Sketching music: representation and composition

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Abstract

The process of musical composition is sometimes conceived of as an individual, internal, cognitive process in which notation plays a passive role of transmitting or recording musical ideas. This thesis questions the role played by representations in musical composition practices.

We begin by tracing how, historically, compositional practices have co-evolved with musical representations and technologies for music production. We present case studies to show that the use of graphical sketches is a characteristic feature of the early stages of musical composition and that this practice recurs across musical genres ranging from classical music to contemporary electroacoustic composition. We describe the processes involved in sketching activities within the framework of distributed cognition and distinguish an intermediate representational role for sketches that is different from what is 'in the head' of the composer and from the functions of more formal musical notations. Using evidences from the case studies, we argue in particular that as in other creative design processes, sketches provide strategically ambiguous, heterogeneous forms of representation that exploit vagueness, indeterminacy and inconsistency in the development of musical ideas.

Building on this analysis of the functions of sketching we describe the design and implementation of a new tool, the Music Sketcher, which attempts to provide more under-specified and flexible forms of 'sketch' representation than are possible with contemporary composition tools. This tool is evaluated through a series of case studies which explore how the representations constructed with the tool are interpreted and what role they play in the compositional process.

We show that the program provides a similar level of vagueness to pen and paper, while also facilitating re-representation and re-interpretation, thus helping bridge the gap between early representations and later stages of commitment.

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This thesis is dedicated to my daughter Thaïs.

Chapter 1

Introduction

Levi Strauss wrote about music that it is: “the supreme mystery among the human sciences” [50]. The practices of composition also remain, at large, mysterious. We adopt in this thesis a technological view point to analyse composition as a task involving equipments and artefacts, in particular notations and representations. The New Grove Dictionary [65] defines ‘notation’ as follows: “A visual analogue of musical sound, either as record of sound heard or imagined, or as a set of visual instructions for performers”, thus considering notation as a reflection of the composer thoughts. Many studies of cognition – which we discuss further in this thesis – have shown that the use of representations impacts the cognitive process. This thesis questions the understanding of music composition from a technological stance: what are the techniques and technologies, the concrete and individual actions involved in composition, and what are their role in the shaping of a composition? Are all of these processes facilitated by technology and computer programs?

We characterise that the early stages of music composition often involve sketching on paper. These sketches range from informal drawing and diagrams to partial drafts of the composition. We aim at understanding the role played by these sketches in music composition and to design and evaluate a computer program that provide similar functions to that of pen and paper. This highlights several methodological challenges for this thesis: How to observe creative practices, where idiosyncrasy prevail? How can we turn these observations into a design idea? And finally, how to evaluate a prototype and verify its integrity with the task it was designed to achieve?

1.1 Thesis outline

We begin by examining the development of music representations since the inception of notation for instruments (chapter 2). The initial motivations underlying the development of music notation were the need for a memory aid and the need to communicate music. By tracing how technology, forms of representation and composition practices co-evolved, we argue that music representations play a role in composition practices that go beyond the memory aid and communication. In chapter 3, we review studies of representations from the view point of musicology and cognitive science. The goal of this chapter is to determine a theoretical framework in order to ease the observation of contemporary representations. An additional constraint in the choice of the framework is that we aim at developing a computer program in response to the findings expected in the next chapter. Chapter 3 thus chooses a method that allows us to observe processes and facilitates turning these observations into computer-based functions. Chapter 4 presents case studies focusing on the representations developed by four composers. Using the framework previously defined, this chapter characterises the representations produced in the early stages of composition as facilitating the design by means of under-specified semantics (vagueness), re-representation, inspection, revision or edition. Chapter 5 informs the design of a program that attempts to address the characteristics raised in the previous chapter. A review of existing programs allows us to distinguish the salient features of sketches that are not addressed by computer programs from the features that are already addressed. We then present the requirements and the design rationale for the development of a *Music Sketcher*. Three successive iterations of the program are presented in this chapter in order to give an account of the technological and conceptual challenges that were faced during the design of the program. Chapter 6 present a formative evaluation of the prototype. The goal of this formative evaluation is to raise usability issues and conceptual mismatches in the program. In individual studies with four expert composers, which were video taped, we collected original sketches drawn with the Music Sketcher and in-depth interviews with the composers, which are transcribed and reproduced in appendixes. The formative evaluation led to a list of features needed for the improvement of the Music Sketcher. The last part of chapter 6 reports how these improvements were made. Chapter 7 presents an evaluation of the program that explores its adequacy with the initial requirements. The evaluation is qualitative. The methodology is illustrated by a full transcript of an evaluation that shows the evolution of the representation across thirty screen shots taken two minutes apart. This case study serves as a model for further analysis: the processes identified in this case study are compared with the other case studies, including those obtained during the formative evaluation. The findings are decomposed in three sections. We first discuss how vagueness is characterised in the studies, which shows contrasting results. Second, we discuss the role of re-representation and re-interpretation, which is observed in most drawings. Finally, we categorise the properties of our *digital sketches* and present a critical comparison with paper sketches. The last chapter (chapter 8) summarises our findings. We give an overview of the contribution of each chapter. This is followed by a critical reflection that discusses the choices made in the course of this thesis. Finally, we present the future works envisaged to continue this research.

1.2 Vocabulary

It is useful to define several terms which recur in this document: *representation* and *external representation, notation* and *sketches*. These definitions specify the meaning of these terms within the scope of this thesis.

1.2.1 *Representation* and *External Representation* (ER)

Following Norman (1988, 1993) [61, 60] the term *external representation* distinguishes the knowledge "in the world" to the knowledge "in the head" (internal representation). A particular stance of this thesis is to consider that in music composition, external representations constitute a form of "knowledge in the world", which contribute to the cognitive construction of a given piece of music. External representations are usually distinguished in two categories: text-based and graphical forms of ER. We examine in this thesis mostly graphical forms of ER. Our study focuses on their role rather than their nature and we don't attempt to distinguish the role of text-based ER from visual ER. In general, we use the term *representation* in this thesis to designate the visual artefacts produced by composers with the intention to *represent*, *illustrate* or *abstract away* a musical *idea*. We don't distinguish this term from *external representation*, which explicits that the representation is external to the brain. Our concern in this thesis is the designation of the actual production that is intermediate to the construction of a musical piece. We consider all the visual elements produced in the course of a given composition as *external representations* or *representations*.

1.2.2 *Notation*

In the music literature, the term *notation* refers in most cases to the Western system of music notation. In this thesis, we consider a broader sense for the term notation than encompasses the Western notational system and other autonomous notational systems developed by individuals (such as developed by Ligeti, see section 4.2). We follow the perspective of the ethnomusicologist John Blacking (1973) [6], who does not distinguish one notational system against another but rather contrasts the properties of literate music systems with those of oral music systems. We aim at understanding the dynamic relationships that exist in music composition between composers and notational systems. The variety of notational systems suggests that music composition activities are characterised by a variety of dynamics involving the annotation of musical aspects. Chapter 2 presents an overview of the notation systems that we consider. First, we trace the development of the Western notation system. We then discuss the role of several other notational system.

1.2.3 *Sketches*

We define the term *sketches* following Goldschmidt (1991) [29]. In her study of architecture design, Goldschmidt observed that a category of drawings – which she calls "study sketches" – is integral to the early stages of the design process: "These sketches, often scribbled on lightweight, transparent tracing paper, are usually made very fast and are sometimes so idiosyncratic that they are only comprehensible to their maker". We explore in this thesis the role played by similar "study sketches" drawn in the early stages of music composition. Music *sketches* occupy an important place in the musicology literature: Beethoven's notebooks, for example, have been the object of in-depth scrutiny (see e.g. Mies (1975) [55] and Johnson (1985) [41]). Hall and Sallis (2004) [32]) characterise music sketches as drafts of a final score. In this thesis, we extend the corpus of *sketches* usually considered in the music literature to include informal drawings and diagrams – which may not contain any reference to Western notational system (such as an abstract, idiosyncratic drawing of the aesthetic intentions).

Chapter 2

A Technological History of Tools for Musical Composition

This chapter analyses the role of technology in music composition throughout its historical development. We present a review of Western music notation, and present argument to show that notation developed into a tool for composition. According to the *New Grove Dictionary of Music and Musicians* [65], two motivations underly the initial development of notation: the need for a memory aid and the need to transfer music knowledge. However, notation rapidly evolved to become a support to music composition. The notation, originally devised to keep a record of a composition, became a means to produce music, while still being able to keep track of the compositions. This chapter then identifies and discusses the processes responsible for this shift in the paradigm of music making, from the inception of notation (circa 9th century), to the 20th century, where another shift occurred with the ability to record sounds and –later – the use of computers. We argue that the role of notation is integral to structuring music composition.

In the first section of this chapter, we illustrate the role of technology in music composition with examples from the musicology literature (excerpt of scores and findings from musicologists). In the second section, we discuss briefly the impact of recording technologies in music composition. Although recording technologies impacted many aspects of music (e.g. performances and listening experiences), we restrict the scope of this section to a presentation of the major contributions of recording technologies to music composition. Finally, the last section of this chapter traces the development of computer-based representations in three permeable paradigms: digital audio workstations, sound synthesis programs and real-time music programs.

2.1 The first musical representations

Music notations may be regarded as an ensemble of formalised signs intended to communicate music between composers and musicians, support the teaching of music and its memorisation. These signs may also be spoken syllables, words or phrases, the latter being often referred as 'oral notation'. Oral notations developed mainly in non-literate societies; communication about music technicalities would occur through speech using syllables or onomatopoeias. In literate societies, the first attempts to notate music followed the premises of writing, and there are traces of notation for several civilisations such as ancient Mesopotamia or Egypt as early as the second millennium BCE (see [65]). However, the neumatic notations that led to the scores used nowadays in Western Europe are dated from the 9th century BCE. Before this period, music was transmitted from generation to generation by performance, shared or face-to-face practices. Musicologists agree that in these ancient times, music was not experienced via an abstract form such as a representation, but through its memorisation (see in particular Berger (2005) [5]). The transmission of musical forms was also affected by the frequency of performance and the functions given to music in a given culture. In the Middle Ages, notation was transmitting pitches and rhythms. Nuances and dynamics were presumably transmitted orally and it is still a debate nowadays amongst musicologists how these nuances and dynamics should be interpreted. It is not until the 15th century in Western Europe and the invention of the printing press that the notational system allowed compositions to be considered as a fixed product.

