direct-feedback (both of which require a greater critical understanding than Docampo Rama provides) highlights a lack of sensitivity to design related issues in comparison to the knowledge gained from observing older users. The lack of incorporation of the detailed historical analysis of interface styles that was provided earlier in her thesis also suggests an inherent difficulty in transferring the 'interface style' of one generation to the next.

At this point, it is evident that the researchers discussed thus far in this chapter deal primarily with how designers can deal with the effects of cognitive ageing in order to make certain products easier, or simpler, to learn. As Docampo Rama (2001) highlighted at length, the role of past experience appears to be critical to making the learning process as smooth and seamless as possible, which is particularly important for older people due to the claims that they struggle to process novel information and increasingly rely on already learnt procedures.

It follows, then, that prior experience has become implicated with design research as key to making the learning digital media in old age a more implicit process.

Figure 5 Digital (button) and analogue (dial) based microwave interfaces.

Research conducted by Tim Lewis, Patrick Langdon and John Clarkson (Langdon, Lewis & Clarkson, 2007; Lewis, 2007; Lewis, Langdon & Clarkson, 2008) attempted to understand how significant an impact the combined prior experiences with products has on how a user performs with a new product.

> Prior experience is determined by a user's ability to acquire, store and retrieve relevant information in their long term memory (LTM). A human information processing approach to cognition can model these processes and considers carefully the roles played by both working memory [...] and LTM. (Lewis *et al.*, 2008, p.96)

Lewis *et al.* (2008) grounded their definition of prior experience as a cognitive ability of the user and, as with the human factors researchers, draw upon the cognitivist information-processing paradigm of the mind. Lewis *et al.*'s research highlighted the key role that measurable declines in cognitive ability appear to have in the difficulties certain users encounter when interacting with certain products. In an initial study of digital cameras, it was observed that the more experienced a user was with a particular style of interface then the quicker they perform set tasks (Langdon *et al.*, 2007). Following this, Lewis *et al.* (2008)

compared the use of two microwaves by a group of people of differing ages in an attempt to identify whether different types of interfaces resulted in different levels of performance. The microwaves differed primarily in the nature of their type of interaction. One microwave had an interface formed of two analogue dials; the other had an interface based on a numerical keypad and menu buttons and a digital display (Figure 11). Based upon these differing interaction styles and the assumption 'that the more experience a user has of similar products, the quicker they will learn the operation of a new one' (Lewis *et al.*, 2008, p.96), it was hypothesised that the older participants would perform better using the dial microwave rather than the button microwave. The subsequent research identified that the dial interface led to better performance for all, an effect that was all the more pronounced with the older participants (Lewis *et al.*, 2008).

Going by these observations, and in line with the claims of Docampo Rama (2001), a greater familiarity with dial interfaces rather than button interfaces for the older group could be a fundamental reason behind the emphasised gap between the ability to perform quickly with the differing interaction styles. Lewis *et al.* (2008) noted that in general, however, an individual's prior experience did not necessarily relate to their performance with either microwave.[42] Instead, it was noted that the participants identified as having higher cognitive information-processing abilities were those that performed better in the use of the button interface. Lewis *et al.* (2008) postulate that it might be the case, then, that interfaces such as dials, down in part to their analogue as opposed to discrete and sequential style of interaction, are less cognitively and perceptually demanding.

The online presence of this research project comments that 'the guidance on how to design to include users with cognitive disabilities needs to be that much more extensive and in a form the designers will use' (Cambridge EDC, 2009), eluding that past research has not provided information that is useable in design terms. In an article describing the microwave study, Lewis *et al.* (2008) argue that designers have a preference for more generalised and concise advice to shape their designs rather than specific guidelines. In reading Lewis's *et al.*'s study, however, there is little advice with which a designer can work. It is asserted that prior experience may be an important feature in an older person's performance with certain new forms of product interaction, whilst at the same time suggesting that the microwave

[42] This could be down to limitations in the method of acquiring information about each participant's previous experience with microwave interfaces in the past, which appeared to place an emphasis upon the symbolic and positioning qualities of the interface. Whereas Docampo Rama (2001) alluded to broad interactional styles that were seemingly transferred over generations of both the design of technologies and populations, Lewis and colleagues appears to take a more discreet method of dismantling the interface into individual, disconnected components.

study displays little correlation between prior experience and performance. Instead, in terms of Lewis *et al.*'s microwave study, it was proposed that products and interfaces that enforce sequential and discrete forms of interaction are inherently cognitively intensive for the user by design. Despite this potential contradiction emerging from their studies, Lewis *et al.* argue that prior experience holds a key role in developing more usable digital media products for older people, and studies performed by O'Brien (2010) lend support to Lewis *et al.*'s argument.

In light of the work of Docampo Rama (2001) and Lewis *et al.*, (2008) there appears to be a strong relationship between the cognitive disconnection older people are observed as suffering when attempting to interact with digital media products and the fundamental incompatibility of their long term memory with contemporary styles of interface design. In particular, the theoretical basis of technology generations appears to offer an opportunity for designers to explore and develop cognitively inclusive approaches to design.

2.3. Intuitive interaction

It is possible to design intuitive digital media products that are inclusive of groups of older people by going through an iterative process of identifying the metaphors of prior experiences that can be mapped onto new digital products, reducing the effects of cognitive dysfunction in later life.

The claims made regarding prior experience by Lewis *et al.* have been picked up by research groups at the Queensland University of Technology[43] and Technische Universität Berlin[44], both of which focus upon developing digital media products and interfaces based upon the notion of intuitive use. (Blackler *et al.*, 2003; Hurtienne *et al.*, 2008) These researchers note how intuition, intuitive use, intuitive interaction and similar terms have been in use by designers for some time with little clear definition of what the terms may mean (Blackler & Hurtienne, 2007). Both groups offer their individual definitions. Through an analysis of literature from cognitive psychology, design, and subsequent empirical investigations, Blackler and colleagues established a definition of intuitive use as the following.

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[43] The research at Queensland University of Technology is lead by Althea Blackler, whose doctoral thesis (Blackler, 2006) initially explored the notion of intuitive interactions with complex digital products. For the ease of reading the main body text, this group's work will be referred to as Blackler *et al.*, and specific studies, papers and articles will be individually referred to as and when necessary.

[44] The research at Technische Universität Berlin is mostly lead by Jörn Hurtienne, and for the same reasons noted in footnote 43 this group's work will be referred to Hurtienne *et al.* This research has more recently transferred from Berlin to the Engineering Design Centre, at the University of Cambridge.

> Intuitive use of products involves utilising knowledge gained through other experience(s). Therefore, products that people use intuitively are those with features they have encountered before. Intuitive interaction is fast and generally non-conscious, so people may be unable to explain how they made decisions during intuitive interaction. (Blackler *et al.*, 2007, p.2)

A similar definition of intuitive use is provided by Hurtienne and colleagues: 'A technical system is intuitively usable if the users' unconscious application of prior knowledge leads to effective interaction'[45] (Blackler & Hurtienne, 2007, p.8). Although the ideas of these two groups emerge from different theoretical frameworks and sets of terminologies, these definitions ground both lines of questioning within the trajectory of cognitively inclusive design as discussed thus far in this chapter, as evidenced in the work of Schieber (2003), Fisk *et al.* (Fisk *et al.*, 2009; Rogers & Fisk, 2003), Docampo Rama (2001) and Lewis *et al.* (Langdon *et al.*, 2007; Lewis, 2007; Lewis *et al.*, 2008). Although the definitions of intuitive use quoted above have their differences, both research groups consider themselves as talking in complementary terms (Blackler & Hurtienne, 2007). Despite this, however, due to the fundamental differences in the evidential grounding of these two research projects it is worth examining the projects separately in more detail.[46]

2.3.1. Intuitive interaction and user familiarity

The research at QUT lead by Althea Blackler proceeded from defining intuitive interactions with products as being quick and unconscious as a result of a compatibility with a particular user's previous experience (Blackler *et al.*, 2006). Intuitive interaction here appears to be a rather inexplicable phenomenon. As alluded to by Blackler *et al.*, people appear to struggle

[45] The definition of intuition offered by the intuitive interaction researchers, as described in the main text, might be best thought of as referring more explicitly to identifiable prior experience rather than intuition as it is used in philosophical and psychological terms. Richard Gregory notes that intuition is 'arriving at decisions or conclusions without explicit or conscious processes of reasoned thinking' (Gregory, 1987, p.389). The definition provided by Blackler *et al.* and Hurtienne *et al.*, whilst alluding to a level of immediate understanding, suggests that the process of intuition can be described when thought of in terms of designing interactions between people, products and interfaces.

[46] Although in Blackler and Hurtienne (2007) an agreement appears to be made that these two research groups are discussing similar trajectories, their approaches are based upon very different conceptions of human cognition. Blackler *et al.* draw upon literature situated within the cognitivist information-processing models of cognition explained in chapter three. Hurtienne *et al.* speculate that there may be something more to understanding human cognition than abstract and functional mental processes, invoking how the human body may be as much involved in cognition as the brain or central nervous system is. Looking at the development of Hurtienne *et al.*'s argument over time, it appears this aspect of their argument is becoming increasingly prominent. Hurtienne *et al.* appear to struggle in communicating the potential relevance of this alternative model of human cognition to the issue of temporal change; chapter six of this thesis, drawing upon a similar paradigm of cognitive science as Hurtienne *et al.*, attempts to resolve this problem.

when asked to explain what is or what is not intuitive to them; it just occurs or does not. Blackler *et al.* (2006, p.2) allude to the research of Docampo Rama by arguing that '[i]ntuitive interaction involves the use of [implicit and unconscious] knowledge gained from other products and/or experiences [...] products that people use intuitively are those with features they have encountered before.' Through a number of empirical studies of people using and interacting with various types of digital interface, Blackler *et al.* (2007) define three principles of intuitive interaction.

> 1. Make function, location and appearance familiar for features that are already known. Use familiar symbols and/or words, put them in a familiar position and make the function comparable with functions users have seen before.
>
> 2. Make it obvious how to use less well-known features by using familiar things to demonstrate their function, appearance and location.
>
> 3. Increase the consistency within the interface so that function, appearance and location of features are consistent between different parts of the design. Use redundancy in order to maximise the number of users who can intuitively use the interface and the ways in which they can choose to complete their tasks. (Blackler & Hurtienne, 2007, p.4)

A cursory reading of the above principles suggests that the development of intuitive interactions may be a relatively simple process of user research. In the transfer from principles to practice, however, the process of intuitive interaction turns out to be increasingly complex. Blackler and Hurtienne further decompose the principles as being formed of the following components.

> Principle 1 relates to the simpler end of the continuum, where body reflectors, population stereotypes or familiar things from the same domain are applied. Principles 2 relates to transferring things from other domains, including the use of metaphor. Principle 3, internal consistency and redundancy (represented by the dottedline), needs to be considered at all times and so it surrounds the other principles. (Blackler & Hurtienne, 2007, pp.3-4)

The above statement requires some unpacking. Blackler *et al.* argue that intuition in interaction starts at the most basic level of interaction; that of body reflectors, 'which are based on the embodied knowledge learned so early [in life] that it seems almost innate'. Beyond references to Bush (1989) and then the supposition that body reflectors are somewhat analogous with Norman's (1988) concept of affordance, however, Blackler *et al.* provide little insight into how the application of body reflectors in design may be achieved.[47] The next component, population stereotypes, refers to the cultural conventions in terms of the products and interfaces that people would have experienced from an early age.[48] 'Familiar features' or 'things from other domains' refers to the crux of Blackler *et al.*'s (2006, p.7) argument that 'familiar features from the same and different domains would be the main mechanism for designers to use in order to apply intuitive interaction.' A key aspect of the transferral of familiar features from one domain to another is the identification and application of metaphors. 'When a person has relevant experience in a different domain, metaphors could be used to relate that knowledge to a new situation' (Blackler *et al.*, 2006, p.7). 'External consistency' is another concept that refers to the relationship between the designed system 'with things outside the system' (Blackler *et al.*, 2006, p.9). Citing Nielsen (1989), they argue that a digital media interface should be consistent with the expectations of the user's experience of other available systems.[49] This also requires that the system has internal consistency; features within the same product should relate well with one another and not conflict with one another. For example, 'if the function of the feature [of an interface] requires a metaphor, that metaphor is applied to the appearance and location of that feature, so that the metaphor remains consistent' (Blackler & Hurtienne, 2007, p.7). The final component of the principles, redundancy, refers to the inclusion of different modes of communication of various functions within the interface as is feasible, to ensure that 'as many users as possible can use an interface intuitively' (Blackler *et al.*, 2006, p.4).

[47] Although both Bush (1989) and Norman (2004) refer to aspects of mutuality between the body of human beings and the designed environment, both of their arguments are founded on a rather different basis. Bush is based within the heritage of product semantics and how certain body-like imagery and forms might become manifest in the design of a material products. Norman (1988), developing a notion of affordance conceived by James Gibson, comes from a cognitive psychology background and understands an affordance to be the perception of an opportunity for interaction for a particular group of people. Whilst the human body is invoked in both accounts, this occurs from highly contrasting perspectives. Norman's account of affordance will be discussed in more detail in chapter five of the thesis.

[48] The notion of population stereotypes, as it is used by Blackler *et al.*, is somewhat similar to Docampo Rama's technology generations (described earlier in this chapter).

[49] It is notable how the notion that systems should share the manner in which interfaces are designed is problematic in a socio-economic context, where manufacturers attempt to ensure their brand is often easily distinguishable from their main competitors. This notion also limits the potential for interface diversity—which is a key necessity for inclusive design. What is a good system for one person is not necessarily for another—the sharing of properties between systems and limiting the choices made available to the user is highly problematic. These points will be touched on from the perspective senescentechnic design later in the thesis.

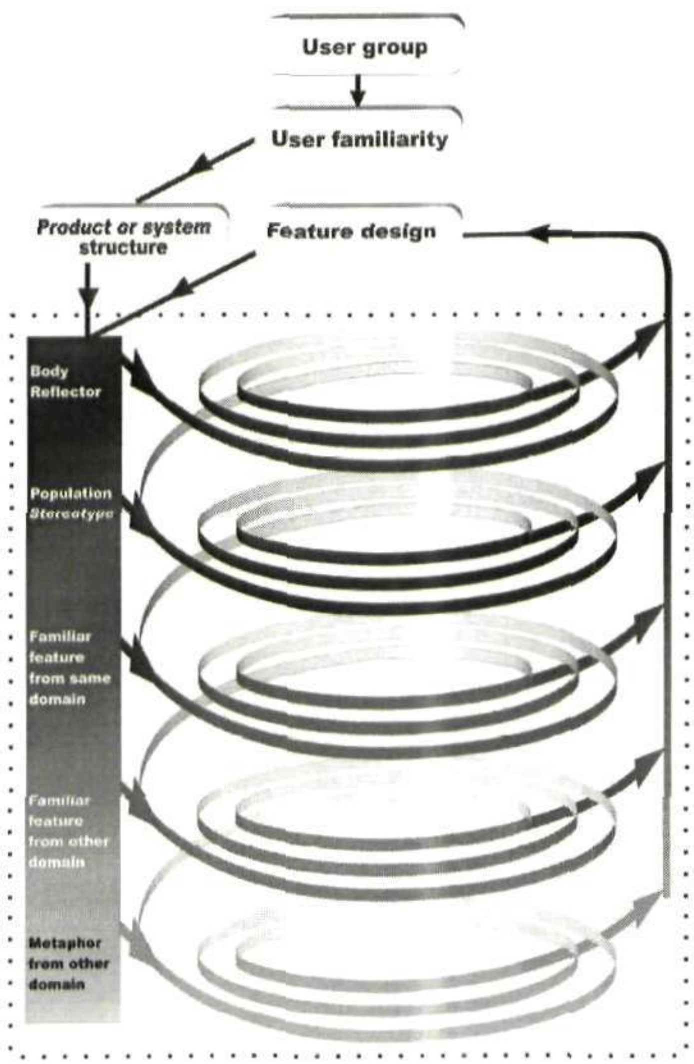

Figure 6 Conceptual tool for designers to aid the development of intuitive interactions. Taken from Blackler *et al.* (2007).

Blackler *et al.* suggest that 'newer' technologies will inherently be less familiar to users and a designer would need to increasingly apply metaphors and familiar feature from other domains in order to communicate to the user how to interact with the novel. Although a novel digital media product suggests the necessity of learning and a period of 'un-intuitiveness' to the interaction, Blackler *et al.* (2006, p.10) are keen to argue that this need not be so. 'If the principles [...] are used, it should be possible to design an interface at any of these levels which people with differing levels of Technology Familiarity could use intuitively.' In order to convey how these multiple methods may fit within an iterative design process, Blackler *et al.* provide a 'conceptual tool' to apply intuitive interaction (Figure 12). The conceptual tool developed by Blackler *et al.* introduces the above principles and theories from the continuum into an iterative spiral that 'represents a design process with a variety of entry and exit points' (Blackler & Hurtienne, 2007, p.6). Starting at a given point and working down, the designer would be able to 'establish the earliest point at which a familiar thing can be applied to each feature' (Blackler & Hurtienne, 2007, p.7). In the context of a novel technology, which may have no set conventions to be based upon, it is argued that 'a metaphor which relates to something that is familiar to the users would need to be applied' (Blackler & Hurtienne, 2007, p.7).

The above, and very brief, explanations of Blackler *et al.*'s framework emphasises how the process of intuitive interaction—something that these authors initially suggest is indescribable—could be described through a highly complex compilation of exploratory user research.[50] This elaborate process can thus be applied into the design of a digital media product to make it intuitive to use, even if the media or technology is completely novel and has no initial reference points to explain its use. In terms of the cognitive limitations of old age, Blackler *et al.*'s proposals are useful as part of the wider strategy of cognitively inclusive design as a way of avoiding the use of abstract reasoning by emphasising past experiences. This point will be elaborated after the second intuitive interaction research project is introduced.

2.3.2. Intuitive interaction and prior knowledge

In a similar vein to the research of Blackler *et al.*, the IUUI research group ground intuitivity based upon an individual's prior knowledge. Hurtienne and Israel (2007) define the prior knowledge of human beings as stemming from a number of experiential sources, ranging from innate 'universals' to the specific expertise a person gains from experiencing a certain profession or pastime. Hurtienne and Israel (2007, p.128), like Blackler *et al.*, conceive of these sources of knowledge in reference to interaction as a continuum in which the 'frequency of encoding and retrieving of knowledge increases' from the top to the bottom (Figure 13). It is claimed that the lower the level of knowledge appears within the continuum, the more generalisable and useful such knowledge is to a large group of people.

[50] The authors of this framework note the lengthy timescales involved in this design process (Blackler & Hurtienne, 2007; Blackler *et al.*, 2006).

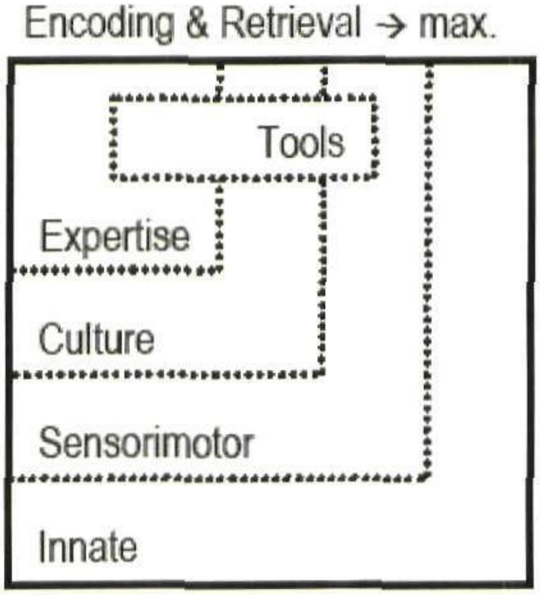

Figure 7 Continuum of knowledge for intuitive interaction. Taken from Hurtienne and Israel (2007).

As a way of exploring these lower levels of knowledge, the authors draw upon the work of cognitive linguists and philosophers George Lakoff and Mark Johnson[51], in arguing that human thought is fundamentally formed of 'recurring dynamic patterns of bodily interactions' that develop into image schema of the mind (Hurtienne & Israel, 2007, p.130). One example of an image schema is UP-DOWN, which is a basic attribute of human sensorimotor knowledge as a result of the experience of gravity. Lakoff and Johnson (1980) suggest that such basic image schemas are transposed onto other aspects of daily life in metaphorical fashion. For instance, UP may equal HAPPY, whereas DOWN may equal sad. UP may be ALIVE, DOWN may be DEAD. UP may be LOUDER, DOWN may be QUIETER. Hurtienne *et al.* (2009a) use this latter metaphorical extension to discuss the example of the Touchplayer developed by Pirhonen *et al.* (2002). The Touchplayer is an adaption of the Windows Media Player interface to run from touch-sensitive controls, rather than on a point and click graphic user interface. The Touchplayer was designed to be hung on a belt on the side of the user and was operated using various gestures of the hand; to turn the volume up, the user swiped the panel up, to turn down, swiped downwards. To skip, they swiped forwards, to go back, swiped backwards. Tapping the pad started and stopped the

[51] Lakoff and Johnson (1980; 1987) have argued that human thought is mostly comprised of metaphorical reasoning based upon experiential aspects of the human body. Lakoff and Johnson's claims are situated within an alternative paradigm from within the cognitive sciences that places a greater significance on the human body and the environment in the emergence of cognitive phenomena and experience. Although this thesis does not develop Lakoff and Johnson's particular account due to limitations outlined in the main text, arguments from this paradigm of cognitive science are discussed at length in chapters five and six.

player. Hurtienne *et al.* (2009a, p.256) noted that the difference between the two systems was that the 'Touchplayer strongly relies on sensorimotor knowledge and embodies this in interaction instead of presenting symbols with weak sensorimotor associations' and that it 'uses stronger image schemas' compared to a traditional interface, which used LEFT to RIGHT controls for volume and track skipping.

Hurtienne *et al.* suggest that image schemata, such as those applied in the design of the Touchplayer, can be metaphorically extended to understand and structure the abstract concepts required to interact with novel digital media products and interfaces, making these products more intuitive to use. The 'universal character' of image schemas, 'their – in the course of life – extremely frequent encoding in and retrieval from memory and their unconscious processing makes them interesting' (Hurtienne & Israel, 2007, p.130) as a way for implementing digital media, such as in tangible user interfaces, or to describe the stereotypes of a population of users (Hurtienne *et al.*, 2009b). Rather than the explicit metaphorical references that are favoured by Blackler *et al.*, Hurtienne *et al.* emphasise how there may be benefit in harnessing the unconscious and bodily dependent sensorimotor knowledge that, it is argued, is universal to all human beings.[52] In terms of the cognitivist definition of cognition, the proposals of Hurtienne *et al.* (and their origins in the work of Lakoff and Johnson) do not refer to functional cognitive processes. In terms of Hurtienne *et al.*'s argument, however, the application of image schemas may free cognitive resources that would otherwise be used for basic aspects of interacting with digital media interfaces. By freeing up these resources for more complex processes, it is argued that the learning process is made simpler and more intuitive for a non-expert user.

2.3.3. Intuitive interactions for older people

Both the research of Blackler *et al.* and Hurtienne *et al.* was initiated in terms of the development of intuitive products for a general population; however, both teams of researchers have noted the particular applicability of their projects to older people and the associated changes to cognitive functioning. For example, Blackler (2005) observed that

[52] This claim is made by Hurtienne *et al.* in a number of texts, but it is arguable that image schemas (or at least sensorimotor knowledge) are not universal, or at least consistent, to all human beings. In some respects, this is noted by Lakoff and Johnson (1999), who suggest that the manner in which image schemas form are also a result of the body in relation to the environment (including the cultural environment). Image schemas would therefore differ drastically between contexts and cultures. In terms of this thesis, however, Hurtienne *et al.*'s claim is problematic as it does not account for people whose cognitive experience may be significantly impeded by sudden changes to the way their body relates to the environment. The thesis attempts to resolve this issue in chapter six.

throughout studies with various age groups, older people consistently appeared to encounter greater difficulty in using various types of interface in an intuitive manner. Initially, Blackler (2006, p.231) considers whether these may be down to the 'well known factors of aging such as speed of reaction times and cognitive processing' but she then goes on to postulate whether there may be more to these interactivity issues. If younger people are able to interact more intuitively than the old, even if the older people have a certain level of familiarity with such devices, it may be that there are temporal issues related to cognition, the brain and interaction that designers must take into account. As Blackler (2006, p.231) asserts:

> one possible explanation is that children and teenagers are at the right age to learn new things and their brains are more receptive to laying down this information. An older adult may still have their mental models based around the interaction techniques they learned in their youth, which are now obsolete, and it is known that older people need to make more effort in order to learn new things.

Taking Blackler's above assertions, a response to these issues in terms of the intuitive interaction framework of Blackler *et al.* would examine more fully what these 'mental models' of older users comprise of. In terms of intuitive interaction, these mental models may be implemented in the redesign of digital media products and interfaces through metaphorical representations.[53]

Hurtienne *et al.* (2008) also recognise the relevance of their ideas to inclusive designers. In defining image schema as being part of a very basic, almost universal sensorimotor level of knowledge, they suggest that they are 'accessible to the widest range on people' (Hurtienne *et al.*, 2008, p.115)[54]. In a later paper, Hurtienne *et al.* (2009b, p.257) go on to state that '[t]he universitality' of image schemas 'predicts that user interface features designed with image schemas should be equally usable by members of different technology generations' (referring to Docampo Rama's research) and offer promising insights for inclusive design. In terms of ageing, they suggest that the emphasis of sensorimotor

[53] Lawry *et al.* (2010) have extended the earlier intuitive interaction research into the area of ageing. Thus far, however, their results appear to be inconclusive.

[54] It appears that Hurtienne *et al.* (2008) assert this point but perhaps need to examine the claim in a little more detail. It might be that the concept of image schema been 'universals' to a great many users falls down in an inclusive approach to design. Of course, on one hand the inclusive approach to designing is about finding aspect of human beings that are suitable for one and all. However, an inclusive approach is also about looking at the specific differences between groups of people and approaching the design of products and services that take account of these differences. The argument that image schema are useful to inclusive or universal design approaches may fall down once it is taken into account that the groups of people often targeted by inclusive design require a more specific understanding as their image schema due to their fundamentally different embodiment to the 'typical' human being. Differing embodiments would lead to different forms of sensorimotor knowledge. The perceptual abilities of older people might be attuned to interacting with the world in a differing manner; this theme will be elaborated in chapter six of the thesis.

knowledge, as applied in the design experiment of the Touchplayer, avoids having to use limited and deteriorating cognitive capabilities, as is the case with older people interacting with many contemporary digital media interfaces.

The research of these two groups into the relationship between intuitive interaction and human ageing is still ongoing, therefore this thesis can only infer its relationship based upon the proposals made in their work thus far. In relating the intuitive interaction studies to the context of older people interacting with digital media, the suggestion is that in identifying the properties of a group of older persons prior experiences—such as symbols, interface types, aesthetic styling cues, or the underlying 'universal' image schema—designers can develop more 'familiar', or intuitive, interactions with new forms of media. Taken in terms of cognitive ageing, the intuitive interaction research is a useful component within an attempt to develop cognitively inclusive digital media products. By understanding the metaphors by which older people make sense of the media and products they encounter, whether these refer to past technologies or projections of sensorimotor knowledge, then the necessity to develop new conceptual knowledge as to how to use the technology (which likely requires significant use of working memory) will be reduced. As a result, the intuitive interaction research—along with the human factors research and Docampo Rama's technology generations—influence what this thesis defines as a contemporary account of cognitively inclusive design, which is defined in the concluding section of this chapter.

2.4. Cognitively inclusive design

It is possible to remove cognitive friction from digital media products through a process of cognitively inclusive design.

The loosely affiliated research projects brought together in this chapter are part of a perspective on designing that in this thesis is defined as cognitively inclusive design. This title is used to suggest that the collection of research discussed provides guidance to designers of digital media that better affords the inclusion of cognitive functioning of older people. As a result, cognitively inclusive design attempts to ensure that the design of digital media products and interfaces suitably match the claims of the cognitive psychology of ageing. By understanding how the features of the digital media interface relate to the cognitive functioning of older people, and by amending designs to better suit aged cognition, it is suggested that the disconnection between older people and digital media can be resolved. It is possible to summarise the claims of cognitively inclusive design in reference to the cognition in later life into three key points:

1. The information processing functions of older people are significantly reduced as a result of cognitive ageing. Therefore, digital media must be designed to reduce the amount of information it provides at once for the human information processor to deal with—it should be "chunked".
2. As a result of the reduction in information processing functioning, older people struggle to attend to correct information if a significant amount of stimulus is presented at once. Therefore, digital media products and interfaces must be designed to only present information that is absolutely necessary.
3. An older person perceives how to use a technology based upon the symbolic and metaphorical basis of their long term memory. The digital media product and interface can be designed to metaphorically represent the historical interactions of the group of older people to be designed for; in doing so, long term semantic and procedural memory will be invoked, meaning less working memory and attention is required to be applied.

It is possible to add a fourth aspect to cognitively inclusive design (although, as will be identified in chapter three, in terms of tradition cognitive psychology it would not be classed as a 'cognitive' aspect of interaction) which, as argued by Hurtienne *et al.*, benefits the learning of an interface:

4. Older people make sense of aspects of the world through bodily metaphors (image schemas). Digital media products must be designed to make use of these basic capabilities of human beings, freeing up cognitive resources for more information intense aspects of interactions with digital media.

If these four features of cognitively inclusive design were to be integrated within an iterative design process of a novel digital media product, the research discussed within this chapter suggests that the outcome will be a product that places less strain upon the limited information-processing abilities of an older person. Cognitive studies of ageing postulates that cognition in old age is poor at processing the novel but strong at recalling long term stored knowledge; as such, digital media that reflect this in their design will better connect with older people. Returning to Dreyfuss' (1955 [2003]) terminology from chapter one, there will be less friction between people and digital media; or, in Blackler *et al.*'s (2006) and Hurtienne *et al.*'s (2009) terminology, the interaction with digital media would be more intuitive. In terms of the argument portrayed in this and the preceding chapters, where both the human cognitive system and the digital media system are conceived as information processors, the exchange of information from one system to the other would become more fluid. There would be a greater opportunity for cognitive connections, and the media is designed in such a manner to offer maximum opportunities for incorporation into the everyday activities of older people.

In the following, an example will be provided to demonstrate the above principles of cognitively inclusive design as it relates to the design of a novel digital media product.[55] In a previous research project (*'Photo Reel'*, Vines, 2007), the author has observed through meetings and group discussions with older people (in this scenario, the stakeholders) that there was an increasing desire to collect and view digital photographs, yet a reluctance to engage with a personal computer to do so. Following in the lineage of Docampo Rama and Blackler *et al.*, the designer, in collaboration with the stakeholder group, explored examples of photography concepts, media and the related interactions from what constitutes the formative period of the user group. A number of initial concepts were developed by the designer in light of the collaboration with the stakeholders. These initial concepts focused upon the role of references to technologies and media such as picture frames, photograph slides, picture albums, slide projectors, film reels, and film negatives. In order to reduce the strain on cognitive working memory, the initial exploratory process developed into concepts that were devoid of abstract iconography and graphic user interfaces. Rather, the concepts were developed based upon the ideas of tangible computing[56] and information-appliances[57], focusing upon computational products designed with one activity in mind, instead of the

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[55] This example discusses a project developed during the author's Master's projects, although the description is slightly altered in the thesis' text compared to the original documentation. The original, unpublished, research can be found in full in Vines (2007), and part of the study was published within Vines and Thompson (2007).
[56] Tangible computing, or Tangible User Interfaces (TUIs), were conceived as a reaction to the predominance of the Graphic User Interface (GUI) in the design of computational and digital media systems. 'Rather than make pixels melt into an interface, TUIs use physical forms that fit seamlessly into a user's physical environment. TUIs aim to take advantage of these haptic interaction skills, an approach significantly different from GUIs.' (Ishii, 2008, p.34)
[57] Norman (1998, p.53) defined an information appliance as '[a]n appliance specializing in information: knowledge, facts, graphics, images, video, or sound. An information appliance is designed to perform a specific activity, such as music, photography, or writing. A distinguishing feature of information appliances is the ability to share information among themselves.' Norman's main reason for coining the information appliance was to 'break through the complexity barrier of today's personal computers' (1998, p.53), instead arguing for less general-use machines that were better suited to individual practices.

multiple tasks and activities of a typical personal computer. The benefit of emphasising single activity products devoid of complex graphic interfaces is demonstrated in the reduction of the amount of 'layers' within the interface, and a lessened necessity to keep information in short term and working memory (Docampo Rama, 2001). Along with this, as argued by Hurtienne *et al.*, incorporating certain aspects of the basic sensorimotor knowledge of older people via tangible interactions, would mean fewer cognitive resources would be taken up. The initial concepts, once further developed (by the author) in order to be less taxing on the cognition of older people, were re-proposed to the stakeholder group. Through a process of rough prototyping and scenario role-play, the stakeholders helped in identifying the most appropriate concepts to be developed into a proof-of-concept. The participation of the stakeholders highlighted a concept based upon a photographic 'reel' that could be used to both store and view digital images, and a number of proposed compatible devices (Figure 14), as particularly relevant to the aspirations of this group of people.

Figure 8 Photo Reel. John Vines.

A number of issues were identified with the stakeholders in the initial exploratory prototyping of what became entitled the 'Photo Reel' concept, most of which appeared to relate to limitations in their cognitive functioning. One issue was that the magnifying screen on the front of the main reel device was used to both view pictures and rotate them; rotations were made using buttons on the side of the screen. In the participatory workshop and testing, however, it appeared that stakeholders had difficulties making the abstract transformations required to link the movement of the buttons to the rotation of the images. Another issue observed in group participation was the manner in which pictures were transferred from one device to another (such as from the Photo Reel to projectors, or picture frames). In the exploratory prototyping, it was proposed to provide a small device that acted as a pick-up and drop tool from one device to another (Figure 15). The pick and drop device would work by touching one edge of the device against the picture to be picked, and then placed against a surface again to drop it. A seemingly simple interaction to the designer, the stakeholders struggled to conceptualise what could have been a somewhat abstract process.

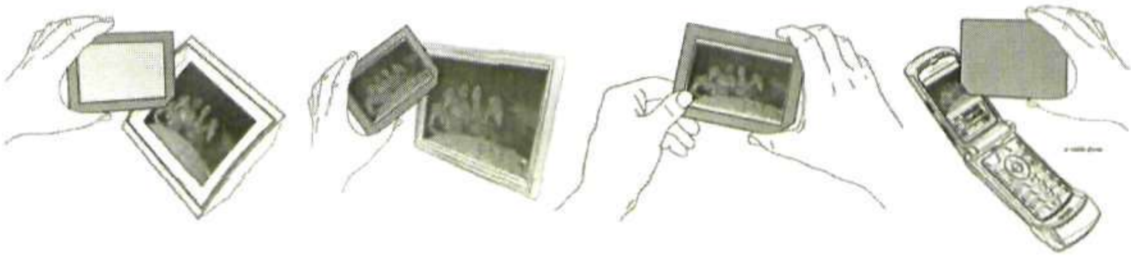

Figure 9 Image tool. John Vines.

Both of these limitations in the initial prototype, which appeared to emphasise the cognitive limitations of the older stakeholders, were resolved through exploring metaphors from within the historical interactions of the stakeholders that were relevant in the context of the sharing of photography. Of a number of metaphors that were experimented with, it appeared that replacing the magnifying screen with a 'slide' mechanism resolved many of the conceptual fallibilities of the initial prototype (Figure 16). The slide could be removed from its cage, physically rotated, and replaced to move a picture around. In order to move an image from one device to another, the slide could be removed and placed into the other devices. Multiple slides could be used, so that multiple pictures and multiple devices could display images simultaneously.

Figure 10 Slide interaction. John Vines.

Although testing with the device was limited, the 'Photo Reel' appeared to be a successful example of cognitively inclusive design. It was initially conceived to reduce cognitive effort, harnessing the basic sensorimotor knowledge and metaphors of long-term procedural and semantic memory. The Photo Reel provided an example of how cognitively inclusive designing, when incorporated into an iterative design process involving the participation and observation of stakeholders, can result in digital media products that provide novel forms of media content to older users without the burden of applying abstract reasoning and cognitive information processing.

However, whilst on the surface cognitively inclusive design appears to resolve the problem of the cognitive disconnection between older people and digital media, it is also rather problematic as an approach to design. The cognitively inclusive approach to design, as that applied in the design of the Photo Reel, is trapped in nostalgic connotations of designing the new. The designer takes for granted that past experience can be reduced into an array of symbols, representations and properties that are transferrable to the design of novel products and interfaces. As will be explained in the following chapter, it is possible to identify these traits of cognitively inclusive design as embedded within the cognitive psychology of ageing literature that it relies heavily on. In particular, it will be argued that the various design approaches brought together in this chapter relies upon a reductionist, cognitivist model of human beings interacting with digital media. What is meant by the term cognitivist, and how this relates to the cognitive study of older people, will be explained in detail in the following chapter.

Chapter 3

Understanding 'cognition' in cognitively inclusive design

Question: What does the term 'cognition' mean as it is used in cognitively inclusive design, and what are the implications of age related changes to its functioning?

3.1. Contemporary cognitive inclusive design research is founded upon a cognitivist philosophy of mind, which understands cognition as a functional system of information-processing.

3.2. The cognitive study of human memory is particularly influenced by the cognitivist paradigm of information processing, which has been characterised by attempts to reduce memory into discrete, functional systems.

3.3. As people age, their ability to encode and recall complex memories deteriorates, whilst the basic information-processing abilities required to transform and manipulate short-term memories are substantially limited.

3.4. Old people are understood to be poor processors of information but a storehouse of long term memories, claims that largely influence cognitively inclusive design.

3.1. The historical roots of cognitivism

Contemporary cognitive inclusive design research is founded upon a cognitivist philosophy of mind, which understands cognition as a functional system of information-processing.

Much of the cognitively inclusive design research described in the previous chapter draws upon a large array of cognitive psychology research that has investigated how the mind changes in later life. As was noted in the previous chapters, concepts such as working memory and various forms of long term memory have been invoked as being related to the cognitive disconnections that occur between older people and digital media. These concepts will be discussed in more detail later in this chapter. Before discussing these, however, it is useful to be more fully understanding of the roots of these concepts within cognitive psychology and cognitive science.[58] What is meant by the term 'cognition' in cognitively

[58] The thesis notes that a significant amount of research and literature that discusses the design of digital media products and interfaces for older people often draws upon evidence from the cognitive psychology of ageing without necessarily discussing what 'cognition' or 'cognitive' may refer to. The assumption might be that

inclusive design, and what are the implications of its definition when applied in design? In the first half of this chapter, it will be noted how these concept of cognition that influence much of cognitively inclusive design are rooted in a philosophy of mind known as cognitivism. This and the following sections trace some of the historical roots of the concepts of memory used in cognitively inclusive design in order to understand several of the underlying assumptions of the discipline's study of human thought as it is applied in design.

Contemporary histories of cognitive psychology portray the discipline as developing from the resurgence in the scientific study of mind in the interdisciplinary field of the cognitive sciences, which is itself a collection of interrelated but often independently studied disciplines (Hatfield, 2002).[59] Central to the foundation of the cognitive sciences in the mid-twentieth century was the philosophy of the human mind that came to be called cognitivism. The influence of the cognitivist model of mind can be observed in contemporary studies of cognitive ageing that underpin contemporary investigations in inclusive design at the time of this thesis.

In order to understand the cognitivist philosophy of the mind, it is helpful to recognise the epistemological context in which it developed. Contemporary accounts of the history of cognitive science, such as that provided by Howard Gardner (1985), claim that cognitivism was a hostile response to behaviourist psychology that dominated Western psychological experimentation from the early to mid-twentieth century.[60] Behaviorism focused purely on what was deducible from observing the external actions of the organism, denying the relevance of internal structures in the organism in understanding interactions in the world.

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cognitive psychologists studies the brain; or the mind; or consciousness. This is not necessarily the case. This thesis attempts to provide a deeper understanding of how certain paradigms of the scientific study of cognition informs designers developing novel digital media for older people. In order to do this, this thesis proceeds from a perspective that as much critical attention must be paid to the scientific study of cognition, and its discontents, as should be to its application by designers.

[59] Along with cognitive psychology, the cognitive sciences are typically defined as extending to the disciplines of artificial intelligence, linguistics, and neuroscience (Hatfield, 2002).

[60] Behaviorism was based upon the principle that the only way human psychology could be studied scientifically was through the observable actions of the organism in the world. It rejected any possibility that there the mind could be scientifically studied as it was internal, hidden and private. Instead, behaviorists asserted that thought was fundamentally visible in behaviour, and that learning could be explained by the conditions of the environment rather than any internal psychological or mental state. As such, behaviorists argued that 'thoughts, feelings, and intentions, mental processes all, do not determine what we do. Our behaviour is the product of our conditioning. We are biological machines and do not consciously act; rather we react to stimuli' (Gregory, 1987, p.71). The emergence of cognitivism and cognitive science in the mid-twentieth century afforded a return to the scientific study of human thought. It appears that popular historical accounts of the nascent period of cognitive science (such as Gardner (1985)) present Noam Chomsky's (1959) critical review of Burrhus Skinner's (1959) book 'Verbal Behavior' as the moment where behaviourism was felled by cognitive science. As Hatfield (2002) notes, however, it is somewhat problematic to take that this one publication as such a pivotal moment in the history of cognitive science, especially as latterly it is understood that Chomsky's review was based upon a number of critical misinterpretations of Skinner's claims.

For a behaviorist, the denial of the internal mental apparatus of human thought as a suitable project of scientific study was founded upon the argument that the mind could not be observed other than through introspective or psychoanalytical methods(Gardner, 1985).[61] The mind and mental processes, it was argued, were completely hidden from external human sensing.

If behaviourism can be portrayed as being only interested in the external, observable, actions of organisms, cognitivism can be described as internal centric, understanding interactions in the world primarily from the internal mental states of human beings. A key influential factor in the transformation of the scientific acceptability of studying the human mind was the development of computation. For many scientists disillusioned with behaviorism, computation provided evidence that it was possible to understand the functional attributes of a system—its information—without having to observe its physically operating mechanisms. As such, 'the activities of the computer itself seemed in some ways akin to cognitive processes' (Neisser, 1976, p.5).

In order to understand how human cognition became described as being similar in its operation to computation, it is helpful to understand some of the influencing factors that shaped the move from behaviour to cognition in the mid-twentieth century.[62] A lot of the groundwork for the formation of the cognitive sciences was performed by researchers associated with the study of cybernetic systems, such as Norbert Wiener, Warren McCulloch, Walter Pitts, and John von Neumann.[63] Dupuy (2009) identifies that the co-extensive

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[61] Introspection is a 'method of data collection in which observers examine, record, and describe their own internal mental processes and experiences' (Colman, 2006, p.389). Psychoanalysis, most prominently known through the influential work and writing of Sigmund Freud (in works such as *Studies on Hysteria* (Breuer & Freud, 1955 [1895]) and *The Interpretation of Dreams* (1913)) was a method of investigating the (mostly unconscious) human mind. The unconscious as understood in psychoanalysis should not be confused with the unconscious, non-conscious and non-declarative in much of cognitive psychology. Colman (2006, p.788) states that the psychoanalytic unconscious is understood as 'a part of the mind containing repressed instincts and their representative wishes, ideas, and images that are not accessible to direct examination.' As psychologists attempted to greater align their discipline with scientific approaches, introspection and psychoanalysis became increasingly isolated from the academic community due to the un-replicable and non-objective nature of claims and findings.

[62] To cover the full and diverse history of the cognitive sciences is out of the scope of many a thesis, and even more so in a short section of a thesis moving between a number of discrete disciplines. Howard Gardner (1985) provides a detailed, if somewhat dated, account of the early years of cognitive science that is sympathetic to the cognitivist philosophy of mind. Steve Heim (1991) provides a useful synthesis of a large amount of archival material from the developmental years of first-order Cybernetics, which heavily influenced the development of the cognitive sciences but is often left out of the latter's history. Similarly, Jean-Pierre Dupuy (2009) presents an analysis of similar material to Heim in order to highlight how intimately connected contemporary cognitive science is to first-order Cybernetic, arguing how the fundamental limitations of the original Cybernetics research, that lead to its failure, are evident within current research and practice. Varela *et al.* (1991) also provide a useful chapter-length overview of this period of time.

[63] Norbert Wiener, primarily a mathematician, was a particularly influential founding member of the original cybernetics movement. Cybernetics, which can be understood as meaning 'the science of control and

development of computing and the mind could be observed as occurring in three acts. 'The first assimilated the mind to a logic machine. The second treated the brain as a machine as well. Since the machine is considered to operate the same in each case, mind and brain were inferred to also be one and the same' (Dupuy, 2009, p.65). The third act, Dupuy argues, was the 'construction of the first ultrarapid electronic calculating machine, ENIAC.' In describing these acts, Dupuy is referring to how, in its cybernetic form, the mind was understood as a form of calculating machine prior to the existence of the computer (whereas in cognitive science, the opposite understanding prevails, where the computer informed the study of the human mind).[64]

During this same period of time, Claude Shannon was developing his influential information theory.[65] One of the central attributes of Shannon's information theory was the notion that 'information can be thought of in a way entirely divorced from specific content or subject matter' (Gardner, 1985, p.21). Norbert Wiener (1948) introduced Shannon's theory into cybernetic research, arguing that the meanings and values communicated between devices—be that a machine or the human mind—are completely separate from a particular physical embodiment. As a result of the earlier cybernetic research, there was an analogous nature to the development of computational systems—computers, robotics, artificial life—and the notion that the brain itself is somewhat computational in its nature. As Dupuy (2009) argues, the human mind was essentially mechanised.

In terms of its use in the developmental period of the cognitive sciences:

> [t]he analogy to the human system and to human thought processes was clear. The human brain [...] corresponded to the computational hardware; patterns of thinking or problem solving [...] could be described entirely separately from the particular constitution of the human nervous system. (Gardner, 1985, p.31)

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communication in the animal and the machine' (Gregory, 1987, p.810) (where animal includes human beings). A key component of cybernetics is the notion of feedback, which is 'the transmission and return of information' (Wiener, 1948, p.96). Feedback, Wiener argued, was a key feature of all natural and artificial systems of interaction (or information exchange) in order for some form of effective action to emerge.

[64] Dupuy (2009) notes that John von Neumann, one of the founding figures of computing and artificial intelligence, was heavily influenced by McCulloch and Pitts (1943) article that argued neural networks and the brain could be modelled with mathematical, logical, calculus. Von Neumann noted that McCulloch and Pitts were suggesting that neural networks essentially operated at two levels; that of a physical system, and that of a model running on top of the physical level. In terms of the original computers, von Neumann transformed this idea into the distinction between hardware and software (Dupuy, 2009).

[65] Claude Shannon, along with Warren Weaver (1949) is often attributed to the development of information theory, which used at length by some of the early pioneers of cybernetics—particularly Wiener—in terms of the communication channels between cybernetic systems; be these human or artificially intelligent systems.

Cognitivism, at least to begin with, rather explicitly used the computer as a reference point for the human mind to be studied. Along with considering mind and body in terms of hardware and software, the virtuous circularity between computational technology and the human mental apparatus developed into a number of other synergies. 'Human beings, no less than computers, harboured programs; and the same symbolic language could be invoked to describe programs in both entities' (Gardner, 1985, p.31).

Having a generally agreed theory of mind founded upon computational logic meant that research into artificial and human forms of cognition were somewhat co-extensive with one another. The terminologies used to describe the machine were also used to describe the human, whilst the distinction between the mental and physical embodiment was strictly adhered to. For example, a key attribute of cognitivist theory is the extrapolation of the representational qualities of computational systems to the human mind.[66] In the cognitivist tradition, representations are necessary as a way of connecting the realms of the physical and mental, and are generally discussed in terms of symbols (Varela *et al.*, 1991). In cognitivism these symbols are conceived as being comprised of dual qualities; they have both physical and semantic resonances.[67] It is argued that whilst symbolic representations exist on a physical level in the human body of the human being (most likely to be the central nervous system or the brain), somehow, semantic meaning and values are attached (and it is the latter that matter to the cognitive scientist). The duality of symbolic representation in cognitivism is

[66] It is important to distinguish the notion of representation from how it is used in cognitive science, computer science and the design of digital media, and in theories emanating from the humanities. Within cognitive science and psychology, representation may be understood in terms of mental representations. The manner in which definition is defined may differ drastically depending upon the ontological perspective of a specific research project. For example, a traditional perspective such as cognitivism, especially in terms of its counter-argument to behaviorism, would argue that science cannot explain cognitive behaviour without presupposing that the mind, in some respect, represents features of the world (Varela *et al.*, 1991). Problematically, the concept of representation leads to questions regarding dualities between mind (the cognitive) and body (the physiological), or body and world, along with further issues as to where these representations exist physically. As a consequence, certain paradigms of cognitive science (such as those of James Gibson (1986) and Varela *et al.* (1991), to be discussed in chapter five) argue against the existence of mental representations. In computer science, more specifically, representations are understood in a different context but perhaps share similarities conceptually with its usage in cognitive science. Essentially, computers act upon computational symbols, which represent a certain numerical state of the computational system. Typically, digital interfaces are designed around another layer of representations that make this numerical state accessible to human beings (as in Graphic Interfaces). In literature more aligned with the humanities, representation may be understood in terms of reflecting certain cultural values. As Manovich (2001) highlights, the numerical and interactive representations have yet another layer of representation to consider; that of representations used to reference other cultural artefacts, technologies and media. In terms of cognitive science in its traditional, cognitivist, format, discussion of cultural representations and subsequent conversations of meaning and qualia are not a factor.

[67] In extreme perspectives, such as that argued by Jerry Fodor (1975), it is suggested that human beings have an innate language of thought that allows them to map the experiences of the world onto a set of representations that are fully available, yet completely sub-conscious, from birth (Hatfield, 2002). Fodor expands the theories of his mentor Noam Chomsky, who had introduced the notion of universal grammar. Chomsky (1965) argued that all human beings have a universal area of the mind/brain where a limited set of symbolic rules govern the acquisition of any language.

another transformation of computational logic into the study of human cognition. A typical computational system only directly interacts with the physical state of the symbols, the semantic value attached to these symbols—their meaning—is arbitrary for the computer to do what it needs to do.[68] In extreme functional accounts of cognitivism, the dualism of symbolic representation is evident but also simultaneously actively denied; for example, Fodor (1975) and Putnam (1988) argue all that is necessary to understand human cognition are the semantic values of the computations—the physical qualities of the hardware, although present at some level of analysis, are inconsequential in terms of cognitive functioning.

Varela *et al.* (1991) usefully summarise the cognitivist philosophy of mind and provide a definition of human cognition to be taken forward in the remainder of this chapter.

> *Question 1*: What is cognition?
> *Answer*: Information processing as symbolic computation – rule-based manipulation of symbols.
>
> *Question 2*: How does it work?
> *Answer*: Through any device that can support and manipulate discrete functional elements – the symbols. The system interacts only with the form of the symbols (their physical attributes), not their meaning.
>
> *Question 3*: How do I know when a cognitive system is functioning adequately?
> *Answer*: When the symbols appropriately represent some aspect of the real world, and the information processing leads to a successful solution of the problem given to the system. (Varela *et al.*, 1991, pp.42-43)

3.2. The influence of cognitivism in the study of human cognition and memory

The cognitive study of human memory is particularly influenced by the cognitivist paradigm of information processing, which has been characterised by attempts to reduce memory into discrete, functional systems.

[68] This disconnection between the physical and software embodiments of computational systems appears to also influence the manner in which people interacting with computing systems on a expert level interact with them. Winograd and Flores (1986) document this well in *'Understanding Computers and Cognition'*, one of the key texts that offer a critique of the cognitivist tradition as it is applied within artificial intelligence and human-computer interaction research in a 1980s context. Winograd and Flores note that '[t]he computer programmer or theorist does not begin with a view of the computer as a physical machine with which he or she interacts, but as an abstraction—a formalism for describing patterns of behaviour. In programming, we begin with a language whose individual components describe simple acts and objects. Using this language, we build up descriptions of algorithms for carrying out a desired task. As a programmer, one views the behaviour of the system as being totally determined by the program. The language implementation is opaque in that the detailed structure of computer systems that actually carry out the task are not relevant in the domain of behaviour considered by the programmer' (Winograd & Flores, 1986, p.87). They argue that the computer can be considered in terms of three main level of representation that are discrete from one another; the physical machine, the logical machine, and the abstract machine (Winograd & Flores, 1986).

Cognitivism was considered a useful way of studying the psychology of human beings as it provides insights into the functioning of the human mind without burdening psychologists with relating their observations to the physiology of the body. As Endel Tulving, discussing experimental psychology in the mid-twentieth century, notes:

> psychology was an autonomous scientific discipline that did not have to learn from any other and was best kept from the possibly corrupting influences of other disciplines, such as neuropsychology or physiology. Every graduate student of experimental psychology at the time knew that there was nothing useful that one could learn from physiology and that smart experimentalists stayed away from brain-damaged amnesic patients, because we had problems enough with more-or-less normal sophomores and their minds and did not need any extra troubles. (Tulving, 2001, p.9)

In comparison to its neighbouring disciplines of linguistics and artificial intelligence, psychology as a discipline was seemingly slower in its uptake of the cognitivist philosophy of the mind (Gardner, 1985); however, once its usefulness was highlighted its uptake appears to have been dramatic. Ulric Neisser, in his 1967 work *Cognitive Psychology*, contributed significantly to the integration of cognitivism into experimental psychology. Neisser discussed cognitive psychology as supplementary and coextensive with what he termed 'dynamic psychology', which he defined as beginning with 'motives rather than with sensory input' (Neisser, 1967, p.4). Alternatively, cognitive psychology dealt with 'all the processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used' (Neisser, 1967, p.4). For example, if 'asked why I did a certain thing, I may answer in dynamic terms, "Because I wanted . . .," or, from the cognitive point of view, "Because it seemed to me . . ."' (Neisser, 1967, p.4)[69]

As with the prevailing thought of cognitivism at the time, Neisser's (1967) descriptions of the mind disembodied the cognitive psychological properties of human beings from the body and world. Another trait that Neisser (1967) took from cognitivism was the analogy of the computer as a way of explaining the reasoning behind this disembodiment.

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[69] Neisser, in his 1967 text, appears to draw a distinction between the cognitive and the emotional, and suggests that rational thinking and emotion are fundamentally polar (although mutually beneficial) opposites. Gregory notes how the 'peculiar characteristics of emotional behaviour and experience have been repeated stumbling blocks in the attempt to see nature as rational, intelligent, and even sublime.' (Gregory, 1987, p.218) Historically, scientists dealing with cognitive behaviour and processing tend to avoid references to emotions. In recent years, the research and writing of Antonio Damasio (such as Damasio (1994)) has seemingly given emotion research within the cognitive science greater credibility, although often emotion in such areas of research becomes just an new process of cognitive behaviour (such as attention, or memory).

> The task of a psychologist trying to understand human cognition is analogous to that of a man trying to discover how a computer has been programmed. In particular, if the program seems to store and reuse information, he would like to know by what "routines" or "procedures" this is done. Given this purpose, he will not care much whether his particular computer stores information in magnetic cores or in thin films; he wants to understand the program, not the "hardware." By the same token, it would not help the psychologist to know that memory is carried by RNA as opposed to some other medium. He wants to understand its utilization, not its incarnation. (Neisser, 1967, p.6)

The integration of the language between the mechanical and the mental was seen to be particularly relevant to the discipline of cognitive psychology.

> Computers accept information, manipulate symbols, store items in "memory" and retrieve them again, classify inputs, recognize patterns, and so on. [...] The coming of the computer provided a much-needed reassurance that cognitive processes were real; that they could be studied and perhaps understood. (Neisser, 1976, pp.5-6)

Although Neisser (1967) found usefulness in using the analogy of information processing and certain computational terminologies in describing aspects of human cognitive psychology, he was very clear that he did not consider human mental processes as being like a computer.

> The occasional and analogic use of programming concepts does not imply a commitment to computer "simulation" of psychological processes. It is true that a number of researchers, not content with noting that computer programs are like cognitive theories, have tried to write programs which are cognitive theories [...] none of them does even remote justice to the complexity of human mental processes. Unlike men, "artificially intelligent" programs tend to be single-minded, undistractible, and unemotional. Moreover, they are generally equipped from the beginning of each problem with all the cognitive resources necessary to solve it. (Neisser, 1967, p.9)[70]

Neisser (1967) highlights the plausibility of working with the ideas that emerged from the cognitivist philosophy of mind, and its metaphorical use of computation, without fully advocating the hard-line views argued by its key figures (Gardner, 1985). The view portrayed to the psychology community by Neisser was that analogies to computation and mathematical logic were useful but not to be taken at face value. One way of interpreting Neisser's (1967) use of terminologies, including 'information processing' and 'program', is as place-markers

[70] Neisser's last sentence above is particularly relevant to the discussion of artificial intelligence and its relationship to human forms of knowing. There has been a growing amount of evidence over the past two decades that suggests that the idea of an intelligent agent being 'pre-programmed' to live in a predetermined world is just not practical in everyday contexts—be it for a human being, an animal, insect, robot or other (see Brooks, (1999; 1986); Pfeifer & Bongard, (2006)). These arguments are discussed in more detail in chapter five of the thesis.

until more appropriate concepts and descriptions became available.[71] In the following years, however, the terminologies used in the nascent cognitive psychology became increasingly analogous with those from the cognitive and computer sciences; information, storage, executive control, processing, input, output and subroutine became increasingly common ways to explain human cognition (Neisser, 1976).

Shannon's information theory and subsequent theories of information-processing heavily informed the formation of the cognitivist theories within psychology. Predating the work of Neisser—around the same period of time as information theory was being introduced by the cybernetics researchers into contexts far broader than Shannon initially envisaged—some psychologists began examining the usefulness of information as a way of describing and studying the attributes of human memory.

The research of George Miller (1956) is noted as significant in introducing information theory to the study of memory.[72] In Miller's (1956) case the interest was in the capabilities of the mind to filter and process information perceived from the world. Miller was seemingly fascinated by the observation that human beings dealt with stimuli or objects of memory in a dramatically different manner beyond seven items. Miller determined the mind itself as a form of information input-output device.

> If you will now imagine a communication system, you will realize that there is a great deal of variability about what goes into the system and also a great deal of variability about what comes out. The input and the output can therefore be described in terms of their variance (or their information). If it is a good communication system, however, there must be some systematic relation between what goes in and what comes out. That is to say, the output will depend upon the input, or will be correlated with the input. If we measure this correlation, then we can say how much of the output variance is attributable to the input and how much is due to random fluctuations or "noise" introduced by the system during transmission. So we see that the measure of transmitted information is simply a measure of the input-output correlation. (Miller, 1956, p.344)

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[71] This is perhaps notable by the manner in which Neisser, in his follow up 1976 text *Cognition and Reality*, emphasises how the then maturing discipline of cognitive psychology was showing signs of being overly focused on the idea of information processing and computational processes. The focus upon information processing, which required highly rigorous and repeatable laboratory experimentation, lacked any 'ecological validity' (Neisser, 1976, p.7). Neisser's later ideas, which mostly opposed his earlier cognitivist argument portrayed in 1967 as a result of the inherent lack of consideration for everyday situation, will be discussed in chapter five of this thesis.

[72] Miller was not alone in investigating the possible usefulness of information theory and its associated concepts in experimental psychology. William McGill's paper 'Multivariate Information Transmission' (McGill, 1954) predated Miller's first published work on information theory principles in psychology. In terms of the historical influence on the cognitive psychology of ageing, however, this thesis identifies Miller's work as introducing certain key ideas that appear to still influence contemporary studies within this field.

Miller (1956) introduced the first prominent example of taking the information theory approach to tracing data through communication systems into the realm of human psychology. Whilst the straight application of information theory and computer science to the study of human memory is highly problematic[73], and this thesis will present the case for an alternative in chapters five and six, the basic principles of Miller's work still appear to resonate in the concepts of ageing memory used within cognitively inclusive design. At the time Miller provided a radical move in providing a method for tracking how information flowed from the environment, through the mental apparatus of human beings, and back out again. Although Miller (1956) did not go as far as visualising this relatively simple idea schematically, it could be deduced that it would be somewhat akin to that of Figure 3.

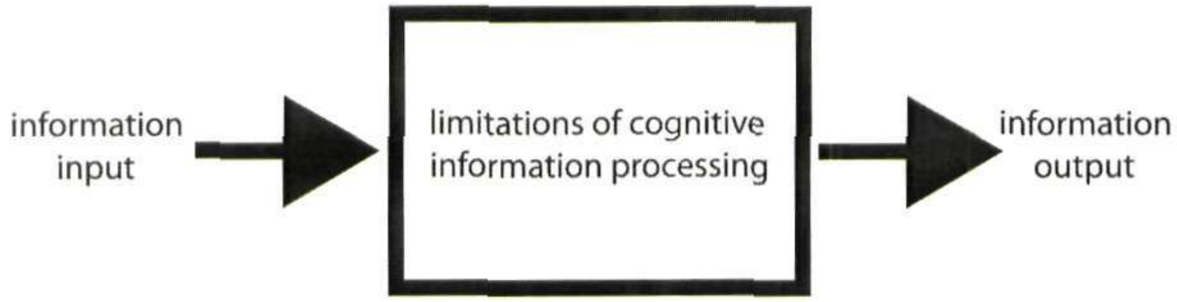

Figure 11 Interpretation of Miller's (1956) basic model of human cognitive information processing.

During the same period of time as Miller was conducting his studies, Donald Broadbent (1958) was investigating the information processing capacities of the human mental apparatus in a similar manner. Whereas Miller (1956) focused solely on the correlations between the input and output from the studied subject, Broadbent (1958) attempted to track information through the organism as it gets processed into and out of various types of storage. This meant that rather than purely correlating information going into and out of the organism, Broadbent (1958, p.299) proposed it may be possible to break this up into stages or steps for further correlating. Broadbent went as far as providing a schematic 'information-flow diagram' that somewhat visualised the processes, systems and sub-systems

[73] The period in which Miller was working on his application of information theory to psychology was a time in where many scientists of the human mind felt studying information as key to understanding the human psyche. 'The enthusiasm—nay, faddishness—of the times is hard to capture now. Many felt that a very deep truth of the mind had been uncovered' (Luce, 2003, p.185). Claude Shannon questioned the applicability of information theory to areas of study beyond those of the study of communication that is original work intended. Shannon is quoted as stating 'information theory has perhaps ballooned to an importance beyond its actual accomplishments', (cited in Johnson (2001)) highlighting his scepticism of information theory's usage in a wide array of fields during the 1950s.

associated with the flowing of information through the mental apparatus of the human subject (Figure 4).

The use of flow and schematic charts as a tool for describing the models of the human mind appeared to be logical due to the engineering-derived approach to these new techniques of learning about the mind. Although various approaches to the discipline of cognitive psychology were devised during its formative years, the informational theoretical approach developed by Miller and Broadbent appeared to be of particular interest. (Gardner, 1985) Following Miller and Broadbent, many of the information-theoretical studies were focused upon various aspects of memory. In such studies, information flow charts such as those introduced by Broadbent became increasingly commonplace. More significantly, however, his claims that human memory could be separated into discrete steps and functions became widespread, with the development of elaborated models of memory formed of many components and sub-components. Although the pioneering work of Miller and Broadbent is now considered highly limited, the fundamental characteristics of their research (for example the increasing compartmentalisation of memory in cognitive psychology and the underlying information theoretical basis of cognition) are still evident in the application of ageing memory research in cognitively inclusive design.

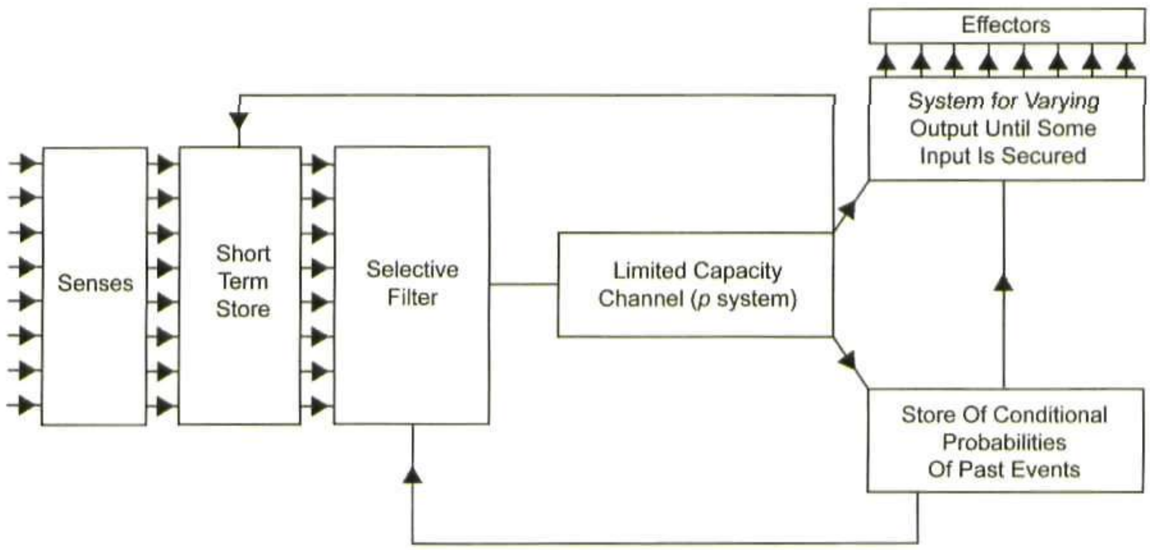

Figure 12 'A tentative information-flow diagram for the organism' adapted from Broadbent (1957, p.299).

3.3. Cognitive concepts of memory and human ageing

As people age, their ability to encode and recall complex memories deteriorates, whilst the basic information-processing abilities required to transform and manipulate short-term memories are substantially limited.

Traditionally, psychologists have found the division of memory into short term and long term variants useful as it provides a way of 'categorising memories by the length of time over which they are retained' (Stuart-Hamilton, 2006, p.99). 'Short-term memory is the temporary storage of events and items perceived in the very immediate past: that is, events and items that occurred no more than a few minutes ago, and usually a much shorter period (i.e. the last few seconds)' (Stuart-Hamilton, 2006, p.99). Whereas,'[l]ong-term memory seeks to be a permanent store of information' (Stuart-Hamilton, 2006, p.100). It appears, however, that the introduction of information theory into the psychological study of memory (as discussed in the previous section) marked the opportunity to further define and isolate functional components of human memory beyond these initial distinctions. Atkinson and Shiffrin (1968) made explicit the idea that human memory could be separated into three key components; the sensory register, short term storage and long term storage (Figure 5). Atkinson and Shiffrin defined these components as the following:

> Incoming sensory information first enters the sensory register, where it resides for a very brief period of time, then decays and is lost. The short-term store is the subjects's working memory; it receives selected inputs from the sensory register and also from long-term store. Information in the short-term store decays completely and is lost within a period of about 30 seconds. [...] The long-term store is a fairly permanent repository for information, information which is transferred from the short-term store. Note that "transfer" is not meant to imply that information is removed from one store and places in the next; we use transfer to mean the copying of selected information from one store into the next without removing this information from the original store. (Atkinson & Shiffrin, 1968, pp.14-15)

Atkinson and Shiffrin's model was key in the development of cognitive psychology literature as it introduced the idea that memory can be reduced beyond the broad areas of short and long term forms of storage. Although this model is of less relevance contemporarily, it popularised the notion that human knowledge production, acquisition and recollection can be separated into discrete steps (Matlin, 2005).

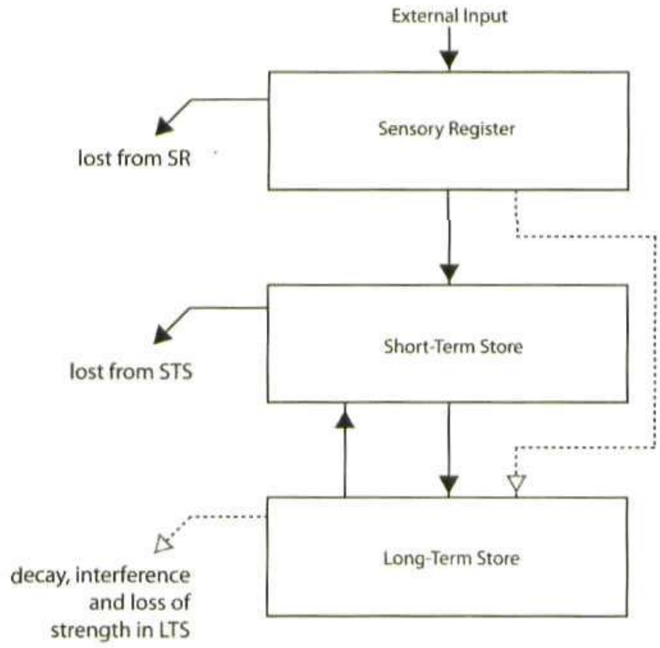

Figure 13 Atkinson and Shiffrin's proposed structure of the human memory system. Adapted from Atkinson and Shiffrin (1968, p.17).

Although a useful starting point for the cognitive study of memory, there was a view within the memory research community that the modal model offered by Atkinson and Shiffrin did little justice to the complexities of human memory and overly simplified its operation (Baddeley, 2007). Atkinson and Shiffrin's (1968) model assumed that if an individual holds information in short term storage long enough, then it gets transferred to the long term 'fairly permanent' store. Alongside this assumption, Atkinson and Shiffrin also suggested that a person required their universal short-term store to be functioning correctly in order for information to be transferred to the long term store. A number of cognitive experiments, in particular those of Alan Baddeley and Graham Hitch (such as Baddeley and Hitch (1974)), observed that these underlying claims did not stand up, leading to two alternative positions of understanding the components of memory.[74] These coexisting approaches individually examine the short term and long term aspects of memory, and although studied separately have become complimentary to one another and integrated in the cognitive psychology literature. As will be explained, these approaches are particularly important to the subject of this thesis, as they appear to heavily influence cognitively inclusive design.

[74] Baddeley and Hitch's argument against Atkinson and Shiffrin is discussed later in this chapter.

3.3.1. Levels of processing, long term memory and ageing

Fergus Craik and Robert Lockhart (1972) developed an alternative to Atkinson and Shiffin's model which became referred to as the 'levels of processing' effect. Craik and Lockhart (1972) argued that rather than being merely dependent upon holding information in short term storage for a certain length of time, the transfer of information into long term storage was more related to the type of processing that is performed on the information. Whereas Atkinson and Shiffrin's model separated the processing of information and the perception of information into distinct and separate stores, Craik and Lockhart (1972) argued that perception and the cognitive processing of information were more intimately connected.

> [W]e prefer to think of memory tied to levels of perceptual processing. Although these levels may be grouped into stages (sensory analyses, pattern recognition, and stimulus elaboration, for example) processing levels may be more usefully envisaged as a continuum of analysis. Thus, memory, too, is viewed as a continuum from the transient products of sensory analyses to the highly durable products of semantic-associative operations. (Craik & Lockhart, 1972, p.683)

The position outlined by Craik and Lockhart is that the manner in which information transfers from perception to long term memory can be thought as a continuum moving from the shallow to the deep. The principle behind this conceptualisation is that the shallower information is processed, the less likely it is to be transferred to long term memory; the deeper it is processed, then the more likely it is to be remembered (Craik & Lockhart, 1972). Baddeley explains what constitutes deep processing based upon these claims:

> They [Craik and Lockhart] suggested that probability of subsequent recall or recognition was a direct function of the *depth* to which an item was processed. Hence, if the subject merely noted the visual characteristics of a word, for example whether it was in upper or lower case, little learning would follow. Slightly more would be remembered if the word were also processed acoustically by deciding, for example, whether it rhymed with a specified target word. By far the best recall, however, followed semantic processing, in which the subject made a judgement about the meaning of the word, or perhaps related it to a specified sentence, or to his/her own experience. (Baddeley, 2004, p.2)

As Baddeley (2004) highlights, levels of processing varies based upon the manner information was perceived, subsequently transferred to memory, and how this transferral interacts with previously stored memories. For example, as Craik and Lockhart's argument goes, information that is only quickly gleaned from the environment would, consequentially, only have a minimal amount of processing. Alternatively, information that is repeatedly perceived, has relevance to already stored memories or happens to be particularly relevant to whatever task is at hand, would incur a deep level of processing and be more likely to be transferred to long term storage. Furthering the computational metaphor, Craik and Lockhart's work established a then novel focus on the relationship between the manner in which information was 'encoded' from perception to the brain and the organisation of long term storage.

Although the suggestion of understanding cognitive processing as a continuum from shallow to deep suggests memory could be understood as a dynamic process, Craik and Lockhart's influential theory has rather amplified arguments for the compartmentalisation of human memory in cognitive psychology. As noted above, prior to Craik and Lockhart, psychologists were already decomposing long term memory into smaller, distinct components, the most frequent being the divide between explicit and implicit or declarative and nondeclaritive memory (Baddeley, 2004). In the context of psychological study, explicit (declarative) memory refers 'to tasks in which people are directly tested on episodes from their recent experience; in performing the tasks people are instructed to remember events and presumably are aware that they are recollecting previous experiences.' Contrastingly, '[i]mplicit memory is revealed when performance on a task is facilitated in the absence of conscious recollection' (Graf & Schachter, 1985, p.501).

Endel Tulving (1972), both influencing and influenced by Craik and Lockhart's level of processing theory[75], developed an argument for the further separation of memory systems by suggesting that the declarative/explicit further compartmentalised into semantic and episodic memory systems.[76] Tulving (1972) classified episodic knowledge as the explicit recollection of past experiences and their temporal relations, whereas semantic knowledge related to a person's general knowledge of the world and the understanding of concepts,

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[75] Endel Tulving and Fergus Craik collaborated at great length over the course of their careers in cognitive psychology and their theories developed and informed one another. The relatedness of Tulving's theory of semantic and episodic memory to Craik and Lockhart's is perhaps best emphasised by Tulving's collaborations with Craik on a number of 'levels of processing' studies at the University of Toronto (such as Craik and Tulving (1975)).

[76] Endel Tulving is a prominent example of cognitive research that focused upon the separation of particular memory systems within the cognitive psychological discipline; however, his work is one of the most oft-cited examples, particularly in conceiving the distinction between semantic and episodic memory. Although Tulving mostly restricted categories of long term memory to semantic and episodic, a brief search of literature reviews and synthesis articles identifies a huge array of alternative classifications. Concepts such as semantic memory, autobiographical memory, implicit memory, declarative memory, explicit memory, procedural memory, and episodic memory, among others, are all identified as reducible functions of human long term memory. Despite all these diverse and, on occasions, only subtly different concepts of memory within cognitive psychology, almost all these concepts can be distinguished into either explicit/declarative or implicit/non-declaritive forms (Stuart-Hamilton 2006).

labels and their relations. Later on, Tulving added the concept of procedural memory to his theory of the organisation of long term memory, whilst also slightly adjusting these definitions.

> Procedural memory enables organisms to retain learned connections between stimuli and responses, including those involving complex stimulus patterns and response chains, and to respond adaptively to the environment. Semantic memory is characterized by the additional capability of internally representing states of the world that are not perceptually present. It permits the organism to construct mental models of the world [...] models that can be manipulated and operated on covertly, independently of any overt behaviour. Episodic memory affords the additional capability of acquisition and retention of knowledge about personally experienced events and their temporal relations in subjective time and the ability to mentally "travel back" in time. (Tulving, 1985, p.387)

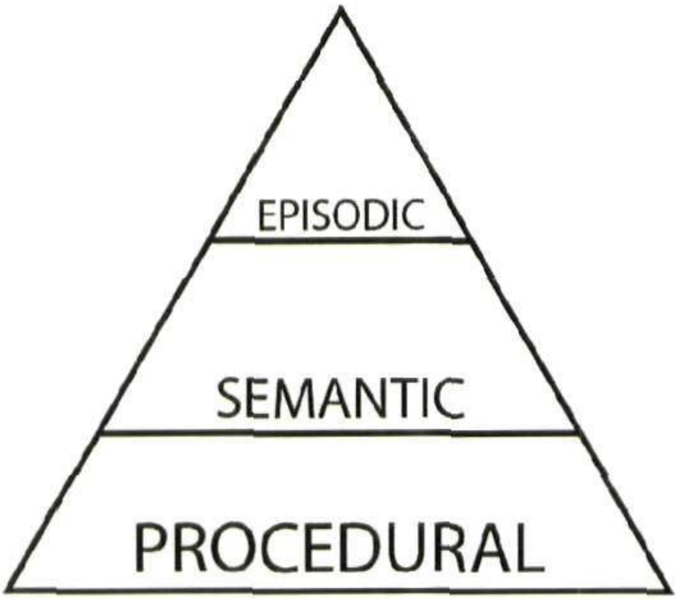

Figure 14 Tulving's monohierarchical tri-memory system. Adapted from Tulving (1985).

The definition of procedural memory provides an aspect of implicit memory and learning that Tulving had not previously considered in his definitions of semantic and episodic memory. *This tri-memory system Tulving developed (Figure 6) was conceived to be* 'monohierarchical', meaning higher-level forms of memory could only exist if the organism possesses the lower-level system. (Tulving, 1985) Therefore, episodic memory is dependent upon semantic memory, and thus semantic memory is dependent upon procedural memory.[77]

[77] Within more recent literature that cites and develops Tulving's concepts the monoheirachical basis of his argument appears to be either not considered or disregarded. This is particularly evident when Tulving's concepts are transferred from cognitive psychology into the broader human factors literature. For example, Scheiber (2003) describes episodic, semantic and procedural memory as discrete entities that are not necessarily dependent upon one-another.

Tulving's theory works neatly with the framework developed by Craik and Lockhart (1972) as it supposes that those processes that require less perceptual processing—the almost automated procedural processes—are the more basic cognitive processes. The semantic system is built upon the procedural, and thus the episodic on top of the semantic, requiring greater amounts of perceptual and cognitive processing.

The cognitive memory systems defined by Tulving (1985) have become a regular test-bed for the study of the effects of the human ageing process on the performance of long term memory. The general consensus within the literature suggests that aspects related to the semantic and procedural systems are generally robust in later life, whilst episodic memories decline in reliability (Schieber, 2003).[78] Experiments into why episodic memory declines more than procedural or semantic systems in older age have suggested that it is related to a reduced ability to integrate perceptual information with already existing memories (Schieber, 2003). If we are to subscribe to Craik and Lockhart's (1972) levels of processing framework, then limitations in the ability to process and encode information from perception into long term memory storage provides an explanation for the limitations in episodic recollections. If we assume that, with age, the functions related to the encoding and processing of information deteriorate, but are still functioning at a limited capacity, then the memory systems requiring the deepest level of encoding (such as episodic memory) would be those that become the most observably dysfunctional.

Studies of ageing and long term memory certainly suggest that there are 'robust' areas of cognitive functioning where there is little decline in ability. At the same time, however, these studies also suggest there may be problematic elements related to the storage of new long term memories. There appears to be a consensus within the cognitive psychology

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[78] Two words of caution should be considered throughout the discussion of the differences between young and old in psychological studies. Firstly, differences between groups of people are inherently hard to quantify and qualify through experimental procedures. Stuart-Hamilton (2006, p.61) notes that 'the 'true' size of a decline may be different from what has been measured. This is a common theme in psychological studies – since researchers cannot open up the brain and see thought taking place, everything has to be inferred from behaviour and this inevitably means that some error creeps in.' Secondly, all studies of ageing also have the problem of grouping together individuals in order to compare old, or the very old, or the middle-aged, or teenagers, to one another. Individual variances in the participants of a particular test is not always documented in the published material, although Rabbitt (1984) is an example of a comparison between young and old that does. Rabbit's study measured mental abilities known as fluid and crystallised intelligence, which will be discussed in more detail later in this section. Rabbit noted that in testing, when discussed as whole groups there was little change in certain abilities between young and old but large differences in others. The conclusion that might be drawn from reading such results is that all the older people declined in this one ability, but Rabbitt (1984) observed this was simply not the case. Although there were more poorly performing older people on this particular ability measure, there were a number of older participants who had not had any decline (Rabbitt, 1984). As such, all of the generalised changes with age in certain cognitive abilities highlighted in this section need to be read bearing in mind they are not inevitable for all. As much as this is true for psychological studies, it is also the case in any discussion of older people interacting with digital media.

literature that the deterioration in the capability to encode and retrieve certain long term memories is rather a side-effect of more significant changes occurring in areas of human *short term memory* (*Park & Gutchless, 2005*; Park *et al., 1996*; *Salthouse, 1994*; *Salthouse,* 1996). In particular, changes to the cognitive functions associated with working memory, a concept developed and investigated at length by Alan Baddeley and colleagues, are heavily implicated in many of the cognitive limitations that appear to manifest later in life.

3.3.2. The significance of working memory in the study of cognitive ageing

The levels of processing framework of memory brought about a significant interest within the cognitive psychological discipline in the study of long term memory storage. It appeared to Alan Baddeley and Graham Hitch that a similar depth of discussion related to the short term aspects of memory, and how such a system may interact and relate to perception and long term storage, was somewhat lacking (Baddeley, 2007). Baddeley and Hitch (1974) focused in particular on the claimed over-simplification of the short-term aspects of memory that was found in the previously introduced modal model of memory by Atkinson and Shiffrin. In a similar vein to that of Endel Tulving's monohierarchical framework of long term memory, Baddeley and Hitch (1974) proposed that rather than the short term store of memory being made of a singular component, it was itself a multiple component system formed of a visuospatial sketchpad, a phonological loop and a central executive (Figure 7).

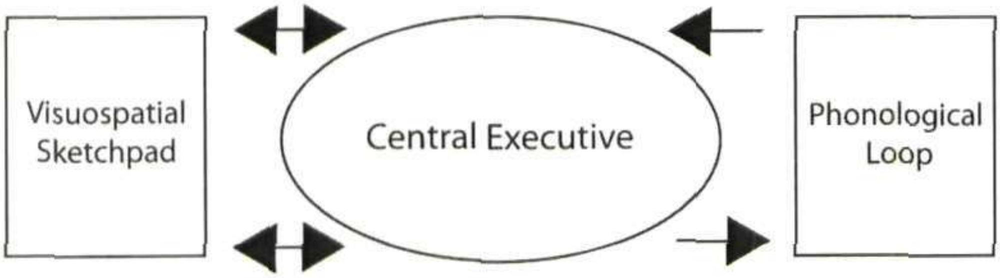

Figure 15 Baddeley and Hitch's original proposal for the working memory system. Adapted from Baddeley (2000).

In the intervening years since its initial conceptualisation, Baddeley and various colleagues have refined and expanded the model of working memory. Over time, the initial three components have multiplied, as did the arrows distinguishing the flow of information from one system to another. The refinement of the model initially focused on the role of the central executive, which was initially argued to be a somewhat general purpose system that controlled attention, as it appeared to lack conceptual and empirical clarity. This led to the identification of an 'episodic buffer' that formed 'an interface between the three working memory subsystems and long-term memory' (Baddeley, 2007, p.13), as shown on the right in Figure 8. This alteration to the model allowed for an increased level of integration between Baddeley's model and the research of numerous other cognitive studies focused upon the role of information processing into and out of long term memory (Baddeley, 2007). Further studies that focused upon the role of emotion on cognition led to further additions to Baddeley's (2007) model of working memory. The initially simple, yet powerful, model of working memory has over time sprouted multiple sub-systems and become increasingly complex (as visualised in Figure 8).

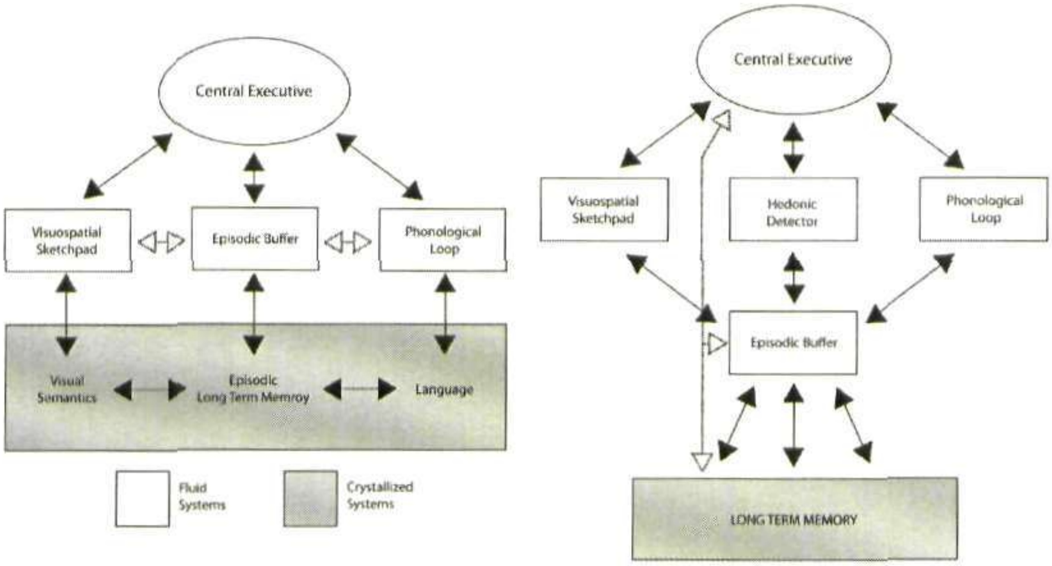

Figure 16 Further developments to Baddeley and Hitch's model of working memory.

Although the continuous expansion of Baddeley's model of working memory suggests some limitations to its conceptual basis, it has proved to be highly influential and robust within cognitive psychology. Baddeley (2007) puts this down in part to the working memory research being seemingly compatible with much of the levels of processing research focused upon long term storage. As shown in Figure 8, it appears that the assumption is that working memory acts as a type of dynamic and fluid ability of processing and attending to certain perceptual information, whereas the long term memory act as a crystallized, 'solid state' of storage. Although long term storage interacts and has information placed into and out of it all the time, the suggestion appears to be that it is a far less dynamic process than the components of working memory.

Working memory research is particularly central to cognitively inclusive design as declines in its functioning are some of the most profound and often observed changes to cognition in later life (Baddeley 2007). Beyond this, changes to working memory are often considered to be linked with problems with other memory systems. Park and Gutchless (2005, pp.218-219) note that '[s]tudies have conclusively demonstrated that both speed of processing and working memory mediate most, if not all, age-related variance in long-term memory', suggesting that whilst the aforementioned changes in episodic memory are significant, they are possibly just an after-effect of the more significant limitations to these crucial functions of human cognition. In particular, it has been observed that in relatively simple short term memory tasks there appears to be no significant difference between the ability to recall information between younger and older people (Stuart-Hamilton, 2006)[79]. As soon as short term memory tasks become more complicated, however, and require a person to transform information or having to remember multiple bits of information for various tasks, older people are noted to significantly suffer (Stuart-Hamilton, 2006). Stuart-Hamilton observes that 'memory span is relatively unaffected by ageing – the principal deficit is in organising the material that is to be remembered and in juggling different tasks when doing something more complex than simply remembering a list of items' (Stuart-Hamilton, 2006, p.103).[80] In terms of his model of working memory, Baddeley (1986) cited deteriorations in the central executive as the primary reason for these declines in ability. It would appear that whilst certain aspects of long term memory continue to function well in old age, essentially, older people are poor processors of information.

[79] Basic short term memory word span tests assess the 'primary' attributes of short term memory. The concept of primary memory in contemporary cognitive psychology is often attributed to Waugh and Norman (1965), who argued that short term memory could be divided into a more basic store (primary) and a larger, transformative store (secondary). Craik *et al.* (1995) note how Waugh and Norman's separation appears to invoke an earlier description made by William James about the features of short term consciousness. James' descriptions, along with Waugh and Norman's experimental research, are somewhat evidenced in Baddley's model of working memory.

[80] It does not appear to take much complication of the standard word span tests to make the differences between young and old become more noticeable. Craik (1986) had young and older people perform what was a standard word span test with the added necessity to read back aloud the list of words in alphabetical order rather than the order in which they were initially read out to them. Craik (1986) observed that even a very simple extension to the already simple word span tests can highlight the declines in working memory ability older people must contend with.

3.4. Older people are poor processors of information

Old people are understood to be poor processors of information but a storehouse of long term memories, claims that largely influence cognitively inclusive design.

It is possible to summarise the historical and theoretical basis of the cognitive psychology of ageing—as it is applied in cognitively inclusive design—in the following points:

- The findings of the cognitive study of memory research are suggested to be important to many of the changes that are understood to occur in the human cognitive system as people age.
- The dominant way of conceptualising memory in cognitive psychology of ageing is that it is formed of various sub-systems of information processors.
- These information-processors can be separated into dynamic, transformative and fluid mechanisms (such as the working memory system) or static, stored and crystallized mechanisms (many of the long term memory systems).
- These memory systems are understood in an abstract functional manner, distinct from the physiology of human beings.

The above claims do not provide a particularly positive description of cognition in later life. As Ian Stuart-Hamilton (2006, p.127) puts it, 'the familiar complaint of many older people that their memories 'aren't what they used to be' seems in the main to be justified. Memory does decline in later life, and despite a few areas of relative preservation [...] the outlook is downwards.' As people age, it seems as though the cognitive abilities dramatically emphasise the static; the development of new memories is lost and as a result leaves only the traces of the past.

Moving briefly outside the cognitive study of ageing memory, research into the fluid and crystallized sub-components of human intelligence[81] provides complimentary observations. Raymond Cattell[82] and his student John Horn considered that whilst all

[81] Human intelligence here is described in the context of its study within the discipline of experimental psychology, building upon the foundational research of Charles Spearman (1904; 1923; 1927). Spearman developed a 'Theory of Intelligence' that divided intelligence into 'general' and 'specific' forms. For Spearman, intelligence was understood as the quantifiable ability for an individual to perform well on intelligence tests, where general intelligence was a figure representing one's continuous intellectual ability applied over tests, and specific intelligence representing the intellectual abilities used on highly specialised tasks.

[82] Raymond Cattell is a particularly controversial figure within psychology. Although his research into fluid and crystallized intelligence is generally considered his significant contribution to the discipline, in recent years his work has become overshadowed by the ideological nature of some of his other writings. As Tucker (2009) argues in great length and detail, much of Cattell's work on intelligence is rooted in his broader interest in eugenics and 'Beyondist' theology. Although similar criticisms were made of Charles Spearman, whose work

intellectual skills make use of the ability of general intelligence, certain types of task require the utilisation of specialist sub-systems of intelligence (e.g. Cattell, 1971; Horn, 1978; Horn & Cattell, 1967). Cattell and Horn developed the concepts of fluid intelligence and crystallized intelligence to describe specific intellectual abilities they felt were observably and behaviourally separable. Cattell (1971, p.98) states:

> immediately it can be seen that the crystallized ability (gc) expressions, through judgmental, discriminatory, and reasoning nature, operate in areas where the judgments have been taught systematically or experienced before.

Whereas, fluid intelligence:

> is an expression of the level of complexity of relationships which an individual can perceive and act upon when he does not have recourse to answers to such complex issues already stored in memory. (Cattell, 1971, p.99)

Horn and Cattell (1967) noted very early on in the development of these separate components of human intelligence there appeared to be dramatic shifts in certain abilities in reference to the age of tested participants. *They noted that fluid intelligence was typically higher in* younger adults than older adults, and vice-versa for crystallised intelligence. Their initial observations have been similarly noted in numerous comparisons between fluid and crystallised skills in young and old since (e.g. Cunningham, Clayton & Overton (1975); Hayslip & Sterns (1979); Rabbitt *et al.* (2004)).[83] It is noteworthy how the definitions of fluid and crystallized intelligence complement the division of working and much of long term memory as alluded to by Baddeley and others. It is equally notable how the observations of these intellectual abilities with age compare well with the cognitive study of ageing memory; the fluid and transformative skills decline in ability, the crystallized and stored skills maintain ability.

The cognitive psychology of ageing research presents a scenario where older people are fundamentally limited in perceiving and acting in the world as a result of the significant deterioration of cognitive information-processing that occurs in old age. In situations where an older person is required to process considerable amounts of information, an example being

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greatly influenced Cattell, it is Cattell's prominence as a significant academic within the contemporary scientific study of human psychology that has perhaps made Tucker's claims all the more provocative. Although this thesis does not attend the provocative issues addressed by Tucker, it is perhaps important to consider the ideological context Cattell's research was performed in when applied in design.

[83] Stuart-Hamilton (2006) notes that the only notable difference between Horn and Cattell's (1967) original study and subsequent tests appears to be that the original authors may have, if anything, underestimated the age at which fluid skills begin to decline.

when interacting with digital media products and interfaces, certain aspects of the interaction exchange will take more effort to process, or may not be cognitively processed at all.

An approach to designing based upon the knowledge from the cognitive psychology of ageing will have a number of limitations. Primarily, as was highlighted in the previous chapter and discussed in more detail in the final sections of this chapter, a designer working with the claims of cognitive change in later life is always going to be identifying ways to limit the interactivity of digital media, not increase it. Secondly, by applying the cognitive psychology of ageing literature within a design process, cognitively inclusive designers appear to implicitly subscribe to a reductionist model of human-technology interaction. Whilst this thesis is not a critique of reductionist methods, such as cognitivism, as they are used in cognitive psychology and science, there are problems when the principles underlying this discipline are transferred into design theory and practice without critical reflection. These issues will be explained in detail in the following chapter, which highlights the limitations of contemporary cognitively inclusive design and its reliance upon cognitivist concepts of ageing memory.

Chapter 4

The problems of the current cognitive approaches to design

Question: What are the potential limitations of the contemporary approach to cognitively inclusive design in reference to the broader context of research on interactions between people and digital media?

4.1. Whilst cognitively inclusive design focused upon the prediction, inscription and prescription of interaction, there are both practical and philosophical reasons as to why this is limited in an approach to designing digital media products for older people.

4.2. The focus on prediction, inscription and prescription appears to be the result of a fascination with constructing models of users in order to generate design outcomes; in doing so, the designer fundamentally limits the agency of the people who use their products.

4.3. The constructions made in cognitively inclusive design are useful as they provide fixed points of reference for the designer to work with; the issue of cognitive ageing, however, requires a sensitivity to the ongoing temporal changes to cognition that occur as people age, and how these relate to interactions with digital media.

4.4. Designers requiring an explanation of the cognitive disconnection between older people and digital media are currently limited to the cognitive psychology of ageing as the dominant knowledge on changes to the ageing mind, which makes it difficult to move away from the preceding limitations.

4.5. From the limitations identified in this chapter, it is possible to propose a number of themes with which an alternative to cognitively inclusive design might be developed.

4.1. The limitations of prediction, inscription and prescription.

Whilst cognitively inclusive design focused upon the prediction, inscription and prescription of interaction, there are both practical and philosophical reasons as to why this is limited in an approach to designing digital media products for older people.

In chapter two, a number of research projects attending to the cognitive disconnection between older people and digital media were brought together under the title of cognitively inclusive design. Chapter three identified how much of cognitively inclusive design is founded upon certain principles rooted in the cognitivist philosophy of mind. Cognitively inclusive design is based upon the examination of the past experiences and technological familiarities of older people in order to bypass the information-processing limitations of cognitive ageing. This process, it is argued, leads to a subsequent exploration and application of metaphors and references to historical forms of interaction in the design of novel digital media products and interfaces. It appears, therefore, that the process of cognitively inclusive designing is focused upon identifying how attributes of the user—in this case their cognitive abilities, bodily experiences and prior interactions with technology—may be reflected in the designed outcome.

One way to convey the process of the contemporary approaches informing cognitively inclusive design is that of predicting, inscribing and prescribing the actions of the older user of a digital media product. The designer makes certain predictions as to how an older person may act within a particular technological context; these predictions are used as a generative mechanism for the design process and subsequently inscribed into the design of a digital media product. The user is conceptually prescribed how they can and cannot act with a product as a consequence of the features of their past experience the designer indentifies as contextually relevant. In the case of cognitively inclusive design, this prescription emerges as a requirement for design as a result of cognitive ageing, which suggests older people make best use of digital media when drawing upon prior experiences with technologies.

This chapter will address some of the implicit problems within this design approach on both a practical and philosophical level. The prominent work of Lucy Suchman (1987), which developed from anthropological critiques of early human-computer interaction research, highlights how reliance upon cognitivist models of human psychology in the design of interactive systems leads the designer to make predetermined plans of how a user will interact with a particular system. Suchman (1987, p.3) argued that such a designer 'treats a plan as something located in the actor's head, which directs his or her behavior' and prescribes action 'at every level of detail' (1987, p.27).[84] Although the use of a plan as a way of modelling the cognitive functioning of a user is useful (as it is deemed to be in the studies discussed in chapters one and three), Suchman (1987, p.39) takes issue with them being used

[84] When referencing the concept of using a plan to predict and inscribe interactions between a user and a technological system, it appears that Card *et al.*'s (1983) GOMS method of analysis and the traditional human factors approach to analysing and redesigning digital products were primary targets for Suchman's (1987) argument. Although Suchman's (1987) argument was published over a decade prior to much of the work described in chapter three, it might be fair to assume these approaches, focusing upon the description, prediction and inscription of a person's relevant prior experiences, would be included as problematic design processes.

as a 'generative mechanism for action'.[85] Her argument is founded upon ethnographic observations and her subsequent analysis of novice users trying to use a then-novel 'double-sided scan' feature of a photocopying machine and an 'expert-help feature' intended to simplify its use. She further argues that the help feature, designed with a plan for human actions, tasks and goals in mind, did not hold up on a practical level, especially in light of the manner in which people appear to make sense of situated activities. Suchman (1987) argued that a constraining factor for most people interacting with novel digital products is the limited access that an object such as a 1980s Xerox photocopier has to the intentions of the user. In order to get around this:

> the designer of the expert help system attempts to circumvent those constraints through prediction of the user's actions and detection of the effects of actions taken. When the actual course of action that the user constructs proceeds in the way that the design anticipates, effects of the user's actions can be mapped to the projected plan and the system can be engineered to make an appropriate response. (Suchman, 1987, p.169)

In her analysis of users interacting with this system, Suchman (1987) observed attributes of the human interaction with the technology that emerged in real-time and could not be accounted for in the *a priori* modelling of the user inscribed in the design of the system.

> The new user of a system [...] is engaged in ongoing, situated inquiries regarding an appropriate next action. While the instructions of the expert help system are designed in anticipation of the user's inquiries, problems arise from the user's ability to move easily between a simple request for a next action, "meta" inquiries about the appropriateness of the procedure itself, and embedded requests for clarification of the actions described within a procedure. (Suchman, 1987, p.169)

Highlighting the ethnomethodological and conversation analysis backdrop of her research, Suchman argued that the user interprets aspects of the machine's communications as they would in conversing with another human being, but this is an expectation that the machine cannot live up to.[86] A plan is just one factor that forms a person's interaction with a digital media product and that, in the practical context where everyday activities take place, interaction is rather unpredictable. Instead of focusing upon *a priori* modelling, Suchman

[85] The use of cognitive psychology and rationalistic methods within the design of technological systems has been argued against for some time, with prominent scholarship such as Suchman (1987; 2007), Winograd and Flores (1986), Agre (1997) and Coyne (1999).

[86] Much of Suchman's (1987) analysis of human-computer interactions was based upon a method of ethnographic analysis called ethnomethodology, originating in the work of Howard Garfinkel (1967). In HCI, ethnomethodology is typically used as a way of analysing ethnographic observations of the moment-by-moment conversational interactions between people in particular situational contexts.

argued that designers of digital media systems examine the situated actions of groups of people. She defined situated action as 'an emergent property of moment-by-moment interactions between actors, and between actors and the environments of their action' (1987, p.179). The move from the cognitive scientific stance to situated action realigns the designer's role from engineering the information passed between the symbolic system of human cognition and the symbolic system of computational apparatus, to being an observer of the situated activity and designing in response to the analysis of these observations.

Suchman's work illuminates how modelling the user in an *a priori* manner is overly restrictive in the context of designing digital media interfaces. In the example of the novel photocopier system, it appears that the cognitive model of the office worker applied by the systems designer—from cognitive science[87]—fails to account for the non-cognitive situational context.

At the same time as Suchman was developing her account of human-machine communication, Winograd and Flores (1986) provided their seminal critique of artificial reason. Winograd and Flores, through readings of Heidegger, Gadamer and Maturana, developed a phenomenological perspective on the use of technology that un-concealed the depth at which reductionist and rationalistic conceptions of human thought and communication had penetrated the then nascent field of human-computer interaction. Both Winograd and Flores (1986) and Suchman's (1987) critiques have heavily influenced human-computer interaction research since. Winograd and Flores (1986), however, is considered somewhat problematic as their alternative framework for human-computer communication—based upon Searle's speech act theory—can also be considered heavily rationalist (Suchman, 1993). Suchman's alternative approach—based upon ethnographic observation and ethnomethodological analysis—has found much more favour within human-computer interaction research, leading to a paradigmatic change from the emphasis on cognitive models to the exploration of the situational context.[88] The subsequent 'ethnographic turn' (McCarthy

[87] This refers to the co-extensive development of computer science and cognitive science, particularly during the period of time that Suchman's original argument was developed in. As was discussed in chapter two, cognitive and computer science were developed alongside one-another and the knowledge of computational engineering and programming informed the study of human cognition, and vice-versa. The computational paradigm of understanding the human mind, it was argued, would be particularly useful when developing computer systems where people needed to communicate with computational machines. This is particularly noteworthy in Card *et al.*'s (1983), where Newell's background in cognitivist approaches to studying the mind is particularly apparent.

[88] After Suchman's (1987) initial publication, the analysis of ethnographic and observational material became increasingly popular within studies of human-computer interaction, particularly in the context of augmenting workplaces with computer technologies. Prominent examples of the use of ethnomethodology in workplace studies is a series of studies of air traffic control (ATC) centres, initially developed at Lancaster University by Hughes *et al.* (Harper & Hughes, 1993; Hughes *et al.*, 1995) with further studies taking place at other centres as

and Wright, 2004, p.34) in human-computer interaction lead to a greater emphasis on the social construction of activity (such as Nardi, 1996) and the distribution of cognition around social environments (such as in Hutchins, 1995).

The influence of Suchman's argument is particularly evident in Paul Dourish's (2001) later argument that it is the user that manages their own couplings with a digital media product, and not the designer. Coupling, for Dourish (2001), is the intentioned process of making a connection with a digital system—and this process is under the control of the user, not the designer. It is difficult for the designer to predict exactly how a person may couple with a digital media product, and a design approach that attempts to do so may be inherently flawed. Dourish suggests that this is both a practical and a philosophical issue for design, bringing the ontological stance of the designer into question. By 'designer's stance' Dourish (2001, p.172) refers to 'the designer's conception of what he or she is doing, and in particular, of his or her role in an interaction between the user and the artefact.' He argues that:

> This stance has to be transformed when we recognize that users play a much more active role in determining precisely how a technology will meet their needs—needs that are continually changing, and that will be satisfied using a variety of features of the setting, of which the technological artefact is only one. In other words, the precise *way* in which the artefact will be used to accomplish the work will be determined by the user, rather than by the designer. Instead of designing ways for the artefact to be used, the designer instead needs to focus on ways for the user to understand the tool and understand how to apply it to each situation. The designer's stance is revised as the designer is less directly "present" in the interaction between the user and the artefact. (Dourish, 2001, pp.172-173)

Dourish argues here that the immediate consequence of this altered stance is an alternative array of design activities and concerns. 'In particular, the designer's attention is now focused on the resources that a design should provide to users in order for them to appropriate the artefact and incorporate it into their practice' (Dourish, 2001, p.173).

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a result (Berndtsson & Normark, 1999; Mackay, 1999; Rognin *et al.*, 1998). The ethnography of the workplace, in its actual settings, highlights the activities of the air traffic controllers in a highly different manner to that noted in procedural manuals of the work. The studies by Hughes *et al.* (1995) highlighted the significance of the 'flight strips', a piece of card that represent certain data of an aircraft as it is in the control of the ATC's airspace. A simplistic analysis of the flight strips may be that they merely hold and communicate information, and could be augmented or replaced by a digital representation instead. However, a deeper ethnomethodological analysis suggests that they are far more integral to how work is done; they hold handwritten information of various individuals, move across the centre from one station to the next, and can be configured in sequences that represent the air traffic as it is. The assumption may be that the 'basic' card strips aid the greater technological representations of radar systems, whereas in practice it is the other way round.

The arguments of Suchman (1987) and Dourish (2001) highlight a key limitation to the contemporary approaches of cognitively inclusive design discussed in chapter two. The practical methods and philosophical stance of cognitively inclusive design lead to a situation where the designer is implicated as the manager of couplings between older people and digital media. By focusing upon the role of metaphors and prior experience, cognitively inclusive design is primarily about predicting the interactions between a group of people and a particular digital system. The designer, through the examination of historical resources and groups of typified stakeholders, identifies what interactions, features, symbols etc. relate to the context to be designed within and make the initial interaction process as simple as possible. These problems can be highlighted by returning to the case study of the Photo Reel, discussed near the end of chapter two. A media context was identified, in the form of photography and its digital counterpart, and the personal histories of media and product interactions of a limited group of users participating in the design process were explored. These personal histories were used as the key to prescribing the coupling between older people and this media context. Therefore, seemingly abstract aspects of the original iteration of the Photo Reel were refined to better match the histories of technological interactions of these users. The process of designing the Photo Reel was a case of continuous prediction and subsequent prescription of what prior experiences this group of older people could bring to bear when interacting with this type of technological context.

It is important to emphasise that even in situations where the designer explicitly mediates the coupling between people and technology, the user still controls their intentional choices in terms of how to interact with specific aspects of a digital media product or interface. Problematically, however, the stance of the designer, and their subsequent design activities, reduces the amount of choices made available to the user. In the example of the Photo Reel, the stance and activities of the designer focused almost entirely on prescribing how the user couples with the digital media product. Therefore, the possibilities of interaction—or to manage coupling—are inherently limited for the user. The continuous referral to historical modalities of interaction, although well intended in terms of usability or intuitivity, leads to a situation where the connections a user can make are prescribed by the designer based upon their analysis of the stakeholders and the products context. This leads to a particularly paradoxical situation; the designer, acknowledging that older people seemingly struggle to connect to novel digital media products and interfaces, mediates the connection process through older media. Consequentially, novel learning never takes place outside of this extra layer of representation enforced on the user by the designer. As noted, whilst areas of HCI and interaction design have taken on board arguments favouring the examination of situated social context and have moved beyond using primarily cognitive models to generate the design of media interfaces, this conversation is lacking within cognitively inclusive design. A reason for this may be that cognitively inclusive design, as a consequence of the prevailing claims from the cognitive psychology of ageing, is trapped in a discourse of constructing between older people and digital media.

4.2. The limitations of constructing fit between older people and digital media

The focus on prediction, inscription and prescription appears to be the result of a fascination with constructing models of users in order to generate design outcomes; in doing so, the designer fundamentally limits the agency of the people who use their products.

The issue of predicting, inscribing, and prescribing is a side-effect of designers constructing fit between people and the products designed for them. Johan Redström (2005) argued that much of post-Modernist design, both in terms of industry and research, has evolved into a discourse centred upon getting a better fit between object (be this an electronic consumer product, a service, a media interface, or a piece of furniture) and user. In common design processes, as in the inclusive design process discussed in chapter one, this better fit is established through researching who the potential user is, what makes them who they are, and communicating the message of how to use a particular design to this user. 'Design, then, becomes a matter of using the right 'language' to express the functionality and intended use of the object' (Redström, 2005, p.126). Redström argues that even though interaction design research has shifted from predominantly focusing upon physical or cognitive attributes of users, towards a greater awareness of 'user experience', this theme of communicating ideas to users still prevails. This more recently introduced strand of 'experience design'[89], although moving the goalposts somewhat, still attempts to fit design to the user. 'By providing the right material preconditions, we aim to make people more productive, more willing to consume [...] through our designs' (Redström, 2005, p.128).