2.1.1 The neumatic notation

According to *New Grove Dictionary* [65], the earliest surviving neumatic notation for Western *plainchant*[1] date from the 9th century. It is not known precisely when and where they were first used (see Levy (1987) [49] and Hiley (1993) [35] for discussion). These notations represent points or a short line called *neumes* above a text. In the music sense, neume denotes a musical element, while, in general Latin *neuma* meant gesture, sign or movement of the hand.

On the example given on figure 2.1, neumes are drawn above the text more or less as a freeform curve. The vertical position of the signs indicates the pitch, the horizontal position indicates to which syllable the changes of pitch apply. The information given on the pitch is rather

[1] Plainchant is a rhythmic singing of words of religious texts.

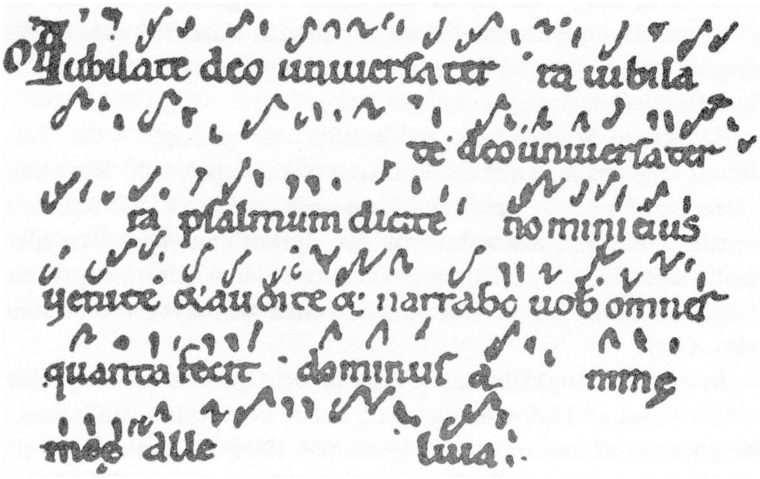

Figure 2.1: Example of early neumes

approximative. There is no determined reference to a fixed pitch. Moreover, the vertical variations of the neumes do not communicate an exact interval between two notes sung in succession. Noticeably, the rhythm is also approximate. The horizontal position refers to the text, which is sung at a pace determined by the singer. The interpretation of rhythm and pitch intervals were transmitted orally within the groups where music was taught. A fixed notation of pitch was later devised, attributed to Guido of Arezzo in the 11th century. This notation uses staves to identify the pitch. Guido was a monk of the Benedictine order in Italy. While in the monastery of Pomposa, he noted the difficulty that singers had in remembering Gregorian chants. He invented a method intended to help singers to learn chants faster. He claimed that his method would teach chant in 2 years rather than 10. The notation was then a horizontal set of four line that supported notation of a fixed interval between notes. A line is used to indicate the note of reference, usually C or F. The pitches of the neumes are indicated through their vertical positions on the staff, the highest frequencies in the upper part and the lower frequencies in the lower part. The neumes have to be read one after the other from the left to the right. Guido also gave a name to the neumes, the do – re – mi – fa – sol – la scale, which is still used in Latin countries. In Germanic countries, they are replaced by letters, from A to G. The manuscript reproduced in figure 2.2 represents a score based on d'Arezzo' s notation, dating from the 14th-15th century.

The Guidonian system also employed clefs that indicate the pitch for each line and colours to distinguish semitones. The spread of Guido's notation in Western Europe was facilitated by Pope John XIX, who commissioned Guido to annotate the Roman liturgical books in order to keep a record of the songs. Two main aspects of this system were of considerable influence to

Figure 2.2: Graduale Aboense, hymn book of Turku, Finland. 14th-15th century

the notation systems in Europe: the notation of a determined pitch and the definition of intervals.

2.1.2 Notation in the Middle Ages and the development of complexity

In the Middle Ages, before notation became used to transcribe music, music was more or less freely interpreted in performance. Emma Hornby (2002) [38] suggests that up to the early 9th century, there was no standard neumatic notation[2]. Instead, she indicates that tradition must have been carried by memory. It is not known how stable the repertoire remained when it was transmitted orally, nor how freely the performance was interpreted. However, from the late 10th century, performance of liturgical chants was guided by numerous conventions. According to the study of Western Plainchant by David Hiley (1993) [35], these conventions have brought about representational means enhancing the precision of notation:

> "The notes used for reciting passages with longer text, how to start and end phrases, which intermediate goals to aim for, which phrases were opening phrases and which closing phrases."

Noticeably, these conventions would allow many possibles interpretations, in particular regarding the rhythm of the chant. Performance, to some extent, could be considered as a live act of improvisation in a manner comparable to a jazz standard that is interpreted each time it is performed.

[2] Hornby's suggestion focuses on the neumatic notation for Mass Proper chants.

The set of conventions transmitted by treatises such as *Musica Enchiriadis* [24] would assist the composition process, which could arguably have been done entirely in the mind (see Berger (2005) [5] for discussion). Up to the Middle Ages, scores were not considered as compositions but as transcriptions of melodies which were originally composed and transmitted orally. At this time, the impact of representations on music composition was probably non existent. However, the rapid evolution of music in terms of diversification and complexity since the 11th century suggests that notation started to play a key role in the development of music composition at least from the 13th century (contra Wegman (1996) [88]).

From 1170 to 1250, the Notre Dame School in Paris hosted composers who were the first known to have composed (and notated) polyphonic music. One of these composers, Perotinus, composed 4-voice polyphonies (organum quadruplum). He is the first composer whose music has survived. This period is also known as Ars Antiqua (c. 1170 – c. 1310). Although there has been different treatises written on rhythmic notation before this period, it is in 1240 that a treatise established a convention on polyphony (*De mensurabili musica*, by Johannes de Garlandia). The convention on rhythm had an important impact on the music to come. As a musical genre, polyphony mainly allowed dissociating the staff from the text, thus enabling notation to develop its own *grammatology* as well as a *graphemology* (see Levy (2004) [48]). Levy argues that it is when music notation acquired a system comparable to writing that it developed a grammar on its own. Composers would be able to use this grammar in order to compose. For Levy, the first examples of "complex" scores are dated from the 13th century[3]. Levy argues that the complexity reached in the composition *Viderunt Omnes* results from the use of notation as a means of composing. The score was elaborated in a way that indicates that it could not have been done only with the ear. Busse Berger (2005) [5] has a more nuanced opinion on the impact of notation in *Ars antiqua* . She argues that memorisation was central in the composition process until the 15th century. Although she recognises the role played by notation, she does not consider it to be as central as the role of memory in composition. According to Berger, the training that singers received in monasteries relied almost entirely on the memorisation of existing liturgical chants. Singers would undergo an extraordinary training whereby they would memorise up to 72 hours of music and be able to compose a polyphonic chant without the aid of a written support. Berger suggests that notation played a supporting role in the composition of polyphonic works,

[3] *Viderunt Omnes* by Perotinus contains canons, voices permutations and a 4-voice polyphony.

and also in order to support the memorisation of polyphonic chants that were always sung by heart. She argues that memory was equally central in performance and that scores would never be used in a performance but would rather be memorised and sung by heart in the period ca 800-1500. Berger further suggests that architectural structures have been used as aides for composer throughout antiquity and the Middle Ages, arguing that, following Aristotle, images and texts have to be structured to help memorisation.

> "While ancient writers preferred memorizing streets or houses, medieval structures are monastic or diagrammatic, such as with Bradwardine, who superimposes group of five, or with Hugh, who uses every imaginable geometric shape. All stress the importance of structuring the text in a specific order. "

The treatises she refers to[4] are not directly concerned with music composition but with strategies of memorisation of texts and ideas. Berger however present argument to show that the memorizing of music followed a similar process to the memorizing of texts. Finally, she argues that visual memorisation has been used as a means of composing. In two treatises of the late 13th century [5], the verb *respicere* was used, which usually describe visual memorisation in menmonic treatises. *Respicere* means literally "to look back". Berger makes the controversial argument that if the theorists were referring to composition by ear only, they would not have used the term *respicere*. However, evidence of the growing importance of notation in the composition processes seems to imply that composition could not have been done by memory only. As we shall argue later, the *Ars subtilior*[6] repertoire clearly acknowledges the use of visual signs as central in its composition processes.

We agree with Berger that memory must have played – and still plays – an important role in music composition. According to Latour (1990) [46], the physical properties of the notation medium itself – e.g. visible, persistent, movable, two dimensional – distinguish it as a modality. Notation has inherent possibilities that orality does not possess and we argue that visual representation of notes would not only assist the transcription of music but also suggest original ways of creating music movements and support the assignment of these movements to various voices.

[4] Thomas Bradwardine's treatise *De memoria artificiali* written around 1333 and Hugh of St Victor's treatise, *De tribus maximis circumstatiis gestorum* written in the early 12th century.

[5] *Ars cantus mensurabilis* by Franco de Cologne, ca. 1280, and *Speculum musicae* by Jacques de Liège

[6] Generally dated ca. 1377-1412 at the end of *Ars Nova*. *Ars subtilior* was an self-professed elitist movement where music, because of its complexity, was meant to be understood by the few who could read music scores. It had a limited impact, possibly due to its complexity.

Evidence indicate that from the 13th century, notation started to be used also as a tool to compose rhythms and pitches. From the 13th century, composition and notation co-evolved: the question is disputable whether this is notation that enabled new form of compositions or if new musical ideas suggested novel notations. It is presumable that both hypothesis are equally playing a key role in the evolution of both notation and music.

2.1.3 The development of counterpoint

From the 14th century, treatises and compositions arose from both sacred and secular initiatives. Although notation remained the invariable support for composition, many scientific discoveries were – directly or indirectly – influencing composition. Amongst them, the printing press (1447) facilitated the exchange of scores and the spreading of musical notation. It is during the Renaissance that the concept of counterpoint was extensively elaborated. Counterpoint is a range of organisational features, involving the simultaneous sounding of separate musical lines. It derives from the Latin *punctus contra punctum* ("note against note"). This notion appears as a consequence of the ability to represent music, which is also pointed in Berger's conclusion:

> "Just as writing led to word games and crossword puzzles, notation led to notational games. A singer would not be able to sing a melody retrograde without locating it on the staff or hand; he would not be able to apply the rhythmic manipulations we have observed in the tenor without notation. Thus, mensural notation utlimately resulted in what we would consider a modern artwork, a composition where the composer would determine the pitch and rhythm of every part, where he would develop a sense of ownership."

The elaboration of superposition of musical phrases in counterpoint is linked to the ability to project music – a time phenomena – on a spatial dimension like a sheet of paper. This projection frees the composer from the intrinsic constraints of memory and allow them to experiment complex forms of music. We now turn to a review of the role played by visual representations in the music of J.S. Bach, as observed by musicologists.

2.1.4 The role of visual representations in the music of J. S. Bach

Bach frequently used geometrical methods such as symmetry or inversion as part of his composition processes. A short review of his work examines the extent to which visual representations play a role in composition and if it can be observed from the scores. Following Cantagrel (1982) [14] and Goncz (1991) [30], we report how abstract visual processes, such as geometry, influence his composition processes. We also emphasise the matching of representations between abstract processes and the resulting scores.

As discussed earlier, visual representations started to be used as a means for composition in the 13th century. The evidence presented by Levy is just a small sample of the music that was composed at that time[7], however, they mark the beginnings of an increase in complexity within music. Within a few centuries, music evolved from monodic liturgical chant to operas or symphonic orchestras, where more than a hundred instruments would play synchronously. We argue that the representation of various instruments on a score enabled a computational offloading which favours the development of visually-based composition techniques contrasting with memory-based techniques. Notational systems can be considered as important factors of the increasing complexity, not only for their abilities to represent the voices, but also because of the combinatorial and computational aspects following the discretisation of the note. We review in this section the case of a few music scores of J.S. Bach whose representations match other disciplines, such as mathematical representations.

The importance of mathematics in Bach's music has been emphasised by many musicologists and also by texts Bach wrote himself (see Cantagrel (1982) [14]). In particular, algebraic and geometric notions were used during the composition processes. For example, the algebraic value extracted from his name, 14 (B =2, A =1, C= 3, H = 8) is of recurring importance. With the initials of his first name "J. S.", the sum becomes (10+17+14 =) 41, the inverse of 14. He used both values in the choral *Von deinen Thron*, which has a first sentence of 14 notes and a total length for the first choral of 41 notes. His last compositions, and among them the *Art of Fugue* contain various numeric combinations and references. The melody of the *Art of Fugue* has also 14 notes (see figure 2.3).

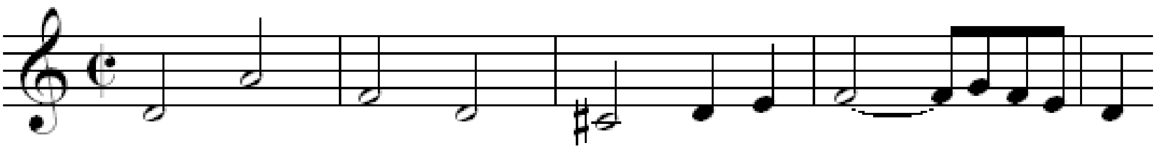

Figure 2.3: Subject of the Art of Fugue, J.S. Bach

[7] *Ars Subtilior*

Originally, the fugue designated a piece of music based on canonic imitation. But unlike the canon, which is based on a repetition of a single subject, the fugue overlaps different subjects. The order in which they are overlapped is determined by counterpoint and harmonic rules. The figure 2.4 is a model of a Bach's opening fugue of BWV182, *Himmelskönig, sei willkommen*. A, B, C and D refer to the themes, T and D to the entries of theme A in tonic and dominant (see e.g. [30, 66] for more detailed studies of Bach's fugues).

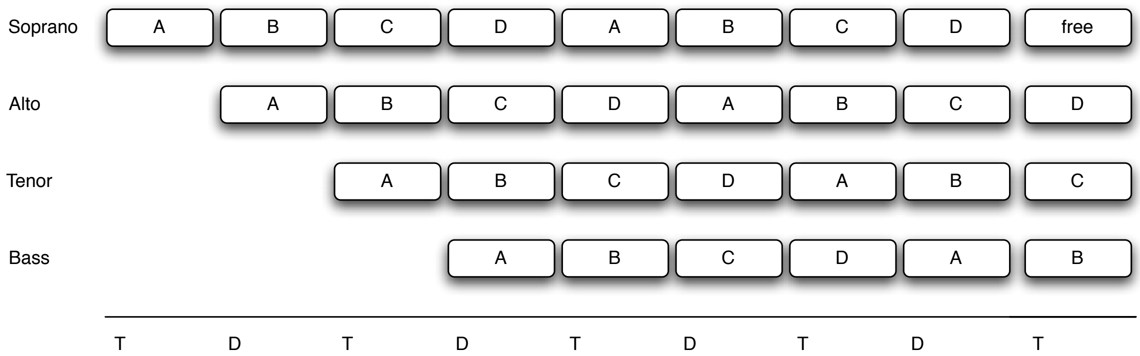

Figure 2.4: Model of the opening fugue of BWV182 by J.S. Bach

Canons, being single subjects distributed to the singers, were presumably composed from memory (see [5] for discussion). In contrast, fugues introduced abstract rules of organisation, geometrical or visual, which seem to contribute to the composition at a structural level. The *Art of Fugue* is considered as a masterpiece of counterpoint techniques. The processes used seem overly formal, and leads to reject a common idea that music composition are transcribed directly from mental imaginings of music. This causes us to question the aesthetic role of abstract representations in the composition process. J.S. Bach was trained as an organist. His practice and expert audition must have played an important role in his composition processes. However, we formulate the hypothesis that Bach might have used abstract rules for two purposes. First as an aid to memorise the structure of a piece (following Berger's statement on the role of memory in music in the Middle Ages). Second, he would use these rules as hypotheses that he will either evaluate in front of his organ or experiment on a music score. Xenakis described in Delalande (1997) [91] that he used formal rules as musical hypotheses that he evaluated in the process of composing. Arguably, Bach has been using abstract rules for the same purpose.

2.1.5 Discussion

An intertwined relation exists between the increasing complexity of Western music, the increasing complexity of notation and – indirectly – the progresses in science (exemplified by the invention of the printing press). Music composition is characterised by evolutions of style, where composers aim at producing music that is different to what has been composed before. The influence of abstract processes on music that we noted in Bach's music is noticeable in the 20th century by the use of statistics in Schoenberg's music, the use of architecture plans in Xenakis' music, as well as metaphors of a great number of physical and mathematical theories in electroacoustic music (such as chaos theory with Bernard Parmegiani or Francois Bayle).

During the periods that followed Bach's time (Classical, Romantic, Modern), the complexity of compositions increased, exploring the dimensions of timbre, motives, counterpoint, harmony or orchestration. The example of Bach is not idiosyncratic: written music developed more and more abstract rules to organise sounds, associated with complex and innovative harmonic constraints.

At the time Bach was composing, music was often written without precisions of which instruments should play the various parts. A fugue could virtually be played by any combination of instruments, assuming that they were able to play within a given tessitura. When symphonic orchestras became popular, composers started to specify the setting of instruments. This led to explore two dimensions in music composition. First, the combination of all the instruments together was considered, and later theorised as *Klangfarbenmelodie*[8] by Arnold Schonberg [70], amongst others. Second, the various dynamics and ornamentations on each instruments, which also play a key role in timbre and performance, started to be represented on scores. This is yet another feature that can be abstracted and represented, thus organised at the same level as notes, rhythms and nuances. It is worth noticing that representing gestures is conceptually different from the representation of notes, as it is not the representation of the music itself, but of what is required to produce it. This is a step further in the abstraction, which opened possibilities that are still explored in contemporary music, by e.g. Helmut Lachenman in his piece *Salut für Caudwell*, where the score describes very precisely how the performers must play their guitar. They gradually destroy them to obtain unique sounds as well as a unique performance. These new elements of notation complete the *grammatology* and *graphemology* (see Levy (2005)) available

[8] *Klangfarbenmelodie* means tone-colour-melody in German. The term was coined by Arnold Schonberg in [70]. It refers to the melody of timbre created by the merge of several instruments.

to composers to create a grammar of their own.

2.2 Recorded sounds in music composition

From the 1960s, Western music changed consistently, along with notations, music equipments and cultural exchanges. In this section, we explore the role played by the sound recorders, which enabled to store music on a fixed device. We examine the role it played in the way we listened to music and the impact on music composition.

Music making has been marked by an evolution since the invention of the phonograph by Edison in 1877. The democratisation of the phonograph changed the way we listen to music, but it has also a deep impact on composition and performance, since music was storable and available outside concert rooms, not only as an abstract notation. Composers have since used recording devices as an endless memory, able to reproduce at will events which were previously of an ephemeral nature. Recording technologies influenced the composition process by allowing an extensive and unlimited analysis of musical content. Also, the fact that music could be played everywhere enlarged the music culture of composers. Some of them would borrow consciously or unconsciously melodies or rhythms heard in other pieces. The composer John Oswald borrowed intentionally large samples of music to recompose it in his way (see Cutler (2004) [20]).

Recording technology enabled the folk music tradition to be conserved and fixed on a disc and later on tapes. The phonograph technology is based on the reproduction of sound waves as indentations on a tinfoil. Although this representation could not be used to compose music with a graphical interaction, it enabled multiple innovations in both folk and contemporary music practices. In most cases in classical written music, young composers are taught the works done before them, and how to be able to reproduce their style. It is the same with folk music, but the lack of written notation induces that learning it depends on listening, as well as the practice of at least one instrument. Recorded sound allowed musicians to listen to songs as much as desired, instead of relying on their memory, in order to reproduce a style. The recordings of traditional songs and their availability as objects enlarged the sources of influence of every musician. In written music, Antonin Dvorak, Leos Janacek, Bela Bartok or Gustav Mahler – to name a few – introduced numerous reference of folk music in their works. Adorno (1996) [2] has presented data to show that Mahler incorporated the *Ländler*[9] in his work. It is interesting to note that his

[9] *Ländler* is an Austrian folk-dance which developed first into the minuet and then into the waltz

music was highly criticised during his lifetime, and that he has been lately appreciated by the public when LP records of his work were available.