Redström argues that rather than designing products based upon a centralisation of the user, designers have gravitated towards designing the user instead. Decisions made during the

[89] Experience design, as Redström (2005) uses it, refers to the increased focus on expanding traditional models of use (as in the lineage of cognitive psychology, human factors, and ergonomics) into the realm of emotion and experience. This usage of the term experience design is not to be confused with the recent research into experience-centred design by McCarthy and Wright (2004; Wright and McCarthy 2008), which takes a more reflective approach to understanding the experiences of people using technology. This latter approach will be discussed in the final chapter of the thesis.

design process related to what type of product or service is being designed, and what type of person would be using such a product or service, require certain assumptions as to how certain groups of people would use certain types of products from the beginning of the design process. Through this process—be it with the participation of users, or the acquisition of knowledge about users from other domains—the designer constructs an image of who will be using what. Redström (2005), much like Suchman (1987) before, argues that very rarely does the construction a designer makes of both a particular products use and the user who will use it—which is fundamentally a prediction—correlate with how products and objects are actually used.

> While the process of people becoming users certainly is in focus in user-centred design, it is often from the perspective of how to make it as fast and efficient as possible: what needs to be done in order to make the intended use of the object easy to understand, its functions easy to learn, the product immediately appealing, etc. Use, however, seems to be a kind of on-going achievement, the results of a continuous process of encounters with objects and how one acts upon them. (Redström, 2005, p.131)

The argument of Redström (2005) is highlighted in the earlier stated account made by Suchman in terms of human and machine communication, wherein the predictions and prescriptions of the designer failed to match the contingencies of the situated activity. It is argued by Redström (2005), however, that beyond just failing to adequately predict the actions of people in relation to the designed object, such user-centred approaches to designing tend to focus upon reducing the space for opportunities of interaction. He comments that:

> [c]reating a tight fit leads to a reduction of the ambiguity in how to interpret the object in terms of use. When asking 'what is the use of this?', there is a ready answer and we do not have to think further about what it means. [...] As the possibilities for alternative interpretations are systematically reduced as a result of the designer's attempt to optimise the design with respect to fit, the room for finding our own solutions, possibly coming up with interpretations that are more interesting than the original intent, is reduced to a minimum. (Redström, 2005, pp.132-133)

This is particularly evident in cognitively inclusive design, wherein the very purpose of the design process is to identify the prior experiences of particular groups of people in order to limit the opportunities for interaction with the interface. In terms of usability or intuitive interactions, this fit between the user and technology is portrayed as beneficial. Redström, alluding to interactions with products as an ongoing and in some cases effortful experience, considers such reductions as repressing the user. Almquist and Lupton (2010) take up

Redström's argument to suggest that a key problem of design research has been the division between the use of objects and the meaning of objects. Drawing upon user-centred design research after Norman (1988), they argue that much of design research—in terms of studying the user—focuses on designing affordances. Almquist and Lupton (2010, p.7) argue that:

> [t]heories of use, usability, and users have grown out of the fields of engineering, cognitive science, and design research, and have been heavily influenced by Norman's notions of affordance (or perceived affordance). In order to communicate the use of an artifact, the designer aims to make explicit specific affordances by intentionally embedding cues for people who use the object. [...] The designer becomes concerned with embedding content and action into artifacts so that the function of the object is immediately understood by the subject.

The concept of affordance and the work of Norman (as developed in Norman (*1988*; *1999*; 2002; 2004) is heavily implicated by Almquist and Lupton (2010) in the centralisation of studying the user in the design process. Affordances are (in Norman's account as it is described by Almquist and Lupton) the glue between the subject and the object; affordances communicate how to use a product or interface to a particular audience of users.[90] If affordances are designed into products then, it is assumed, users will understand the product and use it accordingly. This position—based upon the notion that use can be designed into an object based upon knowledge of the user—is problematic in that it fundamentally places the decision making process in the power of the designer, rather than the agency of the user (*Almquist & Lupton, 2010*).

This issue has been critically discussed in the field of the history of technology in relation to the design of new media. Michael Punt (1998) highlights how the history of personal computing and associated media technologies is a strong example of where technologists, businessmen and designers, influenced by the perceived potential of new technological developments, have mismatched technological potential to the needs, desires and aspirations of potential users. Punt (1998, p.63) argues how it is somewhat remarkable 'that the PC survived as a consumer product, given the gulf between the consumers and the producers' ideas about the machines.' He contrasts further the development and deployment

[90] As Almquist and Lupton (2010) highlight, the theory affordances was developed by Norman from the ecological psychology of James Gibson (1986). In its translation from the ecological psychology of Gibson to the design of everyday products by Norman, significant attributes of the original theory have been maligned. Although Almquist and Lupton (2010) do not go into detail regarding the differences between Gibson and Norman's accounts of affordance, it appears worthwhile to examine the notion of affordance in greater detail. In chapter five, this thesis will begin to develop an alternative foundation for thinking about cognition as it relates to human senescence and older people interacting with digital media based upon developments of Gibson's original account of affordance over the later definitions offered by Norman.

of CD-ROMs, which at one point was predicted to 'transform education and popular entertainment in unbounded ways. This medium [...] would be used to store data in a great variety of forms [...] which would be accessed associatively to provide a powerful value-added learning tool' (Punt, 1998, p.63). Highlighting how, as of 1998, many of these predictions had not come true, Punt (1998) contrasted the technologically determined approach of CD-ROM design with the emergence of the internet as a popular medium. He argued that:

> the network of networks which we call the Internet, is often frustrating and irregular, yet it has an enormous constituency of active participants trying to make it work in unscientific ways. It is a hit and miss technology that uses an ugly and burdensome language called html, slow screen refreshment rates, and low resolution, but it has captured a popular imagination in ways that have taken industry and dedicated media analysts such as Ted Nelson by surprise. (Punt, 2005, p.79)

Although the internet is a coming together of a large amount of discrete technological components and the hard work of amateurs, it has been 'appropriated by popular culture in ways that its inventors could not have envisaged' (Punt, 2005, p.79). Punt (2005) reflects this was supported by the non-technologically determined emphasis of the medium's development; the technological potential merely played a supporting role in the ability for the audience to engage and actively participate in the communities and content that emerged.

This brief excursion into the history and social construction of technology highlights how historical analysis is useful to current designers in highlighting the central role of the user—whomever this may be—in the ongoing changes in meaning, use and application of technological systems.[91] Rather than taking history in terms of nostalgia—which becomes invoked in cognitively inclusive design—designers would benefit from using the numerous historical analysis of technology and science to reflect upon their own practice and process. In contrast to the social construction of technologies, the approaches informing cognitively inclusive design are explicitly focused upon what Redström (2005) called 'user design'. These approaches to design are primarily concerned with the *a priori* construction of a representation of the user as much as it is the construction of designed object. By going

[91] Punt's historical analysis of personal computers, CD-ROMs and the internet is just one example of a variety of histories of technology that have highlighted the profound agency of cultures and groups of people in giving technology its meaning. Bjiker *et al.* (1987) present a comprehensive anthology of some of the original social construction of technology texts, including studies examining the social context of the development of technologies such as Bakelite, synthetic dyes, missiles, and medical imagery. Nye (2006) describes a large array of technologies, such as the bicycle, the automobile and the distribution of electricity in the United States, whose success or development has been shaped primarily by social and cultural factors rather than technological possibilities.

through this process of constructing the user and the technology, a best possible fit is made that leads to the correct appropriation of a product by a group of consumers. This is particularly evident in the work of Blackler *et al.*, wherein it is suggested that in situations where a technology or media is completely novel, it is necessary to establish what references may work from other contexts for particular groups of users. In terms of a design stance focused upon usability, or intuitive interactions, Blackler *et al.*'s approach is acceptable. If taken in light of Redström's (2005) argument, and considered within the wider understanding of the social construction of technologies, then such a closed stance in design substantially limits the agency of potential users.

4.3. The limitations of concrete constructions

The constructions made in cognitively inclusive design are useful as they provide fixed points of reference for the designer to work with; the issue of cognitive ageing, however, requires a sensitivity to the ongoing temporal changes to cognition that occur as people age, and how these relate to interactions with digital media.

The tendency to construct a fit between older people and digital media that appears in cognitively inclusive design can be viewed as a consequence of an assumption that older people, digital media, and the contexts these constructions interact in, are concrete and fixed. Groups of people in this context are considered to be somewhat concrete in terms of their cognitive functions (or lack thereof) and prior experiences; individual members of these groups are considered to be suffering certain deteriorations at definable moments in their lifetime; the contexts older people are understood to engage with technology in are concrete, static and, as such, describable in fixed terms.

For example, it is possible to observe the concrete constructions of the older user in both the tools and methods of the human factors of ageing studies, and also the design process for intuitive interaction described by Blackler *et al.* Human factors research, as discussed at the end of chapter one and the start of chapter two, is very often performed in reference to the corpus of scientific knowledge about the user—such as that provided by the cognitive psychology of ageing. As Rogers and Fisk (2003, p.2) stated, '[h]uman factors researchers aim to match the demands of a system to the capabilities of the user'. This is emphasised in the guidelines for designers provided by Schieber (2003), which are essentially a matching of the demands of digital media interfaces to the cognitive capabilities of older people. Kline (2003, p.85) notes that the guidelines offered by Schieber (2003) are consistent with 'the principle of "the greatest good for the greatest number" [... and] appropriately emphasizes findings regarding normal age-related changes that come from well-controlled, small-group experimental studies.' In these human factors studies, the knowledge of cognitive deterioration comes in the form of concrete points of reference (in terms of specific ages or age-ranges for changes in specific functions) and 'normal' becomes a mean or an average. A concrete construction of the 'normal' older user is created, which the next stage of design activities can be centred upon. Whilst this may be a necessary consequence of standardisation and contemporary commercial design practice, such a perspective lacks sensitivity to the diverse and ongoing changes that all human beings, and particularly people later in their life, are engaged with.

The concrete constructions of the cognition of older people found in human factors studies are observable in the proposals made by Blackler *et al.*, only this time in terms of prior experience with technology rather than specific cognitive abilities. To recollect from chapter two, Blackler *et al.* proposed the following principles as key to developing intuitive interactions:

> 1. Make function, location and appearance familiar for features that are already known. Use familiar symbols and/or words, put them in a familiar position and make the function comparable with functions users have seen before.
>
> 2. Make it obvious how to use less well-known features by using familiar things to demonstrate their function, appearance and location. (Blackler & Hurtienne, 2007, p.4)

In order to establish familiarity it is necessary to ask questions such as: Familiar for whom? Familiar in relation to what? What makes certain properties of interfaces more familiar than others? How can a symbol and/or feature from one context be transferred to another without losing its familiarity? Whilst in terms of usability these are appropriate questions, now informed by the work of Suchman, Dourish, Redström, Punt and the history of technology, these questions appear as problematic. It is assumed that prior experience can be identified by designers, transferred symbolically onto newly designed products and interfaces, and comprehended by the user with some immediacy. The problematic nature of the metaphorical approach is noted by Blackler *et al.* in reflection upon their own argument; 'familiar terms can have multiple meanings' and what is familiar 'to one user is not [...] to others' (Blackler *et al.*, 2006, pp.15-16). Rather than identifying this as a limitation, Blackler *et al.* (2006, p.16) reaffirm their approach with caution; '[m]etaphors should be selected for their appropriateness to the target market and should be matched to the experiences and capabilities of typical users'.

Similarly, the argument presented by Hurtienne *et al.*, although coming from a different perspective on cognition to that of Blackler *et al.* and the human factors community before, appears to characterise diverse groups of technology users, such as older people, as concrete entities. To recap, Hurtienne *et al.* argue that there is certain basic, low-level sensorimotor knowledge—known as image schemas—that all human beings have developed to make sense of abstract situations. Designers, Hurtienne *et al.*'s argument goes, would do well to exploit these image schemas of sensorimotor knowledge within digital media products in order to make interactions more intuitive and familiar to the user. It appeared that the application of image schemas may have particular benefits to inclusive design as they are 'accessible to the widest range on people'[92] (Hurtienne *et al.*, 2008, p.115) and '[t]he universitality' of image schemas 'predicts that user interface features designed with image schemas should be equally usable by members of different technology generations' (Hurtienne *et al.*, 2009a, p.257). By making the most of this sensorimotor knowledge, which operates on a non-conscious level, then cognitive resources would be freed for more intensive aspects of interacting with digital media products. In terms of older people, Hurtienne *et al.* argue the application of image schemas navigates around the limitations of cognitive functioning in later life.

Hurtienne *et al.*'s argument is founded upon a paradigm of cognitive science that is rooted in the inseparability of the human body and its interactions with environments from cognitive functioning and experience. Hurtienne *et al.* state that:

> [i]mage-schematic designs should be less susceptible to variations in users' cognitive ability like working memory capacity, attentional resources, decision-making, etc. Similarly, cognitive losses should affect knowledge on the higher levels of the knowledge continuum earlier than image schemas that reside on a lower, earlier obtained and more strongly rehearsed level of knowledge.' (Hurtienne *et al.*, 2009a, p.257)

[92] It appears that Hurtienne *et al.* (2008) assert this point but perhaps need to examine the claim in a little more detail. It might be that the concept of image schema being 'universals' to a great many users falls down in an inclusive approach to design. Of course, on one hand the inclusive approach to designing is about finding aspect of human beings that are suitable for one and all. However, an inclusive approach is also about looking at the specific differences between groups of people and approaching the design of products and services that include these differences. The argument that image schema are useful to inclusive or universal design approaches may fall down once it is taken into account that these people require a specific understanding as their image schema are different to the 'typical' human being. They have differing bodies and differing embodiments of sensorimotor knowledge. Their perceptual abilities are tuned in a differing manner for differing specialisms.

The limitation of Hurtienne *et al.*'s proposal, however, is that if we are to take a position that argues mind, body and world are inseparable in cognitive experience, then ongoing temporal changes to the physiology of the body and how this relates to the world will subsequently alter the manner in which the world is perceived, cognised, and acted upon. If lower-level sensorimotor and image-schematic cognitive abilities are left intact in later life, then they may be somewhat out of synchrony with the ongoing changes to an individual's body and environment.[93] Whereas the design activities of the human factors researchers and Blackler *et al.* proceed to universalise a process of temporal change into static reference points, Hurtienne *et al.* seek to apply a universal (and seemingly static) reference point onto a process of change.

The problems associated with dealing with a state of ongoing change in a traditional design process appear to be evident within some of the paradoxes of the approaches that inform cognitively inclusive design. This paradox is highlighted by how the construction of older people in cognitively inclusive design flips between two extreme accounts. In one extreme, the older person is portrayed as lacking certain abilities and encountering a state of profound temporal change and deterioration in their cognitive functioning; this temporal change, however, can only be reflected in design through concrete definitions based upon moments in this transition. On the other extreme, the older individual is constructed as holding certain universal forms of knowledge formed through their own bodily interactions; these universals, it is argued, are still present in old age, and designers would be wise to make use of this user knowledge in the design of digital media products and interfaces. In the first extreme, the designer is aware of changes to people over their life span, but can only model human beings in terms of concretely defined moments. In the latter extreme, the designer is aware of aspects of human sense-making and cognition that go beyond the contemporary, cognitivist, definitions, but fails to consider that these universals may also change over a lifetime.

Problematically, inclusive designers dealing with the disconnection between older people and digital media are immediately presented with a discourse that focuses upon the losses of ageing. This is particularly evident in cognitively inclusive design, which, in drawing upon the dominant literature of cognitive psychology of ageing, attempts to fit objects to the older user as a result of the claimed losses of cognitive functioning. If the group of people to be designed for are in a state of profound and ongoing change, then it is no

[93] This point, which is not discussed in Hurtienne el al. (2009a), is elaborated throughout chapter six of this thesis where a framework for understanding senescent, rather than ageing, cognition is developed.

longer possible to support a design process that attempts to develop technological contexts and, thus, digital media products, in light of static and concrete points of reference. With some consideration, attributes of these extremes will be brought together by this thesis into a framework that takes into account the ever-changing, contingent, and emergent dynamic aspects of interactions between older people and digital media. Referring to older people and the digital media they interact with in terms of an ongoing change, or achievement, will highlight the limitations of contemporary inclusive practice, whilst also offering an alternative way of thinking about the problem of cognitive disconnection.

4.4. The limitations of applying the cognitive psychology of ageing in design

Designers requiring an explanation of the cognitive disconnection between older people and digital media are currently limited to the cognitive psychology of ageing as the dominant knowledge on changes to the ageing mind, which makes it difficult to move away from the preceding limitations.

The limitations of contemporary approaches to resolving cognitive disconnections identified in this chapter—those of predicting and prescribing interactions, of designing for a fit between person and technology, and of lacking a sensitivity to the dynamic and temporal aspects of the issue being investigated—appear as consequent side effects resulting from the claims of the cognitive psychology of ageing. Cognitive psychology, as the dominant resource of knowledge on how cognition alters as a result of human ageing, portrays older people as in a state of sudden and continual cognitive deterioration. This deterioration is particularly significant in terms of the abstract reasoning that is necessary to learn and connect to a novel digital media interface. As a result of these claims, designers with an inclination to include accounts of cognitive deterioration into the design process are immediately presented with a construction of the user that is inherently limited in their capabilities. As a consequence, digital media products and interfaces are designed with the effect of restricting the interactional possibilities of the older user. This is not intentional but rather a consequence of a reductive approach. As was observed in chapter two, one strategy to respond to the claims of limited cognitive capabilities is to subsequently limit the opportunities to interact with the digital media system. As Schieber (2003) noted, a designer would be wise to ensure that as little 'irrelevant' information and clutter is presented to the older user of a digital system as possible. By sending less information at a time to the cognitive information-processor to process, then the older user does not experience such an overload of their, substantially limited, cognitive functions.

Beyond the design of consumer-oriented products and interfaces that are of interest to inclusive design, the tendency to treat older people as suffering losses is repeated in much of the research examining ageing and technology. For example, research on intelligent systems and technologies are supposed to 'enable elders to live more independently by compensating for diminished mobility, assisting those with memory impairment, and providing remote monitoring capabilities' (Marling, 2009, p.182). Marling suggests that:

> [i]n the near future, it is possible that smart devices will automatically open doors, refill prescriptions, and control home comfort systems. Smart wheelchairs will enable those unable to operate standard wheelchairs to navigate smoothly. Reminder systems will help elders to remember to take medications, to keep appointments, and to complete unfinished tasks. (Marling, 2009, p.182)

The systems that Marling alludes to in this quotation are designed specifically to compensate for the deterioration in cognitive functioning that occurs with age. Researchers at the Georgia Institute of Technology have developed an 'aware home' that is filled with a wide variety of sensor technologies that constantly monitor and model the activities of the people interacting with the systems perceivable environment (see Mynatt *et al.* (2001), Abowd *et al.* (2002), and Rogers and Mynatt (2003)). In developing a model of what is expected of the person interacting with the environment, the home provides prompts through various interfaces to its inhabitants if certain activities that the system expects have not been performed. A similar system is implemented in the 'autominder', an intelligent automatic reminder system integrated within a mobile robot (Pollack *et al.*, 2003). The autominder acts as a reminder system for certain activities—such as going to the lavatory every few hours—that an older person suffering from pathological memory loss requires reminding of throughout the day (Pollack *et al.*, 2003). As an intelligent agent, the autominder observes the older person's activities and builds a schedule or plan of what they do on a daily basis, actively altering this schedule based upon what the individual does, and issuing reminders as and when it is observed certain tasks have not been completed (Pollack *et al.*, 2003).

An alternative way of conceptualising affective-assistive technologies has been provided through the technological augmentation of the loss of physical abilities in old age. Examples of products making use of these technologies are intelligent walking frames[94] and

[94] For example, smart canes (Dubowsky *et al.*, 2000) and smart walking frames (Wasson *et al.*, 2001) that are able to provide feedback to visually and cognitively impaired users regarding proximity to objects in the environment.

intelligent wheelchairs[95]. Technological interventions such as these typically replace certain physical functions that older people no longer appear to have; however, there are also examples of augmenting weakened physiology. One area of research of physical technological augmentation relevant to ageing has been exoskeleton research. For example, HAL-5 (Hybrid Assistive Limb-5[96], Figure 17), claimed to be 'a cyborg-type robot that can expand and improve physical capability', became the first commercially available exoskeleton in the world (Cyberdyne Inc, 2010). Based upon research led by Yoshiyuki Sankai at Tsukuba University, HAL-5 picks up on minute electrical signals from the muscles of its wearer in order to interpret their movements and support certain physical abilities. HAL-5, when worn, feels weightless—the exoskeleton supports its own weight and that of its wearer (Cyberdyne Inc, 2010). Although HAL-5 was possibly intended for activities beyond that of enabling senior citizens to continue their gardening activities, it is seen as part of the field of developing technology that supports Japan's rapidly ageing population.[97]

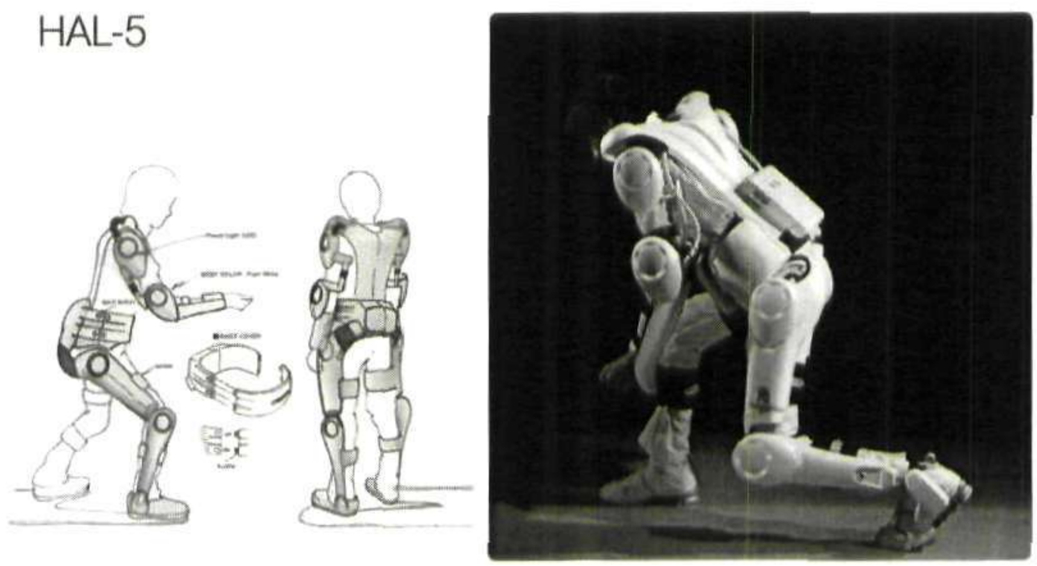

Figure 17 The HAL-5 robot suit. © 2005 CYBERDYNE Inc.

[95] Two prominent examples of intelligent, or smart, wheelchairs are Wheelesley, developed at the MIT Artificial Intelligence Laboratory (see Yanco (1998; 2001)), and NavChair (see Levine *et al.* (1999)).

[96] The full description of HAL reads: 'When a person attempts to move, nerve signals are sent from the brain to the muscles via motoneuron, moving the musculoskeletal system as a consequence. At this moment, very weak biosignals can be detected on the surface of the skin. "HAL" catches these signals through a sensor attached on the skin of the wearer. Based on the signals obtained, the power unit is controlled to move the joint unitedly with the wearer's muscle movement, enabling to support the wearer's daily activities. This is what we call a 'voluntary control system' that provides movement interpreting the wearer's intention from the biosignals in advance of the actual movement. Not only a 'voluntary control system' "HAL" has, but also a 'robotic autonomous control system' that provides human-like movement based on a robotic system which integrally work together with the 'autonomous control system'. (Cyberdyne Inc, 2010)

[97] Whilst a significant amount of the advertising surrounding HAL-5 is focused upon its potential benefits to elderly or disabled people, or perhaps for commercial activities where strength is required (as in warehouses), its most viable application might be in military contexts.

Due to the medical contexts of assistive technologies, there is an inherent response to treat the technology as supportive and as unobtrusive as possible (unless required). Within descriptions of the assistive technologies discussed within this sub-section, there is an emphasis upon the role of technology to fill in for certain lost abilities, or to make life in old age as simple as possible. One reason for this may be the use of robotics and artificially intelligent technologies as replacements for care workers and hospital staff (many examples of which are described by Roy and Pineau (2009)). Another reason may be the overwhelming focus of much ageing literature on deterioration in crucial abilities, as prevails through much of the cognitive psychology of ageing literature. This is not to argue that assistive technologies are inherently flawed—they are very often developed and designed in response to the very important needs and requirements of certain individuals and communities. As Marling, in a review of literature entitled *Intelligent System Technology for Enhancing Quality of Life*, states:

> [w]hen physiological and/or cognitive decline prevents elders from performing daily activities that keep them safe and healthy, they cannot remain at home. [...] Technological assistance can compensate for some of these problems, enabling elders to remain longer in their own homes in safety and comfort. (Marling, 2009, p.183)

In terms of developing cognitively inclusive digital media products, however, it may be necessary to move beyond reflecting the deteriorations and limitations of becoming old. In the same anthology as that containing Marling (2009), Lesnoff-Caravaglia argues that:

> [a]ssitive devices [...] are geared essentially to maintain the status quo. Aging, however, should not be geared toward normative behaviour. Rather, this is the time of life when uniqueness, individuality, interests, and enthusiasms untempered by responsibilities and spontaneous expression of feeling can best come forth. Technology helps this, of course. Nonetheless, it is assistive rather than an end in itself. It reduces physical difficulties but needs to allow the emergence of the person, one more unique and satisfying than previously known. Rather than retard aging, technology can move individuals to a level of aging not yet achieved, but one that is now possible. (Lesnoff-Caravaglia, 2009, pp.30-31)

Lesnoff-Caravaglia appears to suggest here that digital media and new technologies may not merely be an assistive presence in the lives of older people but actively afford novel opportunities to go beyond the traditional tenets of ageing as a process of deterioration. She does not extend opportunities for advice as to how these futures may manifest, however, and the remainder of this anthology she edits appears to be a continuation of the 'status quo'.[98]

Returning to the attempts of cognitively inclusive design to reconnect the cognitive functioning of older people to the design of digital media products, it appears that whilst the discourse is less explicitly medical, there continues to be an emphasis on loss due to the application of knowledge from the cognitive psychology of ageing in a human factors-esque approach. Liam Bannon (1991, p.25), in a critique of the human factors approach to designing interactive systems, argued that there is:

> an implicit view of ordinary people which, if surfaced, would seem to treat people as, at worst, idiots who must be shielded from the machine, or at best, as simply sets of elementary processes or "factors" that can be studied in isolation in the laboratory.

The opinion of Bannon, informed through years of working within the human factors community and the ICT industry, can be levelled against the contemporary approaches that inform cognitively inclusive design. Although areas of the human-computer interaction and interaction design community have largely distanced themselves from human-factors-esque approaches, instead focusing almost on 'practice'[99], there is something about the ageing process of human beings that still requires a theoretical basis accounting for cognition. As a consequence, the designer attempting to reconnect older people to novel forms of digital media appears to be in a dilemma. By using the cognitive psychology of ageing within both the analysis and (re)design of digital interfaces, designers can never move beyond knowledge of a user that restricts the possibilities for interactions. At the same time, cognitive psychology of ageing provides what appears to be the most useful body of knowledge with which to understand the reasons why digital media products and interfaces, designed in certain ways, are difficult for older people to incorporate into everyday activities. Inclusive

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[98] It is noteworthy that in the aforementioned volume, Lesnoff-Caravaglia (2009) authors sections on the age-related changes in a number of biological systems, whilst subsequent chapters in the anthology examine vision, hearing, and ergonomics. This theme recurs throughout the anthology, with the exception of a curious concluding chapter called *Gerontechnological Ontology: Human Experience within Extraordinary Frameworks*. This chapter, authored by Lesnoff-Caravaglia, harshly contrasts with those that preceded, offering insight into alternative ways of conceptualising ageing and future old people. As curious as it is, it appears that gerontology, much like cognitively inclusive design, would struggle to move towards the open-ended and experiential frameworks described by Lesnoff-Caravaglia if it remains attached to the prevailing assumptions of the discipline. It might be impossible for the 'gerontechnology' community to move towards a new level of ageing if the traditional model of developing technology and digital media to be supportive of the process of deterioration with age persists.

[99] Practice is a vague term, but appears to be prevalent within much of the post-cognitivist and post-human factors HCI and interaction design community.

design discourse, minus cognitive psychology, appears to be devoid of any strategies that reconnect older people with digital media beyond people-centred methods of designing.

4.5. Beyond limitations: towards 'senescentechnics'

From the limitations identified in this chapter, it is possible to propose a number of themes with which an alternative to cognitively inclusive design might be developed.

This chapter has examined a number of prevailing themes of the approaches informing cognitively inclusive design that highlight why contemporary approaches to the design of digital media products for older people are limited. Contemporary cognitively inclusive design focuses upon the forced reconnection of older people and digital media. These contemporary practices focus upon the prediction, inscription and prescription of interactions between people and technology; a tight fit between the cognitive and physical functions of the older person and the functions of the technological objects; and concrete and universalised descriptions of groups of older people and the technologies they use.

Whilst cognitively inclusive design provides an answer to the problem of cognitive disconnections between older people and technology, it is somewhat limited in reference to moves made in interaction design theory and practice over the past two decades and ignores the agency of user's; an agency which, as the history of technology shows, has always existed even if malnourished by the design process. The focus upon usability and knowledge about the user has ushered in approaches to resolving the disconnect that attempt to make products simpler, easier to learn, less distracting and better matched to the capabilities of certain groups of people. In particular, the observation that there is a cognitive disconnection between older people and novel digital media has lead to an inclusive approach that focuses upon the designer communicating messages regarding the use of a product in an explicit, and supposedly non-interpretable, manner.

Problematically, however, it appears that designers require some sort of support in navigating the problem of cognitive disconnection between older people and technology. The cognitive psychology of ageing is particularly useful to designers of digital media that is inclusive of older people; it provides some explanation as to the goings on in the black-box of the ageing mind, giving a backdrop to some of the problems designers may have encountered when working with older users, and, in the case of human factors literature, also give some concrete advice as to how to navigate around these problems. At the same time, in its application in design frameworks, such as in the practice and theory surrounding cognitively inclusive design, it implicitly frames older people, and the process of ageing in general, as deteriorating in certain key abilities; as an increase in fallibility; and as a reduction in information-processing functionality. In cognitively inclusive design, as a result of drawing from the knowledge of cognitive ageing, older people can never truly connect on their own terms with digital media; the cognitive psychology of ageing denies them of the very abilities required to do this.

The critical engagement with this body of work so far suggests working towards an alternative series of strategies for designers dealing with cognitive disconnections between older people and technology. In order to distinguish these new strategies from the contemporary approaches, ageing will in the following be distinguished from senescence. Senescence as a term is used in this thesis in reference to its usage within the biological sciences, referring to the cellular alterations of an organism beyond a moment of maturity. Whilst this thesis does not enter into a discussion with the biological sciences and does not aim to argue in favour of biological determinism, distinguishing the term senescence from ageing in this manner is useful to the argument developed in the following chapters for three key reasons. Firstly, as will be highlighted in the following chapter, considering temporal change to a particular organism's cognition in biological terms requires the observer to attend to the mutuality and inseparability of an organism and its surrounding environment. Secondly, taking cognition as inseparable from the encompassing environment provides an alternative lens with which to theorise how and why cognitive disconnections may occur later in life. Thirdly, the consequence of this alternative lens is that rather than developing an account of cognitively inclusive design, these alternative questions and strategies will provide a basis for what is coined in this thesis as 'senescentechnics'. Before exploring this argument in detail, it is possible to make five proposals for the basis of senescentechnics as a consequence of the discussion within this chapter. Primarily:

(i) *a future senescentechnics proposes to provide an understanding of how human cognition changes in senescence that is not laden as purely losses, or reductions and avoid designing digital media and technology to act purely as a supportive role for the decay in physiological and cognitive functioning in old age.*

The consequence of the contemporary use of cognitive psychology of ageing in design leads to an immediate situation where older people are conceived as unable to couple with digital media on their own terms. In light of the claims discussed in this chapter, however, the enforcing of couplings by decisions made in the design process somewhat limits the agency of the people who use technologies. Therefore:

(ii) *a future senescentechnics will provide an understanding of relationships between older people and digital media products where the senescent human is not considered in immediate opposition to digital media, and vice-versa.*

Rather, as described by Redström (2005), interaction needs to be understood within the same temporal frame of reference as the ongoing changes to senescent cognition. It can be stated that:

(iii) *a future senescentechnics conceptualises changes to human cognition with age as an ongoing dynamic in relation to digital media, wherein the state of the product and its interfaces are affected by the people interacting with it and vice-versa, in a continuous engagement over time.*

This is not to argue that a senescent conceptualisation of older people and digital media means an instant connection between a designed outcome and the user. Instead of attempting to design for a perfect fit between people and media, which suggests that cognition and prior experiences can be designed for, instead cognition and experience happens to emerge through interaction. Therefore:

(iv) *a future senescentechnics conceives of interactions between older people and digital media not as a form of instantaneous and obvious communication of use, functionality and meaning, but instead is open to being incorporated flexibly into the activities and experiences of the older person.*

A major implication of the suggested framework is that the process of predicting, inscribing and prescribing that dominates cognitively inclusive design is no longer tenable. A greater amount of flexibility is required on the part of the designer. Finally, then:

(v) *a future senescentechnics conceives older people as interacting with digital media based upon the contingencies of the situation and forming their own connections with the products they engage with, not those predetermined by the designer.*

The remainder of this thesis will unpack these five statements in more detail through an original investigation. The following chapter commences the exploration of a senescentechnic alternative by discussing research from within the cognitive sciences that deals with issues that are somewhat analogous with the debates within interaction design discussed within this chapter. In explaining this work, the next chapter will outline the basis for a senescent understanding of cognitive decoupling.

Chapter 5

Cognition and inseparability

Question: Is it possible to return to the cognitive sciences and identify alternative strategies for the basis of senescent human cognition to the problematic cognitive psychology of ageing?

5.1. It is possible to conceive of human cognition as inseparable from the body and world, encompassed in an individual's Umwelt, within which cognition is the perception of and acting upon affordances.

5.2. It is necessary for there to be coherence between body and world in order for an economy of cognitive functioning to emerge.

5.3. Human cognition continually enacts and re-enacts the Umwelt through a history of structural couplings; these couplings are somewhat closed, yet also open to new couplings to emerge in the future.

5.4. It is possible to conceive of the Umwelt of a person and the affordances they perceive as dynamic and continually in a state of change based upon innumerable factors; human cognition allows for the continued integration of these factors into a coherent understanding of the Umwelt.

5.1. Inseparability, the *Umwelt* and affordances

It is possible to conceive of human cognition as inseparable from the body and world, encompassed in an individual's Umwelt, within which cognition is the perception of and acting upon affordances.

Cognitivism, as discussed at length in chapter three, is founded on a fundamental separation of human thought from the human body, and a subsequent separation of human beings from environments. As the discussion in the previous chapter highlighted, the implication of cognitivism when applied in the design of products is that a middle layer of representations can be designed that enables the immediate communication of a product to the cognitive functions of a perceiver. Whilst the use of cognitivism in design applications is problematic, it will be argued here that alternative paradigms of cognitive science are useful in generating design strategies. In particular, various attempts have been made within cognitive science to explain human cognition in terms of a greater reliance upon the human body and relations with the world. In the following chapter, an explanation of the cognitive disconnection between older people and digital media products will be provided based upon what will be defined as a senescentechnic understanding of cognition. Before proceeding with this explanation, however, it is necessary to examine in more detail discussions surrounding cognitive science that argue cognitive experience is fundamentally inseparable from body and world.

When discussing cognitive experience, as opposed to the cognitive function of an older person, it is useful to think in terms of a person's particular *Umwelt*.[100] The term *Umwelt* derives from the work of Jakob von Uexküll, a Swiss biologist whose research focused upon analysing the behavioural ecologies of animals. Von Uexküll (1957, p.11) stated that the first principle of the *Umwelt* is that 'all animals, from the simplest to the most complex, are fitted into their unique worlds with equal completeness. A simple world corresponds to a simple animal, a well-articulated world to a complex one.' Von Uexküll contrasted the *Umwelt* to the *Umgebung*. Both the *Umwelt* and the *Umgebung* related to the manner in which the world was perceived by a specific animal (including human beings). The *Umwelt* referred to the phenomenological world of the organism, whereas the *Umgebung* was the appearance of an objective reality to a particular animal.[101] Von Uexküll's argument was that the everyday world of organisms—as it is experienced—was rooted in the complementary nature of their physiological make-up, and how this fitted the environment. Von Uexküll suggests that objective descriptions of the *Umwelt* of different organisms can only ever be speculated and provisional, giving a conceptual glimpse into the *Umwelt* of an individual perceiver. Von Uexküll related the study of an animal's *Umwelt* as like placing a bubble around its world and attempting to move beyond the human conception of the *Umgebung*.

> Perhaps it should be called a stroll into unfamiliar worlds; worlds strange to us but known to other creatures, manifold and varied as the animals themselves. The best time to set out on such an adventure is on a sunny day. The place, a flower-strewn meadow, humming with insects, fluttering with butterflies. Here we may glimpse the worlds of the lowly dwellers of the meadow. To do so, we must first blow, in fancy, a soap bubble around each creature to represent its own world, filled with the perceptions which it alone knows. When we ourselves then step into one of these

[100] *Umwelt* is a German word, which is best understood in English as referring to 'surrounding world', although is commonly translated as 'environment'.

[101] *Umgebung*, when translated from German to English, often becomes a synonym to *Umwelt* and used as also referring to 'environment'. In terms of von Uexküll's work, however, these words had very distinct usages as defined in the main text.

> bubbles, the familiar meadow is transformed. Many of its colourful features disappear, others no longer belong together but appear in new relationships. A new world comes into being. Through the bubble we see the world of the burrowing worm, of the butterfly, or of the field mouse; the world as it appears to the animals themselves, not as it appears to us. This we may call the *phenomenal world* or the *self-world* of the animal. (von Uexküll, 1957, p.5)

The concept of the *Umwelt* highlights how the development of theories of cognition (be this either functional or experiential) isolated from and devoid of the encompassing phenomenological and ecological relationships of an individual is limited outside of the laboratory. These problems have been identified within cognitive science. In chapter three, the work of Ulric Neisser was discussed as pivotal in introducing cognitivist philosophy into experimental psychology—focusing upon examining the 'programs' and functional properties of the human mind—rather than how it relates to the physical embodiment of the organism. Less than a decade later, however, Neisser had become highly critical of the ideas he proposed in 1967. Neisser (1976) provided a damming verdict on the then still developing cognitivist paradigm of studying human cognition and positioned his writing against the very information-processing models of cognition that he found so useful nine years prior.

> The study of information processing has momentum and prestige, but it has not yet committed itself to any conception of human nature that could apply beyond the confines of the laboratory. And within that laboratory, its basic assumptions go little further than the computer model to which it owes its existence. There is still no account of how people act in or interact with the ordinary world. (Neisser, 1976, pp.6-7)

> The villains of the piece are the mechanistic information-processing models, which treat the mind as a fixed-capacity device for converting discrete and meaningless inputs into conscious percepts. (Neisser, 1976, p.10)

There were a number of issues with the information-processing model of studying cognition that concerned Neisser (1976). In the context of the discussion to be developed here, however, his key point is the issue of 'ecological validity' (Neisser, 1976, p.33).[102] Neisser states that ecological validity is of great importance to the cognitive psychologist as '[i]t reminds them that the artificial situation created for an experiment may differ from the everyday world in crucial ways' (Neisser, 1976, p.33). He argues that in cognitivist information-processing studies, the participants are isolated from extraneous perceptual information and treated as a static entity which receives and decodes information from the

[102] Neisser attributes the idea of ecological validity to the work of Egon Brunswick (1956), although his usage of the term is rather different to Brunswick's original definition.

world. Rather than considering activity and movement as a key feature of human perceptual and cognitive experience, cognitive psychologists consider them as 'mere nuisance or sources of blur' (Neisser, 1976, p.109). In terms of the everyday cognitive experience of the world, however, such nuisances and blur is common, he argues, to the point where taking it out of consideration would amount to developing a potentially invalid, if not useless, understanding of how human beings cognize.

The final chapter of Neisser (1976) investigates how psychologists and behavioural scientists make attempts to predict human behaviour based upon the formation of cognitive models of the organism (in the former's case) or by responses to environmental stimuli (in the latter case). He argues that the idea that the way human beings behave in the world can be predicted, based upon models of purely functional aspects of the psychological apparatus, is misplaced. At the same time, he argues that the idea that purely environmental aspects can condition human beings to respond in a particular manner is also incorrect.[103] Instead, he suggests that in order to understand the actions of human beings, it is necessary to know as much about the environment as it is to know about the psychology of the individual. Whilst still rather functionalist, Neisser (1976) usefully discusses this idea in terms of skilled and novice chess players.

> One of the characteristics of a good chess player is his skill in picking up relevant information from the board. [...] The master succeeds because he can perceive certain aspects of the position that escape a lesser player; structural characteristics that, once seen, constrain the locations of the pieces themselves very precisely. [...] he quite literally sees the position differently—more adequately and comprehensively—than a novice or nonplayer would. Of course, even the nonplayer sees a great deal: the chessmen are carved of ivory, the knight resembles a horse, the pieces are (perhaps) arrayed with a certain geometric regularity. A young child would see still less: that the pieces would fit in his mouth, perhaps, or could be knocked over. A newborn infant might just see that "something" was in front of him. To be sure, he is not mistaken in this; something is in front of him. The differences among these perceivers are not matters of truth and error but of noticing more rather than less. The information that specifies the proper move is as available in the light sampled by the baby as by the master, but only the master is equipped to pick it up. (Neisser, 1976, pp.180-181)

In order to comprehend the psychology of a human being, especially when concerned with the practicalities of everyday or expert ecologies, Neisser (1976) argues that it is necessary to examine the interactions between the human subject and the environment and the relations between the two; he implies the necessity to account for human cognition in reference to an

[103] Although Neisser (1976) does not directly reference any particular works, it is highly probable that he is referring to the behaviourist study of human psychology briefly described at the start of chapter two.

encompassing *Umwelt.* Neisser (1976) appears to assert that there may be an objective reality for human beings to perceive, but the perception of this information is always dependent upon the history—the knowledge produced over time—of the individual. This history, however, is not formed of the properties, icons and symbols of the world as understood in cognitivism (and cognitively inclusive design) but instead an ongoing dialogue within the *Umwelt.* Neisser's later work focused on incorporating techniques into cognitive psychology that examined 'traditional' cognitive phenomena (such as memory) in terms of relations with 'real' events, ecologies and everyday activities. For example, rather than focusing upon controlled testing of memory within the laboratory, Neisser and his collaborators examined the flaws of human memory in naturalistic contexts such as the recollection of events (examples being birthday parties, political scandals or spacecraft explosions (as in Neisser and Hyman (2000)) and how interactions with the environment and other organisms provide knowledge of the self (as in Neisser (1993)).[104]

The influence of *Umwelt* theory is particularly evident in the writings of perceptual psychologist James Gibson, who held a similar discontent with the cognitivist information-processing theories of human psychology to Neisser. Whereas Neisser developed various methods, techniques and studies that examined typical cognitive phenomena in naturalistic contexts, Gibson's work could be considered a rather more polemical opposition to traditional cognitive science.[105] There are two key reasons why Gibson's work is particularly relevant to this thesis. Firstly, his research is already familiar to the interaction and product design communities, through his concept of 'affordance' (Gibson, 1986) and its subsequent redefinitions for the design community (as has already been touched upon in chapters three and four). Secondly, Gibson's theory of affordances, especially in terms of recent

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[104] Since the late 1970s, when Neisser published his concerns regarding the ecological invalidity of cognitive psychology, there has been an increase in 'cognitive' studies in what are considered more naturalistic contexts, such as the collections published in Neisser (1993), Neisser and Hyman (2000), and Winograd *et al.* (1999). The earlier discussed work of Suchman (1987), along with Lave (1988) could also be considered as naturalistic studies of cognition, although their arguments, perhaps as a result of their ethnographic basis, tend to be somewhat distanced from and problematic for the cognitive science community.

[105] Both Neisser and Gibson appear to have influenced one another, and Neisser in particular highlights his gratitude to James Gibson and his wife Eleanor Gibson in the preface to *Cognition and Reality.* Comparing the two corpus' of work of Neisser and Gibson, however, highlights how much their perspectives differ as much as they are similar. Neisser could be characterised as attempting to introduce ecologically valid perspectives on traditional cognitive and experimental psychology concepts, whereas Gibson appeared to reach much further in his opposition to his contemporaries. In the preface to *Cognition and Reality*, Neisser points out how some of his major concerns with the development of cognitive and information-processing psychology were influenced by James and Eleanor Gibson, whilst also highlighting how many of his ideas (developed from traditional experimental psychology terminologies) are not compatible with the 'Gibsonian' principles (Neisser, 1976, p.xii). Particularly problematic for the cognitive psychology and science community is that Gibson's does not necessarily provide definite evidence backing up his claims, instead appearing to rather provoke thought and speculation beyond the then dominate cognitivist principles (Goldstein, 1981).

developments in cognitive science, provides a useful basis with which to provoke thought about the way in which older people cognize within the *Umwelt*. Before explaining Gibson's theory of affordance, it is necessary to introduce some generalities to Gibson's last work.[106] Chemero (2009) defines Gibson's ecological psychology as constituting three main principles; perception is direct; perception is for action; perception is of affordances. Although it is the theory of affordance that is particularly useful to the argument to be articulated in the following chapters, it is given that affordance follows from the previous two principles. These principles will now be explained in more detail.

5.1.1. Perception is direct

The cognitivist accounts of ageing cognition introduced in chapter three characterised human cognition as the transformation and computation of mental representations, most likely in the brain or central nervous system of the human being. Gibson (1986) departs from this prevailing approach, founding ecological psychology on the notion that animals directly perceive the environment.[107] For Gibson (1986, p.147):

> *[d]irect perception is what one gets from seeing* Niagara Falls, *say, as distinguished* from seeing a picture of it. The latter kind of perception is mediated. So when I assert that perception of the environment is direct, I mean that it is not mediated by retinal pictures, neural pictures, or mental pictures.

He argues that when an animal perceives a part of its environment, it is in a manner that is unmediated by inner mental representations. Gibson's theory of direct perception was in contrast to his earlier research, which had focused on the physiology of the eye in constructing visual perception, leading him to assert in this earlier work that visual perception was dependent upon the retinal image of the human being (as in Gibson (1950)). This earlier work, much like that of Neisser's, was studied within controlled laboratory conditions, where eye movement was purposely restricted and visual perception was examined based upon predefined visual stimulus. In his later work Gibson's (1986) was more interested in the natural context of vision. He argued 'that natural vision depends on the eyes in the head on a

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[106] Gibson passed away shortly after the publication of *The Ecological Approach to Visual Perception* (originally published in 1979) and, therefore, could not provide any greater clarification on his last claims.
[107] Gibson used the term 'animals' throughout his text, although it is evident that he considered human beings as just another set of animals that had a particular body and perceived a particular set of affordances as a result. As such, this thesis interprets Gibson's use of the term animal as it refers to human beings, or more specifically senescent human beings experiencing a process of temporal cognitive change.

body supported by the ground, the brain being only the central organ of a complete visual system'[108] (Gibson, 1986, p.1). In ecological approaches to understanding perception, that human beings have a body formed in a particular way and that this body enables the engagement of actions within environments is fundamental to how human beings perceive in everyday activity. The introduction of the active body in the study of perception and cognition was unheard of within contemporary cognitive science at the time of Gibson's writing, and lead to the second principle of ecological psychology highlighted by Chemero (2009); perception is for action.

5.1.2. Perception is for action

> Moving from place to place is supposed to be "physical" whereas perceiving is supposed to be "mental," but this dichotomy is misleading. Locomotion is guided by visual perception. Not only does it depend on perception but perception depends on locomotion inasmuch as a moving point of observation is necessary for any adequate acquaintance with the environment. (Gibson, 1986, p.223)

The interconnectedness of action and perception follows from human beings being able to directly perceive the world. In wanting to consider the perception of human beings in terms of more naturalistic contexts, Gibson (1986) emphasised the role of the active organism in an environment, rather than wanting to study the isolated perceptual or cognitive system in the laboratory. In terms of ecological psychology, then, 'we must perceive in order to move, but we must also move in order to perceive' (Gibson, 1986, p.223). As Chemero (2009) highlights, the interconnectedness of perception and action in this way also means that action also informs perception and cognition. As small pockets of cognitive science have moved towards studying perception and cognition in everyday situations, the interconnectedness between perception and action has become a central feature of post-Gibsonian research.[109] As Chemero and Turvey (2007a) note, in Gibson's terms the human being and the environment

[108] Gibson's later work primarily appeared to attack his previous position on visual perception. The differing nature of his most popular works can mean contradictions and confusions appear in references to his texts. This is not helped by Gibson's somewhat complicated description of the ambient array of information and affordances in his later work, which can be off-putting to even the most philosophically engaged cognitive psychologist. Chermero (2009), although a firm supporter of Gibson's ecological theories, notes how Gibson often appears to contradict himself, even within the same paragraph. The manner in which Gibson changed his theoretical positioning can be clearly seen in a series of letters he publicly exchanged with Ernst Gombrich, Rudolph Arnheim and Nelson Goodman after his article *On Information Available in Pictures* (Gibson, 1971) in the journal *Leonardo* in 1971 (see Gombrich *et al.* (1971) and Goodman (1971)).

[109] The interconnectedness of perception and action has become a central theme of post-Gibsonian ecological psychology and, more recently, the embodied and enactive cognitive sciences. These ideas will be further explained throughout the remainder of this chapter and those that follow.

are an inseparable pair, and the perception of the environment and the actions of an agent are equally so. For Gibson, cognition is not consigned to certain mental representations of the perceiver, but is the engagement of perception and action.

5.1.3. Perception is of affordances

Chemero (2009) proposes the theory of affordances can be understood as an ontology that ties together the notion of direct perception and the interconnection of perception and action (Chemero, 2009). Gibson (1986, p.127) defined the affordances of the environment as:

> what it offers the animal, what it provides or furnishes, either for good or ill. [...] It implies the complimentarity of the animal and the environment.

Affordances are Gibson's way of conceptualising the opportunities for actions that are an objective part of the environment but perceived relative to a specific animal. The affordances of the environment, he argued, can be understood as a system of meaning that is external to the animal.

> [Affordance is] a radical hypothesis, for it implies that the "values" and "meanings" of things in the environment can be directly perceived. Moreover, it would explain the sense in which values and meanings are external to the perceiver. (Gibson, 1986, p.127)

Affordances, as Gibson originally defines them, do not refer to purely physical opportunities for action but phenomenal opportunities as well. These affordances, although claimed to be part of the environment, are always to be considered in relation to a particular animal. For example, properties such as horizontal, flat, extended and rigid:

> would be physical properties of a surface if they were measured with the scales and standard units used in physics. As an affordance of support for a species of animal, however, they have to be measured relative to the animal. They are unique for that animal. They are not just abstract physical properties. They have a unity relative to the posture and behaviour of the animal being considered. (Gibson, 1986, pp.127-128)

It would appear that in one sense, an affordance can be treated as a physical property of the environment, objectively measured as long as it is relative to a particular agent. At the same time, it appears an affordance offers a more subjective role of shaping that agents experience of the world through shaping its behaviour.

> An important fact about the affordances of the environment is that they are in a sense objective, real, and physical, unlike values and meanings, which are often supposed to be subjective, phenomenal, and mental. But, actually, an affordance is neither an objective property nor a subjective property: or it is both if you like. An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behaviour. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer. (Gibson, 1986, p.129)

For Gibson, then, affordances are neither physical nor phenomenal—they are both and neither. Gibson claims that if the dichotomy of subject and object is no longer possible based upon a perspective of affordances, then neither are other traditional dichotomies such as natural/artificial and cognitive/cultural.

> It is a mistake to separate the natural from the artificial as if they were two environments; artifacts have to be manufactured from natural substances. It is also a mistake to separate the cultural environment from the natural environment, as if there were a world of mental products distinct from the world of material products. There is only one world, however diverse, and all animals live in it, although we human animals have altered it to suit ourselves. (Gibson, 1986, p.130)

The theory of affordance appears to be about something more than culturally attached meaning. Affordances, Gibson suggests, rather than being cultural[110] are the meeting point for an essential aspect of experience that is not part of the subject's personal world, but one that is shared and experienced by an entire species in their ecological niche.

> The child begins, no doubt, by perceiving the affordances of things for her, for her own personal behaviour. She walks and sits and grasps relative to her own legs and body and hands. But she must learn to perceive the affordances of things for other observers as well as for herself. An affordance is often valid for all the animals of a species, as when it is part of a niche. (Gibson, 1986, p.141)

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[110] It is suggested by a number of authors, particularly within design, that the theory of affordances, and ecological psychology in general, is acultural (such as Oliver (2005), McGrenere and Ho (2000), and Norman (1988)). Although it is possible to read Gibson (1986) as suggesting that affordances transcend culture and are universal, a detailed reading suggests that Gibson was necessarily shifting terminologies. As explained in the body text, rather than culture, Gibson refers to ecological niches. Rather than defining culture through the symbols, objects and languages that a definable group of people use, Gibson used ecological niches to suggest a form of mutuality between a certain group of animals with shared qualities of physiology and perception with particular parts of the environment. On a macro scale it is possible to understand ecological niches as universal, but on a micro scale each individual member of a group of animals may have subtly different ecological niches. This is particular evident in Chemero's (2009) analysis and development of Gibson's work, which is discussed later in this chapter.

What may this mean for the perception of objects in the world? Echoing the claims of Neisser (1976), Gibson (1986) asserts that although psychologists have gone to great lengths over the years to identify certain properties of objects (such as colour, elasticity, rigidity, mobility, texture) and subsequently argue that human beings perceive objects based upon combinations of such properties, outside of the laboratory in the real-world of action this is simply not the case. 'We can discriminate the dimensions of difference if required to do so in an experiment, but what the object affords us is what we normally pay attention to' (Gibson, 1986, p.134). Gibson again discards the subjective/objective dichotomy in regards to affordance, as they 'are properties of things taken *with reference to an observer* but not properties of the *experiences of the observer*' (Gibson, 1986, p.137 - emphasis in original). For Gibson, the idea that an affordance may be part of the phenomenal world of the observer is to give way to a dichotomy again; '[t]here is only one environment, although it contains many observers with limitless opportunities for them to live in it' (Gibson, 1986, p.138). By claiming there are limitless opportunities to live in the world, Gibson is referring to the invariance of the affordances in ecology. For example, it might be the case that an observer may not perceive a particular affordance—either because they are not looking for it or that they are simply unaware of it—but that is not to say the affordance, the potentiality for action and interaction, does not exist. As Gibson (1986, p.139) notes; '[a]n affordance is not bestowed upon an object by a need of an observer and his act of perceiving it.'