In contemporary music, the development of *musique concrète* is a significant example showing that sound recorders can be considered as a music composition tool. The generalisation of tape recorders brought Pierre Schaeffer and Pierre Henry to compose in 1948 the piece *Étude aux chemins de fer*, which was made from recordings of trains. Pierre Schaeffer, a French engineer, was then working for twelve years at the Office de Radiodiffusion Télévision Française (ORTF), the French radio and television office. It is in this state organisation that he developed *musique concrète*, literally concrete music, a music made of recorded sounds. While in ORTF, he started research on sounds that he considered as objects, which could be described for their characteristics. He classified sound objects into seven categories : dynamic, harmonic timbre, melodic profile, mass profile, gain, and inflection. The central point of his method was to apply Husserl's phenomenological *epoché* to listen and describe sounds objects outside of the context that created them (see Schaeffer (1966) [68]). The aim he has been pursuing was to describe all the *composable* sounds on the tape technology. It is important to note that the first practices of concrete music, and later on of electronic music had no representation of music apart from the tape itself or the device used to produce the music. As we report later (see chapter 4), external representations have been used to support working with electric devices and equiment, but these were not intended as scores. All the manipulations on the sound were operated on the magnetic band. It is only the second time – after the invention of the score – that a technology enabled to organise sounds in time with its representation. In the case of electroacoustic music, the abstraction (or representation) is the magnetic band, which is cut, mixed or slowed down in order to compose. As for instrumental composition, the manipulation of the representation of music became transmissible. The classification initiated by Pierre Schaeffer provided a theoretical framework to describe sound objects, which, as a concept, could be compared to the notes. This classification enabled a useful vocabulary to articulate the process of composing with sounds. The music itself was fully transmissible, as the tape constituted the medium to be played. Electroacoustic compositions share some of the same characteristics as conventional scored music, which are representation, transmissibility, theory, reference pieces and concerts. The difference is that electroacoustic music does not need performers. From the point of view of the audience, the absence of performers is a major difference at the time of the concert. There is evidence that composers in this field drew graphical scores before or during the composition process. In the 20th century, one of the first tape piece that includes electronically generated sounds and recorded sounds is *Gesang der Jünglinge* by Karlheinz Stockhausen. The sketch reproduced in figure 2.5

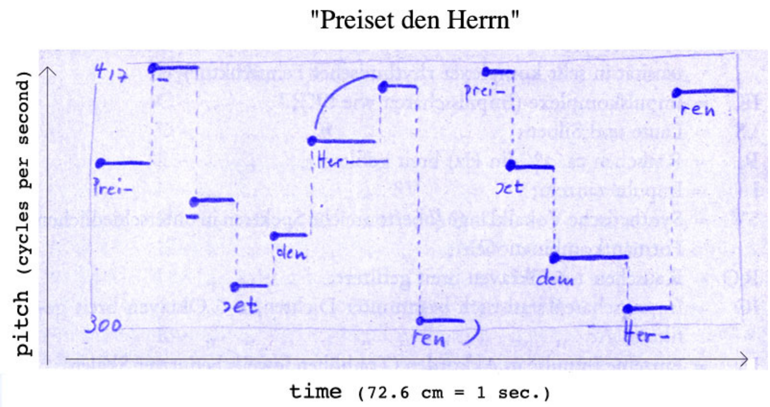

Figure 2.5: Except of Gesang der Junglinge by Karlheinz Stockhausen

is an except of the piece and represent a recurring phrase in the piece which was reproduced as part of the music programme for the first performance of the piece in 1956. The sketch represents time on the horizontal axis, and pitch on the vertical axis. The phrase *Preiset den Herrn*, (praise the Lord) is repeated twice at different pitches, each using syllables with a different duration. This sketch addresses a representational problem for the abstract manipulation of sound samples. This representation does not precise how the manipulation of the sound samples would occur: it focuses on representing sound transformations, not on the devices used to produce them. Most of the time, these graphical notations would be thrown away, as they were of no use once the composition was finished. Noticeably, graphical score emerged at the same time in instrumental contemporary composition, but these were intended as real scores to be interpreted by musicians. Hence, they are well documented. However, with the invention of the computer, sounds and symbols started to be manipulated and represented at the same level.

2.3 Computer based musical representations

We consider in this section the role played by computers in the evolution of music notation. Scores evolved to represent pitch, tempo, dynamics and also playing modes (such as flatterzunge, a way of blowing in a flute) or improvisation (see e.g. Stockhausen (1977), [75] or Feldman (1969), [27]). The notation of playing modes as traditionally used captures abstract gestures rather than concrete sounds. This is significant because it treats aspects of the performance as parameters that can be controlled. This practice has developed to include, for example, scores that explicitly locate musicians in a concert hall, notate the sounds to be played by a tape, or even schematic representations of electronic devices used to transform sound. For example, figure 2.6, although not a score, synopsises the motives and themes played by the orchestra and the electronic events of Philippe Manoury's opera *K*. Such synopsis is not standardised, but is well enough documented to be understood easily. It might have had two roles: first, as a reflexive aid to elaborate the structure (e.g. see how the mental states of Josef K. correlates with sonic events), and second, as an archive document in order to help the reproduction of the opera.

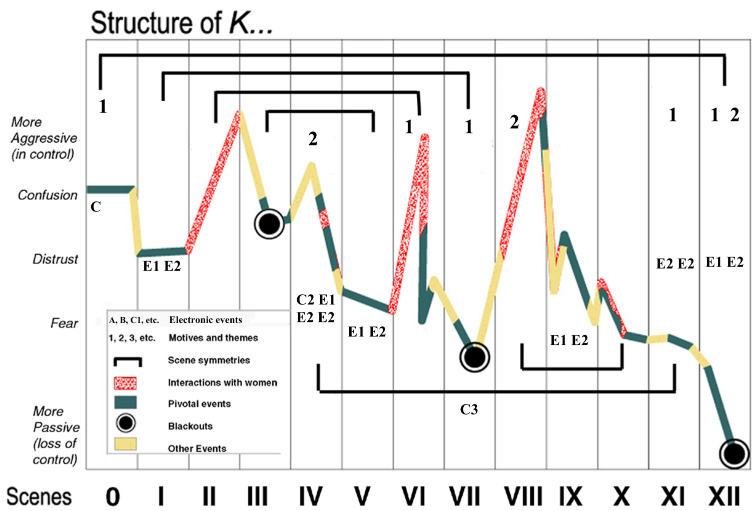

Figure 2.6: Structural diagram of the Opera *K* by Philippe Manoury. Extracted from Ramstrum, [63]

The potential of computers to enhance the manipulability of musical structure was appreciated early on. In 1956, Hiller and Isaacson compose the *Illiac suite for Strong Quartet*. It was compose using an Illiac computer, programed with punched cards. The polyphony was constructed by a variety of counterpoint constraints. The composers stated [36] that their motivations were:

> "To demonstrate that a computer can produce novel musical structures in more contemporary style and to code musical elements such as rhythms and dynamics.[...] To show, lastly, that computers might be used in highly unusual ways to produce radically different species of music based upon fundamentally new techniques of musical analysis."

Such motivations proved right in the following years. Since 1957, computers have been used, as we shall show, to elaborate novel musical structures. However, it is disputable whether computational models such as used in the *Illiac Suite* were of such great influence in comparison with graphical user interfaces developed in the early 80s. Contemporary technologies employ a rich variety of graphical user interfaces for editing and mixing sounds and instruments.

2.3.1 Digital Audio Workstations

Audio representation on computer screens appear in the early 80s, when personal computers started to be standardised. The motivation underlying this development was to enable operations on audio representations. The most common audio representation is the waveform, which shows the waves of alternating pressure over time that characterise sound. The features of digital audio workstation are inspired by what was available beforehand on analogue technologies: record, edit and play back audio. Editing sound includes a variety of functionalities such as manipulating the waveform manually or with programs (plug ins) dedicated to transform certain aspects of audio, e.g. operations on the dynamic, noise reduction or voice enhancement, to name a few. An important functionality of DAWs is the ability to represent multiple tracks vertically, allowing to superimpose audio files to be played at the same time.

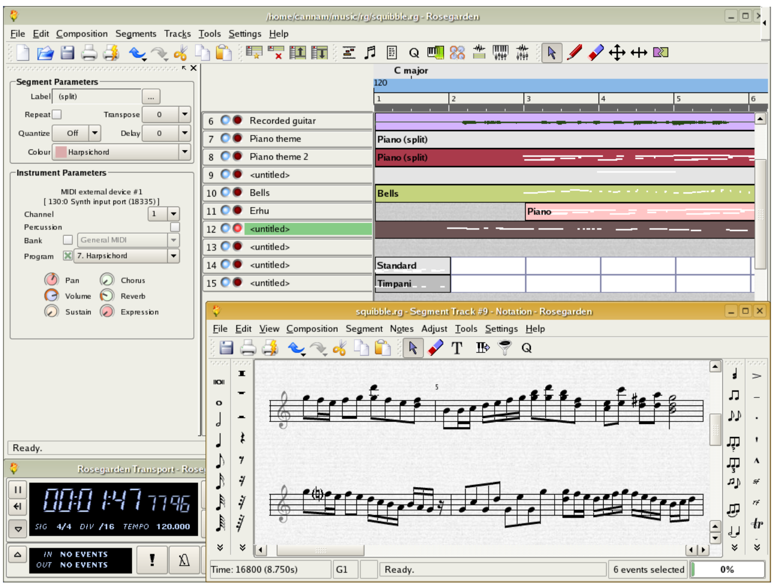

Figure 2.7: Interface of the audio workstation Rosegarden

For example Rosegarden (Figure 2.7), a free music program similar to Cubase, Pro Tools or Nuendo uses a time line paradigm inherited from Guido of Arezzo to represent sounds and symbolic data. Part of the interface represents sequences (shown in the upper right). Another part supports the editing of symbolic data (notes). These systems can provide instant feedback and are commonly used to record instruments and edit them, and sometimes mix those instruments with sound samples. Functions for editing, mixing, recording or equalizing sounds are supported.

DAWs take several forms, whether they are dedicated to music editing (e.g. ProTools, Logic, Cubase) or live performance (Reason, Live). The latest include functionalities such as looping samples, a technique widely used on hardware samplers by DJs.