The theory of affordance provides a powerful but equally controversial characterisation of how human beings interact and make sense of the world in terms of an encompassing *Umwelt*.[111] Although Gibson's work is complicated and at times contradictory, the concept of affordance has become popularised within product design and human-computer interaction. Some of the key issues surrounding the use of affordance in design will now be addressed.

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[111] The theory of affordance is controversial in that a large proportion of cognitive science does not attribute it much worth. There may be a number of factors influencing this. Perhaps strongest of all is the aforementioned conflation and complexity that Gibson himself appears to get into in writing his arguments (see footnote 109). It may also be that the language developed and used by Gibson is rather paradoxical to much psychological research that went before. For example, Gibson uses the term information throughout to describe the ambient optic array, yet a cognitive psychologist reading his work would need to understand beforehand that his basic conceptualisation of information differed drastically to that used within the then prevailing cognitivist studies. Gibson, as was touched on earlier, also could not provide a great amount of evidence backing up his claims, and *An Ecological Approach to Perception* was published just prior to his death, meaning many of his questions were left unanswered. Some of Gibson's ideas were developed further with experimental evidence by his wife, Eleanor Gibson, in particular the interconnectedness of perception and action (as in Gibson (1991)).

5.1.4. The contemporary use of affordance in design

Gibson's theory of affordances is an often cited component of a great variety of design literature. As a result of its generality, and for having been an early account of explaining human psychology in reference to the environment (some of which is designed), affordance has been seen as a useful concept for designers to consider, or even implement.[112] At the same time, however, the use of affordance in design is rather complicated. Although affordances appear to be directly relevant to the perception of designed objects, the theory offers little in the way of direction as to how to improve the design of certain objects to be more or less suited to meeting certain affordances. As Gibson (1986, p.139) goes to great lengths to point out, '[t]he object offers what it does because it is what it is.' Donald Norman (1988) is often considered to have introduced the theory of affordance into the context of product and industrial design as a way of describing certain ergonomic and usability attributes of designed objects. Although Norman—a cognitive psychologist prior to turning to product design—worked alongside Gibson during his career, the conceptualisation of affordances that Norman provides differs dramatically to that of the original definition.[113] Specifically, when Norman (1998) talks of affordances he refers to 'perceived affordances'. One reason for this distinction was Norman's interest in the applicability of affordances to design, rather than metaphysics and psychology.

> In the design of objects, real affordances are not nearly so important as perceived ones; it is perceived affordances that tell the user what actions can be performed on an object and, to some extent, how to do them. In the design of everyday things, proper uses of perceived affordances make the difference between objects that are

[112] It is important to note, as will be noted within the main text later on in this thesis, that the notion that an affordance can be implemented is not in line with Gibson's definition of the concept. As will be argued in the body text, the idea that an affordance can be designed into products and objects primarily emerges from Donald Norman's (1988) transformation of Gibson's theory into design literature.

[113] Although his definition differed drastically, this was not a misinterpretation on Norman's behalf. Norman notes how his definition was different to Gibson's original, but considered this a necessity in moving the theory from psychology to design. At the same time, however, it is important to take into consideration that Norman's background as a cognitive (as in cognitivist) psychologist may also influence his changes to Gibson's theory. As Norman himself states: 'I originally hated the idea [of affordance]: it didn't make sense. I cared about processing mechanisms, and Gibson waved them off as irrelevant. Then, Gibson started spending considerable time in La Jolla, and so I was able to argue with him for long hours (both of us relished intellectual arguments). I came to appreciate the concept of affordances, even if I never understood his other concepts, such as "information pickup." He and I disagreed fundamentally about how the mind actually processes perceptual information (that phrase alone would infuriate him)' (Norman, 1999). In *The Psychology of Everyday Things*, Norman asserted that: 'My view is somewhat in conflict with the views of many Gibsonian psychologists, but this internal debate within modern psychology is of little relevance here' (Norman, 1988, p.14). It is this thesis' argument, however, that these debates are relevant to design practice and theory, especially if there is a subsequent effect on the manner in which designers impose or restrict interactional possibilities upon the users of digital media products.

> understandable and usable from those that are quite unfathomable. (Norman, 1998, p.123)

Rather than being a direct relationship between perception and action, Norman's perceived affordances suggest an extra layer of interpretation that differentiates itself from Gibson's affordances. For example, a poorly designed door handle may be perceived to afford pulling, but the door itself may only afford pushing. Since Norman's incorporation of affordance into design, the concept has gone through a number of transitions departing further from Gibson's original ideas.[114]

Affordance, as it has been debated as a concept within the design discipline, is seemingly problematic. McGrenere and Ho (2000) highlighted a number of conflations of the term, which they determined was often a result of re-interpretations of Norman's definition as opposed to examinations of Gibson's texts.[115] Oliver (2005) argues that the acultural foundations of affordance does not match the socio-communicative requirements of designing, and that the manner in which most designers have appropriated the term completely devalues Gibson's original argument. Oliver notes how the concept of affordance has increasingly become incorporated into frameworks of designing technologies which, although holding certain ontological similarities with Gibson's ecological perspective, essentially keep the label of affordance but transform the concept into something completely different (this can be observed in activity theoretical accounts of affordances, as in Albrechtsen *et al.* (2001)). Oliver (2005) goes on to suggest that affordance, in Gibsonian terms, is also problematic to designers due to being too broad and ineffective on the micro-level of interactions with technologies to be useful. Throughout his article, he notes how Gibson's ecological psychology provided little more than species-level speculation.

> [Gibson's] discussions resort to commonsense examples that are not exhaustive or definitive, merely illustrative. This does not give a method for research or design, and led to Norman's veiled reversion to designing around cultural norms. By conceding that affordances need to be learnt but failing to explain their relationship to 'attunement', Gibson leaves himself vulnerable to the same charge that he levelled at

[114] For example, Gaver (1991) developed an account of affordances that was culturally contextualised, and particularly interested in human beings interacting with then-novel forms of technology. Albrechsten *et al.* (2001) transform the theory of affordances into an activity theoretical framework. Conole and Dyke (2004) focus upon the affordances of educational information technologies, in particular developing Salomon's definition (1993) rather than Gibson's or Norman's. McGrenere and Ho (2000) provide a useful overview of a number of attempts to incorporate the theory of affordances in design theory and practice, yet appear to fall into some of the usual problems of Gibson's complex and sometimes contradictory writing style.

[115] McGrenere and Ho (2000) noted that although a number of design related articles cited Gibson's concept of affordance, it would often only be used to provide historical contextualisation and, typically, Norman's definition of affordance was used.

> cognitive processing theorists [...] there are too many perplexities, and thus this explanation should be abandoned. It is arguable that affordance as a concept in design has lost much of its value due to the vast alterations and redefinitions it has gone through that has taken it further away from Gibson's original conception. (Oliver, 2005, p.412)

Oliver notes that the theory of affordances, in their Gibsonian sense, provides little insight as to the learning of novel technologies (as a system of affordances) due to the denial of culture and cognition. Oliver's argument, however, fails to consider how Gibson does not concretely deny cognition and culture; rather, Gibson resituates these ideas within the ontology of affordances. For Gibson, cognition is perception and action, and culture is the ecological niche that is formed by the affordances between a particular human being and the environment.[116]

Although the concept of affordance has a complicated history in design research—to the extent that Donald Norman now distances himself from the idea[117]—the following chapters will keep returning to the concept in order to explain why it is critical to forming a new understanding of ageing human cognition. In order to do this, however, the thesis is required to move away from the design-orientated interpretations of affordance, with their baggage of social and cultural relativity, and instead develop an account of affordances based upon claims emerging from cognitive science focusing upon human cognitive development embedded within an *Umwelt*.

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[116] The problems identified by Oliver (2005) are valid, but fall foul of the similar problems of other arguments that claim affordances are acultural. This is noted by Gaver (1991, p.81), who notes that the 'actual perception of affordances will of course be determined in part by the observer's culture, social setting, experience and intentions.' Gaver goes on to state that, '[l]ike Gibson I do not consider these factors integral to the notion, but instead consider culture, experience, and so forth as highlighting certain affordances. Distinguishing affordances and the available information about them from their actual perception allows us to consider affordances as properties that can be designed and analyzed in their own terms. Learning can be seen as a process of discriminating patterns in the world, as opposed to one of supplementing sensory information with past experience. From this perspective, my culture and experiences may determine the choice of examples I use here, but not the existence of the examples themselves' (Gaver, 1991, p.81).

[117] Norman has argued that many design practitioners saw the potential in the concept of affordances but interpreted it at almost face-value. In a number of articles (such as Norman (1999; 2004)), Norman has argued that rather than affordance, his definition should be considered as 'perceived affordance', distinguished from Gibson's 'real' affordance. In a recent communication to the PhD-Design email list and a forthcoming book (Norman, 2010) Norman suggested the concept of 'signifier' instead of affordances, although it may be the case that the differences between his definition of the two are little. As was noted on said discussion list, the use of the term signifier rather than affordance might be of equal, if not more, controversy to a community of communication theorists, psychologists and designers.

5.2. The *Umwelt* of autonomous robots

It is necessary for there to be coherence between body and world in order for an economy of cognitive functioning to emerge.

A key focus point of Gibson's perceptual research was that of the active perceiver, exploring the world for perceptual information (its affordances) through movement. Perception and action are necessary for understanding the world. This contrasts sharply with the cognitivist assumption that cognition predetermines both perception and action. The problem of the active or passive cognizing agent has been explored at length within areas of artificial intelligence research aimed at developing autonomous robots. The key contribution of this area of research is that the body, and the manner in which the body allows exploration of the world, are actually the prerequisites of cognition.

Much like the cognitive psychological approach to human cognition, cognitivist artificial intelligence research—or Good Old Fashioned AI (GOFAI) as it is sometimes referred to—focused upon the role of symbolic computation and 'mental' algorithms as central to the development of artificially intelligent agents. Early AI applications were intended to simulate and replace human experts—such as doctors and physicians—but over time it became apparent that the abilities of expert systems in certain cognitive tasks consistently fell short of human beings, despite technological advancements in computational processing (Pfeifer & Bongard, 2006). Pfeifer and Bongard highlight how the traditional sequential and linear symbolic computation was replaced in the 1980s by neural network approaches to AI.

> Neural networks are computational models that are inspired by biological brains, and therefore many of them inherit the brain's intrinsic ability for adaptation, generalization, and learning. [...] However, although there was definite progress, because most of these models were just algorithms like all the others, they did not end up solving the big problems of mastering the interaction with the real world either. (Pfeifer & Bongard, 2006, pp.28-29)

Rodney Brooks argued that GOFAI focused too much on the complexity of internal computations and algorithms in attempts to develop autonomous robots, rather than examining the complexities of the environments these robots would be engaging with. GOFAI, as with cognitivist psychology, considered the internal representations of the computational system the most significant attribute of an artificially intelligent agent. Brooks went against the prevailing cognitivist and connectionist AI to suggest autonomous agents need not be super-complex computationally, but robust and reflective of the complexity of the world (Brooks, 1984; 1986).[118] Rather than attending to the development of internal representations of the world, often formulated *a priori* to the act, Brooks (1990, p.5) argued that 'the world is its own best model'.

In the design of his situated robots, Brooks purposively eschewed providing his robots with a pre-determined representation of the world they were to be deployed within.[119] Instead, the robots were designed to be both embodied and situated. Brooks' early robots, rather than simulating or mimicking human beings, examined what may be considered less-grand examples of intelligence.[120] The robots were designed to have sensory apparatus that picked up information from the environment that was used to engage in the action of the motors that moved the robot through the same environment. It was not necessary to constantly refer to an internal representation of the world in order to ensure correct movement; if the robot questioned its placement in the environment, it would check its sensory apparatus. In this explorative manner, the action and perception of the robot is interconnected and informs one-another. Although Brooks' early work examined relatively simple autonomous behaviour in comparison to human beings, he argued that developing robots that were grounded by their body and environment was a necessary prerequisite to developing higher level cognition. Brooks (1990, p.6) argued that:

> problem solving behavior, language, expert knowledge and application, and reason, are all rather simple once the essence of being and reacting are available. That essence is the ability to move around in a dynamic environment, sensing the surroundings to a degree sufficient to achieve the necessary maintenance of life and reproduction. This part of intelligence is where evolution has concentrated its time—it is much harder. This is the physically grounded part of animal systems.

Key to the notion of using the world as the model for interaction was the development of AI within a body. Most autonomous robots have a body of some sort; however, making the most

[118] Brooks' seminal papers were collected within his 1999 book *Cambrian Intelligence*. Although contemporarily Brooks' work is considered influential, the papers in Brooks (1999) represent a period where the embodied and situated robotics programme his work was an influential part of caused a great amount of distain from within the more traditional artificial intelligence research community.

[119] It is worth noting that although Brooks' earlier work was characterised by arguments against the use of representations in AI, instead encouraging the direct coupling of the perceptual and action capabilities of the robots, in later years his position on computational representations has softened. This can be seen in a reading of *Cambrian Intelligence* (Brooks, 1999), going from Brooks' earlier into his later writing.

[120] For example, one of his early experiments 'Genghis' explored insect-like locomotion. The perception that Brooks' robots were 'less-grand' in their insect-esque levels of intelligence was part of the arguments against much of his earlier work; the dominant perspective within artificial intelligence research was still focused upon attempts to simulate and develop artificial forms of high level intelligence and cognition. For Brooks', however, it was not that the insectoid robots were less intelligent—it was a completely different form of intelligence; intelligence that was embodied, situated, grounded and autonomous.

of the world in terms of action is not just about having a body, but a particular type of body. Honda's Asimo (Advanced Step in Innovative Mobility) is a prominent example of an autonomous robot which, in certain ways, alludes to human physiology (Figure 18). 'Asimo is able to navigate the real world, reach, grip, walk reasonably smoothly, climb stairs, and recognize faces and voices' (Clark, 2008, p.3). Despite these great robotic achievements, however, Asimo is not particularly economical in completing these tasks. Clark notes that:

> [w]hereas robots like Asimo walk by means of very precise, and energy-intensive, joint-angle control systems, biological walking agents make maximal use of the mass properties and biomechanical couplings present in the overall musculoskeletal system and walking apparatus itself. (Clark, 2008, pp.3-4)

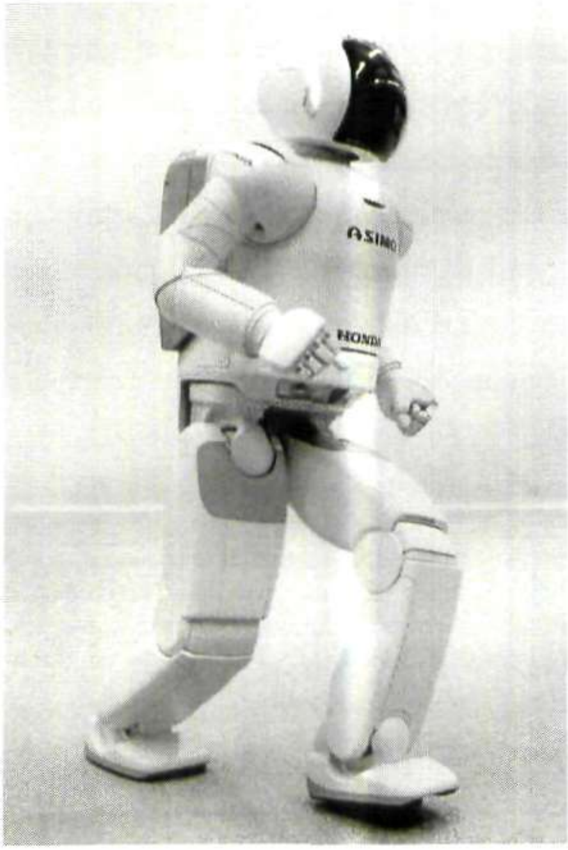

Figure 18 Honda's Asimo robot. © 2009 Honda Motor Company.

Pfeifer and Bongard (2006) suggest that robots such as Asimo, although 'bodied', are not 'embodied'.

> [E]mbodiment is an enabler for cognition or thinking: in other words, it is a prerequisite for any kind of intelligence. So, the body is not something troublesome that is simply there to carry the brain around, but it is necessary for cognition. [...

> M]any tasks become much easier if embodiment is taken into account. (Pfeifer & Bongard, 2006, p.19)

Although Asimo is conceptualised in terms of autonomy in the world, the manner in which it has been developed has lead to a cognitivist-esque result where the 'intelligence' is within a centralised processer—the brain of the robot—rather than distributed through its body.

> This often lead[s] to computationally expensive solutions that not only produced unnatural behaviour, but were also too slow to achieve, for example, running behaviour. Thus, the concept of embodiment not only implies that the agent must have a body—obviously robots do have bodies—it also means that one should follow a particular style of thinking when building robots or generally intelligent agents. (Pfeifer & Bongard, 2006, p.29)

Pfeifer and Bongard highlight how it is not just the fact that robots such as those developed by Brooks' had a body that made them intelligent cognitive agents, it was that they were developed in such a way to have a body that took advantage of the world and intelligence was layered on top. Although Asimos do have bodies, and are highly intelligent on a computational level, as agents they expend a lot of 'mental' energy for very little gain. Instead, Pfeifer and Bongard argue that what is needed instead is an increased consideration of 'morphological computation'; 'that certain processes are performed by the body that otherwise would have to be performed by the brain' (Pfeifer & Bongard, 2006, p.96). Human beings and many other species, Pfeifer and Bongard argue, appear to be rather good at allowing their embodiment to take control of certain actions in the world rather than relying upon conscious control. For example, the muscles and tendons in the human leg are elasticised in such a manner that when walking and running the knee can make small adaptive and dynamic movements without requiring control from the nervous system (Pfeifer & Bongard, 2006). Pfeifer and Bongard (2006) suggest that in order to develop complete, embodied, agents, robotocists and cognitive scientists must take into account how intelligence is distributed around the physiology of the body in this manner.[121]

The embodied and situated robotics research suggests that in order to have robust cognitive functioning, first there is a requirement to have a particular type of body and for this body to be grounded in the environment. In reference to von Uexküll and Gibson, human

[121] Pfeifer and Bongard define five properties of 'complete agents', of which morphological computation is the fifth on a growing scale. The properties are: '1. *They are subject to the laws of physics* (energy dissipation, friction, gravity). 2. *They generate sensory stimulation* through motion and generally through interaction with the real world. 3. *They affect the environment* through behaviour. 4. *They are complex dynamical systems* which, when they interact with the environment, have *attractor states*. 5. *They perform morphological computation*' (Pfeifer & Bongard, 2006, p.95).

beings appear to have such a complementarity between their body and the environment; their *Umwelt* is integrated and coherent, freeing up certain mental processes for more strenuous cognitive activities. It is possible to ask here, however, as to what happens when this integration and coherence is disrupted? This question has some resonance with the temporal changes occurring to the cognition of older people, especially in relation to the broader physiological changes to the body that occur in later life; this theme will be explored further in chapter six. In the following section, the issue of embodiment and environment will be discussed in relation to the enactive cognitive sciences, dealing with human cognitive development and change.

5.3. Enactive cognitive science

Human cognition continually enacts and re-enacts the Umwelt through a history of structural couplings; these couplings are somewhat closed, yet also open to new couplings to emerge in the future.

If embodiment and the situated environment are implicated in the development of human cognition, then the cognitivist idea that human thought is entirely internal information-processing, or of the brain, must be reassessed. A great variety of research within the cognitive sciences has established relationships between embodiment and cognition, to varying degrees of radicalism against prevailing ideas.[122] One influential perspective has been that cognition is inseparable from the lived experience of the world, as is suggested by Francisco Varela, Evan Thomspon and Eleanor Rosch (1991). Varela *et al.* (1991) claim that in the life world as it is lived by the cognizing agent, both knowledge and phenomenal experience are a result of active construction, rather than relying upon decoding an objective reality independent of the agent. McGee (2005) argues that Varela *et al.* proposed a model of cognition based upon a radical constructivist ontology. The significance of this perspective is that it suggests a 'middle-way' between the contemporary dualisms of objective and

[122] Although ontological and epistemological arguments within cognitive science are often shifted into one of two camps—such as cognitivist or enactivist; rationalist or pragmatist; soft or hard; functional or experiential—divisions are usually far less well-defined. For example, philosopher Andy Clark notes that embodied cognitive science can be divided into 'embodied' and 'radically embodied' camps (Clark, 2008). Clark's own argument can be described as a form of wide computationalism (as documented in Clark (1997; 1998; 1999; 2003; 2008; Clark & Chalmers, 1998)). Clark walks a line between cognitivism and enactivism (as in Varela *et al.* (1991)), where he takes on-board aspects of computational and information-processing paradigms of the mind, whilst also arguing for how the body and world is a part of these computational abilities as much as the brain or central nervous system is.

subjective reality.[123] Von Glasersfeld claimed that radical constructivism 'breaks with convention and develops a theory of knowledge in which knowledge does not reflect an "objective" ontological reality, but exclusively an ordering and organization of a world constituted by our experience' (von Glasersfeld, 1984, p.24). These themes of radical constructivism are evident within Varela *et al.*'s proposal of using enactive as the defining term of their paradigm of cognitive science.

> We propose as a name the term *enactive* to emphasize the growing conviction that cognition is not the representation of a pregiven world by a pregiven mind but is rather the enactment of a world and a mind on the basis of a history of the variety of actions that a being in the world performs. (Varela *et al.*, 1991, p.9)

Varela *et al.* argue that in being enacted, cognition in experience is fundamentally groundless. That is, although knowledge appears to be fixed in cognition at certain moment in time, it is only ever provisional and is liable to change at any moment, even if very subtly, as a result of perturbations to human beings *Umwelt* (McGee, 2005). In terms of Varela *et al.*'s positioning of cognition, the *Umwelt* is the result of a history of structural couplings. For Varela *et al.*, the term structural coupling develops directly from Varela's previous second-order cybernetics research[124] into autopoietic cognition with Humberto Maturana.[125] Maturana and

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[123] The ontological similarities between radical constructivism and enactive cognitive science stand in stark contrast to the dominant perspectives on ontological realities that prevails within the cognitive sciences. One way to characterise cognitivist ontology would be as the decoding of information from the world in an internalised, private system of processing. Gibson's ecological psychology opposes this perspective completely. Of course, he does have an interest in the physiology of the animal, but he is clear that the information for making sense of the world is *in* the world, and human beings discover this information as active agents. Maturana and Varela highlight the difficulty of these opposing approaches, highlighting that '[a]ll doing is knowing and all knowing is doing' but also that '[e]verything said is said by someone' (Maturana & Varela, 1987, p.26). They highlight how it is there is validity to ontological perspectives that either emphasise the subjective ideal, or the objective real, or both, or neither.

[124] In chapter two, the thesis highlighted how the original cybernetics movement heavily influenced the contemporary understating of human cognition in the cognitive psychology of ageing. Whilst the earlier cybernetics research could be considered reductionist, focusing primarily on objective understandings of the cybernetic system, second-order cybernetics more prominently acknowledged the subjectivity of analysing cybernetic systems. In particular, second-order cybernetics noted how the observer—be that the designer of an artificial intelligent system, or the scientist experimenting with self-organised biological or cognitive systems—are also a cybernetic system. Heylighen and Joslyn note that 'observer and observed cannot be separated, and the result of observations will depend on their interaction. The observer too is a cybernetic system, trying to construct a model of another cybernetic system. To understand this process, we need a "cybernetics of cybernetics", i.e. a "meta" or "second-order" cybernetics' (Heylighen & Joslyn, 2001, p.157).

[125] Much of Maturana and Varela's work focused upon a theory of self-organisation they coined autopoiesis. They defined an autopoietic system as 'a network of processes of production (transformation and destruction) of components that : (i) through their interactions and transformations continuously regenerate the network of processes (relations) that produced them; and (ii) constitute it (the machine) as a concrete unity in the space in which the (the components) exist by specifying the topological domain of its realisation as such a network' (Maturana & Varela, 1980, p.79). Winograd and Flores (1986) highlight how the technical language of this definition might be off-putting, but 'it is in fact a carefully crafted statement expanding on a simple idea: the essential characteristic of a living system is that it is a collection of components constituting a unity that can live

Varela claimed that structural couplings occur when 'there is a history of recurrent interactions leading to the structural congruence between two (or more) systems' (Maturana & Varela, 1987, p.75). The concept of structural coupling suggests from the outset that certain systems are not integrated. Over time, repeated patterns of interactions between overlapping systems mean they become coupled with one another. In terms of Maturana and Varela's research, structural coupling is a phylogenetic (evolutionary) phenomena where two or more systems, be these formed of a single cell or higher complexity, couple with one another as a result of stable interactions over evolutionary time. Varela *et al.* (1991) position structural coupling in terms of the ontogenetic timescale of the lifespan of a human being. Structural coupling implicates that over the history of a lifetime, the nervous system, the body and the environment continuously and dynamically overlap one another, developing new couplings whilst others diminish (Thompson & Varela, 2001; Varela *et al.*, 1991). The *Umwelt*, when interpreted through Varela *et al.*'s terms, is both closed and open. Much like the embodied robotics research discussed previously, Varela *et al.* are keen to highlight the reliance upon the body and world for cognition.

> By using the term embodied we mean to highlight two points: first, that cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological, and cultural context. (Varela *et al.*, 1991, pp.172-173)

Varela *et al.* stress how human embodiment, its sensorimotor capabilities and the experiences that come from having a body constructed in a particular way are fundamental to the development of human cognition. This body, however, is always situated; cognition is not just about the sensorimotor structure of the physiology of the human body, but how this relates to second and third order structural couplings with the world. Varela *et al.* continue:

> By using the term action we mean to emphasise once again that sensory and motor processes, perception and action, are fundamentally inseparable in lived cognition. Indeed, the two are not merely contingently linked in individuals; they have also evolved together. (Varela *et al.*, 1991, p.173)

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or die. Maturana's central observation is that exactly this simple property leads to the complex phenomena of life. The functioning of an organism as structure-determined system with the potential of disintegration leads to adaption and evolution' (Winograd & Flores, 1986, p.45). Theories of second-order systems and autopoietic self-organisation are fundamental to the development of Varela *et al.*'s (1991) theory of enactive cognition, but will not be developed further in the main text.

The interconnection of perception and action, linked through the structural couplings of the nervous system, the body and the world, highlight the reciprocality and circularity inherent in Varela *et al.*'s approach to human cognition.

Although at the time of formulating their argument the concept of embodiment in cognitive science was not necessarily new[126], what is radical in Varela *et al.*'s perspective is their argument of the reciprocal nature of the body and environment in cognition. It is this reciprocality that forms the structural coupling of cognition. Over the lifetime of a human being, certain patterns of interaction between human and environment are repeated in such a manner that they become structurally coupled. This reciprocality emerges from the circularity with ecology, where 'we are in a world that seems to be there before reflection begins, but that world is not separate from us' (Varela *et al.*, 1991, p.3). To distinguish this approach from other embodied models of cognition, Varela *et al.* (1991) coin their new paradigm as enactive cognitive science.[127] The enactive approach to cognition is comprised of two main points; '(1) perception consists in perceptually guided action and (2) cognitive structures emerge from the recurrent sensorimotor patterns that enable action to be perceptually guided' (Varela *et al.*, 1991, p.173). Within an enacted cognitive science, human perceivers are guided by the actions made available by a particular embodiment and actively 'contributes to the enactment of [... the] surrounding world'[128] (Varela *et al.*, 1991, p.174). Varela *et al.* subsequently define their positioning of cognition in the following:

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[126] A number of scholars and philosophers dealing with the cognitive sciences have provided accounts of cognition that are more rooted in the body. Although this thesis focuses primarily on the works of Gibson (1986), Varela *et al.* (1991) and Chemero (2009), there are multitudes of other works that have informed in subtle ways these ideas. Varela *et al.* cite Dreyfus (1992), Lakoff (1987), Johnson (1987) as preceding examples of accounts of embodiment within cognitive science. More recent examples that have informed this discussion are Lakoff and Johnson (1999), Clark (1997; 2008), Pfeifer and Bongard (2006) and Gallagher (2005), Noë (2004), O'Regan and Noë (2001), Barsalou (2008), Glenberg (1997), Wilson (2002), Thelen and Smith (1996) and Shapiro (2007). Although these arguments may be broadly contextualised as embodied cognitive science, there are huge variances between the literature as to how embodied cognition may be used and defined.

[127] Although this thesis refers to 'enaction' in terms of how it was introduced by Varela *et al.* (1991), the term enaction has been used at length within the earlier work of cognitive psychologist Jerome Bruner. Bruner was a key advocate of the original incorporation of 'cognitive' philosophy into experimental psychology. Bruner (1966) introduced 'enactive' knowledge as part of a three-stage hierarchical model of human knowledge (the other been iconic and symbolic knowledge). Bruner argued that we 'know many things for which we have no imagery and no words, and they are very hard to teach anybody by the use of either words or diagrams and pictures' (Bruner, 1966, p.10). For Bruner, it was this form of knowledge that formed enactive knowledge. Although Varela *et al.*'s (1991) approaches have similarities to Bruner's (1966) understanding of enaction, there are also substantial differences in that Bruner considered enactive knowledge as represented in the mind of the individual and distinct from the iconic and symbolic knowledge, which were privileged higher-cognitive and disembodied status. In light of Vareal *et al.*'s (1991) approach it is evident that Bruner (1966) considered the knowledge of the body as separate from cognitive knowledge. Pia Tikka (2008) observes that recent research on 'enactive interfaces' (Enactive Network, 2007), although referencing Varela's and Maturana's research, mainly emphasises a definition of enaction similar to Bruner's.

[128] Varela *et al.* note the significance of the phenomenological writings of Merleau-Ponty, particularly *Phenomenology of Perception* (2002), throughout their development of their enactive account of cognition,

> Question 1: What is cognition?
> Answer: Enaction: A history of structural coupling that brings forth a world.
> Question 2: How does it work?
> Answer: Through a network consisting of multiple levels of interconnected, sensorimotor subnetworks.
> Question 3: How do I know when a cognitive system is functioning adequately?
> Answer: When it becomes part of an ongoing existing world (as the young of every species do) or shapes a new one (as happens in evolutionary history). (Varela *et al.*, 1991, pp.206-207)

In developing the enactive cognitive sciences based upon notions of structural coupling, Varela *et al.* appear to allude to the possibility that the nervous system, body and environment are not always coupled. Cognition, in this account, appears to be the human capability to ensure enaction; that is, to successfully integrate, or couple, the nervous system, body and environment into coherent system. This is suggested by Thelen *et al.* (1996), who observed that human adults are adept at integrating both perception and action through interconnected sensorimotor networks, whilst children have to develop these abilities. Much of Thelen's research (such as Thelen and Smith (1996)) highlights the manner in which human cognition develops in infancy through the self-organisation of a dynamic system bridging the brain, central nervous system, the body's physiology and the environment. Similarly, Chiel and Beer (1997) have noted the significance of Varela *et al.*'s perspective in terms of understanding how organisms adapt neurally to changes to environments. They note that the then prevailing attempts to identify the basis for organisms adapting to environments had focused upon neurology and the central nervous system (Chiel & Beer, 1997). Chiel and Beer identified this as problematic, however, as the 'nervous system, the body, and the environment are each rich, complicated, highly structured dynamical systems, which are coupled to one another, and adaptive behavior emerges from the interactions of all three systems' (Chiel & Beer, 1997, p.554). In this sense, it is only possible to understand the state of the nervous system in reference to the continuous system of feedback to and from the body and the world.[129]

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highlighting that any account of cognition should make sense in regards to the enacted experience of the world. Like Neisser and Gibson before them, Varela *et al.* (1991) were not interested in static laboratory studies of cognition, but how cognition emerges through real world interactions.

[129] The research described by Thelen and Smith (1996) and Chiel and Beer (1997) are prominent examples of the use of dynamic system theory within the study of human cognition. Thelen and Smith argue that the 'central tenet of dynamic systems is that order, discontinuities, and new forms emerge precisely from the complex interactions of many heterogeneous forces [...] the power source of human cognitive development is not in the separate modules but in their mutual interactions' (Thelen & Smith, 1996, p.37). The dynamicist approach to understanding cognitive development is coextensive with Varela *et al.*'s enactive approach. Aspects of Thelen

5.4. The dynamic affordances of the *Umwelt*

It is possible to conceive of the Umwelt of a person and the affordances they perceive as dynamic and continually in a state of change based upon innumerable factors; human cognition allows for the continued integration of these factors into a coherent understanding of the Umwelt.

In recent years, post-Gibson ecological psychologists have proposed a variety of redefinitions to the theory of affordances that are increasingly suited to the enactive framing of human cognition presented by Varela *et al.* (1991).[130] A recent elucidation of the theory of affordances by Anthony Chemero (2003; 2009) emphasises how affordances are part of the enaction of the *Umwelt*.[131] In terms of the experience of the cognizing agent, Chemero continues the claims of Varela *et al.* that the phenomenal, cognitive and behaviour are inseparable, 'achieved by closely coordinated perception and action' (Chemero, 2009, p.212) as an integrative system. Chemero (2003) differs from Gibson in arguing that affordances are relations between an animal and the environment.[132] More specifically, these relations are between the abilities of the animal and the features of the environment. Chemero (2009) expands his relational account of affordance into the context of real-time accounts of interactions with the world.

> [C]onsider the interaction over time between an animal's sensorimotor abilities, that is, its embodied capacities for perception and action, and its niche, the set of affordances available to it. [...] Over developmental time, an animal's sensorimotor abilities select its niche—the animal will become selectively sensitive to information relevant to the things it is able to do. Also over developmental time, the niche will strongly influence the development of the animal's ability to perceive and act. (Chemero, 2009, pp.150-151)

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and Smith's (1996) use of dynamic systems theory will be explored in chapter eight of the thesis in reference to design.

[130] Again, this emerges from the complicated and contradictory nature of Gibson's argument. Much like it has been in design, the theory of affordance has been highly debated within post-Gibsonian ecological psychology. These discussions often surround the fundamental nature of affordances—whether they exist as objective properties of the world (as in Turvey (1992)), or as relations between animals and environments (as argued by Stoffregen (2003a; 2003b), Chemero (2003) and Chemero and Turvey (2007b)). Although these discussions are valuable, this thesis focuses upon Chemero's (2009) definition, as it is most relevant in the thesis' context.

[131] The thesis will continue to use *Umwelt* in place of animal-environment system, although it is the latter terminology that Chemero (2003; 2009) and Stoffregen (2003b) use.

[132] Although Gibson suggested at various points that affordances are only perceived in reference to certain animals, he was clear in stating that they were invariant properties of ecology. Although Gibson identified affordances as a relation between the animal and ecology, the relation is always focused upon the animal in relation to ecology, and not in completely mutual terms.

For Chemero (2009), if this is what occurs in the relations between animal and environment over evolutionary or developmental periods, then a similar account of affordance can be offered for real-time interactions.[133]

> Over the shorter time scales of behaviour, the animal's sensorimotor abilities manifest themselves in embodied action that causes changes in the layout of the available affordances, and these affordances will change the way abilities are exercised in action. (Chemero, 2009, p.151)

Chemero highlights here how affordances are not simplistic, static aspects of the animal's opportunities for action with the environment, but change, sometimes dramatically, moment-by-moment through real-time alterations in the embodiment of the organism and the layout of the environment. In the case of Chemero's theory of affordances, the animal enacts the *Umwelt* in terms of an ongoing development and achievement. This is not a one way system though of enaction from the organism, as the world also shapes the animal; subsequently, the animal, in turn, can change this world. To reiterate:

> an animal's activities alter the world as the animal experiences it, and these alterations to the phenomenological-cognitive-behavioral niche, in turn, affects the animal's behaviour and the development of its abilities to perceive and act, which further alter the phenomenological-cognitive-behavioral niche, and on and on. (Chemero, 2009, p.152)

Abilities are, for Chemero, a further relation, but this time between the affordance and the animal. In order to perceive a particular affordance, that is to act upon a feature of the environment, the animal requires particular abilities, a sensorimotor coupling. In conceptualising the human variable of affordance as abilities, Chemero (2009) is not suggesting that upon the correct matching of an environmental feature a particular affordance will be executed. Chemero notes that:

> [h]aving the ability to walk does not mean that one will not fall down even in the ideal conditions for walking. This is to point out that there is something inherently normative about abilities. Individuals with abilities are supposed to behave in particular ways, and they may fail to do so. (Chemero, 2009, p.145)

[133] The idea that affordances can be thought of as relations between the animal and the environment are evident in Gibson's original definition. What Chemero (2009) (and also Stoffregen (2003b)) defines as animal-environment systems appears to have a similarity with Gibson's 'ecological niche'. Gibson stated that '[t]he natural environment offers many ways of life, and different animals have different ways of life. The niche implies a kind of animal, and the animal implies a kind of niche. Note the complementarity of the two' (Gibson, 1986, p.128). However, where Chemero (2009) differs dramatically is a move from the evolutionary timescale that Gibson appears to continuously allude to, towards a dynamic, real-time account of affordances.

Also, as Stoffregen (2003b) argues, there are situations where a great many affordances emerge but are ignored. The implication here is that in everyday situations, although affordances may emerge within the *Umwelt*, they are not necessarily exploited by an individual. It may also be that the abilities of particular human beings do not match the potential affordances of the environment. In such circumstances the environment may be changed to suit the abilities of the individual, or the potential affordance influences the development of the required sensorimotor couplings.[134] Chemero (2009) illustrates his theory of dynamic affordances as in Figure 19.

Considering Chemero's account in terms of the enactive cognitive sciences, it can be taken that affordances are the necessary bridge between the autopoietic system of the organism and the environment. As is observed by Thelen and Smith, infant children actively explore their environments in order to identify what it affords; in identifying novel affordances, further subtle couplings with the environment are made, altering both the neural dynamics and sensorimotor couplings of the child, thus aiding the active exploration of further affordances.[135] The child's *Umwelt* is constantly in a state of change; this continuous change is perhaps most apparent in youth but continues throughout an individual's lifetime.

[134] Chemero cites the research of Esther Thelen (1994) that examined the manner in which three-month old infants are able to develop couplings between themselves and the environment. Thelen (1994) trained the infants to spin a mobile by kicking their legs. After learning this ability, Thelen (1994) banded their legs together, making it difficult to continue enacting the perceived affordance. It was observed that the children very quickly learnt to move their legs at the same time in order to spin the mobile (Thelen, 1994). Chemero notes that Thelen's studies are useful as they highlight how, firstly, 'that even very young children actively explore their environments in order to discover affordances. Secondly, these studies show that infants make changes to their behavioural repertoire in order to alter their environment and, in so doing, to alter their phenomenology' (Chemero, 2009, p.201).

[135] The discussion provided here somewhat portrays affordances as a having a positive effect on people. This is not necessarily the case, as affordance can be portrayed as negative as much as positive. Affordances are, of course, not the implementation of certain phenomena (as it may be understood in design accounts such as Norman) but are rather the exploration of phenomena. In exploring certain environment, affordances may emerge that have effects on organisms that may be understood as negative. For example, computer games may afford a lowered excursion of bodily organs and muscle groups for children, making children potentially unfit. Although it may be the case that certain affordances may be perceived as having negative or positive effects on people, affordance as phenomena are fundamentally neutral. An affordance itself does not have agency; rather, it is the collective conditions of particular moments in time, interconnected with the intentions, desires and presuppositions of people that determine the potential positivity and negativity of exploring certain affordances.

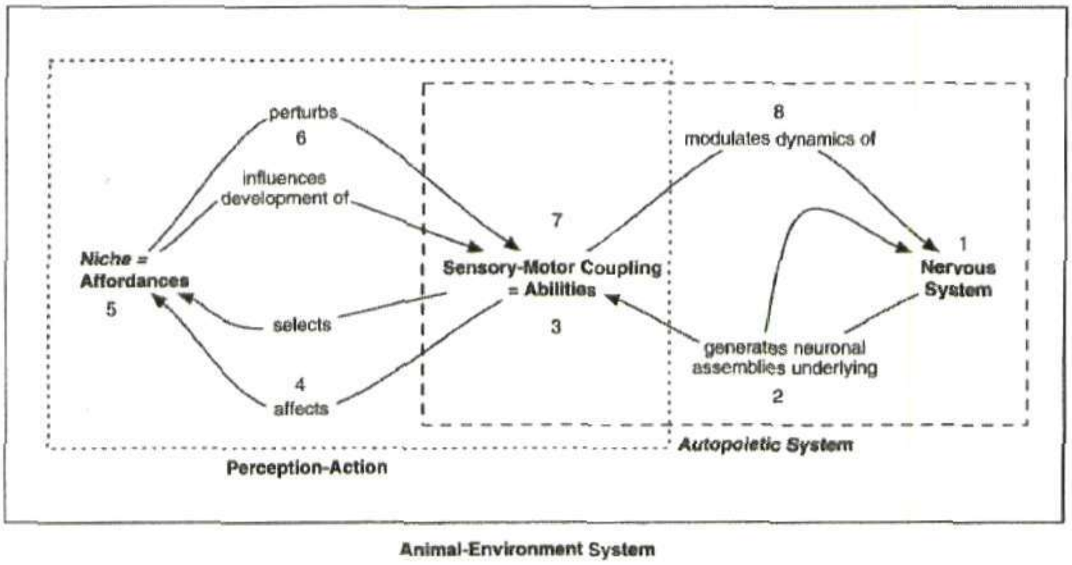

Figure 19 Chemero's (2009) proposition of dynamic affordances. Taken from Chemero (2009, p.153)

The account of cognition described within this chapter has explained it to be an ability of an entire embodied and situated organism that integrates and couples together the nervous system, the body and the environment to allow for the coherent enaction of a world. Affordances, in this account of cognition, emerge as relations between the abilities of particular person and features of their environment (which have resulted from a particular history of structural couplings). The affordances of the *Umwelt* are instable and provisional, changing as a result of alterations to the autopoietic structure of the human and the layout of the environment. These changes are ongoing, altering at a moment's notice yet also traceable over time.

The revision of the definition of human cognition provided by those researchers dealing with ecological, enactive and dynamic aspects of cognitive science provides a basis for the design to think somewhat differently about the cognitive disconnection between older people and digital media products. Problematically, however, little to no research in this area has been performed on the subject of ageing. The discussion of this chapter characterises human cognitive experience as a flexible and plastic process in which perception and action are perturbed by a great variety of neural, physiological, and environmental influences and yet are combined in a rather seamless fashion. What happens, however, when this seeming robust integration goes wrong? The following chapter will examine the relevancy of the perspective of cognition developed here in reference to human senescence, leading to an alternative account of cognitive disconnection.

Chapter 6

Senescent cognition

Question: Is it possible to reinterpret the cognitive disconnection observed to occur between older people and digital media products through a dynamic and enactive understanding of senescent cognition?

6.1. Insufficiencies in the ability to integrate the implicit knowledge of bodily abilities with ongoing activities lead to situations where cognitive resources become limited, the body becomes overtly present and the perception of affordances in the Umwelt becomes somewhat incoherent.

6.2. It is possible to reinterpret studies of relationships between cognitive, physical and sensory deterioration in old age as highlighting a misalignment of an individual's perception of their abilities and the potential abilities of their own embodiment; rather than a process of deterioration, this presents a situation of ongoing experiential blindness.

6.3. Recent studies of the ageing brain suggest that rather than declining in physical and cognitive function, it appears to be highly plastic and engaged in a process of continual re-organisation resulting from the process of senescence and novel interactions in the world.

6.4. A senescentechnic understanding of cognitive disconnect is presented that highlights how the contemporary approaches of cognitively inclusive design are limited in focusing purely on storehouse metaphors of memory. Instead, senescent cognition presents a situation where designers are implicated in harnessing the agency and potential abilities of the embodied and enacting older person.

6.1. Disruptions to the coherency of the *Umwelt*

Insufficiencies in the ability to integrate the implicit knowledge of bodily abilities with ongoing activities lead to situations where cognitive resources become limited, the body becomes overtly present and the perception of affordances in the Umwelt becomes somewhat incoherent.

In the previous chapter, the thesis explained an alternative paradigm of understanding human cognition to that of cognitivism, where cognition is grounded and enacted and considered to be a process of the continued integration of sensorimotor couplings that allow for the perception and action upon affordances. This account of cognition, rather than separating and reducing cognitive functions as discrete to the body and environment, proposed that human thought is inseparable from an encompassing *Umwelt*. Whilst the work of Gibson, Varela *et al.*, and Chemero provide a useful place to begin searching for alternative design strategies than those proposed in cognitively inclusive design, the literature discussed in the last chapter provide little explanation for those moments when cognitive disconnections—where mind, body and world appear to be separated—are observed as occurring. The discussion from the previous chapter, whilst providing an alternative basis with which to conceptualise human cognition from cognitivism, fails to engender a greater understanding of the problems older people encounter with digital media products based upon this framework.

This chapter builds upon the previous discussion by developing an account of senescent cognition that provides a basis for understanding the temporal changes occurring to human cognition in later life. In particular, recent work by phenomenologist Shaun Gallagher (2005) and philosopher of mind Alva Noë (2004), which is synergetic with the arguments of Varela *et al.* (1991) and has examined aspects of embodiment and enaction in relation to changes to integrative systems of the human body, provides a useful place with which to start developing a senescent understanding of cognitive disconnection. This chapter will bring these works together with more traditional studies of changes to the ageing human body, cognition and neurophysiology, in order to highlight certain synergies between a number of studies that have previously been unattended. Following this, the proposal of senescent cognition will be used as a critical lens to reinterpret the previously discussed cognitive disconnections between older people and digital media.

The research of Shaun Gallagher (2005), informed by the phenomenology of Merleau-Ponty (such as Merleau-Ponty (1962 [2002])), is focused upon providing explanations as to how human cognitive experience is grounded in the human body, and how subtle changes to this grounding have profound consequences on an individual's perception and cognition. A significant contribution of Gallagher's research has been the study of interactions between two bodily systems related to the coherency of perception and action; the body schema and body image. Gallagher, developing and synthesising notions developed by Head (*1920*) and Merleau-Ponty (*1962 [2002]*), defines the body schema as 'a system of sensory-motor functions that operate below the level of self-referential intentionality' (Gallagher, 2005, p.26).[136] The body schema operates in a close-to-automatic manner to aid

[136] The usefulness of Gallagher's work is partly in his synthesis of a large amount of disparate literature discussing the body schema and the body image. Gallagher (2005) traces the notion of the body schema to Head (1920). Head (1920) defined the body schema as preconscious (hence prenoetic) system somewhat related to

the positioning of the body in relation to the environment. A correctly functioning body schema affords a situation where aspects of bodily movement are not required to be under conscious control when engrossed in interactions with objects and other people. As Gallagher defines it, the body schema is a prenoetic[137] performance of the human body, suggesting that 'the body acquires a certain organization or style in its relations with its environment' before an individual is consciously aware of it occurring (Gallagher, 2005, p.32). It is not, therefore, just a case that the body schema coordinates the sensorimotor system of the human being in order to engage in a certain activity, but that it is in a constant exchange with the environment. Gallagher (2005) suggests that at times the body schema can expand beyond the flesh of the human and incorporate aspects of environment.

> The body schema allows the body actively to integrate its own positions and responses and to deal with its environment without the requirement of a reflexive conscious monitoring directed at the body. It is a dynamic, operative performance of the body, rather than a consciousness, image, or conceptual model of it. (Gallagher, 2005, p.32)

The body image, on the other hand, is 'a system of perceptions, attitudes, and beliefs pertaining to one's own body' (Gallagher, 2005, p.24). The body image frequently appears in conscious experience and is not equal to the body schema (Gallagher, 2005). An extreme example of the difference between a body image and body schema is that at times one's body image can be brought to conscious attention, whilst the body schema always stays outside of consciousness. The body image is an explicit understanding of what constitutes an individual's own body, rather than the tacit performances of that body. Gallagher (2005) argues that in terms of perceptual experience, the body image distinguishes itself from the environment. If an individual is required to consciously attend their perception to the performance of their body in a task, then the body would be brought forth as the focal point

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cortical system of human physiology, yet authors that developed his ideas (such as Schilder (1935)) defined the body schema as a finalised conscious perception of the self (Gallagher, 2005). It appears to be Merleau-Ponty's definition of schema corporel that most influences Gallagher's definition of body schema, yet Merleau-Ponty's work is also problematic. Gallagher notes that Merleau-Ponty used *schema corporel* 'to signify a dynamic functioning of the body in its environment. The schema operates as a system of dynamic motor equivalents that belong to the realm of habit rather than conscious choice. Nonetheless, the schema works along with a marginal awareness of the body, and Merleau-Ponty often left the relation between the schema and the marginal awareness unexplained. To make matters worse, however, the term *schema corporel* was rendered 'body image' in the English translation of his work *The Phenomenology of Perception*' (Gallagher, 2005, p.20 – emphasis in original). It is prudent to use Gallagher's work, rather than the original definitions, to navigate around this complexity.

[137] Noetic, or noesis, is an Ancient Greek word referring to understand or to know something, often immediately. In terms of Gallagher's (2005) usage, prenoetic is understood as a process of the body that means it is aware of certain relations with the world prior to the beholder's conscious understanding or knowledge of it occurring.

of attention. Gallagher (2005) notes that if people were required to utilise their body image for sensorimotor control, as opposed to the body schema, then action would be 'inexact and awkward' (Gallagher, 2005, p.33). As such, much like the design of robots for a greater embodied and environmental economy (see chapter five), human beings have the sensorimotor abilities to free up cognition to attend to intentional activities, rather than the control of the body in relation to the environment.[138]

The sense of proprioception is a significant sub-system coupled to the body schema. The notion of proprioception is often traced to the work of Charles Sherrington, who described it as a person's sense of movement from the muscles, tendons and joints of the body (Sherrington, 1907). Gibson, during his formulation of the theory of affordances, argued that proprioception was a form of 'egoperception, as sensitivity to the self, not as one special channel of perceptions or as several of them' (Gibson, 1986, p.115). He went on to argue that all the perceptual systems are in some way proprioceptive as well as exterosensitive, 'for they all provide information in their various ways about the observer's activities' (Gibson, 1986, p.115). He stated that:

> [t]he observer's movements usually provide sights and sounds and impressions on the skin along with stimulation of the muscles, the joints, and the inner ear. Accordingly, information that is specific to the self is picked up as such, no matter what sensory nerve is delivering impulses to the brain. [...] An individual not only sees himself, he hears his footsteps and his voice, he touches the floor and his tools, and when he touches his own skin he feels both his hand and his skin at the same time. He feels his head turning, his muscles flexing, and his joints bending. He has his own aches, the pressures of his own clothing, the look of his own eyeglasses-in fact, he lives within his own skin. (Gibson, 1986, p.115)

Proprioception then, for Gibson, was a form of continuous feedback from the environment felt through the body. In engaging with the environment, a person discovers as much about their own abilities and embodiment as they do the world. In order to explore the world—to develop the perception of new affordances—then it is also necessary to have an understanding of one's own body, its capabilities and an unconscious awareness of what to do with this body in relation to the world.

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[138] This is not to say there are not times when the body is controlled by the conscious awareness and therefore a body image. Gallagher uses the example of learning new bodily skills. 'The visual, tactile, and proprioceptive attentiveness that I have of my body may help me to learn a new dance step, improve my tennis game, or imitate the novel movements of others. In perfecting my tennis serve, for example, I may, at first, consciously monitor and correct my movements' (Gallagher, 2005, p.27). In situations, however, where some sort of conscious control of the body is emphasised, they will be complemented by the skills of the body schema to maintain balance and movement.

It appears that the body schema, informed through the various senses of proprioception, is a necessary function of human embodiment that integrates the environment to support enactment; it is crucial to the coherency of the *Umwelt*. As such, an individual with imbalances related to the coupling of these systems would likely have significant issues organising their body in relation to the environment. Gallagher (2005) discusses a clinical study of a patient called Ian Waterman, which presents an extreme example of such a situation (originally described by Cole (1995)). Ian Waterman had no sense of touch or proprioception below his neck as a result of an illness in his late teenage years. His sense of continuous feedback as to the position of his body was void and, as a result, he was effectively paralysed. This is not to say his body was not capable of movement, however. The possibilities for action were still fundamentally the same as before, but the necessary sesnsorimotor coordination to make them happen was lost. Gallagher (2005) notes that over time, Ian Waterman was able to regain movement. This was only possible through emphasising the role of vision in controlling his body. Without visual perception:

> [Ian] does not know [...] where his limbs are or what posture he maintains. In order to maintain motor control he must conceptualize his movements and keep certain parts of his body in his visual field. His movement requires constant visual and mental concentration. In darkness he is unable to control movement; when he walks he cannot daydream but must concentrate on his movement constantly. (Gallagher, 2005, p.44)

Gallagher (2005) and Cole (1995) argue that what is occurring with Ian Waterman is the replacement of his missing body schematic capabilities with his body image. When interacting with the environment, it is impossible for Ian's body to disappear into the background of his intentional activity; he always has to include his body in his conscious awareness. Gallagher (2005) notes that to look at Ian years after his illness, it would be difficult to observe him acting any differently to most healthy adult males. His actions are only possible, however, through his extreme effort and hard work to regain control of his body; medically, Ian Waterman 's proprioceptive system never recovered from his illness.

Gallagher (2005) implicates the body schematic systems of the human body, of which proprioception fulfils a substantial role, as necessary for the seamless enaction of the affordances within the *Umwelt.* Although Gallagher (2005, p.26) argues that the body schema 'is not itself a form of consciousness, or in any way a cognitive operation', in terms of the perspective of enaction developed in this thesis these prenoetic performances are to be understood as directly implicated within the cognitive act of the human being. The body schema provides a necessary integration of sensorimotor systems; it is necessary for structural coupling between neural, bodily and environment systems. Therefore, in terms of senescent cognition, body schematic performances are a crucial part of cognitive experience.

The claims made by Gallagher can be augmented with the work of the contemporary philosopher Alva Noë (2004), who uses clinical studies of patients with perceptual and cognitive dysfunctions in an enactive account of perception.[139] Proceeding from a slightly different perspective to Gallagher, Noë presents a similarly useful characterisation of bodily systems that allow for the integration of a coherent *Umwelt*. Following the work of Gibson, Noë is keen to emphasise that theories of perception are only relevant if they take the perceiving agent to be an active explorer of the world. A consequence of this perspective on human perception is Noë's argument that 'perceiving is a way of acting' and that all perception is 'touch-like' (Noë, 2004, p.1).

> [T]hink of a blind person tap-tapping his or her way around a cluttered space, perceiving that space by touch, not all at once, but through time, by skilful probing and movement. [...] The world makes itself available to the perceiver through physical movement and interaction. [...] Perceptual experience acquires content thanks to our possession of bodily skills. What we perceive is determined by what we do (or what we know how to do); it is determined by what we are ready to do [...] we enact our perceptual experience; we act it out. (Noë, 2004, p.1)

For Noë (2004), human perception is a skilful activity of the whole body. Human beings know how to interact with objects and are aware of the perceptual consequences of certain actions as a result of the implicit sensorimotor knowledge that shapes all experience. Noë (2004) terms this implicit knowledge as sensorimotor contingencies.

> When you move toward an object, it looms in your visual field. When you move around it, it changes profile. In these and many other ways, sensory stimulation is affected by movement. These patterns of interdependence between sensory stimulation and movement are patterns of sensorimotor contingency. Perceivers are implicitly familiar with these sensorimotor contingencies. (Noë, 2002)

Sensorimotor contingencies, then, are an integrative feature of human embodiment that interlinks perception and action and couple being to the world. Over a lifetime, a person becomes adept at understanding how moving around objects has a subsequent effect of how

[139] Noë terms his theory of perception as the enactive approach to perception. He alerts the reader that he takes this name from Varela *et al.*'s (1991) concept of enaction, but that some of his ideas differ from their argument on certain points. These points, although significant in terms of a comparison between the two corpus' of work, do not impede upon this thesis' discussion.

they are perceived; this altered perception thus affects how you act, in a continuous circularity similar to that presented by Varela *et al*. (1991). In terms of enaction, then, the integrative sensorimotor contingencies are necessary in order to seamlessly incorporate the world into experience.

As with the claims regarding the body schematic system made by Gallagher, it is plausible that discrepancies in sensorimotor contingencies have subsequent effects on the ability to interact with the world in a coherent manner. Noë explains such situations as a form of blindness. In the enactive view of perception there are two different types of blindness.

> First, there is blindness due to damage or disruption of the sensitive apparatus. This is the familiar sort of blindness. It would include blindness caused by cataracts, by retinal disease or injury, or by brain lesion in the visual cortex. Second, there is blindness due not to the absence of sensation or sensitivity, but rather to the person's [...] inability to integrate sensory stimulation with patterns of movement or thought. (Noë, 2004, p.4)

This second form of blindness is termed 'experiential blindness' (Noë, 2004, p.4). Experiential blindness occurs when an individual's sensorimotor contingencies do not match the sensations and actions that their body is capable of performing. In a similar vein to Gallagher, Noë (2004) uses clinical examples to support the notion of experiential blindness. Noë takes as an example attempts to restore sight in people blinded as a result of cataracts. The 'surgery restores visual sensation, at least to a significant degree, but [...] does not restore sight. In the period immediately after the operation, patients suffer blindness despite rich visual sensations' (Noë, 2004, p.5).[140] For example, Sacks wrote about one of his patient's reports on his experiences immediately after waking from the operation.

> [H]e had no idea what he was seeing. There was light, there was movement, there was colour, all mixed up, all meaningless, a blur. Then out of the blue came a voice that said, "Well?" Then, and only then, he said, did he finally realize that this chaos of light and shadow was a face—and, indeed, the face of his surgeon. (Sacks, 1995, p.114)

The situation described by Sacks provides evidence to suggest that it is not possible to perceive coherently purely as a result of having the necessary sensory apparatus, but also that

[140] A significant feature of Noë's research is making a case against cognitivist-like models of perception as much as it is developing an enactive account of perception. For Noë, the case of experiential blindness post cataract operation is evidence to suggest the input-computation-output concept of perception and cognition is flawed. He suggests that if cognitivism was correct, then in correcting the sense-organ, it would be akin to 'sweeping aside the blinds, letting the light and thus enabling normal vision' (Noë, 2004, p.4). As Noë explains through examples taken from clinical studies, these claims do not appear to be the general rule.

an individual requires the embodied knowledge of how to interpret and act upon perceptual stimulus. Gregory and Wallace (1963), discussing a cataract patient one month after operation, state that:

> [a]t first impression he seemed like a normally sighted person, though differences soon became obvious. When he sat down he would not look round or scan the room with his eyes; indeed he would generally pay no attention to visual objects unless his attention were called to them, when he would peer at whatever it was with extreme concentration. (Gregory & Wallace, 1963, p.364)

Gregory and Wallace's (1963) patient lacks the necessary practical understanding of how his visual sensations relate to his movements. He lacks a coherent system of sensorimotor contingencies. The new capabilities of his visual sense are not integrated within his whole embodiment. The integration of capabilities with contingencies is a necessary requirement for a coherent enactment of the *Umwelt*.

Both Gallagher (2005) and Noë (2004) provide examples of how aspects of human embodiment related to the sensorimotor system are necessary for coherent interaction with environments. The prenoetic performances of the body (the body schema and proprioception) and the contingencies human beings implicitly deploy when interacting with the environment are necessary cognitive functions in terms of enactive cognitive science. In terms of dynamic affordances, the manner in which affordances are experienced is dependent upon the manner in which these bodily systems integrate perception and action. In the following section, the chapter will examine how the claims made by Gallagher and Noë relate to some contemporary studies of the relationship between physiology and cognition in later life.

6.2. Senescentechnic disembodiment

It is possible to reinterpret studies of relationships between cognitive, physical and sensory deterioration in old age as highlighting a misalignment of an individual's perception of their abilities and the potential abilities of their own embodiment; rather than a process of deterioration, this presents a situation of ongoing experiential blindness.

Returning to Chemero's (2009) proposal of dynamic affordances (discussed in the previous chapter), an affordance is understood to be a relation between the abilities of a particular embodied agent and the feature of the environment. Abilities are, however, not purely a consequence of physical embodiment but also require an individual to hold the knowledge as to how to make use of this embodiment. As was highlighted by Gallagher (2005) and Noë

(2004), implicit capabilities of the sensorimotor system often intervene silently in experience to ensure that human beings do not have to consciously attend to a variety of embodied abilities. When these fundamental bodily systems begin to falter, however, one's body comes to the fore in relation to affordances and, consequently, the perception of affordances becomes somewhat incoherent. In terms of the topic of this thesis, an understanding of how these embodied sensorimotor systems function as a result of human senescence appears to be useful as, in most cases, senescent human beings have bodies.[141] Discussions of embodied or enactive cognition in terms of senescence, however, are somewhat absent.[142] This section bridges the arguments of Gallagher (2005) and Noë (2004) and the enactive cognitive sciences with research from the fringes of contemporary studies of the ageing body and cognition.

In the discipline of ecological psychology and research examining human locomotion and kinaesthesia, it has been acknowledged for some time that the ageing process results in changes to the affordances within an individual's *Umwelt*. An often cited study of these changing relations is the observation related to the affordance of 'stair-climbability' introduced by Warren (1984). In his original study, Warren (1984) attempted to identify whether there was a consistent relationship between measurable components of human anatomy and differently sized staircase steps in terms of whether certain sizes of staircase afforded better 'stair-climbability'. Warren (1984) noticed that there was a consistent relationship between the length of legs and what was the highest step they could climb; this being 88% of the length of the leg. Going by Warren's (1984) argument, in order to design a staircase that is suitable for 'stair-climbability', it would be suggested that steps should be no

[141] It will be assumed here that the thesis is attending to older people that have a body capable of actively exploring environments for affordances. It is particularly important to highlight here that when referring to a body, it is understood that the body of an older person would be rather different to that of younger people and children, who tend to be the focus of much embodied and enactive cognitive science research. The general processes of their enacted cognition may be similar though. The senescent human body is still a body that shapes cognitive experience in a great variety of ways; it just happens to be a body that might be in a profound state of temporal change that requires a greater amount of control from the individual.

[142] There are very few conceptual reasons why embodied cognition in the later life of human beings has gone relatively unstudied, although there may be some very reasonable practical reasons. The circular and developmental nature of Brooks' (1986; 1999) and Varela *et al.*'s (1991) research lend themselves to studies of children and the rapid development of skills instead of the study of older people and processes of senescence, which are typically conceived of to be a slow deterioration. Outside of cognitive science, discussions referring to the ageing body and embodiment have become more apparent in recent social science literature, particular that which extends gender studies and feminism argument to the study of older people (i.e. Calasanti and Slevin (2001; 2006)). Some of this literature is referred to at points in this thesis to elaborate certain ideas. For the most part, however, the discussion of embodiment as it is used in the social sciences complicates the understanding developed through this thesis.

higher than 88% of the leg length of those who will climb it.[143] Konczak *et al.* (1992) and Cesari *et al.* (2003) expanded Warren's initial study to compare younger and older people. These latter studies proposed that, for older people, it is not just a case of using a ratio based upon anthropometric data to predict affordance, but that it is also necessary to account for biomechanical changes to the body that occur with age (Cesari *et al.*, 2003; Konczak *et al.*, 1992). In these later studies, the abilities of older people were conceived in terms of a combination of anthropometric data (such as the length of the leg from a specific point to a specific point) and biomechanical data (the elasticity of muscles and tendons, and the flexibility of certain joints). In terms of understanding interactions with a limited array of staircases in a test situation, this conceptualisation of affordance is adequate. These studies of older people and affordance from ecological psychology, however, appear in some respects to be the polar opposite to cognitive studies. The ecological psychology studies suggest that the physiologically measurable properties of people and the environment are taken to be the key reference points with which to identify whether a certain person's abilities cohere with the environment. Considered in terms of the embodied and enacting senescent human, an extra stage is required to understand how one's own abilities are understood.

Returning to the cognitive psychology of ageing, efforts have been made in recent years to examine the relationship between the previously discussed changes to human cognitive functioning occurring in old age and changes to sensory and motor systems. Ulmar Lindenberger and colleagues noted strong correlations between deteriorations in cognitive and sensory abilities in later life (Baltes & Lindenberger, 1997; Lindenberger & Baltes, 1994). Noting these correlations, these researchers have performed a number of studies of people performing 'dual-task' operations. A dual-task is the completion of a cognitive task (for example, trying to memorise a sequence of words) at the same time as a sensorimotor or physically taxing task (such as walking around obstacles). In one such study, Lindenberger *et al.* (2000) observed that in dual-task situations older people showed significant reductions in both their cognitive and sensorimotor accuracy when compared to younger people. Huxhold *et al.* (2006) suggest that as older people exert a greater amount of cognitive information-processing, they suffer from lapses in the coherency of their sensorimotor system (notably their posture), suggesting that cognition, particularly in later life, is significantly implicated in sensation and action. In more recent studies, Lindenberger *et al.* (2009) have focused upon

[143] Of course, this is a purposely flawed example of affordance in terms of design, harking back to the ideas of Norman (1988) that affordances can actually be designed for. This example is used in the text primarily for illustrative purposes.

exploring the foundations of a common cause to these various cognitive and sensorimotor declines in old age in the neurophysiology of the ageing brain. Although the brain is implicated in embodiment, however, to focus purely on changes to the brain as the cause of sensory and cognitive decline detrimentally limits the consideration that the body and environment are as equally implicated in human thought. This will be elaborated in the following section of this chapter, where a number of emerging neuroscientific studies of the brain will be discussed that presents a radically different argument to that of Lindenberger *et al.* (2009).[144]

The combined suggestions of the ecological and cognitive psychology studies of older people are synergetic with the phenomenological arguments developed by Gallagher (2005) and Noë (2004). Despite these synergies, however, these considerations come from rather discrete and separated discussions within cognitive science. Whilst Lindenberger *et al.* come from a traditional, cognitivist-informed, approach to understanding ageing cognition, their studies begin to invoke the important role the body and its relations to the world play in temporal changes to cognitive functioning. Problematically, however, being situated within a discourse where the body is often considered as a problem, Lindenberger *et al.* might be prevented from moving these ideas further. Contrastingly, Gallagher and Noë present evidence of how the human body and its relations with the world are essential to human beings coping with temporal changes to cognition and subsequent interactions within the *Umwelt*. This discussion, however, is completely isolated from the cognitive study of human ageing. A framework for senescent cognition, aligned with the enactive cognitive science and dynamic affordances, requires that these ideas are taken on board.

It is possible, therefore, to reconsider Lindenberger el al.'s observations in reference to the work of Gallagher and Noë. In terms of the embodied senescent human being, the correlations between cognitive and sensory decline observed by Lindenberger *et al.* (2000) can be viewed as the result of changes to the prenoetic performances of human body and the contingencies these provide to guide perceptions and enactions of affordances in the *Umwelt*.

[144] In the following section, this chapter will explore recent studies of the ageing brain that emphasises quite a different understanding of temporal change to that the studies provided by Lindenberger *et al.* (2009). Whereas Lindenberger *et al.* (2009) are attempting to identify a common cause for cognitive, neural, and sensorimotor deterioration in the chemical and electrical changes within neurophysiology, an alternative perspective is being developed that suggests that the brain may not be the primary focal point of such declines in ability. It should also be noted that in terms of the embodied and enactive accounts to cognition, and as a result senescent cognition, the position that the brain is the central point of cognition and consciousness fails to account for the inseparability of cognition from the *Umwelt*. Therefore, based upon the arguments discussed within this and the previous chapter, whilst the brain is important to human cognition, it is a part of a broader and more encompassing network of systems.

Returning to Gallagher's (2005) discussion of the body schema, it was established that the proprioceptive systems play a pivotal role in configuring the implicit bodily relations and extension into the environment. An alternative reading of the issues highlighted by Lindenberger *et al.* (2000) then is that the cause of the combined sensory and cognitive decline may be related to the proprioceptive and body schematic systems. This interpretation appears to have weight due to observations of reductions in the acuity of proprioceptive feedback in older people compared to younger adults. (Camicioli *et al.*, 1997; Teasdale *et al.*, 1991) The lowered acuity of proprioception with age is not necessarily severe and in habitual activities may not surface; however, in moments where sudden and unexpected reconfigurations of the *Umwelt* occur, proprioception is implicated as a crucial sub-system of human embodiment (Peterka, 2002). Peterka and Loughlin (2004) observed that the reduced accuracy of proprioceptive feedback leads to under and over compensations in certain movements, which are particular evident in older people. It has been suggested that the decreased accuracy in proprioceptive feedback results in an increased risk of trips and falls for older people (Peterka & Loughlin, 2004). This increased risk is not necessarily as a result of misperceiving, but as a result of over or under compensating within dynamic interactions with the environment through conscious, rather than automated, sensorimotor action.

These reductionist studies of the ageing proprioceptive system can be both strengthened and strengthening by being considered within the work of Gallagher (2005) and Noë (2004). Bringing these discrete discussions together highlights how reduced proprioceptive feedback as a result of the process of senescence can lead to, first, an emphasis of conscious perceptual control of the body through the individual's body image and, second, a certain level of ongoing experiential blindness. As people proceed through senescence, one of the key features of their embodied cognitive capabilities, that of proprioceptive sensorimotor integration, provides less acute streams of continuous feedback regarding the interactions between body and world. This alteration in the ability to integrate the *Umwelt* into a coherent whole, and the resulting increased necessity for conscious perceptual action, presents a situation where conscious mental activity is divided. It can no longer be placed primarily into an intentional activity, and the body is perceived in opposition to the environment rather than as situated and extending within it. The sensorimotor contingencies of the senescent human, based upon a certain level of proprioceptive and implicit knowledge that no longer coheres to the physiology of the body, are somewhat misplaced. Instead of there being a coherence between the integration of 'sensory stimulation with patterns of movement or thought' (Noë, 2004, p.4), there is a mild yet continuous experiential blindness. This is not to say this process of senescence is one of deterministic deterioration; rather, it is a state of continuous and ongoing change resulting from some of the consequences of human senescence. Whilst the studies discussed above suggest that proprioception and sensorimotor integration reduces as a result of senescence, there are also suggestions that proprioception in later life is relatively plastic and can be re-integrated (Gauchard *et al.*, 2003; Hay *et al.*, 1996; Li *et al.*, 2008; Xu *et al.*, 2004). [145] This suggests that although human senescence leads to problems in integrating the dynamics of the *Umwelt*, these integrative systems do not so much deteriorate in ability but are rather just misaligned with the changing embodiment of later life.

It is argued here that senescent cognition provides a rather different perspective on the cognitive disconnections supposedly experienced by older people, particularly in terms of engagements with novel digital media products. Senescent cognitive disconnect, as argued here, occurs as a result of a misalignment between the interactions of the physiological basis of the organism and the unconscious sensorimotor knowledge an older person applies to know what is possible with their embodiment. Abilities, in relation to affordances, are not just to be understood as purely cognitive (as in cognitivism), or as physical (as in certain ecological psychology studies) but as the resulting combination of potential couplings a particular embodied being is capable of and, at the same time, what couplings this being actually perceives as possible. To design the space to allow for the enactment of affordances in this situation is to provide the space for the individual to explore not only the possibilities for action in features of the environment, but to reintegrate their knowledge of their embodied capabilities. This requires a complete transformation from the cognitivist proviso of deterioration to that of continued enactment. When discussing human cognition in old age, however, it is difficult to move beyond the prevalent claims of the cognitive psychology of ageing. The following section will explore emerging claims about how the brain changes as a result of ageing in later life, highlighting how the assumptions of continued deterioration in functioning are becoming increasingly unstable.

[145] This will be discussed further in chapter seven, where it will be argued that designers should employ strategies in the design of digital media products that allow for the emergence of affordances that support such reintegration.

6.3. The senescent brain

Recent studies of the ageing brain suggest that rather than declining in physical and cognitive function, it appears to be highly plastic and engaged in a process of continual re-organisation resulting from the process of senescence and novel interactions in the world.

In recent years, there has been an increase in studies of the human brain as it relates to cognition and consciousness. Cognitively inclusive design, as it was introduced in chapters one to three, is based upon the combined claims and observations of a significant mass of knowledge from the cognitive psychology of ageing. As discussed in chapter three, a key feature of cognitivist cognitive psychology is a background assumption that cognition occurs somewhere in the brain, or at most the central nervous system of human beings. This connection between cognition and the brain, for a great many years, remained hypothetical; beyond the neuropsychological studies of brain damaged patients, or post-mortem examinations, there were few ways to study (scientifically at least) the relationship between human cognition and the brain. In recent decades, the development and proliferation of neuroimaging instrumentation, such as Electroencephalography[146], has supported the increased study of the relationship between brain and cognition 'in-vivo'[147] (Cabeza *et al.*, 2005, p.4). Consequentially, it is necessary to introduce another sub-discipline of cognitive science to this thesis; the cognitive neuroscience of ageing. The cognitive neuroscience of ageing is the discipline situated at the intersection of cognitive psychology of ageing and neuroscience. Research within this discipline attempts to correlate cognitive functions (such as working memory, central executive, attention process, etc) to a material basis in the brain. During the infancy of this sub-discipline, the ideas of 'cognition' and 'brain' are purposively kept distinct, although the long term aim of this area of research is to integrate the two (Cabeza *et al.*, 2005).

Early studies attempted to link cognitive ageing to neurological ageing, with an expectation that the information-processing limitations of older people would be represented by reduced mass within the associated parts of the brain. These early studies appear to have

[146] Electroencephalography, often shortened to EEG, is one of a variety of imaging instrumentation used in contemporary neuroscience to examine the structure and functionality of the brain. Other examples include magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI), positron emission tomography (PET), event-related potentials (ERP), event-relate optical signal (EROS) and single photon emission computed tomography (SPECT) (Cabeza *et al.*, 2005).

[147] The term in-vivo stresses that these neuroimaging instruments provide information of living human beings, as opposed to the post-mortem examinations of the brain. Functional neuroimaging technologies, such as fMRI and EEG, provide streams of data over periods of time, so are deemed to be particularly useful in examining neurological responses to certain stimuli or tasks (Cabeza *et al.*, 2005).

observed that this is the case; grey and white matter decrease in mass and 'with age, frontal and hippocampal structures that are central functions to higher order cognition', such as working memory, 'show a decrease in volume, particularly in frontal areas' (Cabeza *et al.*, 2005, p.10). The early consensus within cognitive neuroscience was thus that the ageing brain, deteriorating in mass and structural functionality in key areas, could be associated with the deteriorations in cognitive information-processing as described throughout chapter three.[148] Goh and Park (2009; Park & Goh, 2009) note that this has typically lead to the characterisation of the ageing cognitive brain within a continuum that starts with decline and, at best, ends at preservation, denying the feasibility of expansion. The early collection of cognitive neuroscience of ageing studies, along with the abundant literature of cognitive psychology, holds little hope for older people in terms of their mental abilities; the best that can be hoped for is the preservation of already existing neural or cognitive structures.

Park and Reuter-Lorenz (2009) postulate whether there is more to be explained by cognitive neuroscience. Whilst agreeing that '[l]ittle doubt exists that the extent of cognitive and structural decline is substantial' in old age, why is it that 'people generally function remarkably well even into advanced old age, and do so even in the prescience of a great deal of pathology as discovered at autopsy' (Park & Reuter-Lorenz, 2009, p.183). In recent years, neuroscience has moved towards the increased use of 'functional' neuroimaging instrumentation. The benefit of such instrumentation is that activity of the brain can be observed whilst people are engaged in certain cognitive tasks. The observations made in functional studies of the ageing brain appear to stand in somewhat of a contrast to the earlier imaging studies, which focused more upon the structure of the brain.[149] Whilst it appears to be that the brain reduces in structure in key areas normally associated with cognitive processes such as working memory or episodic memory, the brain also actively reorganises itself in later life in order to adapt to these 'challenges' (Goh & Park, 2009).[150]

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[148] Raz (2002; 2005) provides an overview of the literature making these claims, which is too vast to detail bibliographically here.

[149] Whilst structural imaging provides insight into the anatomical state of the brain, functional imaging tracks the patterns of neural activation that occur over a period of time.

[150] Cabeza (2002) observed that young adults activate only one hemisphere of the brain whilst performing memory and cognitive encoding tasks, whereas older people displayed neural activations that were far more symmetrical. The argument made by Cabeza (2002) is that although it appears to be correct that the areas of the brain that have been related to key cognitive functions such as working memory (in youth) do reduce in structure in later life, the brain restructures its activation patterns and uses still healthy regions of the brains anatomy. Therefore, the areas of the brain used for specific types of cognitive processes actively change throughout lifespan. For detailed reviews of these findings, from a neuroscientific perspective, see Cabeza (2002), Park and Gutchless (2005), Buckner (2004) and Hedden and Gabieli (2004).

Cabeza (2002) suggests that the changes in the structural functionality within the ageing brain leads to a compensatory process wherein the brain transfers cognitive activity to structurally integral parts of the brain.[151] This is furthered by Goh and Park, who argue that:

> *[f]unctional neuroimaging studies have demonstrated quite clearly that the brain has* the capacity to increase the breadth of its function with age. That is, as various insults of aging occur (e.g., shrinkage, white matter lesions, etc.), the brain responds to these changes by expanding its activity or by recruiting additional sites of activation to process the information streaming into the system.[152] (Goh & Park, 2009, p.391)

Park and Reuter-Lorenz (2009) argue for approaches to examining cognition and the ageing brain that identify the reasons why the typical healthy older person is able to mitigate against certain physical and cognitive declines. In a move away from conceiving older people as, at best, preserving or compensating for certain losses, Park and Reuter-Lorenz (2009) discuss the ageing human brain instead in terms of its adaptability to the challenge of 'neural insults'. They explain the brains adaptability through the concept of 'neural-scaffolding', which 'is not merely the brain's response to normal aging; it is the brain's normal response to challenge' (Park & Reuter-Lorenz, 2009, p.183). These challenges, in their view, can be comprised of 1), an internal shock to the neurobiological system, such as the loss of a previously functioning part of the brain's anatomy, or 2) interactions with novel stimulus from the external world (Park & Reuter-Lorenz, 2009). These shocks may be sudden, and require great effort to overcome, or slowly evolve and become compensated for over greater periods of time. 'In response to the [...] neurobiological challenges of aging, new scaffolds can be established, or previously established scaffolds acquired in early development or during new learning can be recruited' (Park & Reuter-Lorenz, 2009, p.185). This is not to claim, however, that the brain is able to compensate completely for these challenges in later life; as Park and Reuter-Lorenz (2009, p.184) put it:

> We presume that scaffolding processes operate with more efficiency in youth, when scaffolding is typically and frequently engaged to meet novel situations and to achieve new learning. With age, scaffolding processes may be invoked to perform familiar tasks and basic cognitive operations as these processes become increasingly challenging with the degradation of existing neural circuitry.

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[151] Cabeza (2002) entitled his theory the 'hemispheric asymmetry reduction in older adults' (HAROLD) model.
[152] Goh and Park refer to a number of studies in arguing this point. For more specific details regarding these changes observed through neuroimaging techniques, see Dennis and Cabeza (2008), Hedden and Gabrieli (2004), Park and Reuter-Lorenz (2009), and Reuter-Lorenz and Cappell (2008).

Park and Reuter-Lorenz use neural scaffolding as a way of conceiving processes that occur throughout the lifetime of human beings. It is suggested that scaffolding occurs at younger ages as a response to the cognitive challenges of novel interactions with the world. In older age, however:

> scaffolding occurs not only under conditions of new learning, but may be invoked even for less novel or practiced behaviors because the existing neural circuitry for performing the task has degraded. These secondary networks may be less efficient than the primary circuitry, but nevertheless result in task performance that is better than could be achieved by using only the primary but degraded network. (Goh & Park, 2009, p.395)

A key point to be taken from the observations of Park and colleagues is that it is those older people who are able to fight against the structural reductions of the brain that appear to be most cognitively proficient. Individuals whose brains are unable to respond to the structural degradation of ageing, therefore, have an increased risk of losing those cognitive faculties related to the deteriorating areas. Goh and Park (2009, p.396) suggest that 'individuals will improve their ability to scaffold and develop effective new neural circuitry if they maintain high levels of engagement in novel activities including learning new things, engage in exercise, or possibly participate in cognitive training.' In terms of a neural perspective on cognitive enaction, older people are actively encouraged to engage in novel interactions and stimulate novel neural circuitry; to not do so may lead to a subsequent lack of novel neural circuitry.

Despite appearing to begin with the hypothesis that the ageing brain will correlate with the declination of cognitive functioning, and initially finding evidence to support this evidence, the cognitive neuroscience of ageing currently appears to portray ageing in a less deterministic manner. There is a hopefulness from the emerging research within cognitive neuroscience that ageing human cognition, as it relates to the brain, can be conceived of as dynamically reorganising itself against shocks to its system. These alternative sets of perspectives from the cognitive neurosciences add support to the notion of senescent cognition developed in this thesis. This is not to argue, however, that in highlighting the claims of neuroscience, any extra emphasis is given to the brain in cognition than the body and the world. In terms of an embodied and enactive account of cognition, although the brain is implicated within the *Umwelt*, it is not to be overstated. The cognitive neuroscience of ageing is useful as it provides a perspective on how the process of senescence alters the manner in which people may make sense of interactions in the world; however, the research still limits itself to the neural stimulation of the brain or, at most, the central nervous system. Park and Goh (2009, p.1206) argue that '[a]s our knowledge rapidly increases about the aging brain, it is now required that any behavioural theory of cognitive aging be neurally plausible.' The problem with statements such as this is that it highlights how there is a prevailing assumption that cognition and human consciousness can be reduced to collections of neural signals. Joyce (2008) highlights how both within academic texts and the popular press, neuroimaging instruments are sometimes given an unquestionable position of providing 'transparent windows' into the inner human body, with the images these instruments produce becoming 'interchangeable with rather than a construction of the real' (Joyce, 2008, p.51). Noë (2009) highlights how neuroimaging instruments such as fMRI and PET provide no more exclusive information on cognition or consciousness than do behaviourist, cognitivist, enactive and a great variety of other arguments. To suggest that any theory or claims of cognition must be accountable to neurological research is to overstate the power of brain imaging technologies, and to exaggerate the centrality of the human brain (devoid of the body and the world) in human cognition (Noë, 2009). Echoing the claim made by Gregory Bateson (1972, p.460) that '[t]he mental world – the mind – the world of information processing – is not limited by the skin', accounts of cognition based upon enaction are not reducible to knowledge acquired through neuroimaging instruments.

Despite the reservations regarding neuro-centric research within the enactive cognitive sciences, as a way of instigating thinking regarding an account of senescent cognition, the claims of Park and colleagues offer encouragement. The senescent brain is not to be assumed to be in a state of atrophy. In addition, the human brain is constantly adapting to the challenges of physiological, biological and chemical alterations to the brain, the body and interactions with environments throughout life; a process that continues into older age. Finally, older people whose brains reorganise in later life, and as such are radically different functionally compared to their youth, are generally those who have the higher cognitive functioning and are in a better position to continue enactment.

6.4. Senescentechnic cognitive decoupling

A senescentechnic understanding of cognitive disconnect is presented that highlights how the contemporary approaches of cognitively inclusive design are limited in focusing purely on storehouse metaphors of memory. Instead, senescent cognition presents a situation where designers are implicated in harnessing the agency and potential abilities of the embodied and enacting older person.

At this point in the thesis, it is possible to provide a speculative reinterpretation of the problem of older people becoming cognitively disconnected from digital media products and interfaces through the lens of senescent, rather than ageing, cognition. To recall, at the end of chapter three it was argued that, as a consequence of the body of knowledge from the cognitive psychology of ageing, older people can be considered as poor processors of information but storehouses of long-term memories. Based upon the argument presented in chapter three (which is founded upon cognitivist principles), ageing cognition is understood to be the temporal deterioration in the information-processing capabilities of the human mind. As a consequence of the ideas developed in chapters four, five and six, however, senescent cognition proposes an explanation of temporal change to human cognition that is not based upon input-output, information-processing models of the human mind.

Before explaining these differences between the ageing and senescent approaches, it is necessary to briefly return to the discussion in the previous chapter. At the end of chapter five, Chemero's (2009) proposition of dynamic affordances were discussed, which suggested that affordances are dynamic experiential properties that are the relations between the abilities of a particular individual and features of the environment. In Chemero's (2009) account of affordances, all phenomena are provisional and continuously changing. The abilities of human beings are the result of a history of structural couplings that form the sensorimotor system. Cognition, here, is the result of these patterns of couplings and ongoing changes in the resulting abilities, and cognition aids the continued enactment of these abilities and the affordances within the *Umwelt*. In light of the discussion of this chapter, however, there is the necessity to supplement Chemero's (2009) proposal so that it can accommodate incoherencies to the enaction of the *Umwelt*. As proposed in this chapter, abilities are not primarily the result of sensorimotor couplings in the manner that Chemero argued; they also depend upon whether an individual is capable of integrating the *Umwelt* into a coherent whole. If the prenoetic role of the body is not acting in a sufficient manner, then the absorption of environmental phenomena into being will not necessarily occur; in such cases, couplings will never be fully instantiated. In these moments of insufficient prenoetic performance, one of at least two experiential qualities will occur; 1) an individual takes over conscious control of the body as it is separated from the environment; or 2) an understanding of the role of embodiment in relation to the world is not engaged, and experiential blindness occurs. As a result of the discussion made in this chapter, the thesis can now compliment Chemero's (2009) dynamic affordances of the *Umwelt* with a consideration for the failure to integrate sensorimotor couplings and a failure to perceive and act upon one's own abilities.

Based upon the differences between ageing and senescent cognition, it is possible to reinterpret the cognitive disconnection between older people and digital media. It is possible to speculate a virtual scenario between an older man (Ted) and his personal computer (PC). In this first scenario, Ted is described in terms of an ageing cognitive information-processor.

Ted the cognitive information-processor

Ted and his PC are separate entities that communicate to one another through an exchange of information. The PC provides a flow of information from the visual representations on its screen, the audio from its speakers and from the array of status lights on its exterior. Ted receives this information through his perceptual apparatus and processes it internally through his cognitive apparatus. Upon the processing of this information, Ted transfers the information through his motor systems and inputs the information back into the computer system via its mouse, keyboard, or exterior operation buttons. The PC within this ecology utilises one of the latest graphic user interface based operating systems, designed for increase intuitiveness and for reducing the complexity of the interface. Despite the advanced nature of the design of his new PC, the information flowing from the media apparatus is in excess to the processing abilities of Ted's perceptual and cognitive systems. As a result of sensory decline, information is transferred through the perceptual apparatus in an incomplete and hesitant manner. The incompleteness of information arriving at the cognitive apparatus is compounded by resulting declines in the material basis of Ted's cognition. The flow of information from the technology is bottlenecked within Ted, meaning there is a reduction in fluid information exchange within the Ted-PC ecology. From an outside observer, it will appear that Ted behaves with the computer in a hesitant manner, with interactions being slow and awkward. It appears to take longer for Ted to learn to complete certain activities compared to younger people.

In this second scenario, Ted is described as a senescentechnic enacting being.

Ted the senescentechnic enactee

Ted and the PC are separate structures that intersect each other and have the opportunity to become structurally coupled. The computer system provides a number of features that afford coupling from human beings with the abilities to act upon their perception. Ted's embodiment comprises of a contingent array of sensorimotor couplings that are the result of a history of interactions at an evolutionary and developmental scale. In order for Ted to develop structural couplings with the technology, he is required to actively explore its possibilities for interaction. As Ted explores possible activities in the interface, the prenoetics of his sensorimotor system would normally support his interaction, incorporating the PC seamlessly into his experience and enabling the development of further novel couplings between Ted and the media interface. As Ted interacts with the PC, however, there is incompleteness to the incorporation of the technology into his experience. Slight alterations in the prenoetic performance of the body means that Ted's sensorimotor abilities are inhibited and the affordances that emerge between Ted and the PC are different to those of other human beings. In order for some sort of coherency to be developed in this process of interaction, Ted engages in a cautious form of interaction where his sensorimotor actions are more explicitly controlled and he is always aware of his separateness from the computer. The affordances that emerge between Ted and the PC are continuously and consciously attended to. The affordances are the result of Ted's perception of his own abilities, not what his sensorimotor embodiment is capable of achieving. The computer, a concretely designed product based upon a predetermined modelling of human interaction, is unresponsive to Ted's altered sensorimotor couplings. Although still a feature of Ted's *Umwelt*, the structural couplings between Ted and the PC are weak and for the most part Ted and this technology are discontinuous entities. From an outside observer, it will appear that Ted behaves with the computer in a hesitant manner, with interactions being slower and awkward. It appears to take longer for Ted to learn to complete certain activities compared to younger people.

The result of the transition from cognitivism (ageing) to enactivism (senescence), then, has not initially provided a solution to the issues of disconnections with digital media products in later life; it has merely realigned the issue. In realigning the issue, however, the limitations of contemporary approaches to cognitively inclusive design are highlighted further. Whilst the contemporary understanding of ageing cognition emphasises the deterioration in function related to human information-processing and memory, the account of cognitive disconnect developed in this chapter notably avoids an explicit discussion of memory. There are two key reasons for avoiding a discussion of memory.

Firstly, concepts of memory as they are understood in enactive accounts of cognition significantly differ from those of the more traditional cognitivist accounts. The traditional models of human memory within cognitivist accounts have a tendency to conceive of memory mostly as a storehouse of knowledge (Pfeifer & Bongard, 2006). In enactive and associated accounts of cognition, however, memory tends to be understood more as in dynamic relations to real-time perceptions and future action. For example, Arthur Glenberg argues that '[m]emory meshes nonprojectable features with projectable features of the environment to suggest actions for that person in that situation. These patterns of action are what make the environment meaningful to that person' (Glenberg, 1997, p.17).[153] It is possible to understand Glenberg's proposal in terms of dynamic affordances; memory is the collection of recurrent patterns of structural couplings that allows for an individual to perceive and subsequently enact environmental affordances. Memory is of the moment and not necessarily perfect; it is connected with and extended into the body and the world.[154] Therefore, memory is an integral part of a senescent account cognition, but here memory is understood in such a manner that it differs greatly from the cognitivist conception that older people are a storehouse of knowledge and prior experience.

Secondly, the move away from relying upon the memory model of older people forces a change in the stance and activities of the designer when developing novel digital media products for older users. The consequence of the argument developed within this and the previous chapter is that the designer is forced to look beyond nostalgic and historical forms of interaction when developing cognitively inclusive interfaces. Whilst explicitly harnessing aspects of long term memory provides more usable digital media interfaces, where the learning process is understood to be at its most efficient when invisible, disconnections within senescent cognition requires designers to account for how older people can encourage

[153] Glenberg (1997) does not deny there being a type of memory as described within traditional cognitivist studies. The problem, however, is that these understandings of memory tend to restrict themselves to recalling past experiences and testable phenomena (such as lists of words, as in many memory tests within cognitive psychology).

[154] Having to understand human memory in terms of its inseparability from the body, environment and situational environments provides some insight into the supposed limitations of cognitive functions such as working memory. Kirsch and Maglio (1994), in their observations of novice and expert players of the computer game Tetris, noted that those who made the better decisions tended to be those players who used the screen as a form of extension to their cognitive functions. The expert players actively turned the shapes around and across the screen in order to develop a quick understanding as to how certain shapes might fit into the open gaps. In some respects these manoeuvres appeared to be self-defeating and completely unpragmatic detours—however, they in fact provided valuable information to the players that their own cognitive functions would struggle to complete. Kirsch and Maglio (1994) coined these epistemic actions. Similarly, Wilson (2002) notes that studies of the limitations to long term memory functions fail to take into account how people use their environment—in the form of books, pictures, archives, and digital media— as storage facilities. It might be true that memory in terms of the functional attributes that are "internal" to a person might be limited, but in most situations memory is far from limited to purely internal or brain-based operations of the individual.

the development of novel structural couplings. Whilst it was always presumed older people could not make novel cognitive couplings, the recent studies of the senescent brain suggests that those who actively engage in a form of sensorimotor and neural reorganisation are those who are most likely to retain cognitive abilities in old age. In light of the discussion in this chapter, it appears that a framework for design that encourages the limitation of developing novel structural couplings between brain, body and environment, focusing instead on harnessing past experiences, is counter to the response required for the continuation of enactment.

In realigning the issue of cognitive disconnection, as is proposed in this thesis, a new critical lens is provided that opens the space for an alternative set of strategies for the design of digital media products and interfaces that engage older people. If, as Gibson (1986) claims, in interacting with the world the agent learns as much about one's own skills, both with a conscious or unconscious awareness, then thoughtfully designed interactive technologies may provide the augmentation of the awareness of one's own sensorimotor abilities that appears to be required in later life. Therefore it is necessary to suggest strategies as to how technological interactions can be designed to support a senescent human to become greater experientially aware, both consciously and unconsciously, of their sensorimotor capabilities and provide the space for a greater array of affordances and potential couplings to emerge with digital systems. This will be explored in the following chapter, which will form broad strategies for designers that harness the agency and potential abilities of older people within interactions with novel digital media. It will also be argued that rather than reducing the agency of the ageing human being as a poor processor of information, the untapped potential of older people as embodied and enacting senescent human beings can be made better use of by designers of digital media products.

Chapter 7

Affordances for senescentechnics

Question: What strategies are available to open up opportunities for the design of digital media products that afford the enaction of senescentechnic cognitive experience?

7.1. A senescentechnic account of affordance requires the eschewing of closure as far as it is feasible; the designing of specific affordances is no longer sufficient, instead the designer must explore the broader and dynamic spaces for affordances to emerge and disappear in.

7.2. Senescentechnics requires spaces that afford opportunities for the augmentation of the self-knowledge that is constructed and continually reconstructed by a senescent human being.

7.3. Senescentechnics requires spaces that afford the older user of a technology to be engaging in an ongoing creative and sense-making process of co-design at the interface of a digital media product.

7.4. Senescentechnics requires spaces that afford a balance for incremental adjustments to the delicate embodied sensorimotor couplings of an older person, providing information as to the provenance and ramifications of real-time interactions.

7.5. Senescentechnics requires spaces that afford ongoing physical activities that are necessary for the reintegration of key proprioceptive and body schematic systems of the senescent cognizer.

7.6. Senescentechnics requires designers to have a sensitivity to the agency of older people as having intentional control over both their embodiment and interactions with digital media products; designers must consider the ongoing process of wear between people and technology, and how digital media wears with older people rather than treating older people as wearing out.

7.1. Design for the enaction of dynamic affordances

A senescentechnic account of affordance requires the eschewing of closure as far as it is feasible; the designing of specific affordances is no longer sufficient, instead the designer must explore the broader and dynamic spaces for affordances to emerge and disappear in.

In previous chapters, affordances were situated within the study of ecological psychology (as in Gibson (1986)) and subsequently enactive (as in Varela *et al.* (1991)) and dynamic (as in

Chemero (2009)) cognitive science. As discussed in chapter six, affordances are understood to consist of a dynamic relationship between a person's abilities and perception of their abilities and the environment. The discussion of affordance in chapters five and six has not been explicitly used by this thesis as a way of understanding the design of a particular digital media product but rather as a way of thinking about how the *Umwelt* is enacted for certain people. In order to move towards a greater understanding of the role of dynamics in terms of older people interacting with future digital media products, it is necessary to understand technology and media, and consequentially the design and interaction thereof, in equally dynamic terms as the senescent human being. Similar to the historical analyses of technology by Punt (2000) and Nye (2006), it is necessary here to take forward the notion that digital media is always in a dynamic process of creation with, and by, users. It will be argued in this chapter that the shift to conceptualising the design of digital media as dynamic is not a reflection of increases in technological complexity but rather is a necessary component of a design response to the senescent account of cognition developed in chapter six.

To conceptualise digital media in terms of dynamics requires a rather different perspective on 'designing affordances' to that used by contemporary design literature (as in Norman (1988)). As a consequence, and as argued in chapter five, this thesis has revisited the original definition of affordances provided by Gibson (1986) rather than using the concept's traditional design usage as appropriated by Norman (1988). It is critical, therefore, to clarify what is meant here by designing affordances. As has been highlighted at length in chapters five and six, cognitivism, which can be viewed within Norman's understanding of affordances, differs radically to enactivism to the extent where designing for cognitivist ageing cognition, or enactivist senescent cognition, require equally diverse approaches.

The account of cognitively inclusive design outlined in chapter two was reliant upon a representational layer of mental content with which to base the design of digital systems. Contemporary inclusive design literature has struggled to move beyond this conceptualisation, seemingly as a consequence of the overwhelming evidence of cognitive deterioration occurring later in life from cognitivist psychological studies. The claims of the cognitive psychology of ageing would suggest it is unwise for a designer to even consider that older people can enact novel technologies in a seamless manner; they lack the very cognitive functions necessary to do this.

In chapter six an account of temporal changes to human cognition later in life was developed that this thesis has defined as senescent cognition, which presents a radical alternative vision of what cognitive disconnect may mean in old age. Instead of a continual deterioration of cognitive ability, the thesis argued that cognitive disconnections emerge as a result of broad changes to the dynamic systems transcending brain, body and world. If cognitively inclusive design was focused upon the prediction, inscription and prescription of specific affordances for the ageing mind, then the senescentechnic domain examines how the space for certain affordances emerges and allows for the continued enaction of senescent cognitive experience with, and through, novel digital media. The consequence of this, as will be argued in this chapter, is that the designer has to take a broader meta-perspective on the situation to be designed for and allow for an open-ended design outcome where the user answers some of the specific questions of affordance.

Affordances, when understood in cognitively inclusive design as defined in chapter two, are actual, real, objective and static properties of the technological environment that offers definable actions to the older person, their body and their cognition. In terms of enaction, however, there are no mental representations for the designer to map an affordance onto. Returning to Dourish's (2001) distinctions, enaction requires both the stance and subsequent activities of the designer to be transformed. Thompson (2008) contrasts the opposing views of cognitivism and enativism in terms of the design of *anoetic* technologies[155], using the useful question and answer framework of Varela *et al.* (1991).

> Question 1: What does design do when it humanises technology?
> Cognitivist Implication: Design manipulates symbolic images by which people read the world so that they can make sense of and give value to technologies (semiotics).
> Enactivist Implication: Design enables people to enact in the world by enabling potentiality of whole human as a distributed soma ...
>
> Question 2: How does design work?
> Cognitivist Implication: Designers create the means to project simple or multiple and complex symbolic meanings. These symbols are primarily experienced by people in reference to a codified cultural understanding of referents.
> Enactivist Implication: Designers intervene in the complex processes by which people form an experience of their world. Their task is to enable people to experience the world 'naturally' without necessarily needing to attach meaning to individualised interactions.

[155] Thompson (2008) provides an historical analysis of industrial design that highlights how designers have struggled to deal with aspects of the *anoetic* (which is understood to consist of aspects of cognition that are outside the main awareness of an individual, yet also present in experience). Technologies that are *anoetic* are those that become somewhat incorporated into a person's being through interaction. Thompson argues in favour of a 'holsomatic' model of human beings that takes into account a wider understanding of experience with technology. Thomspon's (2008) argument is that designers, in struggling to comprehend the ineffability of certain aspects of human experience with technologies, have continuously returned to traditional boundaries of human beings (such as the physical boundary of the skin) in order to 'humanise' technologies. This thesis follows some of Thompson's argument, in suggesting that the inability to deal with the cognitive disconnection that appears to occur between older people and digital media products, has lead certain design communities to reify a concrete and determinist model of human ageing.

> Question 3: How do I know when design is functioning adequately?
> Cognitivist Implication: When people understand the symbols they encounter and react appropriately.
> Enactivist Implication: When people incorporate the designed world seamlessly as part of their experience of being. (Thompson, 2008, p.245)

Thompson (2008) highlights the disparateness of the cognitivist and enactivist positions once translated into designing technologies for human beings. Whereas in taking a cognitivist position the designer is provided with a backdrop of knowledge from the domain of cognitive psychology to distinguish what is and what is not suitable to certain groups of human beings, enaction eschews closure in the design process. In taking an enactivist perspective, the designer takes the human being into account in the fullest range of experience rather than proceeding through a reductive-scientific model, as is the case with cognitively inclusive design. The enactivist designer understands the interaction process as the unravelling exploration of complex interrelationships, which exist on multiple levels between human beings and the world. Instead of attempting to design a closed product in reference to the closed cognitive system of the user, designers are lead to speculate open-ended technological systems that augment the enaction of cognitive experience.[156]

The discrepancy between cognitivism and enactivism suggests a similar discrepancy between cognitively inclusive design (as explained in chapter two) and the enactment of senescentechnics. It is necessary to distinguish cognitively inclusive design from the cognitively *enacted* design of senescentechnics. In senescentechnics, technology is not conceived as an opposing force to human beings that requires neutralising, but instead is

[156] Thompson (2008) argues that research on enaction in cognitive science suggests a radical departure from the contemporary heritage of design, which has struggled to comprehend how technology can expand the 'human soma' beyond the boundary of the body. Thompson (2008) highlights how the intellectual heritage of enaction in regards to designing technologies can be traced to the Vorticist movement of the early twentieth century. Headed by Percy Wyndham Lewis, the Vorticists believed that technology and humanity would become one over time, but with the preservation of the human ego. Wyndham Lewis portrayed humanity as making the most of the new technologies of his time, offering the possibilities of a new sense of ego and being, still loosely attached to the human body but extended beyond it though technological augmentation. The ideas of Wyndham Lewis are implicated within the posthumanist movement, and are not far removed from the later claims of Varela *et al.* (1991) presented in chapter six (although used in completely different contexts). As Thomspon (2008) highlights, however, Wyndham Lewis' writings are often not included in histories of the design of technology despite their apparent relevance with the embodied and enacted modes of thinking that are encouraged within a number of contemporary design and cognitive discourses. Thompson (2008) notes that this is very likely a result of Wyndham Lewis' association with fascist politics. In most literature, such as the aforementioned work of Foster, the Vorticists are gathered together with the Futurists as an intensely right-wing movement, although whether this should actually be the case is up for much debate (see Munton (1997) for examples of this complexity). Much like the philosophy of Martin Heidegger, whose writings were somewhat marginalised from popularity post-Second World War as a result of his politics, it may be difficult to present a reading of Wyndham Lewis devoid of his ideological motivations. However, again like Heidegger, it may be that the climate is as such now that his work can be revisited and contextualised with a concern for current matters on the analysis and design of technology.

constructed to become integrated within the enacted *Umwelt*. It is no longer feasible to suggest certain affordances can be 'designed' in the objective fashion alluded to by Norman (1988). Instead, in the dynamic affordances of enaction, the designer must have a broader awareness of how affordances appear and disappear through interaction so as to create spaces for novel couplings in the *Umwelt* to emerge and be created. The designer, here, is unable to predict and thus explicitly determine, either before or after the fact, what affordances are experienced. This is in stark contrast to cognitive inclusion and the historical tradition of people-centred design, wherein technology is formulated to reduce friction and increase closeness to the abilities of the human in an immediate manner.[157] In the specific case of older people, cognitive inclusion suggests technology is somewhat aggressive to their being, and the designer needs to look towards the structure of the ageing human in order to weaken this hostility.

The aforementioned work of Redström (2005) and Almquist and Lupton (2010) both highlight that critical and experimental design practice provides a potential route out of the continuous striving towards a fit between people and technology by actively provoking the user to question their use of a product. For example, Anthony Dunne and Fiona Raby have established 'critical design' as a provocative aspect of designing which 'uses speculative design proposals to challenge narrow assumptions, preconceptions and givens about the role products play in everyday life' (Dunne & Raby, 2010). Their approach is still concerned with technologies becoming incorporated into the everyday lives of people, but actively considers how design can transform and change certain societal assumptions rather than be submissive to them.[158] Similarly, the 'droog' collective of designers provide an extreme example of a critical design response, emphasising a design stance that attempts to combine functionality, fun, humour and critique.

> The droog mentality could be summarized as 'dry'. 'Dry' as in dry wit, unadorned informality, ascetic irony. 'Dry' as that essentially Dutch inclination to 'do normal' and at the same time critically investigate what you're doing and the way you do it. (Droog Design, 2010)

[157] People-centred design might be argued not to do this, having moved far beyond primarily usability or cognitive models of human beings. In chapter eight, the thesis will argue that, as it is used by the inclusive design community, people-centred design is still focused upon concrete constructions of the user—these constructions just go by different names.

[158] For an introduction into critical design approaches, see Dunne (1999) and Dunne and Raby (Dunne & Raby, 2001).

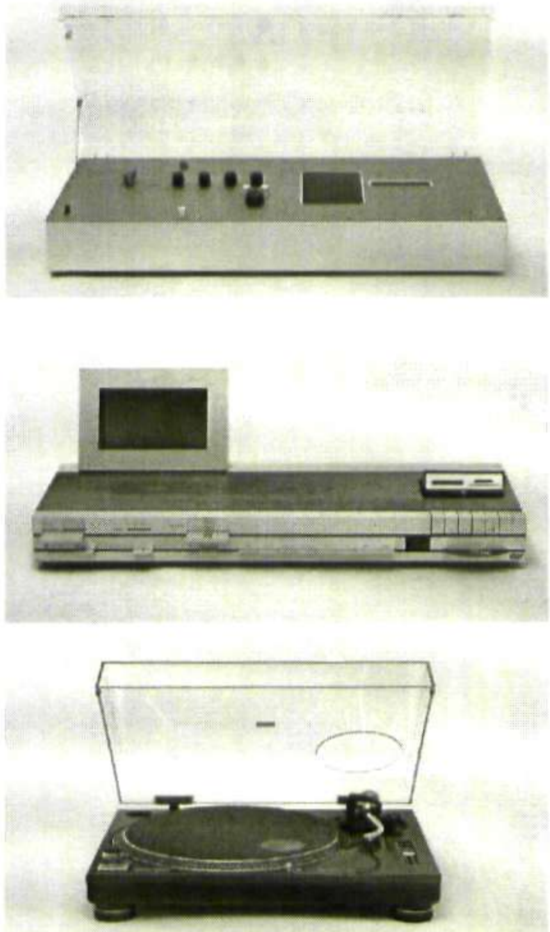

Figure 20 Bootleg objects. Taken from Bader and Wolf (2003).

Droog are an example of a design practice that ignores any formal conception of what constitutes the human being in reference to the object. For example, the works that formed the 'Bootleg Objects' collection by Marcus Bader and Max Wolf could represent, at a glance, a materialisation of the ideas of contemporary cognitively inclusive design. Rebraun, Re-Bo, and Re-SP (Figure 20) are home music system 'classics' that have been altered in such a way that their functionality is changed to varying degrees of subtlety.

> In "ReBraun", recombination is paramount – while most features remained present, they slide along the surface, into new meanings. At the ReBo, nothing has been moved. Instead, an alien object – the touch screen – has slyly integrated himself. Lastly, the record player object Re-SP has not changed at all (apart from three clownish minimanipulations). Rather, its whole usage context has been taken. All of its working functions are completely different than it might seem, and all of its previous controls are now dead. (Bader & Wolf, 2003, p.1)

Externally, the Bootleg Objects are manifestations of an earlier period from the history of technology—on the surface, they can be interpreted as examples of contemporary cognitively inclusive design. Further exploration of the functions (or lack thereof) of these objects reveals, however a subversive reading; a reading where any connection with cognitively inclusive design is merely ironic. Rather than offering the functions that the external aesthetic appears to state, the Bootleg Objects have features that appear to contradict, defamiliarise and invite a certain amount of reflection on the part of their user—and the designer—in order to discover as to what they are and why certain changes may have been made.[159]

Similarly, Gaver and Martin (2000) developed a number of information appliance concepts that eschewed the technological determinism observed in many such concepts in favour of technological plausibility[160], and instead explored certain boundaries regarding what is normally socially and culturally acceptable.[161] In the description of one information appliance concept, 'Dawn Chorus' (Figure 21), Gaver and Martin (2000, p.210) deceptively claim that '[i]t is pleasant to be awakened by the sound of local songbirds, but how much more enjoyable it would be if they knew our favourite music'. In order to implement this

[159] Although Bader and Wolf describe defamiliarisation in general sense of the term, Bell *et al.* (2005) provide a recent example of interaction design research has examined more formally the role of defamiliarisation in the design of digital media systems. In particular, Bell *et al.* (2005) highlight how a process of defamiliarisation highlights might make certain individuals question something that appears so normal to them that it is completely unquestioned. Bell *et al.* (2005, p.152) state that 'reading ethnographic accounts of the UK can have a [...] dislocating effect on UK readers.' Drawing upon a study by Bell (2001), they note that 'people in the UK have to pay for local and national telephone calls by the second and part second. UK residents might respond to such an observation with "well of course, that's obvious, doesn't everyone?" The ethnographic description renders the practice strange and therefore questionable. This kind of observational work is part of the ethnographic tradition of unpacking and interrogating naturalizations of social practices and institutions. In this sense it is implicitly critical: "why should we pay by the second for local calls, no-one else does!" Such ethnographies invite us to look again at our public and private spaces, our social practices, ourselves, and notice, perhaps for the first time, how strange it might all look to other people' (Bell *et al.*, 2005, p.152). Therefore, products that defamiliarise might make the user question their normal behaviours when interacting with and exploring familiar consumer orientated products and services.