Although used by professional studios and composers, DAWs induce a way of composing due to the strong representation of sound files, and the lack of support for the elaboration of complex structures. The representation of music in DAWs has been criticised for the little effective support for creativity that they provide. Kevin Dahan (2005) [21] criticises precisely the multi-tracks paradigm :

> "[...] le fait de restreindre la manipulation des objets compositionnels à un seul niveau d'abstraction - l'approche par piste - rendent difficile l'implémentation et la réalisation de structures musicales complexes (les objets compositionnels), ce qui implique un encombrement de l'espace sonore (i.e. *bruit*), rendant l'accès aux musiques électroacoustiques difficile.[10]"

For Dahan, the scope of this critic does not go beyond electroacoustic music. We shall extend this critic to *actual musics* such as Rock or Jazz, whose structures can hardly become more complex by means of such programs. DAW are designed to simulate the studio environment: they often represent multiple tracks resembling the channels of a mixing desk. These can be panned, muted, effected, equalised. It is questionable whether the representations of DAWs allow going beyond what could be achieved with a mixing desk.

Various music composition tools emerge in correlation with the evolution of computers. Music programs rely mainly on two aspects. First, on the way sound functions are written in a program, and second, the way these functions are handled by the program (the user interface). We focus on the second aspect: the invention of new paradigms for music notation. These paradigms seem to be a consequence of what the technology enabled at a certain time, more than an answer to purely compositional issues.

[10] [...] the fact that the manipulation of compositional objects is restricted to a single level of abstraction - the multiple tracks approach - does not assist the implementation and realisation of complex musical structures (the compositional objects). This implies an obstruction of the sonic space (i.e. *noise*. As a result, the access to electroacoustic music is difficult. *Personal translation.*

2.3.2 Sound synthesis programs: Music N and CSound

Historically, the first notation tool developed for computers was based on the works of Max Mathews. The program, Music I, allows composers to create synthesised sounds using triangular sines. DAWs emerged later and took advantage of the generalisation of graphic user interfaces (GUI) and of the ability to represent waveforms. Most recent notation systems are based on dynamic processes that allow composers to manipulate several representations at the same level (symbolic data, sound files, video files, etc.).

Music I was followed by several versions until Music V, written in Fortran. It is on the basis of Music V that CSound was developed, but this time using the C language. Alike Music V, CSound allows composers to synthesise sounds using a sort of textual description of the score. The example presented below (an extract of score of *Mutations*) is taken from The CSound Book by Boulanger (2001) [9]. A CSound program consists of an instrument (the first part of the program below) and of a score (the last part of the program). An instrument is defined by an addition of oscillators whose frequency, amplitude and duration might vary over time.

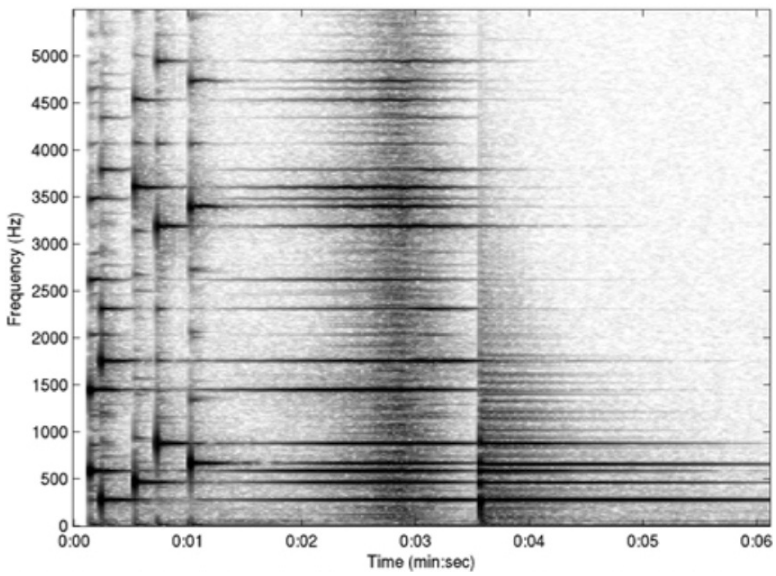

Figure 2.8: Spectrogram of *Mutations* by Jean-Claude Risset. The first seconds show the frequency distribution of a synthesised bell-like sound.

The instrument and score presented below was programed by Jean-Claude Risset in an attempt to design a bell-like sound with a combination of oscillators. He used this program in particular in the piece *Mutations* in 1987, where he explored the fusion of timbres between synthesised sounds and analogical sounds (see e.g. [73] for details).

```
; Risset's instrument design for a bell-like sound

    sr     = 44100           ; Sample rate.
    kr     = 4410            ; Control signal rate.
    ksmps  = 10              ; Samples pr. control signal.
    nchnls = 1               ; Number of output channels.

          instr 1,2,3,4

; p3      =         duration
; p4      =         freq in Hz
; p5      =         amplitude

; ...

; Durations of the partials are a function of the duration of the lowest partial


i12       =         p3
i13       =         p3*.9
i14       =         p3*.65
; ...

; Frequencies of the partials are a function of the frequency of the fundamental

i23       =         p4*.56
i24       =         (p4*.56)+1
i25       =         p4*.92
; ...

; <beginning of the score>
; Risset's score for a bell-like sound
; ...
;       start   dur     freq    amp
i1      1       4       633     2500
i.      +       .       211
i.      +       .       999
; ...
; <end of the score>
```

In terms of the creation of synthesised sounds, CSound has virtually endless possibilities. In theory, the entire domain of audible sounds can be recreated by combination of oscillators. Algorithms can be defined to control the evolution of sounds over time. However, research on physical modeling of virtual instruments has shown that complex timbres are difficult to reproduce. What make this task difficult is that a timbre has to be considered according to two dimensions, a vertical dimension, i.e. the organisation of partials in the spectrum and a horizontal dimension, i.e. the evolution of these partials over time. Both dimensions have to be considered to recreate the timbre of e.g. a piano sound. Given that the usual sample rate in a computer is 44100 per second, the number of parameters that need to be controlled in order to define a specific timbre is tremendous. Although CSound provides a way of defining this data, the high number of parameters required to create original timbres prevent composers to use it at a micro time scale. Instead, CSound would be used at a larger time scale, where functions can control complex interactions between instruments. Its strength resides in the power of programming languages to model complex forms that can not be defined with graphical user interfaces such as offered by DAWs. However, it is questionable whether committing to a programming language is adequate to support music composition. It rather appears that CSound is mostly used to create original sound textures, as opposed to complete compositions.

2.3.3 Real time music programs: Max/MSP and Pure Data

Within programs like Max/MSP or Pure Data, music representation takes a new form. These programming environments display at the same level the program structure and the graphic user interface. Originally, Max was designed as a virtual analogy to the MIDI devices used in music studios for controlling sound samplers. Its role was to provide a richer control over MIDI data, allowing combinatorial operations on symbolic data in real time. Max was then typically use in performances, where the score used by the performers was followed, and MIDI events triggered accordingly. MSP was later added as a library of sound processing, thus enabling to manipulate sound samples in the same environment. To the difference of DAWs, Max/MSP does not build on an analogy of the mixing desk but of the interconnected devices that are in use in a music studio. Each element for data control and sound processing is represented as a ‘black box’ with an input and output (such as a MIDI keyboard for data control, an amplifier for sound processes). The interface allows connecting these boxes together by dragging virtual cables (links) between them. The interface distinguishes yellow links that represent sounds to black links that represent data. Max/MSP integrates digital to analogue and analogue to digital converters (DAC and ADC), which allows capturing and rendering sounds within the program.

In the figure 2.9, the Max icons have outputs, usually represented as small black rectangles at the bottom of an icon (*outlets*). A virtual cable can be pulled from these outlets to another box’s entry (*inlets*). The sound always goes in one direction, from an outlet to an inlet. It is converted to analogue signal to be played by speakers when it is linked to the icon representing a speaker (DAC). Max/MSP and Pure Data include a variety of features to address the micro time scale which facilitates dynamic processing at the sample level. Symbolic data such as MIDI is represented at the same level than recorded sound files and synthesis parameters.

In the figure 2.10, a virtual MIDI keyboard controls sound output and images. Alternatively, a real keyboard could be plugged to the computer to control the same events via a physical controller. Within Max/MSP, programming languages such as Javascript, Java or C can be used

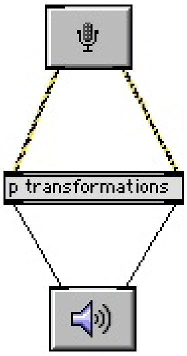

Figure 2.9: Audio integration within Max/MSP

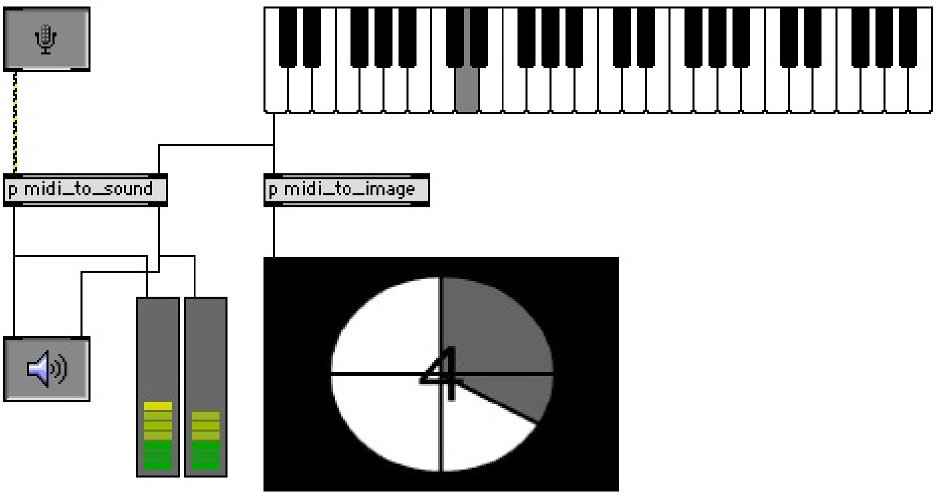

Figure 2.10: Using MIDI, sound and images within Max/MSP

to develop complex operations. A box – such as those presented in the figure – can contain operations written either as a program structure using predefined functions (building blocks) or directly in a programming language. This building block paradigm helps to deal with the level of granularity that the user wants to be able to observe at a time. The way the blocks are built depends entirely from the choices made by the user. A new program is at first a blank page on which the user is free to associate objects together. However, although Max/MSP provided means to control micro time scale, addressing larger time scales is problematic, as Max/MSP does not provide a representation of time. Overall, Max/MSP is largely dependent on a precise understanding of the programmatic aspects, like CSound. A feature of Pure Data called Data Structures allows to control visual aspects with any kind of data, thus enabling to build a visual score using the parameters effectively used in a composition process. Figure 2.11 shows a score built with this program.