[160] Gaver and Martin (2000) argued that '[i]n presenting these proposals we are deliberately noncommittal about the exact technologies that might be used in their implementation [...] in the technology industry a prototype "works" when the technology has been implemented, even if aesthetic and cultural issues are neglected. In design the opposite is true: A prototype "works" when it successfully captures the experience of using a given device, even if implementation issues are not fully resolved. At the same time, we see little value in "science fiction" concepts which rely on technological effects that can or do not exist. Instead, the proposals are intended to be *technologically plausible,* in the sense that it seems likely that they can be realised even if the exact means are unknown or unspecified. In practice, achieving plausibility depends on designers' knowledge and judgement, while an evaluation of the results may depend on discussions with technical experts' (Gaver & Martin, 2000, p.211).

[161] Gaver and Martin (2000) refer to Anthony Dunne's concept of value functions as influencing their works. Dunne and Raby define value fictions as an alternative to science fictions. 'If in science fiction, the technology is often futuristic while social values are conservative, the opposite is true in value fictions. In these scenarios, the technologies are realistic but the social and cultural values are often fictional, or at least highly ambiguous. The aim is to encourage the viewers to ask themselves why the values embodied in the proposal seem 'fictional' or 'unreal', and to question the social and cultural mechanisms that defines what is real or fictional' (Dunne & Raby, 2001, p.63).

possibility, the Dawn Chorus birdfeeder applies behaviourist principles of stimulus-response in providing food to the birds when it senses they can mimic the same song. In using Dawn Chrorus, its owner may enjoy the pleasurable experiences of waking up to birds chirping their favourite song; however, it can also be read as an intervention upon the human tendency to tame nature. (Gaver & Martin, 2000) Whilst typically the critical approaches to design emphasised by the work of Dunne and Raby, Gaver and Martin, and Droog are essentially examples of critiques of consumer-oriented design, Bowen (2009) has recently attempted to develop a design methodology that transforms elements of critical design into the process of developing everyday consumer items.

Figure 21 Dawn chorus. Taken from Gaver and Martin (2000)

A stance on design that suggests products can be designed as critical arguments or questions projected to the user are relevant to the discussion of creating the space for affordances to emerge. Problematically, however, the above design approaches still require a certain level of closure to the designed outcomes. The products are created in a manner to invoke very specific questions from very specific users; Gaver and Martin's bird feeder appears to be directed towards those people who may be concerned with the questions of man's dominance on the environment; Dunne and Raby's (2004) 'huggable atomic mushroom' (Figure 22) assumes a user who is constructed in such a manner that they can recognise the purpose of the societal questions being asked of them; the droog works suppose the 'user' is able to recognise the original uses of the objects in order to engage with the intended humour. Enaction and dynamics, however, determines that such questions—made from specific *a priori* constructions of the people intended to interact with the object—are as limited as the people-centred approaches they appear to critique; the object, and the people intended to use it, are still rather concretely conceived.[162]

Figure 22 Dunne and Raby's (2004) huggable atomic mushroom.

Returning to the discussion in chapter five, Chemero (2009) introduced a dynamic theory to affordances in order to explain how human cognition, perception and action are continuously engaged in temporal change. This, in turn, suggests that affordances are continuously changing as a result of the dynamic nature of the human point of reference. What is not explicitly discussed by Chemero (2009), and is avoided in the ecological psychology literature, is how *Umwelten* affordances do not emerge and disappear solely as a result of changes to the abilities of a human perceiver, but also as a result of ongoing changes to the environment. The environment, just as human beings, must be understood as dynamic. This is not an attempt to animate a feature of the *Umwelt* which, in certain accounts, might be

[162] This may be unavoidable in a design process. It is evident that this thesis—in arguing for closure and non-concreteness—still has to use a model of human beings with which to frame the design process. The senescent human being, rather than the ageing human being, is just another way of understanding a particular group of people and designing in reflection of this knowledge. The key difference is, firstly, having sensitivity to the provisional nature of models and, secondly, as a result trying to ensure that the design process is left to be as open-ended as is feasible.

treated as objective and real. Firstly, in this thesis' argument, this is to emphasise that technology and media requires to be understood as dynamically as the enacting, senescent, human being. Secondly, this is significant as it implies that, in terms of the interactions between a particular older person and a digital media product, the *Umwelt* of the whole system is conceived as providing possibilities for dynamic change. As a consequence, it is not just a case that technologies are conceived as constituting certain predictions of use—as is the case in cognitively inclusive design—but are instead understood in terms of dynamically responding and offering opportunities for action and opening the space for creativity. Within contemporary literature for designing for older people, however, digital media and technology is not conceived in terms of this mode of dynamic engagement. In fact, as is the case in the human factors literature, designers are provided explicit guidance to avoid the necessity for such dynamic engagements when developing products and interfaces that are inclusive of older people.

The following five sections explore some creative spaces for affordances to emerge that are particularly relevant to cognitive disconnection as it is understood in senescentechnics. The purpose of exploring these affordances is to highlight ways in which future digital media products can afford the continued integration and enaction of cognitive experience of older people. Therefore, these short discussions can be considered to be a form of 'technological imaginaries' (Punt, 2000) for designers. Punt (2000, p.20) proposed that the technological imaginary 'refers to the ways in which technology was thought about both in terms of its hardware and as a representation of cultural aspirations – imagined and actual.' Therefore, these speculative discussions are provided in terms of a critical conversation for future design research, when practical tools are available to expand, implement and refine the ideas. These conversations eschew the tradition of guidelines, principles and specifications; in terms of enaction such concrete guidance is restrictive and un-useful. At the same time, however, this thesis understands that in the case of the cognitive disconnect between older people and novel digital media, designers require some form of direction. Therefore, alongside these conversations there are a number of design examples to provide a little more concrete grounding. Again, however, these design examples are somewhat uncertain, plausible and implausible to varying degrees, and rely upon the imagination of the reader to make them fully explicit. The purpose of these conversations and examples is to open up pathways to certain spaces that encourage the emergence of certain types of affordances without the centralisation of prediction, inscription and prescription that dominates contemporary cognitively inclusive design theory and practice. It is suggested that by thinking about these processes in dynamic terms, it is possible to afford the incorporation of technologies into the ongoing enactment of cognitive experience in later life.

7.2. Affordances of self-perception

Senescentechnics requires spaces that afford opportunities for the augmentation of the self-knowledge that is constructed and continually reconstructed by a senescent human being.

It is possible to unpack some of the implications of dynamic technological affordances by returning to Gibson's (1986) original theory of affordances. Gibson reminds us that in engaging in the environment the human being perceives their self as much as ecology. Gibson (1986, p.126) stated that '[i]nformation about the self accompanies information about the environment, and the two are inseparable. [...] Perception has two poles, the subjective and the objective, and information is available to specify both. One perceives the environment and perceives oneself.' Gibson conceptualised perception of the environment and the self as occurring at the same moment, rooted in the idea that perception and action are interlinked (as discussed in chapter five). If knowledge of the self and the world are part of the same spectrum of sensations, then actions on the world provide an equally large amount of self-perceptual knowledge as do the sensations enclosed within the supposed boundaries of the human body (Gibson, 1986). In line with the framework for senescent cognition that this thesis defined in chapter six, however, it is necessary to note that it is not just actions that are the primary source of these sensations for self-knowledge. Rather, it is the perception of what the environment affords in relation to one's own embodiment that provides these sensations. It is argued here that it is what a particular individual understands as an affordance which, thus, confirms their own understanding of their embodied abilities.

Gibson's (1986) claims present a situation where the design of a product and the array of affordances it allows have a consequential effect on the manner in which an individual understands their own abilities. This is to argue that when engaging in an interactive exchange with a digital media product, as much is learnt about one's own abilities as is learnt about the possibilities of the technology; this is a mutual and ongoing exchange.

In terms of senescentechnic cognitive disconnect, or experiential blindness (Noë, 2004), Gibson's discussion suggests it is beneficial to harness this seemingly unconscious self-reflective feature of exploring the world. Noë (2004) argues that in order to go beyond experiential blindness, it is necessary to be an active agent, 'for it is precisely through active movement that one is able to test sensorimotor hypotheses' (Noë, 2004, p.92). An individual suffering from a state of experiential blindness needs to rebuild the knowledge of how their sensorimotor abilities relate to the sensations that are perceived. It is necessary for the individual to develop new sensorimotor hypothesis, as Noë calls them, and test them. In terms of the dynamic model of senescent cognition, this is not a systematic process where the human being goes through certain stages to reach a level of fulfilment but a continuous moment-by-moment process of perception and action. In each moment of interacting within the *Umwelt*, an individual is continually developing and testing their understanding of how sensations and actions relate to both the environment and their knowledge of their own embodiment. To enact a coherent *Umwelt* is to integrate sensations, actions and self-knowledge; to do this it is necessary to continue pushing the boundaries of one's own abilities. Although senescence constitutes a particular type of experiential blindness—a type which is more subtle but as a result less obviously resolved—this process of development and testing is no different.

What Noë's (2004) argument portrays, much like Gibson's (1986) before, is the absolute necessity for active exploration of environments in order to construct knowledge about not only the world, but also the self. Only through this ongoing exploration of embodiment in the world can cognitive experience be coherently enacted and sensorimotor hypothesis be tested. Therefore, this thesis emphasises that *older people, in order to continue the enaction of cognitive experience, would benefit from ongoing active explorations of Umwelten affordances in order to reintegrate their perception of sensorimotor abilities with the potential abilities of their whole embodiment.*

As a consequence of this proposal, the role of the designer of digital media products is not only to consider how a system affords certain actions for certain individuals with certain sensorimotor abilities, but also to comprehend how the system provides a level of reflective self-knowledge fed back to the user. In the particular case of senescent cognition, it is important to highlight the pivotal role digital media provides in augmenting an older person's ability to integrate their self-knowledge with their embodied perceptual-action capabilities, and subsequently aid the enactment of the products interface. It is not just necessary to highlight what a user can achieve in a present moment but also feed information back as to what may be achieved over time through transformations in sensorimotor ability. The affordances perceived at one moment in time between a technological system and a particular individual will differ from those perceived seconds, minutes and longer periods of time afterwards. Conceived as it is here, as couplings between human and technological interaction strengthen, then the possibilities for novel couplings emerge; at the same time, as couplings strengthen, the perception of one's own abilities strengthen too—in a reciprocal, circular fashion. Designers of senescentechnic digital media products can harness this ongoing process of active exploration, rather than focusing upon immediate communication.

Proposed strategy: Senescentechnic digital media products can support the ongoing enaction of cognitive experience by opening opportunities for users to actively explore digital media environments in such a manner that provides active feedback that augments the self-knowledge of how their own embodied capabilities temporally change.

'TraceMap'

TraceMap is an 'App' for smart-phones that provides feedback on one's geographical location in relation to previous routes, journeys and places you have been. It can be used to search for locations (much like Google Maps, and similar) and identifies where these are on the map. It does not provide directions, routes or a map of streets for you to go along. Instead, you are encouraged to be reminded of your previous journeys by looking at the traces, and to make new journeys along streets and roads you have never been down before.

Figure 23 TraceMap interface on touchscreen device.

Dorothy makes her way into town on the bus to the new council house. The new council house is in a part of town that has recently been redeveloped. She goes through her bag and pulls out a small white device. She taps in the address of her destination and a marker appears on screen. The marker is where she needs to get to... but no route explaining how to get there appears.

Those routes that you go down most often become increasingly prominent on the map through tracing your movements. The longer it has been since going down a particular route, the less concretely it is visualised. Therefore, in order to keep a long term memory of these routes then you need to ensure they are re-enacted regularly. At the same time, in order to leave a trace of a new route you need to active explore that area.

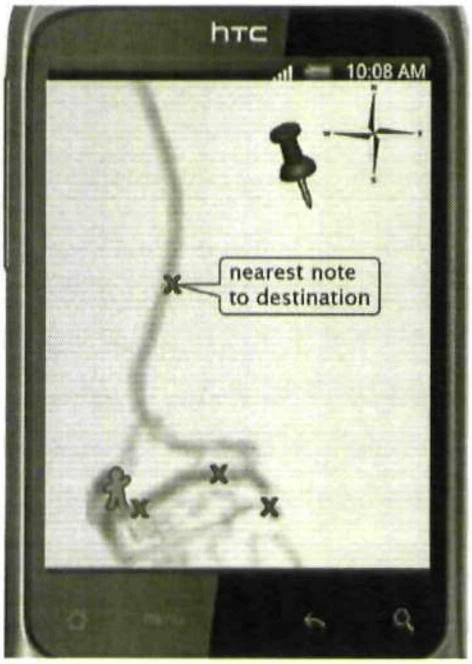

Figure 24 A TraceMap displaying Dorothy's past 'traces' along with planned destination.

Dorothy gets off the bus at a central location in town. She knows this area well—this is acknowledged by her device, which locates her in a swell of traces from recent journeys she has made. As the traces increase in granularity, Dorothy is reminded of previous journeys she has made around this part of town. She begins to orientate herself and becomes familiar with the previous paths she has taken. She still needs to find a way to somewhere new however. Through her past traces she can come nearer to her destination yet to complete this journey she must identify new couplings with her environment. This is challenging for Dorothy, but some comfort is found in always being able to re-trace her movement through the map.

Trace maps highlight how senescentechnic digital media should provide guidance towards active exploration. A TraceMap provides support for a person to find their own routes around a geographical locale and suggests directions for them to pursue whilst not offering concrete directions. Therefore, the user is motivated to find their own paths to their destination rather than relying upon assistive technologies. They have to rely as much on their own embodied capacities of exploring the world as they do the knowledge contained within the device.

7.3. Affordances of ongoing co-design

Senescentechnics requires spaces that afford the older user of a technology to be engaging in an ongoing creative and sense-making process of co-design at the interface of a digital media product.

As has been argued thus far, the shift towards supporting enaction rather than cognitivism highlights the transition of the sense-making activity of people interacting with digital media from being premeditated by the designer to being contingently co-constructed between the dynamics of senescent cognition and the dynamics of the media. The creativity of the individual is implicated as playing at least two roles here within a continuous loop. Primarily, there is a necessity for the older individual to actively form and engage with the interaction process, thus forming their own affordances in terms of a ongoing achievement with the media. Secondly, there is an inseparable role of reflection within this process, which necessarily draws upon the creativity of the older user. Senescentechnics, then, alters the stance of the designer, enabling the human participator to engage in the creation of their interface with digital media; a space provided, but not prescribed, by the designer. The issue of senescentechnic affordances becomes an issue of co-design, and some of the problem solving activities that are normally considered to be the realm of the designer would be passed onto the user.[163]

There are particularities to certain design activities that are sympathetic with senescent cognition and the requirement for affordances offering ongoing active engagements with digital media products. Donald Schön (1991) has argued that studies of various professional practices highlight how knowledge is often developed and reflected upon during dialogical interaction within situations. Schön (1991) has argued that this appears to be particularly significant to design practitioners. In an often cited study of design activity, Schön discusses a dialogue from an architectural review between a student (Petra) and the design master (Quist). Petra's project is focused upon the development of building in difficult

[163] One approach to the issues of introducing co-design into real-time interaction between participants and technology was discussed by the author in a collaboration with Brigitta Zics (Zics & Vines, 2009), which can be found in the thesis' appendix.

space that is based on a slope. At the start of the review, Petra outlines that she is finding it difficult to incorporate the building into the slope; in order to resolve the problem, Petra had listed a number of smaller problems that had to be resolved first in order to move forward. In being unable to develop answers to these problems, however, Petra was stuck. The primary problem that Petra was attempting to resolve—the architectural norm that the shape of the building and the contours of the land must fit one-another—appeared to be the primary source of her difficulties. Quist, in response, suggests that part of Petra's problems was an inability to let go of the problem. Schön notes that instead:

> the main problem, in Quist's view, is not that of fitting the shape of the building to the slope; the site is too "screwy" for that. Instead, coherence must be given to the site in the form of a geometry—a "discipline"—which can be imposed upon it. (Schön, 1991, p.85)

Schön notes that Quist's response to Petra's problems is that she needs to resituate the problem. Petra was attempting to find coherence in a site that seemingly could not afford it. Instead, Quist suggests she starts with a discipline 'a "what if" to be adopted in order to discover its consequences' (Schön, 1991, p.93). Quist makes what may appear to be an illogical move to Petra; he is suggesting that they ignore what she identifies as *the* problem.

> Quist plays out the consequences of the new discipline by carving the geometry into the slope. In the medium of sketch and spatial-action language, he represents buildings on the site through moves which are also experiments. Each move has consequences described and evaluated in terms drawn from one or more design domains. Each has implications binding on later moves. And each creates new problems to be described and solved. Quist designs by spinning out a web of moves, consequences, implications, appreciations, and further moves. (Schön, 1991, p.94)

Quist explores his newly imposed discipline in a pragmatic form of interaction; although he outlines his discipline at the start, he is willing for it to change as he moves through the problem setting.

> Each move is a local experiment which contributes to the global experiment of reframing the problem. Some moves are resisted (the shapes cannot be made to fit the contours), whilst others generate new phenomena. As Quist reflects on the unexpected consequences and implications of his moves, he listens to the situation's back talk, forming new appreciations which guide his further moves. (Schön, 1991, p.94)

Quist performs an ongoing dialogue with the situation. In doing so, he begins to find an answer to Petra's original problem, stating that 'the new geometry "works slightly with the contours'", providing a form of coherence that has only been possible by avoiding the initial problem. In the linear, rational problem-solving world of Petra, Quist's moves may appear somewhat obscure, irrational and a means without an end; to Quist, seemingly taking a pragmatist approach, the solution, if as such could be defined, emerges from the continuous engagement with the situation.[164]

Henrik Gedenryd (1998) synthesises Schön's (1991) account to argue that Quist's cognitive problem solving activity is only possible through his continuous reframing of the problem as a result of his interactions with the local environment—primarily, the sketchpad. Gedenryd (1998) argues that there is a certain quality to the inquiring materials of designing that provides the tools necessary for this form of interactive, world-involving cognition. This type of ongoing enquiry or use of situated materials, however, is not confined to design activities. Gedenryd (1998) determines that in situations where human beings are enforced to cognize about problems 'intramentally'—that is to say, without actively exploring and experimenting with the environment—human cognitive 'performance is underwhelming' (Gedenryd, 1998, p.215). Gedenryd (1998) argued that human cognition performs better when there is an ongoing sense making and construction of knowledge in collaboration with environmental affordances.[165] He defined this attribute of human cognition, which is highly reminiscent of those of Gibson and Varela discussed before, as 'interactive'.

> *Interactive cognition* is meant to indicate that mind, action, and world *mutually* determine an individual's doings, in interaction. Cognition, of course, effects changes upon the world. In conventional cognitive theory, it is the mind alone that determines what an individual does, in a simple causal relation. In interactive cognition, the cognizing individual on the one hand, and the world on the other, *reciprocally* influence each other. In other words, mind and world interactively determine each

[164] Schön's description of Quist's activities highlights how, in some circumstances, behaviours that may appear irrational on an initial observation might actually be beneficial in certain respects. In terms of the problem solving or ideation process of designing, it might be that doodling and sketching are part of the ongoing sense-making activities of the designer.

[165] It may be that enforcing 'mental' interactions, rather than using the world to support or supplement cognition, fundamentally restricts human problem solving. This was observed in the aforementioned work of Kirsh and Maglio (1994) studying Tetris players. Kirsh and Maglio (1994) discovered that when forced to mentally rotate the block shapes rather than physically play with them, then the calculation time was significantly longer. It appears that the thought process was improved by what may initially appear to be relatively superflurious movements made by the player, but these moves dynamically alter the playing environment in a manner that simplifies the calculations necessary in the brain. Kirsh and Maglio (1994) called actions such as these 'epistemic', and opposed them to 'pragmatic' actions. An epistemic action is the performance of some form of change in the environment that does not necessarily directly achieve a desired goal but allows an individual to aid the cognitive processing of a given situation. Rather than situating the cognizer as a separate perceiver of information from the world on which it makes calculations and then acts out moves towards a desired goal, Kirsh and Maglio (1994) paint a picture of human cognitive experience as dynamically entwined and intimately coupled to the environment where it is impossible to separate the 'mental' from the objects that are acted on.

> other, and in particular they interactively determine cognitive performance. (Gedenryd, 1998, p.111 - emphasis in original)

Gedenryd (1998) portrays the interactive nature of cognition as coming to the fore in situations that require the application of abstract thought. Exploring the activities of designers, he notes that design activities revolve around worlds of uncertainties. The use of sketching, prototypes, scenarios, layout mock-ups and simulations allows the designer to situate their self within a world that is uncertain, ill-defined and, at least during the designing process, does not exist physically but emerges within the private *Umwelt* of the designer's activity. Gedenryd (1998, p.157) calls these 'situating strategies', in that they allow the designer to re-create these environments of uncertainty in order to be strategically situated within the 'future situation of use'.[166] The idea here is that the habit of designers re-creating worlds to be situated within provides evidence of the intimately tied nature of cognition and world. By situating themselves within these potential worlds, the designer is able to enable their embodied being to enter an alternative arena where their everyday sensorimotor capacities can be utilised. As Clark (2008, p.155) comments on Gedenryd's claims, '[t]he mock-ups [...] serve no primary purpose other than that of allowing human reason to get a stable grip on what might otherwise prove elusive or impossible to hold in mind'.

Whilst this discussion is not one to be simply universalised, Schön (1991) and Gedenryd (1998) highlight how certain tools used in the design process appear to offer a particular space of affordances to emerge. They enable the construction of imaginary worlds to be enacted that would be limited if left to the pure-reasoning of 'cognitivist' human cognition. The common materials of design appear to afford a certain type of interaction that benefits the continuous exploration and experimentation that Schön's description of Quist highlighted.

> Sketching is made up of very small and simple incremental steps, which yield local control and high sensitivity to feedback. This, in turn, makes sketching into a highly fluid and efficient process, which supports the open ended and conceptual nature of the design work which sketching is typically used for. (Gedenryd, 1998, p.145)

The *Umwelten* of some design activities, it appears, are mutually beneficial to the sense making requirements of parts of the design process. Schön terms this aspect of the designer-

[166] Examples of such situating strategies are numerous, such as Ehn and Kyng's (1991) often documented 'cardboard computers', where cardboard boxes were used within a 'simulated' environment to represent certain possible future technologies without the need of expensive prototyping. Similarly, there has been a recent emergence of design research examining the usefulness of using film documentary and actors within speculative design scenarios, such as the work of Bas Raijmakers (2007).

sketching Umwelt as 'seeing-moving-seeing' (Schön, 1992, p.5), which continuously shifts as the designer attempts to make incremental and experimental changes to both the immediate environment and the activity, or problem, they are attempting to make sense of. Therefore, it is not just that the tools of design afford a certain activity but that the designer's activities are in a mutual specification with the affordances of the tools. More so, the affordances of this micro *Umwelt* support non-concrete activities; for the designer, sketching is a process that does not easily afford ends—it is used as a means to make sense of problems and ideas.

The above model, although not representative of all design activities, provides a useful paradigm for imagining the ongoing sense-making interactions that should be encouraged in the affordances for senescentechnics. Whilst the seeing-moving-seeing process that Schön describes is ocular centric, it becomes apparent that there are qualities of certain design activities that affords opportunities to continuously reflect upon sensorimotor abilities through an active engagement with the world. The designer unwittingly makes novel couplings through spaces emerging before them; enabling the development of new sensorimotor couplings; further enabling novel couplings with the medium and thus also aiding creative problem solving. It is proposed here that this model of design activity, along with certain attributes of design tools, is a useful analogy for thinking about affordances for senescentechnics as such activities emphasise a level of active and interactive engagement that support the enaction of cognitive experience. Therefore, it can be highlighted that *older people, in order to support the enaction of their cognitive experience, benefit from taking over some of the decisions made in terms of real-time and ongoing interactions with digital media that would normally be prescribed by the systems designer.*

Taking the above claim, the system must be conceived in dynamic, affective and effective terms. The designer must consider how the senescentechnic product would encourage the creative and continuously reflective activities of the designer's own sense-making process. The affordances emerging at the contact between an older person and the digital media interface can be considered in terms of an ongoing transition of a means rather than an end in itself; the interface is there to afford the particular sense-making activity (contextualised within a broader activity) rather than to concretely represent an end. The digital product situates an array of possibilities before the fact of the interaction, with which the older human swarms together, exploring and experimenting, to construct their own sense of interaction.

Proposed strategy: senescentechnic digital media products can be designed with a consideration as to how the ongoing, moment-to-moment, contextual, and reflective characteristics of certain design activities constitutes a basis for the real-time interactions between an older person and digital interfaces.

Quixotic User Interfaces

The Quixotic User Interface (QUI, pronounced 'queue-eee') is toolkit for people to use to resolve the problems they have making sense of everyday consumer items. It contains a number of craft materials that can be carried on your person—pens, pencils, labels, erasers, scalpels, card and more. These materials can be deployed as and when seen fit by the user to identify new ways to interact with irritating objects in their lives.

Ken sits himself in front of his computer. Ken does not consider himself a computer expert by any means, but he is certainly proficient enough to get by. Despite this, he can't help but feel the computer causes him an undue amount of problems when he is trying to learn new tricks and skills. As he tries to log on to his internet banking, he begins to imagine how different this could be. He takes out of his bag a number of tools. Having enough of staring at the screen, Ken starts to draw on his monitor with what looks like a thick, black pen.

Figure 25 Ken's QUI toolkit.

The QUI kit allows the 'user' to identify the problems they have with the digital media they interact with on an everyday basis. They begin to ask particular questions of what these devices are forcing them to do: why do I have to interact in this way? By asking questions of how they are forced to navigate digital media and technology, new possibilities for future interactions are unearthed. These are fed back to the systems designers over time.

Ken scribbles away on his monitor. He marks out a new area on screen where he can put his signature. "I've used my signature for banking all my life.... why do they want me to change it now?" He grabs the eraser and rubs out the box where he usually has to enter an elaborate username and password. "I need something that is personal to me, not some silly combination of letters and numbers." Ken actively reconstructs the interface of the banking website. As he does so, he begins to understand better what the bank have presented to him—but at the same time his imagination constructs a new site based upon his own history of couplings with the world.

QUI highlights how senescentechnics requires the people that use digital media products to be considered as active co-designers throughout their history of interactions. Co-design is not to be primarily considered as part of the design process, to be forgotten once the final product is deployed to be consumed. It is part and parcel of interacting with future devices. It gives the 'user' the continuous possibility to enact change, to imagine new possibilities, and to make sense of both the designed world and their own abilities in a reciprocal, moment-by-moment manner.

7.4. Affordances of balanced self-efficacy

Senescentechnics requires spaces that afford a balance for incremental adjustments to the delicate embodied sensorimotor couplings of an older person, providing information as to the provenance and ramifications of real-time interactions.

It is proposed here that designers consider how the emergence of affordances that require an active and ongoing engagement might present a fragile situation for the senescent cognizer. Whilst it may be the case that the above strategies support the ongoing enactment of cognitive experience, it is a fine line between affording a beneficial state and a state where the history of structural couplings of an individual are entirely inconsistent with the offerings of a digital system. In terms of senescent cognition, an older person's situation requires to afford them a balanced self-efficacy.

Contemporarily, the term self-efficacy is mostly used within social psychology, where it suggests, firstly, that a person estimates that certain behaviours will lead to certain outcomes and that, secondly, this person has the conviction as to whether or not they can perform the necessary behaviour (Bandura, 1977). Therefore, a person with a higher level of self-efficacy may believe they are capable of more than their embodiment affords, and a person with lower self-efficacy might believe they are less likely to achieve the necessary behaviour (Bandura, 1977). Whilst self-efficacy is taken to be a rather individual characteristic, it is observed that healthy older people are, typically, more likely to have a lowered sense of self-efficacy than healthy younger people as a result of the perceived changes to their physical capabilities (Bandura, 1994). In terms of senescent cognition, self-efficacy can be interlinked with Noë's previously discussed notion of experiential blindness. The experiential blindness that occurs as a result of the disintegration of sensations with the pragmatic knowledge of acting in the world has a resulting effect on the ability to know what a particular embodiment is, or is not, capable of.

One way of portraying this situation is through the example used in chapter six of reductions in the acuity of the sensorimotor systems related to proprioception. Reductions in proprioceptive acuity as a result of senescence have been associated for some time with older people who encounter an increased risk of trips and falls; the prenoetic performances of the body schema no longer adequately integrates the perception of the environment with bodily actions. At the same time, this leads to a heightened self-perception of the inadequacy of the body to respond to what is perceived. There may be moments of seeming sensorimotor inadequacies where an individual has appeared to overestimate their sensorimotor abilities and, as a result, are more consciously aware of their inabilities and reduce their expectations in future interactions with the environment. Returning to Gallagher's (2005) distinction of the body schema and body image, as a result of the perception that aspects of the (unconscious) body schema have failed, a greater control of interactions with the environment is given over to the (conscious) body image. As argued in chapter six, in using the body image actions are slower and more hesitant; this is confounded by the inherent sense that sensorimotor systems are somewhat failing.

An older person who experiences their sensorimotor embodiment as not acting as they implicitly perceive it should is likely to be suffering a double handicap in that their explicit sense of body movement also provides a deprived sense of ability and coupling with the environment. Their sense that they can achieve certain effects through actions would also be reduced. Consequentially, this thesis argues that *older people benefit from pushing the boundaries of their sensorimotor abilities in order to support the enaction of cognitive experience, yet if these boundaries are pushed too far more harm can be caused than good.*

Another way of conceiving the concept of self-efficacy would be through the experiential concept of 'flow' introduced by Mihaly Csikszentmihalyi and colleagues. Flow is defined as:

> a subjective state that people report when they are completely involved in something to the point of forgetting time, fatigue, and everything else but the activity itself. It is what we feel when we read a well crafted novel or play a good game of squash, or take part in a stimulating conversation. The defining feature of flow is intense experiential involvement in moment-to-moment activity. Attention is fully invested in the task at hand, and the person functions at his or her fullest capacity. (Csikszentmihalyi *et al.*, 2005, p.600)

Csikszentmihalyi *et al.* (2005, p.601) suggest that one of the preconditions for the experience of flow is 'a balance between the perceived challenges and perceived skills.' This state of flow is particularly difficult to achieve, however, and is liable to sudden change.

> This balance, however, is intrinsically fragile. If challenges begin to exceed skills, one typically becomes anxious; if skills begin to exceed challenges, one relaxes and then becomes bored. These subjective states provide feedback about the shifting relationship to the environment and press the individual to adjust behavior in order to escape the more aversive subjective state and reenter flow. (Csikszentmihalyi *et al.*, 2005, pp.601-602)

Taken in terms of a senescentechnic approach to designing digital media products, Csikszentmihalyi *et al.* highlight how the relationship between a person and a digital system is understood as engaging in a continuous transition between moments of complete immersion, boredom and confusion. In order to support the emergence of the optimal state of flow, a digital media interface would have to afford a level of engagement that balances difficulty with simplicity.

A primary requisite of entering a state of flow is for the activity at hand to be relevant to the individual in terms of their desire, motivation and creativity. Therefore, it is important to highlight that senescentechnic digital media products must be contextually significant to the older persons using them. Problematically, however, context is not something that can be designed for. Context emerges as a result of ongoing interactions with technologies, rather than something that can be determined *a priori* by the designer (Dourish, 2004). Gaver *et al.* (2007) identified the limitations of making contextual predictions before the fact and embedding these predictions in the design of digital systems. Gaver *et al.* (2007, p.546) propose that 'instead of systems providing their *own* accounts' of context, 'systems can be designed that encourage people to hold them *to* account' and context is formed around it.

Context, it is suggested by these authors, could be informed by the information and data that a digital media system presents to users, but this is only useful as a way of provoking the interpretation, perceptions, actions and interventions of people. Context, here, is malleable; the designers role would be to identify what types of information and feedback is presented that opens the affordances for certain contexts to emerge.

Proposed strategy: senescentechnic digital media products are contextually malleable, where the designer provides the basic structure for the digital system to become embedded in the activities of a particular user, at a particular moment in time.

Whilst the display of information as it is understood above requires interpretation on the part of the user, in terms of senescent cognition it is necessary to support a balanced self-efficacy in providing information that actively responds to the behaviours of the older user. In terms of supporting optimal states of flow, Csikszentmihalyi *et al.* (2005, p.602) argue that the 'presence of clear and immediate feedback' is crucial. They highlight how, in terms of attempting to engage people in such an optimal state, it is necessary for the technological system to continuously alter its state in reaction to the actions of the individual.

In reference to the ongoing sense-making explorations that the senescent human being is making of their own embodiment, however, it is necessary to provide information that transcends the immediacy of real-time interactions. The potentially fragile nature of efficacy and flow needs to be supported by ongoing references to the history of structural couplings between an individual and the media, whilst offering insight into where certain decisions made by the user will lead in the form of future couplings with the digital system. Rather than determine the routes to be taken by older people interacting with a digital media product, the designer conceives of ways to communicate the couplings a person has already established with a product in the past, and what future actions may be possible as the result of this ongoing history of exchange.

Proposed strategy: senescentechnic digital media products can provide continuous feedback as to the history of structural couplings it has been engaged in. Senescentechnic media affords the spaces for direct and immediate feedback to the ongoing, sense making enquiries of the senescent co-designer, highlighting the provenance of real-time interactions and speculating the future results of these interactions.

Enactive Archive

The enactive archive is a small table-top computer that acts as a media hub within the home. Content is delivered to the computer from film and television archives, amateur video resources, news agencies, production houses and broadcasters. Whilst what content is made available is determined by its distributors, the manner in which it is navigated, interacted with, and personally archived is all constructed by the user through an ongoing process of designing.

Figure 26 Bob pouring his bag of paraphernalia onto the interactive table.

Bob sits down at his desk. On his desk he has a selection of tools: pens, pencils, rulers, brushes, erasers, tape, string and more. He swipes his hand across the front of the desk and a screen lights up from within the rich, dark, mahogany wood. As several seconds go by, images begin to swarm underneath and then slowly settle to an almost stationary state. As it settles, the visualisation returns to almost the state in which Bob left it the last time he used it. Only almost, however, as there have been subtle changes to the interfaces organisation. Some new objects have appeared on the screen from before, and everything is slightly askew, as if a window has been left open and a breeze has swept across the screen. Bob is attracted by a region to the left that is glowing. The glowing suggests there has been some activity in

an area where Bob has spent some time before. He has no idea what it could be though. "I've been to many places over the years".

Personal possessions can be placed on top of footage and be 'glued' to one-another—therefore, visualisations can be navigated through personal objects, and personal objects can be shared with others on the archives cloud.

Figure 27 Bob interacting with his enactive archive.

Bob empties the bags contents onto the desktop. The objects initially appear to be dull and discrete from one another. The physical objects have a strange effect on the visualisation however. The visualisation begins to swarm once again and visual objects begin to be attracted towards Bob's possessions. The glowing region becomes fixated around one of Bob's possessions – a photograph of him with some of his old Navy colleagues. On his past travels through archived videos, Bob had come across a number of videos of his old Navy digs. The last videos Bob had watched were about these old buildings being knocked down. "Ah, I remember, I made some comments about that didn't I... utter disgrace getting rid of those buildings. They are perfectly fine still! Ah, and then I glued it onto this photo of the boys." Previously, Bob had stuck the photo onto some archived news and amateur footage, and also some recent news broadcasts about the future of the buildings. The glowing suggests a sudden surge in activity. Bob gets his pen out and draws rings around the throbbing objects. He grabs his deskbook, which when he opens it unveils an array of new comments and conversations since he left his photograph and thoughts. There is a new article attached to his photograph.... "What's this about them.... blimey, they found an old unexploded bomb under the ol' gal! Well I never... she's not going quietly. We always thought there was some of those left in the ground."

The enactive archive draws attention to how senescentechnics encourages the user to take a greater share in the construction of the interface. Here the user takes over part of the designer's traditional role, making their own usage decisions through an array of tools and objects that have personal value to them. The user participates by sketching out their terms of interaction, and then subsequently deems the archived footage that she or he deems relevant to their personal history. The modes of access that the user constructs and enacts are continuously open to change; they are dynamic and provisional, and new tools can be brought in as and when he deems them appropriate.

7. 5. Affordances of self-(re)organisation

Senescentechnics requires spaces that afford ongoing physical activities that are necessary for the reintegration of key proprioceptive and body schematic systems of the senescent cognizer.

In chapter six, reductions in the acuity of proprioception in later life was identified as a key influencing factor leading to cognitive disconnections, or experiential blindness, in the senescent account of cognition. Even small changes in proprioceptive sensations have potentially severe consequences on a person's ability to coordinate and actively explore and enact the *Umwelt*. Whilst it might be assumed that the reduced acuity in proprioceptive sensations is a result of the typical deteriorations of the ageing human body, studies have highlighted that proprioception is rather plastic in later life. Through rather elementary interactions with certain types of affordance, older people are able to renegotiate their sense of proprioception.

Westlake and Culham (2007) observed that whilst proprioception appears to decline as people age, through a process of balance training it is often possible to reintegrate proprioceptive feedback with the dynamic configuration of sensory, action, physiological and environmental systems. In their studies, Westlake and Culham (2007) compared a group of older participants going through a process of a sensory training exercise with a group who received advice on avoiding trips and falls. Rather startlingly, upon being tested for postural sway after a period of training or advice, it was observed that the group who received sensory training were more stable, whilst those who received advice were less stable than before (Westlake & Culham, 2007). Westlake and Culham's study highlights the plastic nature of the human proprioceptive system, even in old age.[167] These studies illustrate how the preventative approach to resolving the perceived problem of older people having trips and falls—that of teaching older people to be more aware of what they are doing—may actually

[167] The findings of Westlake and Culham have also been noted in similar studies, such as those by Li *et al.* (Li *et al.*, 2008), Xu *et al.* (2004), Beard *et al.* (1994) and Gauchard *et al.* (2003; 1999).

increase the fallibility of the ageing body. When interpreted under the lens of senescent cognition, in suggesting a greater attentiveness to the actions of the body, the prenoetic performances of the body become less implicated in interactions between body and world; this, in turn, results in a heightened awareness of the limitations of one's own body in relation to the environment and, perhaps, a subsequent decrease in the dynamic process of sensorimotor integration. Alternatively, those who exercise the structure of these embodied processes increase the acuteness of their sensorimotor integration systems; their body has not 'improved' suddenly, but their non-conscious awareness of the relations between their sensorimotor system and the environment is heightened. This is to say, the prenoetic performance of their body appears to become better synchronised with the dynamics of the *Umwelt* (that is, the entire brain-body-environment system of the human).

What these experiments suggest is that the ageing body, although in itself trainable to be stronger in terms of exomuscularity, cannot be exercised to regain its previous sensorimotor state. What is possible, however, is that there are particular processes that older people can go through to re-integrate their changing embodiment with their proprioceptive performances. Therefore, whilst it is not possible to return a person to a previous physiological state or an impoverished version thereof, it is plausible that the sensory preconcious sensations that inform senescent cognition can be reintegrated with the contingencies of their dynamic sensorimotor system and, therefore, couple with the environment in a more acute manner. Therefore, *older people benefit from a level of physical excursion that forms the basis for priopriceptive and body schematic reintegration, which subsequently aids the enaction of cognitive experience.*

This places a requirement on designers to consider the benefits of physical interaction and activity in reference to the design of senescentechnic digital media products. Attempts have been made in recent years to develop products and services emphasising physical exercise and 'brain training' for older consumers (e.g. The Brain Fitness Gym (Hope Technology Therapy, 2010)). Similarly, the aforementioned research of Hurtienne *et al.* (2009a; 2009b) have emphasised the potential cognitive benefits that tangible and physical user interfaces may provide for older people.[168] Rather than conceiving the physical aspects of interaction as

[168] As discussed in chapter three and four, Hurtienne *et al.* proposed that by applying the universal image schematic knowledge that structures human interactions with environments into the design of digital media products, it is possible to avoid the limitations of ageing cognitive functions such as working memory. In chapter four, the thesis argued that Hurtienne *et al.*'s argument failed to account for the ongoing basis of temporal change, and proposed the question of whilst certain groups of people may have image schema that

somewhat reflecting the predicted or 'universal' sensorimotor knowledge of the body (as was argued by Hurtienne *et al.* (2009a)), or as moments of intense excursion, the tangible, haptic and physical attributes of senescentechnic digital media products are be embedded within subtle and ongoing and ever changing physical activities.

Proposed strategy: senescentechnic digital media products are embedded within a variety of subtle and ongoing physical activities, affording spaces that provide the continued integration of proprioceptive sensations and body schematic systems, and an ongoing dialogue between the reorganisation of abilities and self-knowledge as it relates to actions in the world.

Slow Objects

Slow objects are transformative media that hide within everyday objects. They are cups, saucers, kettles, tables, taps, rugs... These slow objects appear to be the types of mundane possessions that are common to many a stereotypical middle-England home. The quotidian familiarity of these objects, however, disguises their dynamic values. Slow objects continuously strive to identify ways to make the lives of their owners a little more effortful. They secretly document the movements their owner makes with them, the places where they are left, and the times of the day they are used. Then, when not in use, they find new places to conceal themselves from their owners.

Figure 28 Rose's slow bin that moves in the direction of her most often walked path.

Rose comes downstairs to begin her daily routine. She gets up at 7am most days, goes straight to the kitchen and boils the kettle. The kettle has moved slightly from the position she left it in the previous evening. It has become unplugged.... Audrey fills the kettle with water,

frame interactions in the world, what happens when these image schema no longer cohere to the possible actions of the body?

plugs it into the socket, and leaves it to boil. As she walks to her kitchen cupboard, she realises the handles of the cupboard have moved several inches upwards. She stretches a bit more than normal, reaches the handles, and drags them back down. "If it wasn't them doing this on purpose, I'd swear I was going mad!"

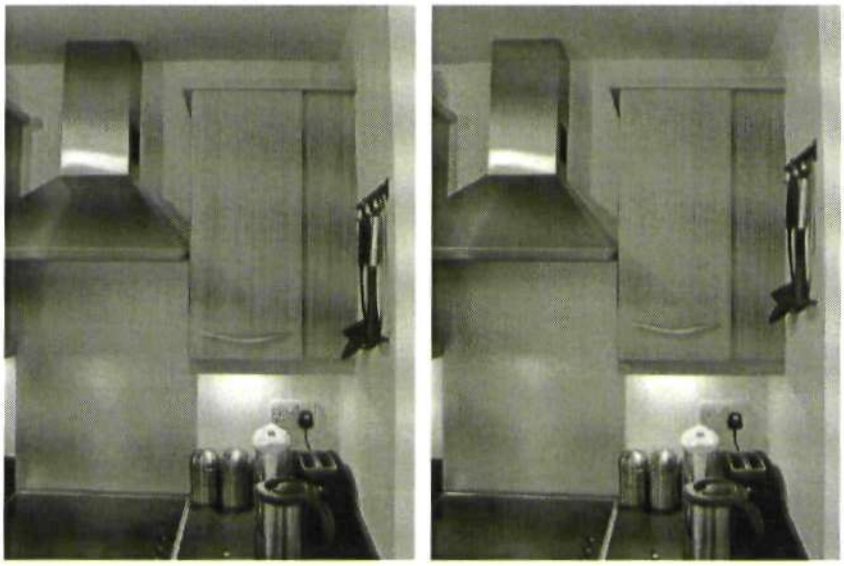

Figure 29 Rose's cupboards and utensil rack that incrementally moves out of her reach.

Slow objects detect how they are held, touched stored, and reconfigure their form in order to unsettle any consistencies. The casual observer would struggle to see the dynamic nature of these objects—their evolution is slow. Yet their slow, but continual, process of change means their owners can never settle into a concrete routine.

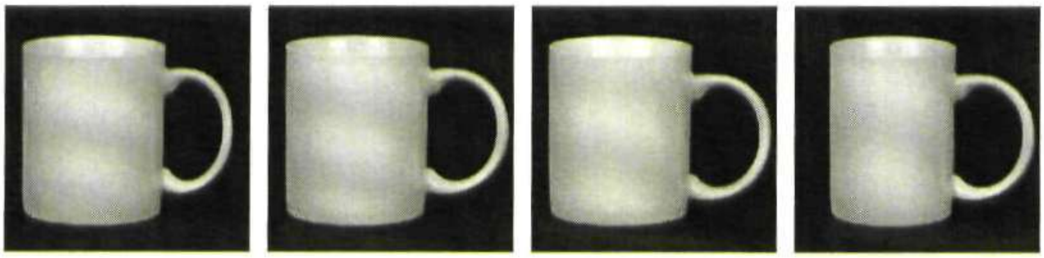

Figure 30 Slow mug that deforms slowly over time.

As she sets her mind to making her cup of tea, Rose grabs the same cup she uses every morning. Overnight the cup has subtly changed its form—it is slightly more bulbous, the handle slightly thinner, the height slightly lower. Yet only slightly. This is not enough to *distract Rose from her daily routine—yet, at the same time, her routine is every so subtly changed as a result.*

Slow objects illustrate how senescentechnic media is never fully realised and stable. Although these objects appear normal and every-day, they eschew routines and repetition by manoeuvring and reconfiguring their position and form all the time. They encourage their users to continually reflect upon their usage of these items—where they are left, and how they are touched and concealed. Their active resistance against regular use requires an equal resistance from those who regularly use them.

7.6. Affording a sense of agency and wear

Senescentechnics requires designers to have a sensitivity to the agency of older people as having intentional control over both their embodiment and interactions with digital media products; designers must consider the ongoing process of wear between people and technology, and how digital media wears with older people rather than treating older people as wearing out.

The two main moves made within contemporary cognitively inclusive design—1) structuring interaction in a manner that places less strain on cognitive information-processing and 2) compensate for lack of fluid abilities by harnessing past experiences—are flawed in terms of an embodied, enactive understanding of senescent cognition. Interactions between people and digital media designed in response to a malnourished cognitive system are likely to produce malnourished perceptual engagements. Rather than predicting how an older person will interact with a digital media product in light of reductionist knowledge on how cognitive, sensorimotor and kinaesthetic systems alter in later life, this chapter has proposed open-ended strategies to support designers that focus on how novel digital media products can be conceived to afford the active exploration and enaction of cognitive experience. Here, there is a requirement for designers to conceive of older people not as formed of a slowly deteriorating self, impoverished of the abilities they once had, but rather encourage the development of new skills and reflect upon their altering embodiment through their agency as individuals.

Whilst designers are still implicated in these strategies, the stance of the designer is such that the older user of a technology is empowered as a producer as much as a passive consumer. Within gerontology and ageing studies, the concept of agency has become a key concern in recent years, with an increased awareness that older people, as individuals, must be empowered to be in control of their own destiny. Tulle argues that Western perspectives on ageing are dominated by a narrative of old age as an 'inevitable, wholesale decline, physical and cognitive, as well as social and cultural' (Tulle, 2004, p.ix). As a result, Tulle (2004, p.ix) concludes that:

> older people themselves operate within a range of expectations, which are bounded by this narrative. Thus older people are either denied agency because they are involved in an inexorable process of decline, or if agency does indeed manifest itself, it is used as a way of pushing back decline.

Cognitive psychology, and subsequent design approaches drawing upon its claims, is situated in a deterministic discourse of deterioration in old age. This and the previous chapter have highlighted that although there are cognitive functions that alter with age that make it more difficult to enact digital media, it is plausible to portray these problems in a less deterministic manner than contemporary perspectives.

Returning to the previously discussed case of Ian Waterman, whose loss of proprioceptive and body schematic systems lead to a reliance on his body image for movement (see chapter six), Gallagher (2005) observed how whilst most people may have a sense of ownership and agency of their body, divisions or discrepancies between schema and image may incur a deprived sense of ownership and agency.

> Initially Ian was unable to control his movements and over the first few days after onset of his condition he felt a loss of embodiment or an alienation from his body. [...] As soon as he was able to see his body and its movements properly, however, even though he had not attained motor control over them, the sense of disembodiment diminished. [...] For Ian, body ownership was re-established very quickly. Yet, because his intentions to move were imperfectly fulfilled his sense of agency continued to be deficient. As he gained more precise control of movement, using a body image framework, his sense of agency was gradually re-established. (Gallagher, 2005, p.56)

For Ian Waterman, Gallagher (2005) argues that whilst his sense of ownership of his body returned relatively quickly, his own understanding that he was not able to enact certain perceptions and actions as he should led to a continuous sense of lacking control over the precise motor control of his embodiment. If considered in terms of senescent cognition, it may be that older people suffer from an ongoing and potentially increasing sense that their agency and intentional control over the body is being incrementally eroded.

By necessity, the moves made in the preceding chapters require inclusive design to move beyond conceptualisations of ageing that portray older people as suffering from deteriorating capabilities which need be accounted for in the design of interfaces. Rather than limiting the cognitive stimulation an interface may provide, and specifically prescribing the human through the process of interaction, the senescentechnic designer examines the spaces for affordances to emerge that support the reintegration of these embodied capacities. Rather than supporting the malnourishment of agency, senescentechnic affordances explore the possibilities for the continuation of coherent, embodied and enacted cognitive experience in later life. *In senescentechnics, older people are understood as being empowered to nourish their sense of agency and be active effectors in their ongoing interactions and engagements with digital media products.*

The shift in the design stance argued for in this chapter requires design activities that examine the level of flexibility to be afforded in the outcome. Rather than focusing upon objective and concrete outcomes that embody what the designer has identified as the requirements of certain groups of older people, this design perspective requires consideration as to how the user moves towards an outcome on their own terms of engagement. The focus of design, therefore, is not on the materialisation of a final technological product, but the ongoing temporal processes of interaction, both in real-time and between people and digital media. Design, here, is the consideration for the process of wear between people and digital media.

Wear may be defined in a number of ways: 'to diminish or decay through use [...] to endure use: last under use or the passage of time [...] to diminish or fail with the passage of time [...] to produce gradually by friction or attrition' (all Merriam-Webster (2010)). Wear is a process of gradual change that can be positioned in both positive and negative terms. Wear between people and digital media suggests an ongoing dialogue where friction between the two systems has beneficial as well as negative consequences. As has been argued in this chapter, a senescentechnic approach to digital media products provokes a mode of thought where moments of intensity and effort are to be understood as necessary requirements if senescent cognition is to be coherently enacted. *Senescentechnics requires designers to consider the ongoing process of wear between older people and digital media; the media wears in and out along with the people who construct it and friction is understood as both advantageous and disadvantageous to the enaction of senescent cognition—designers open the space for wear but it is managed by the older user of the product.*

Sand Computer

The sand computer is intended to last forever yet also wear out. It expresses how computing technologies do have properties that wear. Whilst traditionally these parts that wear out might be concealed, the sand computer combines its form with its hardware function—therefore, the technology wears out in front of the user's eyes.

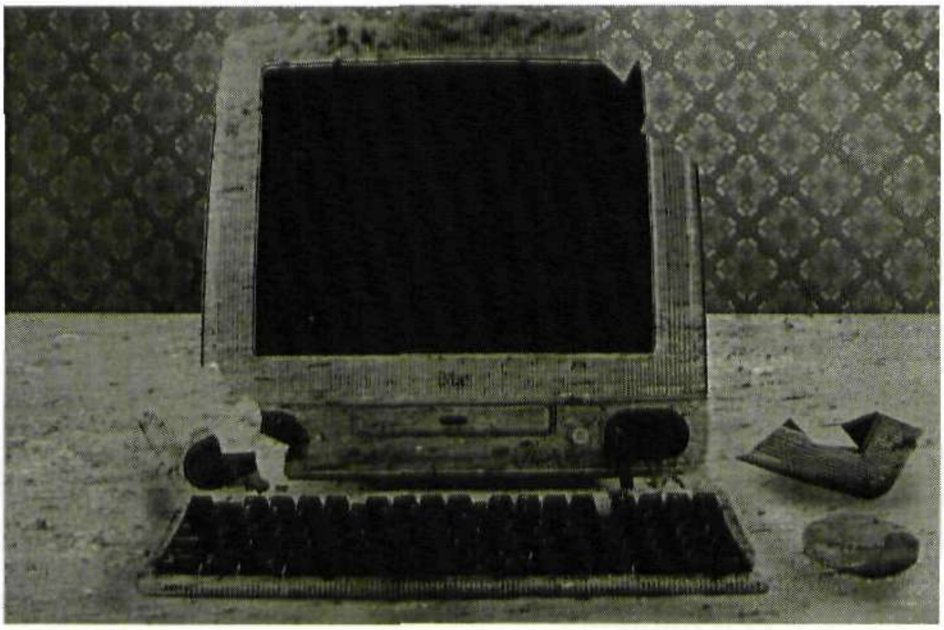

Figure 31 Ted's original sand computer, no brittle and crumbling apart.

Ted walks past his computer. "It has happened again..." Ted's computer is a pile of rock-like rubble. "I only patched it up a few weeks ago!" He picks up a piece of rubble and it crumbles into granules in his hand. "I suppose this time I'll rebuild it properly". Ted puts on his modelling gloves. He begins to scoop up the granules and collect them into separate piles. He moulds the piles into shapes. He could rebuild his computer so it is in a radically different form to how it was before. "I like it how I had it before... did the job for me... just it was starting to fall apart." Ted starts to build up a collection of small cubes that look a little like keys. He gets a small modelling knife and starts to label each key. He removes his gloves and puts on another pair. He begins to mould a roll of the granules together, and then shapes them into a circle. "That can be the screen this time." Ted rolls out a large sphere to

be used as a mouse. Content with his work, Ted switches the machine on for the first time. "As good as new!" he proclaims.