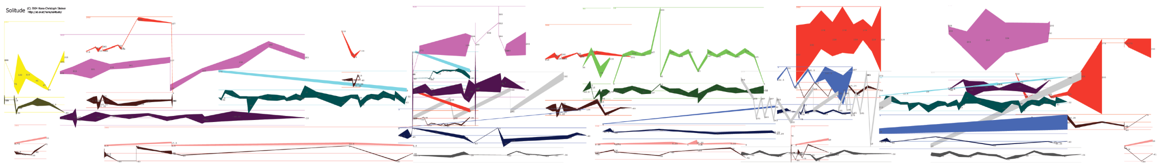

Figure 2.11: Data structures in Pure Data, the example of *Solitude* by H.-C. Steiner

Pure Data *data structures* allow visualizing and controlling the evolution of parameters over time, represented on the horizontal axis. The colours and shapes are used to dissociate visually the various parameters. This feature of Pure Data provides a feedback to the composer during the composition process. About the score, Hans-Christoph Steiner said in his website[11]

> "The visual representation worked well for composition in this style. My biggest problem was finding a way to represent in the score all of the things that I wanted to control. Since I wanted to have the score generate the piece, I did not add a couple of features, like pitch shifting and voice allocation control, which I would have liked to have."

In this case, the composition process was at first facilitated by the visual scoring offered by the program. But controlling parameters over time in Pure Data or Max/MSP remains a challenge in its current form, as the control of parameters is de-correlated from its visual representation (which is different to what a score provides, for example). Although the visual scoring allow

[11] http://at.or.at/hans/solitude/, 26th of October 2007

representing abstract events, the sonic results are constrained by the ability of the user to program the relationship between the visual score and the processes. In order not to overwhelm the score with too much details, Steiner reported not using some features, thus spoiling the piece from certain aspects he could have developed.

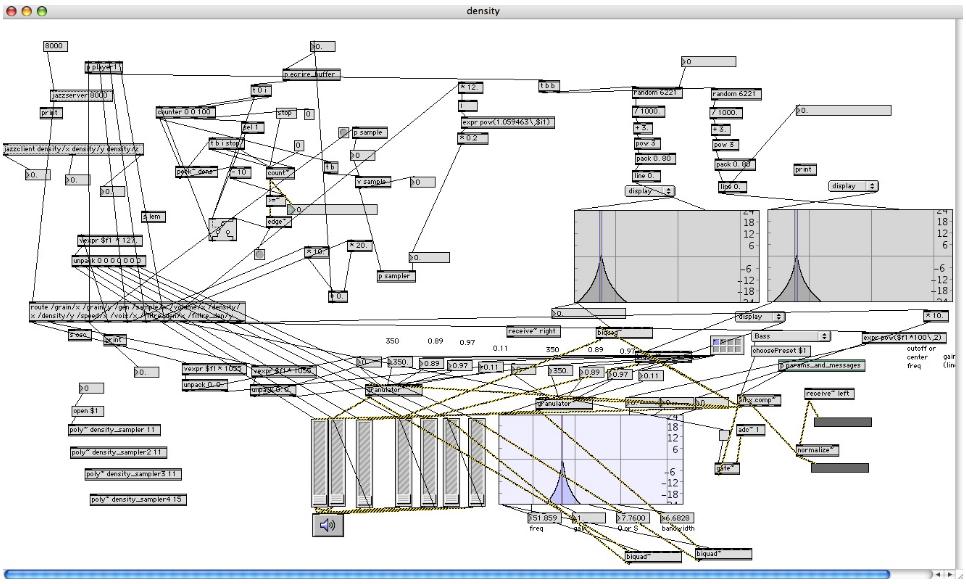

Figure 2.12: A typical work-in-progress patch of Max/MSP. Developed by J.-B. Thiebaut for the composition *Portrait* [81].

The representational strategy of Data Structures in Pure Data appears overall as a first step towards defining a high-level representation in support of composition. However, the de-correlation between the representation and the control of parameters rather postpone the commitment to programming than facilitating it. This is also acknowledged by the author of Pure Data, Miller Puckette, in a personal discussion reported by Kevin Dahan [21]: the patch approach developed in Pure Data and Max/MSP, initially dedicated to real time processes, is not suited for composition. The main difficulty being that these approaches display at the same level advanced representations (such as data structures) and low level operations (such as numerical calculations intervening in a process). Figure 2.12 is a typical example of a situation where a compositional idea develops in a patch. The interface, being saturated with data of all sort, makes its use difficult.

The programs review here highlight several problems in interface design: how to accommodate the need for high-level, abstract representations of a composition with low-level functions of sound processing that participate to the practical elaboration of the composition? How to represent at a similar level the global aspects – of a temporal, structural and abstract nature – and local aspects – sound processing at the micro level? In order to attempt answering those questions, it is useful to consider studies of representation. We aim in the next chapter at defining a framework for the study of music representations, in order to understand the functions served by abstract representations in music composition processes.

Chapter 3

Methodologies for the Study of Music Sketches

"I, as a composer, have no idea how the piece will sound in performance. And why should I?"

Cornelius Cardew, referring to his piece Treatise*, 1971 [16]*

This chapter reviews methodological approaches for the study of music sketches. We consider two areas of research concerned by aspects of music sketches: musicology and cognitive science. We develop from these disciplines a vocabulary for the description and understanding of the role of sketches in music composition practices. The musicology literature provides descriptions of the relationships between composers manuscripts and their final compositions. Through case studies, musicologists explore the materials produced in the course of a composition and trace how musical ideas develop in composition processes. These studies highlight a pragmatic role for music sketches, mnemonic in some cases, structural in others, using vague or precise representations ranging from formal notation to informal drawings.

In order to examine the dynamics of sketching, and the role played by sketches in the mental construction of a composition, it is also useful to consider the cognitive science literature. Paraphrasing Goldschmidt (1991) in her study of architecture drawings, we motivate our study on the basis that *if composers use the sketching tool so persistently, it must be very helpful to their thinking*. We present a review of sketches and design studies in cognitive science in order to enlarge our theoretical framework. Finally, we integrate to our framework the vocabulary of Distributed Cognition (DC), which describes the distributed dynamics of human activities. Following Hollan et. al (2000), we aim at using DC to set up an integrated approach of "observation to theory to design" ([37], p. 183) to bridge the gap between the observation of phenomena and the design of adequate software responses.

3.1 Sketch studies in the musicological literature

In musicology, "the most common motivation [*for sketch studies*] has been an interest in the compositional process in relation to specific works: the 'biography' of the composition, as it were, rather than of the composer (though it should be obvious that 'compositional process' denotes a spectrum of activities far too complex to be equated simply with the writing of sketches)" [65]. In musicology, sketch studies originated from the work of scholars on Beethoven sketches in the period 1860-1880 (Alexander Wheelock Thayer, Ludwig Nohl and Gustav Nottebohm). Beethoven had left a large quantity of sketches, which partly justifies these studies. The other reason underlying the studies of Beethoven is an attempt to understand the creative process of the composer by tracing the development of an idea to its realisation, which in some cases developed several years after it was jotted down in a sketchbook (see Cooper 1990 [17]). Musicological studies thus tend to examine the extent to which early, rough material contributed to the final piece. Such studies sometimes led to the completion of unfinished work (such as Mozart's *Requiem*, Mahler's Tenth and Elgar's Third Symphony). In recent musicological literature dedicated to classical music, sketch studies also aim at understanding and archiving the works of "important twentieth-century composers" [32]. The scope of this work is usually associated with understanding the genesis of 'master pieces'.

3.1.1 The role of Beethoven's sketches

Scholarly studies by Johnson (1985) [41] and Mies (1975) [55] of Beethoven' sketches focus on explaining the genesis of local parts of the composition. These studies aim at determining where – in a piece of music – similarities with sketches could be found. Beethoven' sketchbooks contain unfinished musical movements written at various moments, sometime several years before the movement was finished. The studies examine closely the matching of the sketches and the final score, and attempt to trace a 'biography' of the piece by showing how different movements were created independently to one another. The sketches themselves are not studied for a different role to that it played with regards to the final piece. The sketch studies present a chronological development of the musical process, and acknowledge the role of sketches in support of this development. Cooper (1990) and later Kinderman (2003 [42]) give striking examples of the successive refinements made of the original sketch of a theme until its completion. Kinderman's study presents ten successive drafts of the Opus 109, where the complexity of the score evolves from one draft to the next. Michael Arnowitt's description of Beethoven's sketches also reinforces the impression that a characteristic of music sketches is their transient, incomplete nature, which appears to be a necessary step to the emergence of a finished composition [1]: "Beethoven typically begins with a little sketch, something very short and generally quite uninspired, just a germ of a simple, rudimentary idea that anybody could have written – but then he magically transforms this idea into something so distinctly different it takes your breath away. Somehow, he makes it all meaningful and moving". These accounts on Beethoven practices indicate that sketches play a key role in the development and refinement of the musical *idea*, where successive drafts need to be made before the piece is finished. We shall see later that this is consistent with the role of informal drawing in architecture, which Schon and Wiggins (1992, [69]) describe as a cycle of "sketch, inspect, revise".

3.1.2 Different sketches, different purposes: the case of Béla Bartók

The musicologist László Somfai distinguishes the role of sketches in Béla Bartók[2] works (Somfai 2004 [74]) as follows:

> "*Preliminary memo*: notation of mostly short musical ideas during the preparation for a new work, typically before the intensive improvisation.
>
> *Side sketch*: notation of related ideas, typically on the margin of a draft, either for the continuation of the same work or for another composition, which came to Bartók's mind when he revised the sketch again, prepared the orchestration or copied the manuscript; these are valuable 'sketches in context'
>
> *Partial sketch*: quick elaboration of contrapuntal, harmonic, textural, and most typically scoring problems on a separate piece of paper in the course of the writing of a draft or an orchestration"

According to Somfai, Bartok's sketches are of different natures according to the different stages of the composition process. Preliminary memos are a record of initial thoughts. These

[1] "Beethoven's Sketches", http://homepages.sover.net/ foodsong/bsketches.htm, accessed the 4th of July 2009.