Rather than suggest that the computer is breaking down and needing replacement, the properties of the sand is such that it can be remoulded into new forms and treated like it is new once again. This newness is only temporary—soon, new cracks and holes will appear in its surfaces.

Ted presses the power button to reboot his not so new computer. As he does so, some of the fine granules of sand already come free. Ted grabs a small brush and collects the fine particles in a bag. He isn't going to throw these away... instead, Ted realises how precious this material is. "I can make new peripherals from this!" As he says this, a part of the 'tower' on his new computer crumbles and slides downwards. "Or perhaps I will just have to patch that bit up there...." Ted is constantly reminded of the temporary nature of what he has created, but also that he can continually make new from what falls apart.

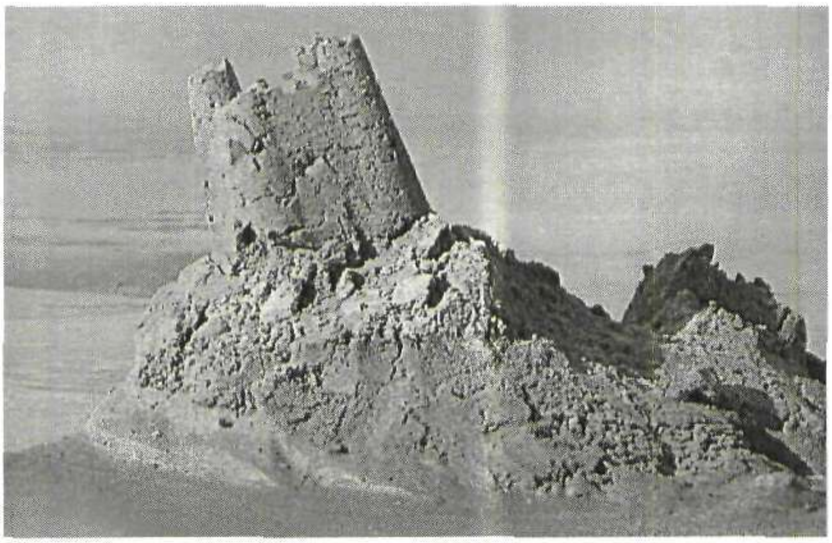

Figure 32 The 'tower' of Ted's new computer, slowly eroding once more.

The Sand Computer illustrates the key prerequisites of senescentechnic digital media products. Firstly, they do not stand idle, they are dynamic and in continuous change, and the changes that occur to them over time are traceable and perceivable. Secondly, senescentechnic digital media need people around them to keep them in such a dynamic state, and subsequently people need to act in a proactive and dynamic manner to keep them maintained.

A senescentechnic design process examining the processes of wear between people and technology asks rather different questions about use compared to a design process that examines how a concrete outcome can reflect the knowledge a designer has collated about specific types of human beings. These questions range from the conceptual, to the practical and technical. For example, how might the design of dynamic digital media products and interfaces alter the pace at which a technology is incorporated into the *Umwelt*? How might new forms of media respond over time to perceived changes to the people in its vicinity? How might new forms of media react to changes in contextual domains and multiple situations of use? How can media interfaces deal with discriminating one person from another reliably over long temporal durations? Questions such as these are for future research to take on board, supported by the conceptual and theoretical basis of senescentechnics as developed in this thesis. Senescentechnics, within this context, provides a novel basis of knowledge with which to consider the design of future digital media products that amplify the agency of the older user in order to allow them to engage in new dialogues with technology, supporting the ongoing enaction of their cognitive experience.

In the above questions issues related to prediction are still present; unlike contemporary cognitively inclusive design, however, prediction is used as a way of opening up spaces for affordances to emerge, not to concretely communicate possibilities for interaction, as will be discussed in the following final chapter. In addition, the final chapter will recontextualise the implications of senescentechnics and the dynamic affordances discussed within this chapter into the broader context of contemporary inclusive design theory and practice. In chapter one, the thesis introduced the inclusive design community before discussing research that has specifically focused on cognitive psychology of ageing. The thesis will return to this broader community in order to discuss the potentials and limitations of current practice and theory to move from the design of concrete outcomes to an emphasis of human agency and wear. It will discuss how contemporary inclusive design is inherently limited in its capacity to incorporate the claims made within this research, and would require a significant amount of negotiation with in order to move towards a senescentechnics understanding of older people interacting with digital media. Building on the previous discussion, the following chapter highlights contemporary design theory and practice that may support such negotiations, which to both a greater and lesser extent are synergetic with the argument of this thesis.

Chapter 8

Afterthoughts: Future inclusivity

Question: Why might current inclusive design practice and theory struggle to incorporate dynamic affordances for senescentechnics, and how might this be negotiated in the future?

8.1. The limitations of cognitively inclusive design can also be observed in how the broader inclusive design community, where designers struggle to comprehend user experience that are not based on a reductionist matching of the user to the technology.

8.2. There are a number of design approaches from outside of inclusive design that might aid the incorporation of senescentechnics in future design practice. In order to fully realise the potential of senescentechnics, however, inclusive designers must look beyond their discipline and its methods and models centred on usability.

8.1. Returning to inclusive design

The limitations of cognitively inclusive design can also be observed in how the broader inclusive design community, where designers struggle to comprehend user experience that are not based on a reductionist matching of the user to the technology.

This short chapter reflects on some of the implications of senescentechnics and dynamic affordances as established in this thesis within the broader context of inclusive design and a number of approaches to understanding users of technology that are emerging within design related literature. This chapter touches upon how the problems identified within cognitively inclusive design are replicated on a meta-level within the practice and theory of the broader discipline of inclusive design. It will be noted how inclusive design, although considering more experiential models of the use of technology, continues to be restricted to constructing a fit between people and technological media. The chapter discusses how the backdrop of assumptions that support current inclusive design theory and practice need to be negotiated with if the ideas discussed within this thesis are to become realised. The chapter continues to provide a brief overview of a number of alternative methodological propositions emerging with design-related research. These alternative approaches offer an opportunity for inclusive design to conceive of both people and technology in dynamic terms. Following this, the chapter concludes the thesis by reflecting upon these negotiations in light of the senescentechnic approach to understanding the problem of the cognitive disconnection between older people and digital media products, highlighting the relevancy of transdisciplinary investigations to examining design-related problems, and providing speculation for the direction of future research.

Cognitively inclusive design, as defined in chapter two, is just a small component of the broader inclusive design community introduced in chapter one of the thesis. Whilst inclusive design, taken at its broadest definition, is not particularly concerned with the specifics of human cognition as it relates to ageing,[169] the tools and methods provided by and to its community of theorists and practitioners are highly analogous with the more specific sub-field of cognitively inclusive design attended to by this thesis. Consequentially, the assumptions that are embedded within the inclusive design process somewhat limit the manner in which the dynamic affordances of senescentechnics can be understood by this important community of designers.

One key argument emerging from the inclusive design literature is that inclusivity is not primarily focused upon usability, which appears to be the focus of attention for the cognitively inclusive designers. Inclusive design, as it is defined in key resources, should be focused upon the improvement of the experiences of products and services for a more diverse range of people (i~design, 2010).

> By meeting the needs of those who are excluded from product use, inclusive design improves product experience across a broad range of users. [...] Inclusive design is not [...] adequately covered by a requirement that the product should be easy to use [and] solely about designing products for a particular capability loss. [...] Inclusive design should be embedded within the design and development process, resulting in better designed mainstream products that are desirable to own and satisfying to use. (i~design, 2010)

Rather than focusing on usability per se, inclusive design emphasises experiential aspects of a particular product, interface or service. Within inclusive design literature, the case for designing for improved user experiences is entwined within the business case for inclusivity.

[169] This is observable in the way in which cognition and psychology are referred to in inclusive design literature but not necessarily attended to in any detail. For example, Coleman *et al.* (2007) only briefly allude to its significance in their influential text: 'Tapping into the opportunities offered by an ageing market requires an in-depth understanding of the changing aspirations of older people and the ageing process itself. Longer life spans mean the almost certain experience of age-related capability loss. Reductions in eyesight, hearing, mobility, dexterity and cognition will come to us all, and disability will be a common experience, but older people do not wish to be stigmatised or singled out as a special needs group' (Coleman *et al.*, 2007a, p.14). Coleman *et al.* highlight the significance of cognition among a great variety of factors but avoid discussing it in detail perhaps in light of the possibility of stigmatising older people. Despite this, however, many of the examples used by Coleman *et al.* (2007) throughout the text emphasise functional aspects of designing for the failing bodies of older people.

This is argued by Coleman *et al.*, who state that there is:

> a powerful, common sense business case for the inclusive design approach, the core of which is understanding and prioritising the user experience. It is also about understanding that the less tangible human factors – identity, emotion, delight, self-expression – are common to us all, and that getting these right for users who are vulnerable to exclusion is an effective way of ensuring that what we design really does enhance life quality, simply and intuitively, for as many people as possible. (Coleman *et al.*, 2007a, p.16)

Within this case for the financial benefits of performing an inclusive approach to design, it is argued that by designing in reference to the needs, desires, and requirements of often ignored, yet socially and quantifiably significant, groups of potential users, then these people are more likely to purchase the products. The broader the consideration for the experiences of a diverse range of users, it is argued, the better placed a particular product is to be purchased and used by more people.

> Every decision made during the design cycle can affect design inclusion and user satisfaction. Failure to correctly understand the users can result in products that exclude people unnecessarily and leave many more frustrated, leading to downstream problems, such as increased customer support requirements that can ultimately reduce commercial success. Conversely, successful implementation of inclusive design can result in a product that is functional, usable, desirable, and ultimately profitable. (i~design, 2008c)

The ultimate profitability of a product, it is argued, comes from the designer matching the needs and requirements of the potential user in the designed outcome. This potential user, who perceives that a particular product or service matches their needs, desires, requirements and abilities, would be inclined to purchase and use a particular company's goods. The design process, therefore, becomes fixated upon establishing the experiential properties of the user which can be inscribed into the end product. Whilst inclusive design theory appears to call for establishing more diverse, experiential and agential models of the user, in practice designers are directed towards the traditional approach of constructing the needs of the user and reflecting these in the designed outcome.

Whilst inclusive design calls for a design approach that is beyond usability, the manner in which experience is conceived appears to be highly analogous with that of the more usability focused research within cognitively inclusive design. As Redström (2005) observes, the shift from cognitive psychology and usability to experience merely relocates terminologies; '[b]y providing the right material pre-conditions, we aim to make people more productive, more willing to consume, etc., through our designs' (Redström, 2005, p.128). The conflation between usability and experience is evidenced in some of the key examples that are used by the inclusive design literature to highlight the best practice of inclusivity. One prominent example, highlighted briefly in chapter one, is the British Telecom (BT) Big Button phone.[170] The phone is designed in order to be inclusive for older people, although it is also marketed for people with sight, hearing and dexterity disabilities in mind. The buttons on the phone are much larger than normal keypads, spaced out further and have a high contrast type font and background colour. A light on the front of the phone alerts a person who is hard of hearing when it is ringing. The ringing level can be adjusted to a number of levels, and the speaker in the handset is loop-amplified to work with hearing aids. The Big Button phone proved a commercial success for BT, and has been critically applauded as a good example for there being a business case for inclusive designing (as in Lebbon (2010) and Cambridge EDC (2005)). The economic success of the Big Button phone has led to the development of a newer model, the 'Freestyle', which was designed from the start based upon an inclusive approach to design. The newer model was developed along the lines of 7 'easy' categories:

- Easy to dial - Large comfortable keys
- Easy to read - High contrast and large characters
- Easy to hear - Comfortable ear bowl, easy volume adjustment and inductive coupler for digital hearing aids
- Easy to hear phone ringing - Lower frequency ringer and increased size of the call indicator light
- Easy to understand - No icons, no abbreviations, keys with single functionality, intelligent function hierarchy
- Easy to answer and end calls - Large, separate keys to start and end calls
- Easy to see who is calling - 2 line dot matrix display, large characters (i~design, 2007)

In terms of inclusive design, the Freestyle is fixated around a model of simplicity and usability. The Freestyle phone could be understood as a response to increasing the usability

[170] Although the BT Big Button and Freestyle phones are used here as a particular example often used by the inclusive design community, an examination of the various toolkits, community websites and publications surrounding inclusive design highlights how most examples appear to equate better experience with better usability. For example, Coleman *et al.* (2007b) use the OXO Good Grips range of kitchen accessories as an paradigmatic example of inclusive design. Clarkson (2007) equates ease of use with better experiences of products, and highlights examples such as ticket machines, kettles, and small remote controls as examples of products and interfaces that are overly complex. Although the argument that these are poorly designed products for certain groups of users is wise, the equation that ease of use leads to better experiences is somewhat less supportable. Websites organised to support the inclusive design community, such as the European Design for All e-Accessibility Network (www.education.edean.org) and the aforementioned inclusive design toolkit (www.inclusivedesigntoolkit.com) support this equation of usability with better experiences.

of a communication device by reflecting the physiological and cognitive abilities of a key target market in the form of the product. The BT 'inclusive' products focus upon what would constitute the commonly understood physiological abilities of certain groups of human beings; the seven 'easy' categories focus upon large comfortable keys (dexterity), high contrast lettering (sight), and reducing the need for perfect hearing. Also, the categories appear to move into the cognitive; no icons, abbreviations and singular levels of functionality; separation and simplification of functions. Although the 'Freestyle' is marketed as an inclusive product—and not specifically for certain markets—it is seemingly embedded within implicit implications of it being particularly useful for those who require products that are designed to meet more specific physical and cognitive demands. Any experiential benefits here are conceived as emerging as a result of the increased usability of the product for these often ignored groups of people.

Often, it appears, objects of inclusive design that are suggested to be targeted to users of various levels of experience and ability, are focused in particular to certain models of traditionally disadvantaged groups of users. For instance, 'SimplicITy' is a personal computing system marketed towards technologically inexperienced groups of people. The system appears to be based upon standard personal computing hardware, running a modified operating system called 'Eldy' which has a simple menu structure from which it is possible to 'send e-mails, browse the web, chat to friends and family using our e-mail addresses, store photos and write short documents' (simplicITy computers, 2010). The marketing for this product states that '[t]he simplicity computer is for people who have had no experience with computers or have found PC's too difficult to use' (simplicITy computers, 2010). The suggestion appears to be that the SimplicITy is marketed for those that might be somewhat put off using novel technologies. Certain decisions in the marketing of the product—such as naming its specially design operating system 'Eldy', and having Valerie Singleton as the instructor within the tutorial videos—suggests that it is more specifically targeted to older users.[171] SimplicITy is a standard technological product which has had a layer added to it to

[171] This targeting of the older 'non'-user of personal computers (through the use of terms such as 'Eldy' and using a former television presenter that the cohort might identify with) which is never explicitly stated within the advertising material of the Simplicity but appears to be an underlying implicit theme, has not necessarily sat well with various internet communities. The chatter found at Computer Act!ve (Computer Active, 2009), appears to identify some of the inherent problems of computing systems such as the SimplcITy. Some commentators have noted how the device belittles 'elderly' people (despite being targeted at people over fifty years, who might be somewhat offended with being considered elderly yet still having up to sixteen years until retirement) into a group who have a very limited range of expectations of what they would like to do with novel technologies. Other issues appear to be related to the cost of the system, the somewhat condescending adverts and instruction videos, the targeting of vulnerable people, and much more. Whilst the SimplicITy is not an

make the product conform to the ability-models of a certain group of users. The 'Eldy' operating system presents the relatively standard activities that are usually bundled in as typical for computer users, and simplifies them to a level that matches the cognitive and visuo-perceptual abilities of a highly typified older person. It is alluded to by the manufacturer's website that the system works beyond just this simple interface, providing a greater level of configurability to the user.

> The simplicity works at two levels: a simple system to allow first time users easy access to the things they are most likely to use - email, browsing the web, chatting and storing photos. For people who master all of this in Eldy and then want to do more advanced tasks as well, they can switch between Eldy and Linux. (simplicITy computers, 2010)

The portrayal that the simplicity offers such a level of configurability to its user is somewhat misleading, however. In order to go beyond the basic interface, it is necessary for the user to use the Linux operating system the 'Eldy' interface is built upon, which is arguably more complicated to navigate for a novice than other contemporary operating systems. Whilst this could be an economic strategy to increase the potential target market for the SimplicITy as a consumer product, it is highly questionable whether a novice user who has mastered 'Eldy' may be proficiently abled to then explore the Linux system.[172]

Throughout the inclusive design literature, the assumption that prevails is that by making technological products and services easier to use—which is often accounted for in terms of physical, sensory or cognitive deteriorations—designers can make the products more enjoyable to users. Subsequently, it is taken that this increases user satisfaction and improves experiences, and therefore develops more financially successful products. Inclusive design takes that it is possible to identify certain properties in the user and match these to the design of an end-product. In order to develop a concrete product that meets the criteria of a user's ability, it is essential that the designer can describe the user concretely beforehand. Much like the cognitively inclusive design sub-discipline discussed at length in this thesis, broader inclusive design practice and theory is based upon what is an implicitly assumed objective and reducible reality. This is to argue that these designers take that there is an objective

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example of the best inclusive design practice, it profoundly highlights the limitations of taking a functional approach to experience without considering the bigger picture.

172 This returns to the issues raised in 'affordances of balanced self-efficacy' discussed in the previous chapter. The SimplicITy computer appears to offer two options; a basic operating system, or a potentially highly-complex (and often unsupported) operating system. There is little room to support the self-efficacy of individuals who become experts (and perhaps bored) at using the basic system, yet do not perceive themselves as having the necessary abilities to engage with the more complex operating system.

reality of information that an individual consumes; by altering the design of this reality we can match it to the consuming abilities of the user. What makes this approach problematic is that this implicitly assumed stance of the designer has a subsequent effect on their activities.

Whilst inclusive design literature appears to call for more emphatic conceptions of human beings as agential and experiential users of products and services, the continued objectification of the user appears to restrict this area of design from moving forward. Therefore, current inclusive design practice and theory, and senescentechnics, is incompatible with one another. In the following concluding section of the thesis a number of alternative design approaches currently being developed will be connected with, which might support an inclusive designer who wished to bridge the gap between their tradition and senescentechnics.

8.2. New conversations for future senescentechnic inclusive design

There are a number of design approaches from outside of inclusive design that might aid the incorporation of senescentechnics in future design practice. In order to fully realise the potential of senescentechnics, however, inclusive designers must look beyond their discipline and its methods and models centred on usability.

The previous section highlights the stark contrast between the assumptions made within contemporary inclusive design theory and practice and the senescentechnic approach to the design of digital media products. It would be rather difficult, therefore, to jump from inclusive design to senescentechnics without negotiating between the two. In this concluding section, the thesis touches upon emerging areas of design research that are useful for bridging the gap between inclusive design and senescentechnics by opening up ways of integrating dynamics, change and experience into the design process. The section will conclude by summarising the thesis and recognising the benefits of transdisciplinary research in providing new insights to everyday design problems.

Based upon the previous section, it appears that practitioners and theorists of inclusive design, in its contemporary form, would struggle to conceive of the ageing human being as a dynamic entity that is always in a state of flux. By trying to make certain predictions about use and the user, inclusive design subscribes to concrete and static descriptions of people and technology. In recent years, attempts have been made by design researchers to identify new methods and tools to help bridge the divide between the apparent need to embed a process of prediction within the design process and the understanding that people, technology and ecology is dynamic. For example, Love (2010) presents the argument that designers should make greater use of computational dynamic systems tools when dealing with 'wicked problems' that are formed of one or more feedback loop.[173] Love (2010) argues that it is becoming possible to simulate and develop computational models of large, dynamic, interconnected systems to predict how certain behaviours emerge from complex situations and design outcomes.

Love's (2010) argument can be taken one stage further, by applying dynamic systems tools as part of the design outcome as well as within the design process. Since the mid-1990s, a number of projects developed at the Affective Computing Laboratory at MIT (as described in Picard (1997; 2009)) have utilised dynamic systems tools within computer systems that continuously monitor and affect people that are interacting with or within range of the system. Drawing upon then-nascent artificial intelligence research, Picard (1997) explored how physiological data could be perceived by interactive systems and, in turn, provide affective feedback and content back to the human participant. Affective computing does not just examine how human beings respond emotionally to certain interactions, nor just how models can be developed for technologies to better sense and react to these emotions, but to develop engaging interactions where people are actively affected by the computer and, subsequently, actively effect the computational system. Therefore, affective computing is a way of monitoring and reacting to the real-time emergence of dynamic affordances between people and technology.

The types of dynamic tools used in Love's and Picard's work are useful when considering the future practical application of senescentechnics. Looking back to chapter seven, it is notable how the 'spaces for affordances' and their associated design examples allude to aspects of dynamic systems tools and affective computing to varying degrees. Whilst offering a way towards thinking about people and technology as dynamic, however,

[173] According to Churchman (1967, p.141), wicked problems were originally defined by Horst Rittel as a 'class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing.' Rittel conceived of wicked problems in light of the highly indeterminate and mega-multifaceted nature of many design problems. Whilst Rittel illuminated how complex the process of design is, Buchanan (1992, p.16) observes that he leaves the question '[w]hy are design problems indeterminate and, therefore, wicked?' unanswered. Buchanan (1992, p.16) argues that 'the answer to the question lies in something rarely considered: the peculiar nature of the subject matter of design. Design problems are "indeterminate" and "wicked" because design has no special subject matter of its own apart from what a designer conceives it to be. The subject matter of design is potentially universal in scope, because design thinking may be applied to any area of human experience.' It is problematic to believe that the wickedness can be taken out of these problems, and Churchman notes the moral and ethical implications of situations where designers believe this is so. Love (2010) does not discuss these issues in his brief paper, however, and it seems to be his argument that wickedness can be controlled by accurate simulations *a priori*.

these ideas can lead to conceiving people as purely reacting to the changing stimulus an interface provides. Thus, Love's (2010) and Picard's (1997; 2009) suggestions are still highly problematic in the context of this thesis—as discussed at length in chapter four, making detailed predictions about how people react to technology and media and appropriate it into their personal and shared lives is always going to be of limited use. Despite these limitations, however, their work offers a route towards bridging the dichotomy between static, concrete inclusive design and the dynamic, temporality of senescentechnics.

As was discussed in chapter four, over the past twenty years there has been an increased focus within the fields of human-computer interaction and society and technology studies on approaches to understanding people using technology in non-deterministic, non-predictable terms. This has been particularly evident in recent years, as HCI researchers have dealt with the shift from primarily studying technologies in workplaces to trying to understand how people use digital media and technologies in every art of their private and shared lives. For example, McCarthy and Wright (2004) argue that HCI research is required to not only investigate how people *use* technology, but to understand how technology is *lived* and *experienced*. Building upon the lineage of the participatory design movement and philosophy of pragmatic aesthetics[174], McCarthy and Wright (2004) call for designers to find a new sensibility towards working with 'users' in their everyday life.

> It requires us to see these familiar things in terms of felt life, empathy, and the aesthetics of everyday experience. User needs and requirements are not the focus of our enquiry. Rather the focus is an understanding of individuals, their concerns, desires, aspirations, values, and experiences. The relation between designer and "user" is not an objective one in which the designer stands outside of the user's situation. Instead, it is one in which the designer and user are in mutually influencing, empathic dialog... (Wright, Wallace and McCarthy, 2008, p.19)

Rather than taking the human subject as something to be observed and researched into, instead Wright *et al.*'s argument suggests the user must be considered as a co-designer and co-researcher within the design process. Wright and McCarthy (2008, p.638 – emphasis in original) argue that 'understanding an *other* or more specifically, knowing the user' in their lived and felt life involves understanding what it *feels like* to be that person, what their situation is like from their own perspective'. As Krippendorff (2006) notes at length, a designer is always restricted in terms of their understanding of the user—it will always be a

[174] Wright and McCarthy's work is influenced by the literary criticism of Mikhail Bakhtin (1981) and the pragmatist philosophy of John Dewey (1929; 1934), which has been used to inform these authors approach to experience-centred design (as developed in (McCarthy & Wright, 2004; Wright *et al.*, 2008)).

second-order understanding. To take the experience-centred approach that McCarthy and Wright argue for, however, is to argue that through sensitivity to the experiences and values of particular individuals, however, the designer's second-order understanding comes closer to the first-order understanding of the user of a particular digital media product.

The increased notability of experiential models of people interacting with digital media within HCI is relevant to this thesis for two key reasons. Firstly, as discussed at length in chapter seven of this thesis, it encourages designers to loosen their hold on the design process and empower the user in the design process by including them within the creative and decision-making process. The user is treated as an expert in their own right, bringing to bear their own experiences into the design process. This is not to just treat people as subjects within the design process, but to take a more closely coupled, long term view on the interactions between one expert (the user) and another (the designer/the computer scientist/the engineer/the gerontologist). Secondly, what McCarthy and Wright highlight is that to understand people using technology in experiential terms does not require radical methodological interventions. Rather, through critically engaging with ideas and knowledge from other disciplines (in their case philosophy and literature theory) designers are provided with a new critical lens that can be used to look for very different phenomena and types of design outcome.

Taking heed of the above, the nearest future of senescentechnics research might be to use it as a new critical lens to be incorporated within a more traditional inclusive design approach. To take an example, let us return to section 1.2 of the thesis where the inclusive design community was initially introduced. It was noted that one of the tactics to ensure a people-centred approach to inclusive design was to go through a process of 'discover, translate, create, develop' (i~design, 2008b). Whilst the description offered by inclusive design focuses upon reductions and 'user design' (Redström, 2005), it is possible to reinterpret these with a senescentechnic lens.

A senescentechnic inclusive design process

Discover: The exploration of the design context through a dialogue with necessary stakeholders. This leads to the first output of the process, an understanding of what type of activities and practices are to be supported.

Translate: The conversation of this context into a senescentechnic understanding by asking the following questions: What tools are to be given to users that enable suitable couplings in this context? What dialogue with the user best suits this design context, and how might the sensorimotor couplings of the designer become more understanding of those of the user? What are the most suitable ways to ensure a balance between the affordances for senescentechnics?

Create: The creation of a preliminary tool kit that allows the "user" to begin marking out their initial couplings with a digital media product. Evaluation here is done by the user themselves, through their ongoing interactions and iterative couplings they make to the interface to access contextually relevant "data".

Develop: The designer observes the ongoing couplings that emerge and disappear between the user and the digital media product. The role of the designer here is to evaluate and develop ways in which this ongoing relationship may be maintained, balancing flow and hindrance, effort and ease, application and reflection.

The above reformulation of the inclusive design process is not intended to be detailed and thorough but instead to offer some insight into how it can be interpreted through a sympathetic awareness to senescent cognition. Instead of focusing upon closure and designing the user, the designer's expertise is focused on tracing the couplings the user makes. In tracing these couplings over time, the designer does not look to find ways to bring people and technology closer—instead, they explore ways in which the dialogue can continue. Notably, unlike as it is described in section 1.2, there are no solutions here in the traditional sense—instead the solution is in the maintenance of couplings between people and technology, and the enactment of cognition.

This brief discussion of possible future directions for senescentechnics suggests that there are a number of design-related approaches that offer opportunities to bridge the epistemological chasm between inclusive design and senescentechnics. What is clear, however, is that in order to move from inclusive design's tradition of prediction, prescription and inscription, then its community of practitioners and theorists must look beyond traditional design methods, processes and models of usability. A design discipline that closes itself off from debates ongoing in related, or even distanced, disciplines is likely to become malnourished and blind to radical transformations that alternative domains of knowledge provide. As discussed in chapter one, whilst the methods and tools of inclusive design are useful in certain contexts, when attempting to get a hold on issues related to the cognitive disconnection between older people and digital media, this community is substantially limited. In chapters two and three, it was observed that cognitively inclusive design, which can be seen as one attempt to move beyond inclusive design, has mostly taken on board reductionist studies of ageing cognition from cognitive psychology. Chapter four identifies how whilst cognitively inclusive design is trapped in a discourse of reductionism and deterioration of human cognition, similar literature within the discipline of human-computer interaction has been critiqued at length. Subsequently, for the most part much of human-computer interaction research has moved away from applying cognitivist models of the human mind in the design of digital media products. Rather than moving completely away from the insights that cognitive science provides for the design of digital media products, however, this thesis has renewed conversations with the cognitive sciences and has re-interrogated the issues of the cognitive disconnection through the lens of enactive cognitive science and dynamic affordances; an approach this thesis defined as senescentechnics. In chapter five, these alternative paradigms emerging within cognitive science literature were introduced. Following this, chapter six reinterpreted the issue of the cognitive disconnection between older people and digital media based upon a senescent approach to understanding cognition, which brought together synergies in the work of Gallagher, Noë and emerging cognitive neuroscience of ageing research. Based upon this reinterpretation, chapter seven discussed a number of conceptual spaces within which senescentechnic affordances emerge between older people and future digital media products. Rather than providing specific guidance to designers, chapter seven instead opened up some potential directions for future senescentechnic inclusive design practice and theory in light of the argument developed in chapter four, five and six.

In bringing together until now discrete bodies of knowledge, the thesis has developed a novel critical lens with which to evaluate and critique the contemporary use of reductive, usability focused models of people and technology within both inclusive design and the more specific sub-field of cognitively inclusive design. When transferred into a new perspective on designing, this lens highlights how the expertise of the designer must be shifted from that of making a tight fit between people and technology, to understanding how people can make technology fit them—and how this fit can be challenged and maintained over long periods of time.

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Zics, B. & Vines, J. (2009) 'The Mind Cupola and Enactive Ecology: Designing Technologically Mediated Experiences for the Aging Mind'. *Consciousness Reframed X: Experiencing Design, Behaving Media*. Munich, Germany: 19-21 November.

Appendices

9.1 Appendix 1: Author's publication, presentation, seminar, and training list

9.1.1. Papers and publications

Vines, J. 2010. The failure of designers thinking about how we think: The problem of Human-Computer Interaction. In: Blassnigg, M., Drayson, H., Punt, M., Vines, J., Zics, B. 2010. *Transtechnology Research Reader 2010*. pp.98-105. Plymouth, University of Plymouth. Available online at http://www.trans-techresearch.net/research/reader

Zics, B. Vines, J. 2010. The Mind Cupola and Enactive Ecology: Designing technologically mediated experiences for the aging mind. In: Blassnigg, M., Drayson, H., Punt, M., Vines, J., Zics, B. 2010. *Transtechnology Research Reader 2010*. pp.205-214. Plymouth, University of Plymouth. Available online at http://www.trans-techresearch.net/research/reader

Zics, B. Vines, J. 2009. The Mind Cupola and Enactive Ecology: Designing technologically mediated experiences for the aging mind. *Consciousness Reframed X: Experiencing Design, Behaving Media*, MHMK University of Applied Sciences, Munich, Germany, 19-21 November 2009.

Vines, J. 2009. The Ageing Present: Neurophysiological change and the relational affordances of technological objects. *Doctoral Colloquium of the International Association of Societies of Design Research 2009: Rigour and Relevance in Design*, COEX, Seoul, 18-22 October 2009.

Vines, J. 2009. Embodied and ecological cognition and the design of engaging technological artefacts for older individuals. *Nordes2009: Engaging Artifacts*, The Oslo School of Architecture and Design, Oslo, 30 August – 1 September 2009.

Thompson, S., Vines, J. 2009. Enacted Experience and Interaction Design: New Perspectives. *Proceedings of the Third International Workshop on Physicality*, HCI 2009, Cambridge, UK, 1 September 2009.

Vines, J. 2009. The failure of designers thinking about how we think: The problem of Human-Computer Interaction. *Failed Design: What were they thinking*, Bard Graduate Centre, New York, USA. 24 April 2009.

9.1.2. Conference, workshop and seminar participation

Transtechnology Research seminar series, University of Plymouth, Plymouth, UK, October 2007 – December 2010.

International Network for Trans-disciplinary (post-doctoral) Research sandpit, University of Plymouth, Plymouth, UK, 12-13 October 2010.

Scale Electric Workshop, University of Plymouth, Plymouth, UK, July 2010.

Consciousness Reframed X: Experiencing Design, Behaving Media, MHMK University of Applied Sciences, Munich, Germany, 19-21 November 2009.

Nordes2009: Engaging Artifacts, The Oslo School of Architecture and Design, Oslo, 30 August – 1 September 2009.

International Association of Societies of Design Research 2009: Rigour and Relevance in Design, COEX, Seoul, 18-22 October 2009.

Doctoral Colloquium of the International Association of Societies of Design Research 2009: Rigour and Relevance in Design, COEX, Seoul, 18-22 October 2009.

Failed Design: What were they thinking, Bard Graduate Centre, New York, USA. 24 April 2009.

Philosophy of Perception Workshop, Cardiff University, Cardiff, UK, March 2009.

Consciousness Symposium, University of Plymouth, Plymouth, UK, 19 June 2008.

AHRC Network Methods: Immersive Vision Theatres, University of Plymouth, Plymouth, UK, 13 December 2007.

Body, Brain, Behaviour seminar series, University of Plymouth, Plymouth, UK, October 2007-June 2008.

9.1.3. Research training

An Introduction to Career Planning; UoP Skills Development Workshop; 15 November 2007.

Negotiation Skills; UoP Skills Development Workshop; 19 February 2008.

Rapid Reading; UoP Skills Development Workshop; 27 February 2008.

EndNote for Beginners; UoP Skills Development Workshop; 2 May 2008.

EndNote for Advanced; UoP Skills Development Workshop; 12 August 2008.

Preparing effective poster presentations; UoP Skills Development Workshop; 5 November 2008.

Introduction to qualitative research methods; UoP Skills Development Workshop; 6 November 2008.

Tell the world about it – getting your research into the media; UoP Skills Development Workshop; 17 November 2008.

Research Owning and Using; UoP Skills Development Workshop; 22 January 2009.

CV Writing for non academic roles and the creative job search; UoP Skills Development Workshop; 28 January 2009.

Writing Up and Completing the PhD; UoP Skills Development Workshop; 27 January 2010.

Preparing for the Viva; UoP Skills Development Workshop; 01 March 2010.

Debating Skills; UoP Skills Development Workshop; 27 April 2010.

Impact Factor; UoP Skills Development Workshop; 30 April 2010.

9.1.4. Exhibitions

Vines, J. 2010. Ageing Futures. *Boundary Works I*, Wandesford Gallery, Cork, Republic of Ireland. Exhibition website: http://www.transculturetek.com/boundarywork/

9.2. Appendix 2: Papers written and delivered during doctoral research

9.2.1. 'The failure of designers thinking about how we think: The problem of human-computer interaction'

Paper presented at *Failed Design: What were they thinking*, Bard Graduate Centre, New York, USA. 24 April 2009.

The failure of designers thinking about how we think: The problem of human-computer interaction

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This paper stems from the author questioning some of the ways that designers think how we think, particularly in the context of developing interactions between people and new technologies. Through looking at the role of designers thinking about how we think in the field of Human-Computer Interaction (HCI), the paper notes that there is a division between two distinct models of human thought and consciousness; the model of the cognitive mind and the enacted world. The dominant model in HCI research, the cognitive model, claims that an individual's thought process could be understood in a similar mechanical and computational manner as the technology. The alternative model of enaction claims that mechanizing the subject in such a way reduces the potential to understand and influence the unified, dynamic nature of lived human experience; however, this model appears to be seldom implemented within contemporary HCI design research. The paper intervenes to explain how the specific example of usability studies of older participants interacting with computing technologies might exemplify how the mechanization of the way people think produce a shortcoming in the HCI design process. The paper presents these shortcomings in the form of a dual failure; firstly, the perception of failure within an older persons cognitive abilities and, secondly, the failure of designers to recognize that the way in which they think people think may be an inherent flaw in their methodologies. The paper concludes by speculating that designers working on understanding and forming relationships between older

people and new technologies might provide a suitable entrance point to introduce enactive principles into contemporary HCI discourse.

The cognitive mind

In examining the field of design it is perhaps surprising to note how little attention is given to how the human thought process relates to the products, interactions, objects and experiences that the designer creates. One of the few design-related fields where researchers have to think about how humans think is the field of Human-Computer Interaction (HCI). The discipline of HCI was brought together through a fusion of researchers within Computer Science, Cognitive Psychology and Cognitive Science; as a result, it borrows heavily the methods and models used in these forming disciplines. Although the influence of Computer Science is significant, the subject matter of this short paper – the question of how certain designers think people think – is particularly relevant to the influence both Cognitive Psychology and Cognitive Science had upon HCI. The cognitive model of the mind (sometimes referred to as cognitivist or cognitivism) that dominates these disciplines treats the human thought process as being a rational and problem-solving feature of the brain that occurs through the coming together of numerous mechanisms and processes that mental activity can be reduced to. The contemporary cognitive model treats the mind as being computational and information-processing device (Neisser 1967), rather like the everyday personal computer. Rather than consciousness being a direct experience of the world, it is claimed that the mind represents what we perceive through a series of complex and internal calculations that subsequently symbolically represent particular phenomena and subsequently direct human action in the world.

The formation of this cognitive understanding of the mind occurred at a time when computational technologies were in their rise. There was a desire by many within psychological disciplines to move away from the then contemporary behaviorist models of understanding the human subject combined with a concerted effort to develop computing technologies and their potential applications. There was a real belief at that time, and in many quarters this is still evident, that internal human states could be described and explained as computational. As such, the development of the technologies, their application into forms of artificial intelligence and the investigation of the human mind as an information processing computational device all developed alongside and with each other, in a virtuous circularity[175].

Bringing the cognitive model back into the context of HCI, designers often attempt to understand how the interactions with a computational interface in this external world relate to the cognitive computational functions and their internal representations within a defined user. Using a cognitive model appears to be particularly useful to the designer of computer interfaces as it is, essentially, a way of describing the brain in the same computational (or computable) terms as the technology. Going further than this, a logical situation is presented *where both the subject and the object can not only be described in the same terms*, but if the cognitive argument is taken to be correct both *operate* on the same terms as well. Designers and researchers within HCI attempt to attune interactions between a user and the technological interface for heightened states of intuitiveness, usability and efficiency, as the conceptual basis of the cognitive model claims that both subject and object share the same symbolic and representational form of intelligence.

The enacted world

There has since been a counter movement within the Cognitive Sciences over the past two decades that argues against the contemporary mechanistic paradigm of cognition towards richer models of human experience that do not reduce human cognition to particular computational mechanisms (Varela, Thompson and Rosch 1991). This new paradigm is often broadly referred to as enaction, or the enactive cognitive sciences, and as such will be referred to in these terms in this paper.

The enactive paradigm suggests that in order to understand the lived human experience of the world and the interactions this comprises of – which would include those with technological interfaces – then we must take that human experience and consciousness comes about not through just processes in the brain but the broader sensorimotor and physiological capabilities of the whole body (Lakoff and Johnson 1980; Gallagher 2005) and how these are coupled to the world one is situated within (Varela *et al.* 1991; Noë 2004; Stoffregen, Bardy and Mantel 2006). Along with challenging the idea that the brain is the centre of consciousness, enaction

[175] For a informative and detailed examination of this period see Gardner (1985).

also denies that the brain is a computational and mechanically understandable device that restricts consciousness to internalized states of the perceiver.

Enaction recognizes that human beings, as with the great array of other organisms and matter, are essentially made from the same 'stuff' as the world they live and with this it is considered impossible to determine one part – just as human thought – as in isolation from the broader system that it both influences and is influenced by (Maturana and Varela 1987; Noë 2009). Whereas the cognitive argument considers an individual's cognitive, action and sensory capabilities all as separate from one another, the enactive perspective unifies them as inseparable entities. Furthermore, this unified bodily ability and experience is situated within a particular world, an ecology[176] one is within at any given moment in time. The unification of mind, body and world aligns the enactive cognitive sciences with ventures within philosophical discourse of phenomenology – the study of human experience – particularly as set out by Maurice Merleau-Ponty. He argued that the common sense of the lived human experience is that it is done so through a particular physiology (Merleau-Ponty 2002), which itself is wrapped within a particular context and world (Merleau-Ponty 1968; Abram 1996).

This shift in paradigms within the cognitive sciences is relevant to this discussion as it suggests that one of the foremost influences upon HCI research, the idea of a cognitive mechanized mind, has been widely criticized and argued against by a growing body of research within the very field that formulated it. For a designer of technological interfaces, such as those within HCI, it asks questions of the model of understanding the mind that appears to be implicitly drawn upon and implemented in the final materialization of the process. If we are to take on board the evidence and observations of the enactive argument, then it becomes increasingly difficult to support the current model of human cognition that is integrated into the design process in HCI as an appropriate way to manage interactions between people and computers. By projecting the mechanistic model of the technology onto the human mind, designers might encourage and create a crudely reduced model of the lived human experience of the world. There have been various endeavors that have attempted to initiate behavioral and experiential models and methods for HCI that, to varying degrees, are more analogous with a unified model of lived human experience (such as Ihde 1993; Dourish 2001; Kaptelinin and Nardi 2006; Stoffregen *et al.* 2006). However, despite the movement

[176] The author notes that the term 'ecology' in this context is related to the environment, world and broader context that an organism exists within, rather than sustainability and 'green design' arguments.

away from cognitive reasoning towards enactive models of consciousness within sections of the cognitive sciences, the majority of HCI research still continues to be dominated by understanding the human subject as mechanical, information processing and computational in their manner. It is possibly the case that the gulf between the cognitive and enactive models of consciousness may be too large to be comprehended within contemporary applications at this time. However, the paper will now argue that studies of older people using new technologies might provide an example of a contemporary dimension of HCI research that could benefit from understanding the rich and dynamic nature of momentary lived experience as set out by theories of enaction.

The cognitive model of older people in HCI

If we are to take a richer understanding of human experience then this points to a short coming, or even a failure, within the methodologies used by HCI designers in understanding interactions between a cognitive participant and the technological system. It will be argued here that this difficulty is particularly evident in usability studies of older people interacting with technology. Within many design fields there is a growing discussion regarding how to develop the methods and tools used by designers in the development of technological objects, devices and systems that are inclusive of older people. This is often connected, either rightly or wrongly, with an assumption that older people struggle in their comprehension of new technologies upon encountering them (Schieber 2003). As such, within HCI and Cognitive Psychology there is a pre-given notion that there must be a cognitive change in the operation of particular information processing abilities of the brain and that through identifying what these changes are it may be possible to redesign computer interfaces to suit.

Through laboratory testing of particular cognitive functions it is observed that older individuals are slower or less competent in tasks and tests emphasizing the use of particular cognitive systems when compared to younger individuals, whereas other aspects of cognition show little change or even improvements. The widely agreed reductions in the typical ageing cognitive model of the mind are that one's ability to formulate an understanding of new abstract concepts, to dynamically reason the holding of information in consciousness for further manipulation and a lessened capability to explicitly and reliably recall some long term memories (Birren and Warner Schaie 2001; Stuart-Hamilton 2006). Those that are considered stable or even improve are related to the storage and retrieval of implicit long term memories and the unconscious recollection of past experiences (Smith and Earles 1996; Stuart-Hamilton 2006).

The result of observing these cognitive alterations once re-considered by HCI designers in the context of older people using seemingly complex technological interfaces is frequently a reduction of visual information in an attempt to reduce complexity and an emphasis on metaphor and analogy of past experiences in order to harness the cognitive functions unaffected by age. Interfaces become seemingly simplistic and potentially intuitive in their function but, in this papers view, could confuse the relationship between an individual and the technology by translating the concepts of one medium or group of products into the context of new technologies. For example, word processing software is analogous with typewriters, email is treated as analogous with the postal service, Internet over Voice Protocol (such as Skype) is a landline phone, and analogue dials and levers are superior to digitalization and graphic interfaces (see as examples Docampo Rama 2001; Schieber 2003; Zajicek 2003; Blacker, Popovic and Mahar 2005). The mechanical understanding of how people think suggests that older people are no longer able to generate new meanings and relationships with technologies, so suggests that the designer should harness to an extreme a lifetime's worth of interaction experience with past technologies. Although there are examples where heavily referencing the past may improve the usability and workflow of a particular task, this paper will conclude with some speculation that this may be problematic. The idea of using metaphor and analogy for a broad user group might be considered inherently troublesome; the technological experiences of one older person might be far removed from others, even if they have lived within similar cultures. However, the application of the mechanical and computation model from the cognitive disciplines onto the user of a technology suggests a dual failure on the part of the designer that goes beyond this initial oversight.

The dual failure of HCI designers thinking about how we think

The story within this paper is formed by a two failures made apparent by the design process. The cognitive model of human thought suggests that as a person ages there is a particular failure in certain computational and information-processing abilities of the older individual that are related to making sense of the new. This presents the first failure that becomes apparent within the design process; a cognitive failure on the part of the user that means they no longer can engage with emerging technologies. It is through the identification of this cognitive failure on the human subject's part that leads to methodologies that focus upon the past experiences of the older person. This paper proposes, however, that the use of a method that explicitly recalls past technological experiences as discrete memories in order to bridge the gap between a new technology and the older participant leads to a second failure; a failure on the part of the design method to allow for engaging and novel experiences with new technologies.

Both of these failures are the results of applying the mechanistic cognitive model of the mind to the studies of older people using new technologies. The model emphasizes the failure to engage with the technology as being on the part of the older person, partially on the basis that if younger adults are able to comprehend technological interfaces then the technology itself is not the cause of the problem. This is problematic as it ignores the many situations where people of all ages become frustrated and confused with the technologies they interact with on a daily basis. This in itself brings the first failure back into focus, as the designer does not recognize that the failure of an older person to engage with new technologies is not as a result of just a reduced cognitive function, but due to the nature of the technologically focused manner the interaction process is conceptualized with.

Returning to the alternative paradigm within the cognitive sciences of enaction, which attempting to understand forms of human knowing within the richer and unified common sense of everyday experience of the body and world, it appears what is necessary may be a similar conceptual change within the methods and processes used to understand and develop human-computer interactions. To take upon an enactive way of understanding the older participator of technologies (or of any age) would require designers to move away from trying to understand the internal mental states of a particular group of users and to instead begin to observe the continuous development and changing of relationships that occurs between a person and the objects, artifacts, systems and technologies that inhabit their world. Rather than focus upon a failure on the part of the human subject, which could now be considered as not a failure at all, we centre attention on the inability for contemporary technological systems to adapt to changes in the people that interact with them. However, until such endeavors move from extraordinary to the contemporary within HCI, the failure of the cognitive basis implemented by designers of technological interactions will still manifest.

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9.2.2. 'Enacted Experience and Interaction Design: New Perspectives'

Paper presented at *the Third International Workshop on Physicality*, HCI 2009, Cambridge, UK, 1 September 2009.

Enacted Experience and Interaction Design: New Perspectives

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ABSTRACT
Interaction design is now of sufficient maturity to warrant a critical discourse of its own. To date much of the published material which refers to interaction design has tended to reflect upon examples of its practice or to draw upon research done elsewhere (computer science or cognitive psychology for example) in order to give validity to its own accounts. Interaction design's is a synergistic consequence of other fields which it uses in order to create its own creative and strategic practice; this is both its strength and weakness. Interaction design can become shaped by the fields it draws upon. The authors of this paper take a cautious view of the cognitive and user models that are typically applied in the development of interaction prototypes. Our ideas, presented here in the spirit of a critical conversation, are founded in an intellectual insistence that interaction design presents a strategic extension of an embodied model of the human as an enacted being. In this paper we outline a way by which interaction designers can understand their role to be an orchestration of that enaction, not merely a mechanistic organiser of 'perceptions' of, 'behaviours' of and the 'understandings' of, systems.

Keywords
Interaction design, design theory, enaction, holsomatic.

INTRODUCTION
In order to facilitate a supposedly more seamless interaction between people and the technologies they use, interaction designers often employ metaphorical allusion and ideas of tacit social affordance. While these approaches have had an undoubted positive effect upon the design of effective interactions they have tended to prevail in academic discourse at the expense of the development of a more subtle understanding of ways in which humans are enacted beings. Enaction does not necessarily imply cognitive understanding, but rather a more embodied and intuitive, perhaps pre-perceptual way of being. In this paper the authors propose that, through a new critical discourse, interaction design is positioned to engage in a theoretical anticipation of the means for people to seamlessly participate in the benefits of technology.

Proceedings of the Third Workshop on Physicality
Physicality 2009, 1 September 2009, Cambridge, UK
Devina Ramduny-Ellis, Alan Dix, Joanna Hare & Steve Gill (Editors)

Interaction design's strategic position as a creative arbiter of science and art means that it should seek the design and implementation of new human experiences which are as real, and as integrative, as those which we take to be a natural evolutionary inheritance. Any ambition of interaction designers in creating seamless and fluid flowing interactions should not necessarily imply a blind acceptance of established interaction methodologies. This foundational paper must be read as a speculative intervention, rather than an instructive reflection of research data; it is intended to be read in a similar manner as one might regard a designer's sketch. The paper introduces our research project and suggests avenues of speculative enquiry, outlining the beginnings of a new 'holsomatic' approach to interaction design. Such a holsomatic approach argues that humans can be understood to be enacted by means of a 'soma', in which the organic human and the inorganic technological are considered to be coextensive.

RATIONALISING EXPERIENCE
Science and the Irrational
Being no better than our ancestors we still have a tendency to consign things for which we can find no rational explanation for to the realm of the spiritual. For some people this alignment of the Fortean with the spiritual is in itself a reasonable enough explanation. Spirits are often a comforting way of describing something beyond the rational. Science on the other hand cannot reasonably accept the spiritual explanation. If something tends to go against the rationality of science and appears beyond intellectual foundation, then science has a habit of consigning it to the occult and beyond reasonable discourse or, worst of all, beyond rational investigation. One consequence of this history is that phenomenological evidence of enaction is largely consigned to the anecdotal. Murphy's 'In the Zone' [19] is a wide-ranging collection of carefully transcribed anecdotes of so-called 'Transcendent Experiences in Sports'. This text, published

by Arkana, (a somewhat alternative new-age publisher) is consigned among other fringe titles. Murphy is the co-founder of the Esalen Institute, his book is couched in somewhat obscure terms, and although its contents are presented in a largely rigorous fashion, it tends to find mysticism and avoid scientific explanation. These experiences, it seems, are not understood to fit with orthodox science and are often described as being mystical – a notion reinforced on the cover description of the text: 'remarkable and mystical things happen to people during sports …' [19]. In a chapter called 'Mystical Sensations' a motorcycle rider describes the experience of riding at considerable speed: 'you feel a calmness throughout your body, even though you know intellectually that you're right on the brink of disaster' [19, p.11]. Murphy and White describe these experiences and point to how people describe this in a rather taciturn manner. Do we sense a growing unease in the reader here; a sense that this paper is verging into rather embarrassing territory? Embarrassment is reflected in many of Murphy's interviewees, apparently reluctant to admit a sensuality that appears to diminish their sense of themselves as understanding 'users' of their perception describe their experience as if it had not really happened without them being conscious of being 'in control', but had simply felt as if it had been automatic.

The phenomenology of enaction is only just beginning to emerge from the realm of the occult, for example in the inclusion of some extraordinary esoteric phenomena by Burger, [3] into academic scrutiny. 'Ouija boards' and phenomena such as 'phantom limb' and 'out of body experiences' were once condemned to languish in the realm of the occult, the concern of the ignorant or the insane who often claimed a connection to some supposed externalised spirit or energetic force. The use of the Ouija is explicitly paranormal; its discussion in rational conversation runs the risk of consigning the speaker to the fringe. However, in 'The Illusion of Conscious Will', the neuroscientist D M Wegner [27] describes a number of scientific 'explanations' of the Ouija and other supposedly occult phenomena. These explanations focus upon the nonconscious function of the soma. The nonconscious should not be confused with the unconscious, as Freudian psychiatry might understand it, but a reference to the functions of the soma that operate beyond human sensuality. Wegner suggests that the function of the soma cannot be entirely understood to be accountable in consciousness. Wegner [27] cites the experiments of the neurophysicist Benjamin Libet [15] and colleagues whom tested the timing between the commencement of somatic activity and the subsequent conscious willing of the movement. Wegner suggests that Libet's research presents a challenge to ideas we might have of somehow being in charge of our bodies and by extension of our free will. This idea is outlined extensively in 'The User Illusion: cutting consciousness down to size' by Tor Norretranders [20]. Wegner suggests that this nonconscious functioning of the body may go some considerable way to explain these aspects of the occult as being moments when the nonconscious reveals itself in ways we are forced to account for in our social lives.

Rejecting the Reduction of Experience

Julien Offray De la Mettrie's 'Man a Machine' [7] is sometimes cited as an example of how science reduces the essence of humanity to that of a mere machine (such as [5]). While it may appear superficially to make that claim, in Man a Machine De la Mettrie actually made a far more subtle proposition for the condition and experience of being alive to emerge from the enacted condition of being in the world. Far from suggesting that mankind was a zombified product of the mechanism of the body, De la Mettrie argued that the world is a product of human interpretation, which is itself conditioned by the world. In his own terms De la Mettrie was clear that humans had evolved to be in the world, and proposed, rather unpopularly in his time, that humanity was naturally inseparable from the world as a being of nature.

'Man's pre-eminent advantage is his organism. In vain all writers of books on morals fail to regard as praiseworthy those qualities that come by nature, esteeming only the talents gained by dint of reflection and industry. For whence come, I ask, skill, learning, and virtue, if not from a disposition that makes us fit to become skill-full, wise, and virtuous? And whence again, comes this disposition, if not from nature? Only through nature, do we have any good qualities; to her we owe all that we are.' [7]

De la Mettrie argues that while the corpus is a form of machine, the human is more than the sum of its mechanistic parts. De la Mettrie argued that while the body and the soul can be understood in isolation, no true picture of the human could be built unless they are considered as one whole. De la Mettrie returns our attention to energy; he suggested that it is the food necessary for the machine that can influence the soul, and courage or stupidity though considered to be essentially a matter of the soul and the domain of the philosopher, it could not be separated from the somatic influence:

'Nourishment keeps up the movement which fever excites. Without food, the soul pines away, goes mad, and dies exhausted. The soul is a taper whose light flares up the moment before it goes out. But nourish the body, pour into its veins life-giving juices and strong liquors, and then the soul grows strong like them, as if arming itself with a proud courage, and the soldier whom water would have made to flee, grows bold and runs joyously to death to the sound of drums. Thus a hot drink sets into stormy movement the blood which a cold drink would have calmed.' [7]

For De la Mettrie it was impossible to reduce mankind to understand him. One can understand something of his nature and behaviour and something of his functioning but can never reduce him as one might a machine of his making.