[2] Bartók was a Hungarian composer, active from 1908 until his death in 1945

initial memos compare to Beethoven's initial sketches: they set out a musical idea that has yet to be developed. These constitute the first trace of a musical piece, its original genetic code. How exactly these memos turn into *drafts* is unclear in Somfai's distinction: the next sketches are identified as *side sketches* written in the margins of the drafts. From a musicological perspective, these side sketches are valuable for the information they provide on the creative dynamics at the time the composer writes the music: they are a record of the revisions and sometimes link the current work with past or future works. Finally, the third type of sketch – *partial sketch* – is typically written on a separate piece of paper and is used to solve local scoring problems. This type of sketch, alike the preliminary memo, is written using standard Western notation. Side sketches, on the other hand can be textual notes, informal drawings, numerical indications or even diagrams. The variety of sketches developed by Bartók as well as the different roles they play in his composition process indicate that there is more in sketching activities than annotating musical ideas. For Bartók, as well as Beethoven and most instrumental composers before the 1950s, sketches might have been used for other purposes than establishing a transitional record of the state of a composition, but the lack of evidence prevents us from elaborating on such cases. We now turn to the study of more recent composers whose archives tend to show that new forms of representations played an important role in composition practices.

3.1.3 Sketches and non-standard representations

In the period following the World War II, many classical composers radically changed their approach to scoring music. This change can be observed in the final form of the notation (i.e. the score to be played by performers). This is exemplified by the works of e.g. Gyorgy Ligeti, Cornelius Cardew, Karlheinz Stockhausen, Iannis Xenakis or John Cage, and to a more peculiar extent, Pierre Schaeffer (see chapter 2 on the use of magnetic tapes). Various compositions were devised using non standard notations. Some would contain explanations of how the score should be read (see in the next chapter an except of Gyorgy Ligeti's score of *Volumina*), but some other would have to be freely interpreted (see e.g. the piece *Treatise* by Cornelius Cardew (1967) [15]). The fact that composers developed non standard representations, and produced them as a final score – as opposed to an intermediate representation – indicates a need for a representation of music that is less determined than standard notation. The development of graphical notation is particularly striking in Cardew's *Treatise*, Ligeti's *Volumina*, or in John Cage's *Music of Changes* (1951) [13].

Many other factors lie behind the development of these non standard representations. Changes in techniques and genres often coincide with aspirations of composers to innovate and differ from established genres (see e.g., the development of opera with Monteverdi's *L'Orpheo*, the influence of Bach's *Well-Tempered Clavier* on instrument tuning, or the development of *Klangfarbenmelody* with Schoenberg). In a similar manner, the development of notational system evolved from aspirations of composers to represent richer aspects of music. Examples of these developments are the notation of improvised or random sections, introduced in Western contemporary music by e.g. Stockhausen or Cage, which required the representation of new instructions. In some cases, non standard representations were developed during the composition process and later turned into standard notation (see e.g. Xenakis' *Metastaseis*), and were in some other cases refined into a graphical score for the performers (see the case study of Ligeti's *Volumina* in chapter 4). An example of use of intermediate representations that use non standard notation is the piece *Metastaseis* by Iannis Xenakis. The composer (who was also an architect) drew lines on millimeter paper before he had notes and durations reported on standard notation. In a similar manner, Gérard Grisey wrote the score of the piece *Partiels* after he had define notes using the spectrogram of a single note of a trombone. However, Cornelius Cardew (who was also a graphic designer) choose intentionally not to conform to formal notation. He wrote 193 pages of music in a format that he describes as "graphic music". The intention was to create a score for improvisers (see Cardew (1967) and (1971) [15, 16]). This score did not have any indications on how to interpret the drawings. Later, however, Cardew composed music in standard notation from extracted pages of *Treatise*. Finally, two examples of intermediate representations developed in the process of composing electroacoustic music must be recalled here, Stockhausen's *Gesang der Jünglinge*, invoked in chapter 2, and Ligeti's *Artikulation*, which is described in the next chapter.

From these examples, it can be argued that representing music to oneself is integral to the composition process. In the cases previously cited, the representation acts not only as the score to be interpreted by the musicians[3], but the intermediate states (of the score) double unequivocally as a means for the development of musical ideas. It therefore appears felicitous to ask the question whether the relationship between the intermediate representations of a piece and its final score did play a role also in Beethoven or Bartók's music. We shall recall that similar relationships were observed in the fourteenth-century *Ars Subtilior* (see Levy (2004) [48]). The musicology

[3] At the exception of the electroacoustic pieces mentioned

literature thus acknowledges a role played by representations in the composition process. This, however, constitutes only a first step towards understanding what this role is. In order to address this question, and to define a suitable methodology for the study of music representations, we now turn to two inter-disciplinary studies of music composition processes, whose methods and findings build on musicology, ethnography and cognitive science.

3.2 Musicology and cognitive science: critical analysis of inter-disciplinary studies

There is a challenge in reconciling disciplines that share a similar research object but have different aims and methods. In this section, we aim at establishing the benefits of an inter-disciplinary approach to our study. We have presented in a previous section the musicological interest to music sketches as the attempt to reconstruct a genealogy of music compositions. It would not make justice to musicology to reduce its contribution to the understanding of sketches to this simple objective (the genesis of master pieces), but it appears, however, that the vocabulary and methodologies traditionally used in this field – in particular the understanding and tracing of rules, genres, styles or techniques in music history – is not entirely adequate to understand how music composition – the creative act of making music – is achieved. Understanding *creativity* poses, in fact, a number of questions that other disciplines than musicology are better positioned to address. Using an example of inter-disciplinary work and contrasting its methods and finding to cognitive science studies, we establish an initial framework and vocabulary for a finer-grain understanding of composition dynamics. We do not aim at discussing an exhaustive list of inter-disciplinary studies, and it is hoped that this analysis will provide sufficient materials to defining our framework.

3.2.1 On the dynamics of music composition, Donin and Theureau (2007)

This study uses a mixed approach of musicology (Nicolas Donin) and situated cognition (Jacques Theureau). The scope of their work is the understanding and occurrence of three notions in music composition: *situated composition*, *idea* and *appropriation* [4]. The authors consider a large amount of documents and technologies produced by the composer Philippe Leroux in the course of the composition *Voi(rex)*. These documents include sketches, plans, hand-written score of

[4] *Situated composition*, *idea* and *appropriation* are emphasised by the authors. See the article for more precisions.

the composition, screenshots taken at various stages of the making of the electronic accompaniment, personal or technical notes, and e-mails exchanged with the performers. The collaboration of the authors with the composer lasted for almost two years. Several interviews took place across this period, where the researchers examined the documents produced and reconstructed the composer's anticipations at the time the documents and score were produced. The study of the materials and the account given by the composer allow the authors to claim that musical composition is a case of situated cognition, where the composition is built through successive situations. These situations – according to the situated cognition theory – constitute the catalyst to *knowing* through the activity of *doing*: in this case, the composer *knows* and *defines* his intentions by engaging to activities such as sketching and using music computer programs. In other words, it is by engaging to these activities (sketching and appropriating the technology) that the composer develops and defines the composition.

In order to produce these results, the authors investigated thoroughly the composition process and the development of the *idea*[5]. The large amount of documents produced revealed that some elements were consistently re-used from one stage of the composition to the next, while others were eliminated. The authors also identified that the interaction with computer programs impacted the composer's decisions, in particular when reviewing recorded improvisations.

We thus integrate to our framework some key elements of Donin and Theureau (2007): first, that composition is characterised by *situations* in which the composer defines and develops the composition; second, that these situations involve engaging with various artefacts: pen and paper but also computer programs and musicians; third, that the musical *idea* in the context of a composition, is equally vague and objective, representing an ideal that has yet to take form in the perception. Finally, we also note that an in-depth, chronological access to composers' materials is necessary to understand and decompose composition processes.

Following Takano (1989) [78] and Zhang and Norman (1994) [92], external representations can play a *propositional* role by structuring the cognitive behaviour and change the nature of a given task. This role was reformulated by Goldschmidt (1991) [29], Goel (1995) [28] or Suwa

[5]It is useful to reproduce here the author's understanding of the *idea*, which originate in Kantian reason and is developed by Deleuze (1994): ideas "present three moments: undetermined with regard to their object, determinable with regard to objects of experience, and bearing the ideal of an infinite determination with regard to concepts of the understanding [...] The undetermined is not a simple imperfection in our knowledge or a lack in the object: it is a perfectly positive, objective structure which acts as a focus or horizon within perception", ([22] , p. 169). Following Deleuze, then, and applying this understanding of the concept of *idea* to the musical domain, suggests that many factors might contribute to the materialisation of this *horizon*.

and Tversky(1997) [77], who have shown that external representations can play a role in facilitating design processes through a dialectic cycle of inspection and revision. It can be argued that intermediate representations (for example a diagram or a sketch) contribute to this cycle even if further developments omit them, for their function is reflexive and thus changes – to an extent that we aim at defining – the internal state of the composer. It appears that in order to better understand the role of sketches, we can not consider their functions from a well-defined perspective: the composer gives evidence in the sketches that a final state of the composition is constantly changing or unknown, and that it is affected directly or indirectly by the dynamics of the representations. Adding and deleting elements from a sketch to the next is consistent with the dialectic outlined above of inspection and revision. Observing sketches from a perspective where the composition activity is considered well-defined – the composer using defined *means* toward a defined *goal* – is not a suited method for the understanding of sketching activities in music composition practices. A methodology for the observation of ill-defined activities excludes *de facto* experimental conditions and quantitative studies. It appears thus useful to consider qualitative methods. We study in the next section an application of ethnography to composition practices.

3.2.2 On ethnography of composition, Bowers (2002)

John Bowers (2002) [10] developed an ethnographically-driven approach to music improvisation practices. The goal of this work is to inform the design of improvising music systems. The ethnography builds on Bower's experience and that of collaborators, and constitute a basis for the collection of first-hand, empirical material. The study analyses the practices in this field of improvised electro-acoustic music and isolates analytic issues. These issues are used to inform the design of technologies for improvisation. The scope of Bowers' work presents similarities with the goal of this thesis: understanding the dynamics of musical practices *and* informing the design of a tool in support of these practices. It is thus appealing to build on Bowers' framework to conduct our analysis. A few practical problems emerged when an ethnography of composers at work was envisaged. Whereas the work of an improviser can be observed on stage, the work of a composer is voluntarily hidden, which makes a study of these practices difficult. An ethnographic study of composers 'at work' was therefore compromised for the very practical reason that composers did not want to be observed when they compose. While accessing first-hand material appeared rather difficult, collecting (selected) materials from the composers was relatively easier. To observe the materials available at hand (numerous sketches from the musicology literature as well as sketches provided by composers), we decided to use distributed cognition to provide an analytic vocabulary in which to discuss the role of the sketches as representations in composition.