'Man is so complicated a machine that it is impossible to get a clear idea of the machine beforehand, and hence impossible to define it. For this reason, all the investigations have been vain, which the greatest philosophers have made à priori, that is to say, in so far as they use, as it were, the wings of the spirit. Thus it is only à posteriori or by trying to disentangle the soul from the organs of the body, so to speak, that one can reach the highest probability concerning man's own nature, even though one can not discover with certainty what his nature is.' [7]

Almost a century ago Wyndham Lewis and the Vorticists, foresaw a new humanity unbound from the constraints of culture. They foresaw a being centred in an ego set in the midst of a swirling and energetic extended condition. This new being would be capable of extending the human further and further into the universe, but would always remain centred on an essentially consolidated ego, bound in some fluid manner to the material body. Set in the midst of an emerging technological culture, the Vorticists proclaimed resistance to technology as, 'a vampire sucking the town's heart and as a gloomy circus. It stirs sentimental, nostalgic feelings which stifle the new generation' [2]. The new ego would be a new sense of being that can be understood now, perhaps as a nascent attempt to understand life as something that was embodied and enacted outwards, rather than resolved outside the body and transmitted to it via the senses. Marinetti [16], like Wyndham Lewis, sought to extend the somatic potential of the body beyond its physical border. Marinetti, however, sought to unbind the ego from physicality and saw in this a glorious destruction: 'Art is the need to destroy and scatter oneself.' The 'body' as a contained entity, had no objective meaning for either Marinetti or Wyndham Lewis. For Marinetti this was an optimistic sign of emerging transcendence from the vileness of the biological organism, though Wyndham Lewis took issue with this claim [18].

Behaviorism and Cognitivism

The Vorticists can be understood now as a largely unsuccessful attempt to resist mechanistic models of the human mind and to put in place a more enacted and dynamic model of being. Contemporary cognitive models of the human as a psychology owe much to the emergence of the study of the human mind during the late nineteenth century, particularly to the laboratory work of Wilhelm Wundt at Leipzig University in 1879 and William James' research in the USA. James is widely credited with establishing the form and scope of psychology and to a considerable extent his model shapes psychology today (see [12]). Early psychologists were emerging in a climate where mind and being had become modelled on somewhat mechanistic models of the human. The Vorticist objection was to the emerging project of reduction of the mind to a largely mechanistic model. The implication being that such a mechanistic reduction might set in train the logic that it would be possible to regulate, or condition, human behaviour. Ivan Pavlov is perhaps the best known today among the researchers who established the field of 'classical conditioning'. Pavlov proposed that an entirely predictable and instrumental model of human behaviour and action might be eventually discovered and conditioned. One way to observe the history of design is as a strategy that has tracked the model of the human as a thinking machine. Design has certainly become consolidated in recent times by the collusion of the instrumental and reductivist methods with the introspective studies of Freudian psychoanalysis. Cross [6], for example, has argued that design, as we understand it today, is rooted in the scientific understanding of human behaviour and recalls Van Doesburg's call for a new spirit in art and design:

'Our epoch is hostile to every subjective speculation in art, science, technology, etc. The new spirit, which already governs almost all modern life, is opposed to animal spontaneity, to nature's domination, to artistic flummery. In order to construct a new object we need a method, that is to say an objective system' [6, p.49].

'Behaviorism' became established as a strategy primarily through its application in various forms as models of behaviour and expectation in factories [11] and offices through Gilbreth's ideas of work efficiency and time and motion studies [21] and other Taylorist modes of scientific management in advertising, marketing and market lead ideals of design aesthetics [13]. Pure behaviorism, however, is no longer understood to be a viable model of the human. During the 1960s models of the human as social construction emerged via theorists such as the American psychologist Burrhus Skinner (who had developed the 'Operate Conditioning Chamber' in which animals win rewards by responding to learned stimuli), attempting to establish a verbal model of behaviorist construction [22]. Rather famously Noam Chomsky was moved to public disagreement over the political and libertarian implications of Skinner's model [4]. Skinner proposed that behaviour was determined by the linguistic understanding of the world; such a model remains surprisingly pertinent in semiotic models of design, and arguably in tangible models of interaction also.

It has been suggested that Chomsky misunderstood the subtlety of Skinner's thesis; nevertheless it is now widely held that Chomsky's criticisms of Skinner can at the very least be seen to encapsulate a new intellectual move during the second half of the twentieth century. Like the Vorticists some half a century before this new move would be against reductivist and behaviorist models of being and towards a reinvigorated model of the human as a significantly more complex construction. If Skinner can stand, for the sake of argument, for a mechanistic model of human understanding that suggested knowledge was externally acquired, then Chomsky argues for a much more subtle coding of human behaviour that results from deep structures of innate behaviour of the species [4]. If this shift tells us anything, it illustrates a dramatic move towards understanding the human as an internally reducible mechanical object - as opposed to external behavioural states - fundamentally separating the cognitive attributes of the human species from the body and world. The intellectual transition provided by Chomsky, among others, in the mid-twentieth century had much bearing on the so-called 'cognitive revolution' within psychological disciplines, notably through the loose federation of sciences dealing with knowledge and cognition – the cognitive sciences. For interaction design this can be seen as an historically significant move, especially within the precise context of Human-Computer Interaction (HCI) where the development of technology and the interaction modes provided was both influenced and provided impetus to the understanding of the human as cognitive, information-processing, and disembodied beings. The interaction designer here becomes a manager of the symbolic communication between two systems of rational logic - the computer and the cognitive apparatus of the perceiver - in order, theoretically, to attune interactions to be as seamless as possible ([26] provides a more detailed explanation of the limitations of this method).

2.4 Phenomenology and Embodied Interaction

In recent times there have been attempts to bring the intellectual impetus of cognitive science together with phenomenological philosophy, particularly the work of Maurice Merleau-Ponty [17] and to some extent in the earlier post-Hegelian ideas of Heidegger and Husserl. These philosophies deal with the 'embodied' experience of being in the world, rather than the constructed cultural conceptions humans build about themselves. The relationship between embodiment and cognitive science will be discussed further below. Before this discussion though, it may be that the term embodiment is already familiar to the interaction design community as a result of Paul Dourish's [9] introduction of the concept to the context of human interactions with digital computer systems and artefacts. Dourish presents a model of 'embodied interaction' through drawing heavily upon a number of the key figures in phenomenology that he identifies as important to the development of embodied interaction; Husserl's phenomenology; Heidegger's hermeneutic phenomenology; Shultz's phenomenology of the social world and Merleau-Ponty's phenomenology of perception. It appears that, in his choice of phenomenologist, Dourish is intent on positing embodied interaction as a methodology that resists genealogy in structuralist or cultural–theoretical method and thereby eschews the orthodox history of interaction design. He starts from his summation of embodied phenomena as 'those, which by their very nature occur in real time and real space'. Dourish proposes that 'embodiment is the property of our engagement with the world that allows us to make it meaningful' [9, p.126]. He locates interaction design in phenomenology by arguing that the physical experience of being-in-the-world cannot be separated from the 'reality of our bodies presence in the world', hence 'Embodied Interaction is the creation, manipulation, and sharing of meaning through engaged interaction with artefacts.' [9, p.126]

Reflecting on interaction design history as it is written, Dourish suggests that the design of human technological interaction has shifted from a focus entirely in the machine foundation in protocols (switches, dials, etc.) towards tangible models of interaction that are distributed and *intuitive. Examples are posited of digital systems that 'lend* themselves naturally' [9, p.42]; these are interactions where people appear not to have to think to act. Dourish is rather uncritical in his understanding of an action; he does not explore what difference there may be between natural or tacit actions, for instance.

Dourish outlines the framework of social computing and, reflecting the thinking that prevails in contemporary design communities, argues that sociological approaches should underpin interaction methodologies. Dourish describes how, after Suchman [23], interaction can be understood as an activity system; we have certain behaviours when we are engaged in activities that interaction designers would be wise to build upon. In this context, tangible interaction and social interaction appear to have a lot to offer one another, Dourish arguing that both aim to 'smooth interaction by exploiting a sense of familiarity with the everyday world' [9, p.99]. He calls upon the concept of metaphorical interaction, but goes on to propose that a collision of ideas of situatedness with ethnomethodological approaches will bring individual experience into the social frame.

ENACTED EXPERIENCE

Enactive Cognitive Science

It is possible to contrast Dourish's interpretation of embodiment as a socially conditioned situation to a slowly unveiling paradigmatic shift within the aforementioned cognitive sciences, where there appears to be a slowly growing conviction that the Cartesian picture of formal, logical, well-defined units of knowledge is upside down; that a radical paradigmatic or epistemological shift is rapidly developing. At the very centre of this emerging view is the belief that the proper units of knowledge are primarily concrete, embodied, incorporated, and lived [24]. Neuro-psychologists, such as Bermúdez and colleagues [1] have argued for some time that the body is the foundation of the sense of the self. In recent years, works such as Lakoff and Johnson [14] and Varela, Thompson, and Rosch [25] have laid out embodied approaches to cognitive studies that attempt to understand what it means to be human in everyday, lived experience. 'If we examine the current situation today, with the exception of a few largely academic discussions cognitive science has virtually nothing to say about what it means to be human in everyday, lived situations' [25, p.xv].

Embodied approaches to understanding human cognition mark in some respects the intellectual drift toward connective, rather than reductive, thought. Emerging from what might be termed an orthodox scientific methodology, embodied understandings of cognition attempt to bring rigour to the subjectivity of lived experiences. 'On the other hand, those human traditions that have focused on the analysis, understanding, and possibilities for transformation of ordinary life need to be presented in a context that makes them available to science' [25, p.xv].

Varela, Thompson and Rosch's The Embodied Mind can be understood as an attempt to reconnect separations of mind, body and world and to bring these hitherto separate epistemes into one conversation. By understanding that the human experience of being is inseparable from the physicality of the reality in which it is situated, an alternative is posited to representational models of cognition in which the world is understood as filtered *through senses, rather as one might experience a gigantic* and immersive picture show. Varela and his co-authors offer 'embodied' models where the world is 'enacted' through series of complex 'structural couplings' – that is, many tiny connections of sense, experience, imagination, memory, knowledge and other somatic systems, interacting to form a meshwork of impressions of being in the world. If representational models suppose a fixed world that is experienced, then the world in embodied thinking is entirely constructed. Varela's concept of 'structural coupling' reflects, although differs from, James J. Gibson's earlier model [10], which while rejecting representation relied upon a largely visual model of the world, albeit one determined by species and habitat. Where Gibson recognises that the experience of the world is determined by the way in which a species is independently evolved in it, Varela and colleagues describe an 'enacted' concept that distributes the world into the species, and the species into the world. Taking this position, the world is understood to be a lived experience enacted in somatic functions, and so humans must learn to be in the world. While some aspects of that world are constructed for some humans by others, this does not mean that these aspects necessarily contain any truth about the world. Dennett [8] sets out a neat and concise review of Varela's 'enactivist' approach in opposition to the dominant 'cognitivist' approaches to cognition:

'*Question 1:* What is cognition?

Cognitivist Answer: Information processing as symbolic computation-rule-based manipulation of symbols.

Enactivist Answer: Enaction. A history of structural coupling that brings forth a world.

Question 2: How does it work?

Cognitivist Answer: Through any device that can support and manipulate discrete functional elements; the symbols. The system interacts only with the form of the symbols (their physical attributes), not their meaning.

Enactivist Answer: Through a network consisting of multiple levels of interconnected, sensorimotor subnetworks.

Question 3: How do I know when a cognitive system is functioning adequately?

Cognitivist Answer: When the symbols appropriately represent some aspect of the real world, and the information processing leads to a successful solution to the problem given to the system.

Enactivist Answer: When it becomes part of an ongoing existing world (as the young of every species do) or shapes a new one (as happens in evolutionary history)' [8, pp.206-207].

Implications of Enacted Experience

Perhaps the easiest way to emphasise the difference in these approaches might be to consider the act of speaking. A cognitivist approach might focus upon the meaning and construction of the words. How has a vocabulary been learned; what is the value of the words used; how are the words used differently in cultures and in changing contexts, for example. An enactivist approach might study the processes whereby the words are formed nonconsciously by the tongue in the palette; how this process is learned as a child; how words are assembled in the mind prior to their vocalisation and how in conversation their delivery is nuanced, seemingly without any thought being given to the process on the part of the speaker. The enactivist approach places the somatic system at the centre of the process. Assuming the speaker does not speak from a predetermined script, many systems are at play in the formation of the conversation in design terms. Re-contextualising Dennet's review into the realm of designing technological interactions has profound consequences for the way in which we might understand the processes designers implement when relating human beings to technology.

Question 1: What does design do when it humanises technology?

Cognitivist Implication: Design manipulates symbolic images by which people read the world so that they can make sense of and give value to technologies (semiotics).

Enactivist Implication: Design enables people to enact in the world by enabling potentiality of the whole human as a distributed soma (Holsomatic).

Question 2: How does design work?

Cognitivist Implication: Designers create the means to project simple or multiple and complex symbolic meanings. These symbols are primarily experienced by people in reference to a codified cultural understanding of referents.

Enactivist Implication: Designers intervene in the complex processes by which people form an experience of their world. Their task is to enable people to experience the world 'naturally' without necessarily needing to attach meaning to individualised interactions.

Question 3: How do I know when design is functioning adequately?

Cognitivist Implication: When people understand the symbols they encounter and react appropriately.

Enactivist Implication: When people incorporate the designed world seamlessly as part of their experience of being.

In taking each question in turn and looking at the implications for design in the 'cognitivist' and 'enactivist' answers to each question it becomes possible to see how enacted or embodied approaches to cognition place a rather different emphasis upon the realisation of the self as a constructed (cognitivist) entity in separation to technology or a self-enacted construct formed through complex coupling in which technology is understood to be coextensive with the soma (holsomatic). Looking back at Dourish's understanding of embodiment as a socially conditioned situation, and its subsequent adoption within the interaction design community, is somewhat far removed from Varela's understanding of embodied and enacted cognition through 'structural coupling'. Dourish appeared to be on the brink of a profound move, towards a distributed view of cognition and the soma, but returns the interaction design discourse to the safety of materiality and behaviorism. Arguably, then, rather than transforming the discourse, Dourish entrenches it in its methodology of analysis. A design methodology that calls for familiarity as its guiding principle is likely to find it difficult to progress, especially when the interaction with a potential new technology may be considered ineffable.

CONCLUSION

This paper has discussed how the diverse disciplines drawn upon and applied by interaction designers have a history of mechanising human experience into reducible and scientifically observable behaviours or measurable cognitive phenomena. In this paper we have attempted to fathom how interaction design might be able to integrate itself as a strategic practice in light of an alternative argument of holsomatic experience, or more broadly that of being enacted, embodied and extended. The paper has discussed how Dourish's 'embodied interaction' has provided usefulness for understanding the lived experience of human interactions with technology but is restricted by grounding itself in the contemporary trajectory of interaction design. In highlighting the implications of enaction to designers, the paper attempted to provide speculative foundation to a potentially profound shift in the contemporary discourse of interaction design from models of humanity that are dominated by the social reduction to behaviours or a cognitive reduction to particular mental processes.

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9.2.3. 'Body, World and Affordance: Towards Engaging Technological Artefacts for Older Individuals'

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BODY, WORLD AND AFFORDANCE: TOWARDS ENGAGING TECHNOLOGICAL ARTEFACTS FOR OLDER INDIVIDUALS.

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This paper addresses the problems older individuals have been observed to encounter when engaging with technological artefacts and how such difficulties may relate to the designers understanding of the normal cognitive ageing process of human beings. This paper suggests that these problems may not be the result of limited cognitive abilities of certain older individuals but rather the manner in which designers understand the complex relationship between the mind and actions in the world. The paper speculates that an alternative perspective on interactions as affordances that occur between the embodied individual and their ecology may benefit design methodologies deployed in creating engaging technological artefacts for older individuals.

INTRODUCTION

There has been growing discussion within the design community regarding the response to the ageing populations of many Western European nations for a number of years. One subject within this area that has generated discussion is the effects cognitive changes have on an older individual's ability to perform certain technology-mediated acts, such as using personal

computers, mobile phones and home audio/visual equipment. Although there appears to be no formal methodology that designers follow when developing cognitively inclusive technological artefacts for older

individuals, there are cases of designers drawing upon knowledge within psychological disciplines that discuss cognitive change. This short paper notes that based upon this knowledge designers may be able to improve the usability of technological artefacts for certain tasks but the resulting interactions may not be considered as novel or engaging.

This paper will briefly overview some of the cognitive changes psychological disciplines associate with the normal ageing process of the human brain. These changes will then be unpacked in relation to the methods and techniques certain designers have used when developing new technological artefacts for older individuals. It will suggest that these methods reduce the mind to discrete processes for exploitation by the designer, which might not be productive in the development of engaging technological interactions for older individuals. The paper will introduce an alternative body of evidence based upon theories of cognition that suggest an individual's cognitive abilities are embodied within the capacities of their particular physiology and enacted within a certain ecology. The paper will argue that the model of interaction underpinning these theories determines that engagement with technological artefacts is a continuous moment-by-moment reassessment of affordances that couple together the sensorimotor capacities of an individual and the ecological environment. The paper speculates that design methodologies relating to the creation of engaging technological artefacts for older people may benefit from considering their changing capabilities in relation to this dynamic model of experience and interactions as affordances.

AGED COGNITIVE ABILITY AND DESIGN REDUCTIONALISM

Designers have often drawn from the disciplines of psychology and neuropsychology in order to understand the changes in the mind as people age, with the intention of relating such changes to the designed world. Neuropsychology traditionally studies and identifies how mental activity relates to certain behaviour, stimuli and pathologies. Francisco Varela and colleagues (Varela *et al.* 1991) argue that such a method is a result of a long standing notion that treats the mind as an information processing machine that can be reduced down to specific processes representing external phenomena, actions and behavioural traits. In the cases of older users of technologies, the processes most often attributed to restricted abilities to engage with emerging technologies are related to an individual's memory and intelligence. Specifically, the areas that relate to working memory and fluid intelligence are widely considered as causing the most difficulties (Stuart-Hamilton 2006, Birren and Warner Schaie 2001). These processes will be briefly explained below.

Working memory is considered the feature of the short term memory system that allows an individual to not only keep information in conscious thought for a short to medium length of time, but to dynamically manipulate such information. Psychologist Alan Baddeley claims this is of particular use in activities that require learning, reasoning and comprehension (Baddeley 1986). It is widely noted that working memory declines in older age (Salthouse 1994), along with the explicit recollection of long term memories (e.g. Smith 1996). However, certain abilities related to long term memory, such as implicit knowledge of previously gained skills and knowledge of words, are shown to be robust later in life (Smith and Earles 1996).

Raymond Cattell (1971) described fluid intelligence as the ability one has to decipher new information or situations without the need to draw upon any prior experience. This is often opposed to crystallized Intelligence, which is the coming together of past skills, experiences and knowledge that may be recalled to be used once again (Cattell 1971). Various lab studies have observed a lowering of fluid intelligence later in life and little change in the crystallized processes (such as Hayslip and Sterns 1979, Singer *et al.* 2003). Much as with the changes observed in studies of memory, this suggests older individuals are less able to develop the skills required for certain 'new' experiences, yet have a wealth of previous knowledge that is still accessible.

Some design researchers have noted that the research within psychological disciplines on ageing intelligence and memory may be of value to designers of new technological interfaces. Mary Zajicek identified how the changes observed in the cognitive abilities of older people could relate to problems that occur upon the use of screen-based computational interfaces, fitting *'precisely the type of exploratory learning required for computer use'* (Zajicek 2001, p.2). Zajicek recommended that certain measures should be taken by designers of interactive technologies in consideration of these reduced cognitive abilities, such as simplifying the functionality of a particular interface by reducing the amount of information that is required to be stored in short term memory. Similar conclusions have been made by a number of HCI and gerontology researchers over the past decade, often resulting as sets of guidelines for the usability of new technologies for aged cognitive ability (such as Schieber 2003).

Other practitioners have attempted to reduce the effects of the presumed cognitive change by avoiding the use of the restricted abilities and exploiting the 'healthy' processes of memory and intelligence. Milli Docampo Rama is one such practitioner, investigating the idea that each generation of certain age ranges belong to particular generations of technological interaction (Docampo Rama 2001). Docampo Rama's research was based upon a cross-validation between sociological, psychological and child development research that had suggested the experiences one has between the ages of 10 and 25 years most strongly shape personal values and skills used in the future (Sroufe and Cooper,1988, Glenn 1974). Docampo Rama integrated this argument with a historical study of technological interfaces through the 20th century to establish a series of technology generations that certain generations of people belong to. It was argued that the integration of previously gathered knowledge from this earlier period in an individual's life harnessed the healthy and able processes of his or her memory, whilst removing layers of complexity reduced load on the less able working memory processes. Tim Lewis (Lewis 2007) and colleagues have explored

Docampo Rama's claims further through usability studies of older people using certain technological products – such as microwaves – with differing levels of interface generations, from mechanical-esque to digitised software-based interfaces.

In certain cases design methods derived from psychological studies of aged cognitive ability can provide heightened level of 'usability'. This paper questions, however, whether a reliance on the past, metaphor, analogy and a discrete understanding of memory constitutes the development of novel and engaging technological interactions for the older individual. In using the knowledge from the psychological disciplines the designer becomes a limiter of potential interactions as opposed to allowing an engaging reciprocation between an older individual and the technological artefacts they encounter.

These approaches take the world as a discrete set of properties that are symbolically stored across the mind for later retrieval. As such, this leads to designers adapting cognitive change through identifying which of these symbolic representations in the mind work still and those that do not, and designing technological artefacts accordingly. An alternative perspective on the relationship between the mind and actions in the world that does not observe the mind as an information processing machine is provided within the embodied and enactive cognitive sciences.

THE ROLE OF BODY AND WORLD

The perspectives outlined above rely heavily on the idea that the mind sysmbolically represents certain external phenomena and treats this as the central 'computational' processing device of human consciousness. Opposing this, embodied models of cognition argue that perception and cognition result from the physiology of the whole body (Lakoff and Johnson 1999, Gallagher 2005). An embodied perspective on cognition takes the experience of a particular individual occurring as a result of the combined sensorimotor capacities (sensory organs, muscles, bone and skeleton structure etc, and the actions these allow) that their body provides. Francisco Varela and colleagues determined that embodiment unifies the perceptual and action capabilities of an individual. Perception and action '*are fundamentally inseparable in lived cognition. Indeed, the two are not merely contingently linked in individuals, they have also evolved together*' (Varela *et al.* 1991, pp.172-173). The model of cognition outlined by this group of researchers suggests that it is no longer possible to separate the mental processes from actual, lived experience. Within this body of opinion the processes of the mind are not a collection of symbollic representations of an outside world that can be discretely exploited; the mind is dynamic and fully intergrated within the actions, interactions and world an individual finds themselves in (Maturana and Varela 1987).

This argument does not stop at the notion of the mind as embodied, as this body is situated in a particular world, or ecology, and is acted, or enacted, within it. Sensorimotor actions both inform and are informed by the wider ecological environment an individual is situated within and the action possibilities it provides (Abram 1996, Noë 2004, Gibson 1979). James Gibson's theory of ecological perception introduced the concept of affordance (Gibson 1979). Gibson claimed that the potentiality for interaction in the environment is one of a mutual conversation between an individual's physiology and the objects, surfaces and artefacts that are perceived at a moment in time (Gibson 1979). Gibson's affordances (not be confused with Donald Norman's adaptation of the concept (Norman 1999)) are invariant properties of the environment; an affordance either exists or it does not. A particular affordance may not be perceivable to a particular individual as a result of his or her embodied sensorimotor capabilities, however, that is not to say the affordance does not exist for others. As a result of this mutuality with the physiology of an individual, affordances can be discovered and lost. A branch that affords climbing up to and swinging on for a child one summer may not the next. This is a significant feature of the theory of affordances, as it suggests that the invariant potentials for interaction are been dynamically continuously reassessed.

Alva Noë expands upon Gibson's concept of affordance to include the ability for an individual to extend and master their sensorimotor skills, '*the possession of which enables a situation to afford an opportunity for action not otherwise available*' (Noë 2004, p.106). Noë uses the example of how a baseball bat may afford little to one individual, but to an individual whom has mastered the skill or is in the process of doing so, it may afford the hitting of an appropriate ball a long distance. This suggests that memory is a dynamic process of the sensorimotor activity that is in continual change; it does not merely act as a static store of information to be referred to but is in a constant fluxation based upon current and planned action in the world (Edelman 1992).

IMPLICATIONS

The current direction of the design of technological artefacts inclusive of cognitive change in older individuals draws heavily from Psychological studies of memory and intelligence. As a result of this, the designer relies upon a method of distinguishing how the design of a particular object relates to the reduced processes of the brain that are considered either healthy or unhealthy in old age. This creates a situation where designers have relied heavily on past experience and simplification of interaction possibilities in order to restrict the claimed affects of cognitive ageing. Theories of embodiment and enaction argue that such a reductionalistic method of understanding action and interaction in the world ignores the dynamic nature of the continual reassessment of mutual affordances between the human sensorimotor capacities and the environment. It is not as simple as reducing cognition, history and experience into discrete factors for investigation, but instead to understand how the individual is in a constant state of flux unified with the activity of the body and the broader environment.

For a designer this would require them moving away from a method that encourages the investigation of the discrete facets of long term memory and intelligence and explicitly introducing past meaning and experience into the technological artefacts they create. Rather, this alternative perspective may remove evidence of the designer, developing technological artefacts that allow for the engagement and interaction with any particular individual – be they young, old or non-human – based upon their particular sensorimotor capacity and the affordances and engagements it allows.

The brief discussion of embodied and enactive forms of cognition has not touched upon how this is affected by certain changes in an individual as they progress through lifetime. Firstly, this is a result of there being little to refer to regarding the intersection between the two subjects – studies of aged cognition, which itself is an ever growing area of investigation, are still based upon an information processing model of the mind. Secondly, it could be speculated that to a proponent of embodied and enactive cognition ageing as a concept may not exist; all that is observed is an alternative set of affordances and mutual couplings between an individual and the environment. Rather than considering a particular person as having 'aged cognitive ability' as they no longer reach the standards set by much younger members of the population, they are just seen as individuals with certain sensorimotor capacities that inform their activity in the world.

Some of the difficulties that theories of embodied and enactive cognition provide for designers is that the language used by either discipline is not coextensive with one another. Future research will have to reframe the terminologies of either field in a manner that is cohesive and induces collaboration and builds upon these synergies. This short paper takes a tentative step towards speculating the usefulness of these models to designers that are relying more frequently on psychological disciplines to provide insight into particular aspects of human behaviour.

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9.2.4. 'The Ageing Present: Neurophysiological change and the relational affordances of technological objects'

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The Ageing Present

Neurophysiological change and the relational affordances of technological objects.

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Abstract: This paper outlines a doctoral thesis investigating claims that difficulties older people encounter in comprehending new technologies may be accountable to a reduced cognitive and neurophysiological capacity that occurs in later life. The thesis questions whether understanding an individual's experience of technology within a reduced and predetermined cognitive model is suitable in design methodologies attempting to alleviate these difficulties. A body of knowledge opposing this view is introduced arguing that neurophysiological change should not be considered through an internal schema but in the way it relates to the wider physiological and ecological context a person is situated within.

1. Original Key Idea

The thesis argues that product and interaction design research should more fully account for neurophysiological capacity in the design of dynamic systems of affordances that emerge between organisms and objects in the development of novel technological experiences for older users.

2. Problem Domain

The thesis is situated within the context of product and interaction design research and the role it plays in the context of an ageing Western European population [1]. The problem attended to by the thesis stems from the difficulty, observed within various disciplines, that in older age it becomes more difficult for a person to participate with and comprehend new technologies [2]. Numerous factors could influence this difficulty in participation; social, financial, cultural, psychological, health etc, many of which have been examined previously within design research. However, this thesis is particularly interested in claims emanating from cognitive science and cognitive psychology that changes in cognitive ability in the later life of most adults results in a reduction in the abilities required to learn a new technology [3-5]. This claim is coupled with other neurophysiological claims that older people have differing levels of activity in brain regions that may relate to this loss in ability [6]. The thesis reflects upon these claims and questions whether the application of research from the cognitive disciplines may be appropriate in the design of new technological objects for older people, and whether there might be potential to provide an alternative route for design research in this area.

3. Related Work

Cognitive science and psychology has traditionally argued in favor of a cognitive model of the human mind. It appears that cognitive models are based on the understanding that mental phenomena are fundamentally computational in their operation and that the brain acts as a form of central information processer managing an individual's perceptual input and respective motor output [7]. Resulting from this, it has been plausible to suggest that the responses to particular phenomena, such as aspects of computer interfaces, can be predetermined through understanding the cognitive schema of a particular group of individuals. Researchers within the cognitive sciences and psychologies have gone to great lengths in attempting to understand how the cognitive model differs in later life and how this affects competencies on certain tasks. Within such studies, it appears to be widely agreed that cognitive systems related to the forming of abstract concepts, the holding of information in short term consciousness, and explicitly recalling certain long term memories reduce in functionality in later life [3, 5]. Studies from this area have also established that the cognitive systems that unconsciously recall and draw upon past experience and knowledge (particularly language and procedures) show little alteration in ability [3, 8]. Neuroscientific research suggests that these changes observed through cognitive modeling may be mapped onto actual physiological alterations that occur in human neural circuitry in later life [6].

HCI and interaction design research has drawn upon cognitive models of the mind previously in an attempt to form strategies for designers to implement when developing technological interfaces that are inclusive of older people [9]. When the cognitive model of older people is integrated into design research it commonly leads to the development of interfaces that avoid the need to use the less competent cognitive systems and/or exploiting the systems that do not alter. Essentially, this suggests that in order to be less cognitively demanding on an older person, technological objects are designed in a manner that draws upon past knowledge through an emphasis on interface metaphors and analogies [9, 10]. Although logically implemented in design research, the application of the cognitive model of mind presents situations where dramatic neurophysiological alterations in a person are modeled in a mechanical and systematic manner; however, the strict predetermined nature of the cognitive model does not meet the requirements of a group of users in a state of rapid neurophysiological change. The application of this model in design research methodologies and practice is also problematic as a result of the reduced level of ability through which the cognitive model claims older people experience the world. In design terms there appears to be a reliance on the construction of past events in human memory as the determining factor through which older people experience a new technology. This presents situations where the older participant is only ever engaging with a new technology based upon metaphors and analogies of past experiences, as identified by the designer, rather than being presented an opportunity to engage their own level of meaning creation.

4. Research Goal and Methodology

A broad review of literature identified the diverse and inter-disciplinary nature of research concerning the relationship between the design of new technologies and internalized changes that occur as people age. From this review it appears that contemporary design research has not addressed discussions of neurophysiological change beyond of the cognitive model of the mind. The thesis speculates that current methodologies and practices within interaction design are limited in their response to this problem due to the rather mechanistic model of cognition and human experience they draw upon and apply. Resulting from this initial discussion, the thesis questions: *Can a broadened understanding of human consciousness in relation to the neurophysiological changes that are claimed to occur in later life provide a less restrictive account of technological interaction for older people?* The aim of this research is to provide an account of human interactions with new technologies through the strategy of investigating the role of the changing neurophysiological capacities of older people as a technique in design. This aim requires the thesis to discuss ideas, concepts, models and language, which have rarely been cited in the design discourse.

As a method, further review of literature and discourse analysis will be applied to address this problem and examine the manner in which designers draw upon the claims from the fields of cognitive science and psychology in order to identify if they provide a suitable response. By approaching the problem in this manner avenues of dialogue are identified, as proposed below, that have not being considered within discussions of the design of new technological objects in relation to the changing neurophysiology of older people. These bodies of knowledge will be integrated into the argument of this thesis along with an analysis of case studies, which together will provide a revised basis to critically engage with current design interventions. The thesis intends to provide a valuable contribution of knowledge for the product and interaction design community that enables to establish a new perspective on understanding design responses to the aging mind.

5. Preliminary Outcomes

The thesis has identified how the cognitive sciences can provide an alternative modeling of how human mental abilities relate to interactions in the world by acknowledging change. In this area of research, often referred to as the embodied and/or enactive cognitive sciences, it is argued that the neurophysiological and mental capabilities of an individual are shaped by the sensorimotor capabilities of their whole body [11]. The whole body itself is situated within the context of an ecology [12]. Arguably, this mode of thought differs from the dominant cognitive paradigm in its move away from relating human-technological interactions as being pre-determinable on the basis of an internal cognitive schema. Rather, it is intended to understand the transactions between embodied organisms and their ecology. These transactions may be understood as relational affordances that are in a constant state of flux [13]. Approaches based upon this particular understanding of cognition have been studied within areas related to human-machine interactions, often within the context of robotics and artificial intelligence [14, 15] but not to such an extent within HCI and interaction design practice. Embodied and enactive research provides a more dynamic account in relation to the neurophysiological changes that occur in later life, which is not offered by applications of the mechanical cognitive model. Rather than determining interaction based upon a predetermined and concrete cognitive schema, the human participator is portrayed as in a constant state of flux in their transactional relationship with the ecology. It is possible to speculate that new technological systems based upon this paradigm would be as open-ended and provisional rather than closed and concrete; this conception may be of particular benefit in the context of aging individuals whom are experiencing neurophysiological change but it may also have implications beyond this group of potential users.

6. Future Research

The preliminary outcomes of this research suggests that the discussion of interaction design in the context of older people with differing neurophysiological capacities requires a similar paradigmatic shift as has been identified within the cognitive sciences over the past two decades. This requires the thesis to reconsider the terminologies, methods and practices employed in this area of design research, from that of the cognitive to the embodied and enactive. By identifying the terminologies and language of this alternative perspective and the usefulness of the associated approach the intervention must continue to be accessible to the design community. The next stage of research includes the continued re-evaluation and contextualization of this alternative body of knowledge in relation to both the established practices of designing for neurophysiological change in later life and the research goal of establishing new practices and research methods/tools for designers to apply.

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9.2.5. 'The Mind Cupola and Enactive Ecology: Designing technologically mediated experiences for the Aging Mind.

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The Mind Cupola and Enactive Ecology: Designing technologically mediated experiences for the Aging Mind

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This paper attends to research within the Human Computer Interaction (HCI) community that aims to make the learning of new technological interfaces more inclusive of older individuals. In particular, the paper unpacks the problematic nature of improving the manner in which the designers of such systems aim to provide an implicit learning process through remediation and metaphor. This paper speculates an alternative approach to conceptualising the learning process by making a distinction between designing for *invisible* usability and *transparent* creation of novel meaning. An example of a technological system that incorporates the concept of transparency is introduced in the form of The Mind Cupola (Zics 2008). It is argued that The Mind Cupola, which is described to be an affective technology-mediated environment, may provide human-technological relationships that highlight aspects of conscious reflection in the participant, supplementing the level of unconscious immersion that is normally the intent of the designer. It is suggested that in highlighting the dynamic and transformative aspect of such interactions, the Mind Cupola provides a perspective on Inclusive HCI that aligns itself with the idea of meaning being enacted by human beings in an emergent system of affordances between the participant, the technological system and the designer.

1. Contemporary Inclusive HCI and Invisible Learning

An 'Inclusive' philosophy to design is about making products, services and built environments accessible to as many people as possible (Coleman 2008). A key focus of Inclusivity research over the past decade has been the rapidly ageing population of many Western nations (Coleman 2008). In this paper, the authors deal with the specific problem of understanding how HCI designers may improve the Inclusivity of new technologies for older people. In particular, it appears that the Cognitive Modelling of older people has had a significant role upon the design and usability guidelines that surround the Inclusive HCI discourse.

1.1 Cognitive Modelling as Prominent Approach to Inclusive HCI

Cognitive Modelling is an approach to understand the human mind popularised within the discipline of Cognitive Psychology in the later half of the twentieth century. It is founded upon the hypothesis that the processes of the mind can be separated from the perception of information in the world and resulting behaviours (Niesser 1967). This approach rationalises human behaviour, suggesting that if we are able to comprehend the Cognitive Model of a particular person then, given a certain sensory input, the behavioural output could be somewhat predetermined (Winograd and Flores 1986). A Cognitive Modelling approach to HCI suggests that the designer can plan for how a user may act with the technological interface by understanding the various systems and sub-systems of their internal cognitive schema. Approaches to HCI that apply Cognitive Modelling of the user as a way of planning for how they will interact has been heavily criticised by various scholars in the past (Winograd and Flores 1986, Suchman 1987, Coyne 1995, Agre 1997). In regards to developing Inclusive HCI for the aging population, however, there appears to be a reluctance to move away from such a method for conceptualising interaction.

A prominent feature of HCI historically has been the remediation of existing tools and practices as a way of communicating an objects use to the user. Early examples, such as Sketchpad (Sutherland 1963), oN-Line System (English, Engelbart and Berman 1967) and Dynabook (Kay 1968), have left a legacy in which the hardware and software followed a largely symbolic and metaphorical form of communication to the user. In more recent history there have been attempts to move the dependency in HCI on graphical and remediated metaphor, towards forms of computing focused more upon how meaning is generated through physical and social context (Dourish 2001). However, it appears that the continued application Cognitive Modelling within Inclusive HCI for older people has lead to a dependency on using remediation of past technologies.

Figure 1 Initial HCI interventions, Sketchpad by Sutherland (1963) (*on the left*) and Dynabook by Kay (1968) (*on the right*), remediated (pen and the typewriter) the human-tool relationship in order to produce initial applications of human-computer relationship.

Why might Cognitive Modelling, heavily criticised by HCI discourse, still be popular within the domain of HCI and ageing? It may be in part down to their being a broad consensus that the measurable cognitive changes that occur in later life have a significant relation to changes in human behaviour (Stuart-Hamilton 2006). The crux of what the Cognitive Modelling of older people suggests is that they will always struggle to make sense of the new once the normal ageing process moves beyond a certain point. Age-related usability expert Mary Zajicek (2001 p. 2) noted that the cognitive changes: '...fits precisely the type of exploratory learning required for computer use' and, as a result of this, there is 'not only a need for familiar technology but for a learning method which makes the user feels more confident in their own ability to learn'. Resonating on what has become a key area of research Zajicek explains the importance of learning methods that attempt to develop more familiar technological interactions for older people in light of the claims from the ageing Cognitive Model. Through accounts such as Zajicek's it can be observed that Inclusive HCI designers appear to focus upon the role of remediating past technologies in order to provide metaphorical expressions of the new and create invisible learning processes and usable devices for older people.

1.2 The Problematic Application of Cognitive Modelling in Aging

Mili Docampo Rama (2001) provides an oft-cited example of such Inclusive HCI research, highlighting that the technological systems encountered between the ages of 10 and 25 years are key to the learning strategies deployed in attempting to adapt to a novel computer-based graphic user interface once certain cognitive abilities decline through normal ageing. It was noted how for many current older people, the dominant 'software' approach to technological interfaces was incomparable to the 'electro-mechanical' generation of technologies they experienced at a younger age (Docampo Rama 2001). Docampo Rama (2001 p.108) suggested that: '...the re-introduction of electro-mechanical style concepts such as the one-to-one relation between function and button' and '...understandable direct feedback about the state of the device' increase the straightforwardness of the older persons use of the technology and to '....reduce the load on a number of cognitive skills that are known to decline with age'. Although Docampo Rama provided only a limited account on this, researchers working with the area of Inclusive HCI and product design have extended her research in developing technological interventions for the aged that rely more upon metaphors to past technologies in order to decrease complexity and improve the intuitive properties of the interface (Blacker, Popovic and Mahar 2003, Lewis 2007). This paper sees these approaches as problematic as they rely upon a learning process centred on a generalisation of past experience of technology, which appears to suppose that the personal histories of a few may be transferable to people of the same age. Through the deployment of this approach, the designer takes a central role in the creation of meaning by the user, restricting exploration and the agency of the older person as a creator of their own meaning through their relationship with the technology.

2. Moving from Remediated Invisibility Towards Novel Transparency

In order to move from the limitations of the above approaches we might start thinking about developing technological systems inclusive of older users that are adaptive to their particular contingencies, but do not restrict the meaning of interaction to a remediation predetermined by the designer. It appears from the above discussion that the HCI community, particularly in the context of designing to be inclusive of older people, are continually looking to achieve interactions affording continuous and immersive states where the technological object disappears from the conscious observation of the user. Some further insight and conceptual differentiation on this matter is provided by Martin Heidegger's (1962) concept of the tool (or *equipment*). As discussed above, it could be suggested that there is a continuous by the Inclusive HCI designer to provide a 'ready-at-handiness' where the user is already a master of the tool they have been presented with. Heidegger used another definition of 'present-at-hand' to describe situations where a person attends directly to the object with conscious intent. As such, Heidegger describes two different types of technological interaction where the technology of use is either *visible* or *invisible* to its beholder.

2.1 Invisibility Versus Transparency

Although the mastering of the tool – making it ready-to-hand – is the optimal desire of the designer, in this paper we are attempting to move from a typical sense of using a tool for the purpose of a particular task towards facilitating situations where novel forms of meaning may be established. It could be suggested, therefore, that a distinction can be made between facilitating a stage between the purely *invisible* and *visible* stages of interaction, through understanding the interactive process as levels of *transparency* (Zics 2008). *Transparency* in the human – technology relationship could be considered as an oscillating process where the designer, through their organisation of the 'enactive interface' or how here will be termed the Transparent Medium, allows interactions that are in a constant state of flux between reflection and pellucidity. This implies that these interfaces incorporates a reflection process (being visible) as a meaning creation into the interaction, favouring a learning process of the user to inhabit novel meaning. This approach, which also resolve the limitation of Heidegger's concept explaining only two possible states of the tool user (Ihde 1991), suggests a great spectrum of states of the user accommodating dynamic evolving of new meaning.

2.2 Transparent Medium as Dynamic Seeing

Although *invisibility* and *transparency* have been discussed in the HCI community it has remained a confused concept. This may be a result of there been little phenomenological differentiation between the state of being pellucid (invisible) and being reflective (non-invisible). However, it may be possible to gather insight from art communities, where scholars have argued that HCI should 'explore the meaning of the interface itself' (Rokeby 1995, p.133) as opposed to a designerly interest the illusion of invisibility. Tiffany Holmes (2002) provides a useful example in the notion of Dynamic Seeing. Dynamic Seeing refers to the design of one's experience through the oscillation between interface visibility and invisibility that occurs through the spectator's processes of mastering the tool and uses this ability to explore the content of the medium. Holmes argued:

> ...that the most engaging component of interactive works is not the actual action or gesture performed by the navigator but rather, the process of actively learning to self-direct one's own passage through a piece. The interactive art experience is one that blends together two individualized narratives. The first is the story of mastering the interface and the second is about uncovering the content that the artist brings to the work. (Holmes 2002, p.90)

Whereas the contemporary Inclusive HCI community provide an invisible process of interaction and use, artists inventing interfaces argue for a greater account of visibility. Holmes perspective is useful to understand what might constitute learning processes in a Transparent Medium, based upon the creation of meaning that enriches the transfer of content in the user experience. This move supports technological systems that enable a participant to enact their own meaning and experience as opposed to a reconstructed creation of meaning, as determined by the designer. In order to provide an example of these ideas, it is necessary to look beyond the examples provided by the HCI and interaction design communities. Rather, the paper draws from the example of the Mind Cupola, a large-scale interactive media artwork that applies the concept of Transparent Medium. In providing an intervention on the design of human – technology interactions formed from a theoretical and philosophical basis, the Mind Cupola emphasises the enacted nature of human experience that is provisional and speculative in comparison to traditional HCI and interaction design interventions.

2.3 The Mind Cupola: A Transparent Medium and Orchestration of Enaction

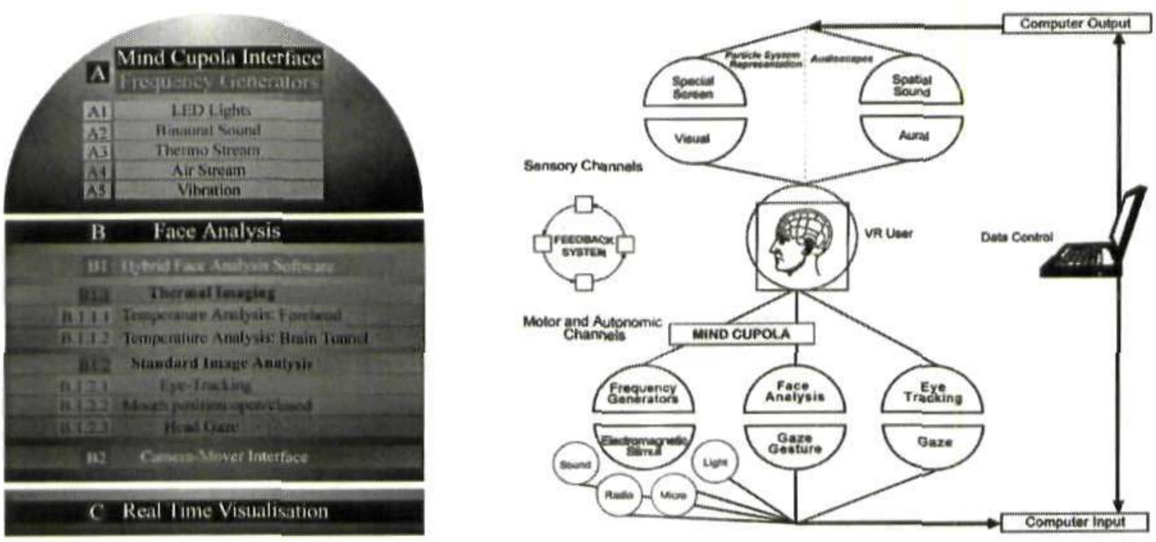

Figure 2 Technological System Overview of the Mind Cupola (*on the left*) and The Representation of the Technological Feedback System of the Mind Cupola (*on the right*) (© Zics 2008)

The Mind Cupola interface is formed of three interconnected systems; a biofeedback perceptive system (face/eye capture system), a frequency-generating affective system, and a real-time visualisation. Although these systems are describable as separate, upon use the system becomes a dynamic whole that incorporates the biological responses of the participator. This dynamic is formed through a continuously changing collection of feedback-loops between the technological system, the responses of the participant and the sensitivity of the couplings as determined by the designer. The dynamic and instantaneous feedback-loops are fundamental in considering the Mind Cupola a Transparent Medium.

Upon encountering the Mind Cupola, users are invited to step into the immersive surroundings and relax. The interaction process fluctuates between the natural reactions of facial and eye movement and controlled responses through which the user learns to produce meaning. According to the user's responses and level of enaction, the system produces affections by altering certain environmental qualities (such as vibration, heating, cooling, sound affect) and challenging the user's attention (through affective visualisation, peripheral vision affect). The visualisation engages the user with perceptive affection that requires both instinctual and conscious control to form a relationship through interaction. Whilst the user might look for hidden messages on the display by using the gaze of their eyes as a control mechanism, at the same time they change their environment through the behavioural analysis of the system. During the mastering the interface process the user reaches immersive states that go beyond typical everyday experiences of technology, more alike to a process of self-observation. This paper proposes that these experiences that bridge the artist's anticipation of enaction and the user's interaction in the environment provide what may be described as an Enactive Ecology, where the dynamic conversation between the artist-environment-user results in meaningful experiences.

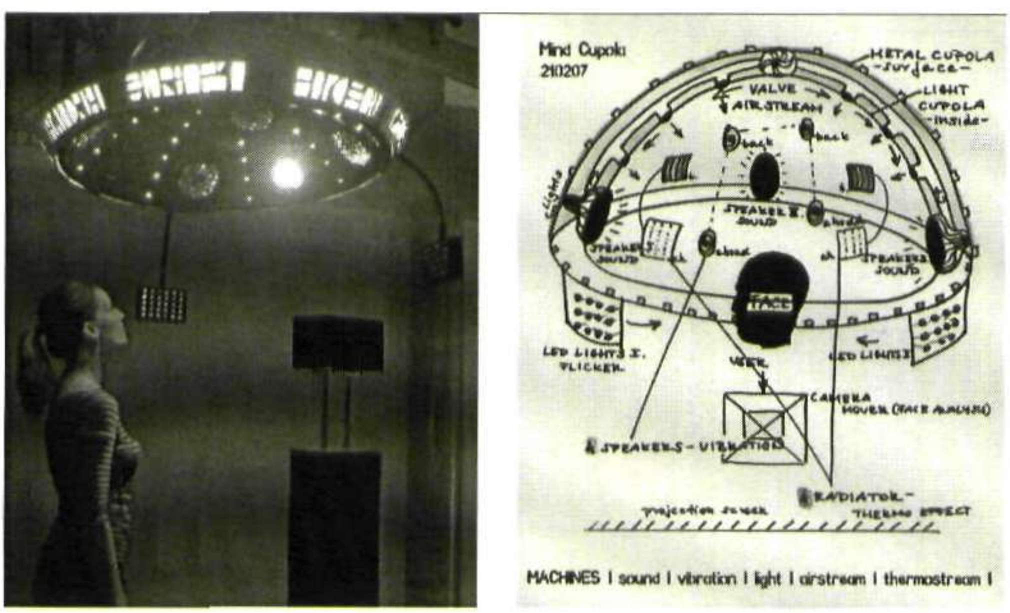

Figure 3 The Mind Cupola's Affective Environment with its user (*on the left*) and the Conceptual Draft of the Cupola's Interface (*on the right*) (© Zics 2008)

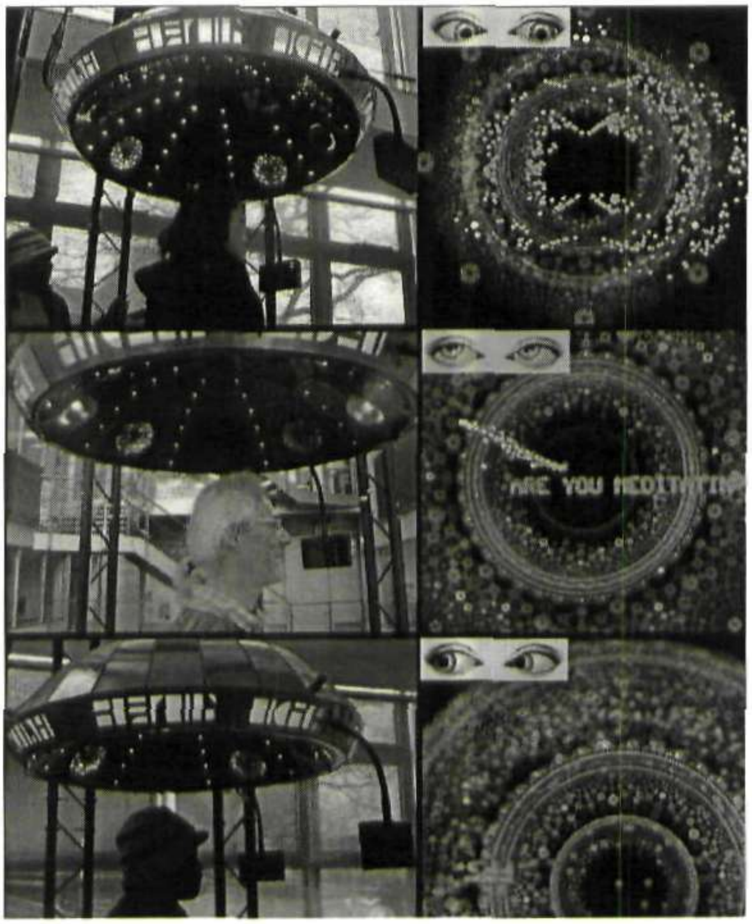

Figure 4 Users in the Mind Cupola and Screenshots of the Affective Visualisation with Corresponding Eye Positions (© Zics 2008)

2.4 From Cognitive Modelling to Cognitive Feedback Loop in the Mind Cupola

The underlying framework of the Mind Cupola is still 'cognitive', in that the feedback-loop is based upon knowledge relating the specific physiological feedback to certain cognitive states of awareness and immersion. However, the manner in which the system is participated with aligns the Mind Cupola as an orchestrator of an enacted perspective on cognition (Varela *et al.* 1991) rather than Cognitive Modelling that removes the mental apparatus from perception and action where meaning is predetermined by the designer of the interface. Rather, in the Mind Cupola meaning is co-constructed relationally between what the capacities of the user affords the technological system, and what the capacities of the technological system affords a this particular user. The participant and the technological system absorb one another to form an integrative whole where the afforded relationships between one another emerge in a reciprocal conversation. In this evolving quality of the interaction process, in which human and machine are interdependently react on each other states, the biofeedback data serve not only to read bio/physiological changes in the user but also to enact new meaning. The

Transparent Medium is a result of self-reflective process when the user re-evaluates his/her knowledge of 'being-in the-world' attaching new meaning to it. This new meaning production fluctuates with the instinct and unconscious (including the newly embodied meaning) actions of human enaction which helps to maintain the cognitive flow in the interaction. The result of such a fluctuation in the human cognition is termed here a Cognitive Feedback Loop.

3. Future Research: Integrating Transparency into Inclusive HCI

Interactive environments such as the Mind Cupola may provide insight into a new area of HCI research situated at the intersection of inclusive design, artificial intelligence and consciousness studies. In the context of HCI that is inclusive of the particular capacities of ageing users, it is suggested here that the Mind Cupola may provide a valid alternative to contemporary interventions in providing a learning process that evaluates and attends to the level of cognitive immersion and stress on the user and alters levels of affection accordingly. This move is founded upon centralising the role of the creation of meaning through levels of *transparency* as opposed to purely intuitive levels of *invisibility*. In making this conceptual turn a move is made from the designer predetermining the meaning of a new technology based upon traditional usability to the designer facilitating the orchestration of an enacted system of affordances between the user and the technological interface. Environments that slowly unravel how a technology operates through states of immersion, meditation and reflection, may present the opportunity for meaning and knowledge to be constructed incrementally through technologically-mediated activity, rather than procedural input/output success/failure routines. In monitoring the effort of the user, environments such as the Mind Cupola present an opportunity to allow the user to appropriate meaning and learn a technology through an ongoing relationship, possibly minimising the perceived limitations of cognitive aging, whilst not relying upon a metaphorical and remediated process of learning. Although the Mind Cupola was formulated on the basis of being an artistic intervention as opposed to a 'designed' purpose, it may be possible to explore how Transparent Mediums and the concept of Cognitive Feedback Loop can translate into the quotidian.

More information about Transtechnology Research and the Mind Cupola project: www.trans-techresearch.net, www.zics.net.

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