3.3 Sketches studies in cognitive science: distributed cognition

Recent inter-disciplinary studies have elaborated on the role of cognitive activities in musical composition. In addition to the studies discussed above, Levy (2004, [48]) observed that the development of musical notation acted as a grammatical system that enabled musical complexity to develop. We now turn to the literature of cognitive science in order to determine appropriate techniques and methodologies for the observation of music sketches.

Studies of representations comprise a range of practices and applications that span across problem solving (Larkin and Simon (1987) [45]), the support of early design process in architecture (Suwa and Tversky (1997) [77]) or the support of communicative interaction (Healey et. al. (2002) [34], Healey and Peters (2007) [33]). Sketches have been studied in various human activities, ranging from playing games to the design of kitchens or clothes (van Sommers (1984) [87]). Drawings in these contexts can serve a range of cognitive and computational functions, as shown by Scaife and Rogers (1996) [67]. For example they can provide a useful way to articulate multiple, parallel constraints that are difficult to express in natural language – such as the relative position and orientation of several locations on a map. More generally they can help with 'computational offloading' – the use of external representations to reduce cognitive load (Hutchins (1995) [39], Norman (1993) [60]).

In contrast to informal drawings of music, music notation provides a well defined syntax and semantics, which is essential for computational applications aiming at producing well defined outcomes. However, there is evidence that some of the benefits of sketching derive from their ambiguity and vagueness. Musical composition is an ill-defined activity, where the initial state, the means to solve the problem and the end state are not clearly specified. As shown by Neilson and Lee (1994) [57], the underspecified semantics of architectural design sketches is integral to the way they are used. In their analysis of 'kitchen design' dialogues they found that there was no consistent mapping of the dimensions of the page onto the dimensions in space. Thus while a table might be drawn with width and depth, in the same picture a chair might be represented by a single 'one- dimensional' line. Amitani and Hori (2001) [3] argued that externalization in a two-dimensional space enable changes in the representation of information during the process of musical composition. Goldschmidt (1991) [29] describes this dynamic interplay between design ideas and sketches as a 'dialectic' and argues that it is a characteristic and key part of the creative phase of design (see also Suwa and Tversky (1997), [77]). Informal drawings of music appear to have a less straightforward mapping between the sketch space and the world. The key dimensions of music – such as temporal or aesthetic structures – have a more abstract relationship to the sketch space.

In order to analyse sketch data and the interplay between the external and internal representation, it is useful to consider the framework of distributed cognition. Following Hutchins (1995a, 1995b) [39, 40], the cognitive properties of a distributed system, such as the system formed by two pilots and a cockpit, differs radically from the cognitive properties of the individuals. The reason for this is that such system carries information that transforms the performance of the task. Hutchins observed a dynamic interplay between the artefacts carrying information, such as indication of the speed of an airplane or fuel quantity indicator, and the cognitive behaviour of the pilots. Hutchins argues that the unit of analysis of distributed systems should include both internal and external representation, as opposed to considering processes that occur only 'in the head'. A first step towards analysing external representations in order to be able to infer the internal representation is to define categories in support of the description of the content of sketches. We build on Suwa and Tversky (1997) study of architects sketches and adapt the information categories described in their approach:

"Many theorists like Larkin and Simon [45] and Tversky [85] have suggested that the pictorial devices for expressing meanings and concepts consist of (a) depicted elements, whether objects, spaces or icons, and (b) spatial arrangement of them. They have also suggested that spatial arrangements have the ability to express not only literal spatial relations, but also abstract or conceptual relations. This analysis suggests three information categories: depicted elements, spatial relations and abstract relations."

Suwa and Tversky argued that the category of depicted elements should also encompass the emerging properties of diagrams described by Larkin and Simon [45], and Koedinger and Anderson [44]. Emerging properties are observed when the role of depicted elements that are embedded as partial elements change as the agent restructure the configuration that includes them. Emerging properties are relevant to music sketches, when, for example, part of a drawing is re-used in a different context, or plays a *propositional* role and transform the internal representation. We thus incorporate to our information categories the distinction made by Suwa and Tversky and name the first category ‘emergent properties’. The emergent properties in architecture drawings concern the description of spaces (areas or places), shapes (corner or surfaces) and ’things’ (abstract descriptions or names). We need to adjust these subclasses to consider musical properties, such as pitch, rhythm, timbre, textures, space, or ‘things’.

Second, we integrate ‘spatial relations’ to our terminology to describe the spatial relationship that might occur in the drawings. The distinction with architecture drawings is that the spatial relations observed in music sketches are more often than not abstract mappings between a musical dimension to a spatial dimension of the 2-dimensional sketch, as opposed to a mapping of the ‘real space’ observed in the real world and projected onto the 2-dimensional paper. For example, a spatial relation often encountered in music sketches associate the horizontal axis to time, or the vertical axis to the pitch of (an) instrument(s). Spatial relations are inherently visual and characteristic of the need to represent abstract concepts or mappings that can not be perceived spatially in the real world.

Third, we integrate ‘functional relations’ to our terminology in order to describe the interactions among depicted elements (pitches, spaces, textures, etc). Examples of functional relations are arrows that link forms, particular elements designed to group objects together, indications of sound transformation or process.

Finally, it is useful to integrate the fourth category devised by Suwa and Tversky, that of ‘background knowledge’. They refer to background knowledge as the specific knowledge about structures, materials, aesthetic standards, preferential evaluation for design decisions, and the interactions with a given environment. We shall consider in this category the knowledge specific to music: (a) domain knowledge about music structures and instrumentations, harmony rules and temporal arrangements, in particular in relation to formal notation; (b) knowledge about specific devices (instruments, but also hardware and software equipments); (c) knowledge about abstract concepts used for the generation of notes (algorithms, numerical annotations).

3.4 Conclusion

We have reviewed in this chapter different approaches to the study of sketching, of inter-disciplinary study of music practices and cognitive studies of the role and dialectics of sketching. These studies have established several notions about the different roles of sketches. In order to constitute a theoretical foundation for our study, we integrate the following notions and concepts:

- Chronological studies of Beethoven's sketches show evidence of a correlation between the complexity of the score and the evolution over time [17].
- Hand-written documents of different natures may be produced in the course of a composition. In Somfai's study of Bartok, these documents serve the purposes of 1) setting out the original idea, 2) annotating changes, precisions in the margin of a draft, 3) support problem-solving activities [74].
- Graphical scores that developed since the 1950s highlight a role for music representations that is either under-specified (e.g. Cardew) or over-specified in *some* aspects (e.g. Ligeti, section 4.2) in contrast to standard notation.
- Donin and Theureau (2007) highlighted that composition is a case of situated cognition, where the *musical idea* develops by engaging in situations such as sketching, planning or interacting with musicians and music software.
- Goldschmidt (1991) and Suwa and Tversky (1997) show further that sketches carry information that help reducing the cognitive load and facilitate the revision of ideas by playing a propositional role. Following Hutchins (1995) and the Distributed Cognition theory, the artefacts used to realised specific tasks carry information that support the cognitive activity. In order to describe how this information takes form on music sketches, we set out (following Suwa and Tversky (1997)) the three main characteristics of sketches that need to be observed: the depicted elements, their spatial relations and their abstract relations.
- These concepts will be used to study original manuscripts and sketches produced in the course of several compositions in the next chapter.

Chapter 4

Case Studies

This chapter presents four case studies of 20th and 21st century composers. The case studies focus on set of sketches developed by the composers in the first stages of composition. In this chapter, we examine the motivations underlying sketching musical ideas in various contexts of composition, acoustic (Ligeti and Báthory-Kitsz), electroacoustic (Ligeti, Freeman) and mixed (Austin). Using the framework of distributed cognition, we aim at observing emergent properties in the sketches in order to get a better understanding of the processes involved in the first stages of composition practices.

4.1 Methodological remarks

We have chosen to present the case studies ordered by composers, and discuss and compare the functions of their sketches at the end of this chapter. The reason for this is to provide a better understanding of each context studied. We argue that by doing so, we provide a more detailed report of the methods used to collect the information and allow, when possible, to investigate how the processes progress chronologically, which is supported by several discussions with the composers. The comments from the composers allow a better understanding of the abstract properties of sketches. The studies are heterogeneous in terms of settings, but also in terms of the quantity and quality of data gathered. We have extensively discussed the sketches with composers when possible, but the amount of feedback between them vary. We have chosen to produce each case independently in order to make these differences in settings more transparent.

The data were acquired through voluntary submission by the composers (to the exception of Ligeti's materials, acquired at the British Library). The composers had been approached in December 2006 via various lists of discussion, when a small survey (not reproduced here) was carried out on composition practices. We selected the materials received according to their level of completeness. The materials submitted had to include all the documents produced in the course of a composition, including informal drawings, side notes or diagrams. It was also important that a chronological order can be traced in the materials. Among the materials received, we chose to study the manuscripts of three composers that matched our criteria, those of Freeman, Austin and Báthory-Kitsz. It has been envisaged to study the documents available on microfilms at the Paul Sacher Foundation, which contains detailed archives for many 20th century composers (including Béla Bartók, Pierre Boulez, Igor Stravinsky or Eliott Carter). However, it was preferred to work with composers whom we can easily communicate with, in order to get explanations for the sketches. The sample studied in this chapter is not representative of the music practices at large, we focused on composers of classical music (orchestral and electroacoustic). The composers are an heterogeneous sample in terms of age, country of residence, and musical traditions. They are however all male composers. Each case briefly traces the biography of the composers.

4.2 Study case 1: György Ligeti

György Ligeti (1923-2006) composed mainly with instruments but also composed several electroacoustic pieces. His work can be assimilated to the tradition of classical music: he composed an opera, several orchestral works, chorals or chamber music. His work was influenced by electronic music as early as 1957, when he wrote several electronic pieces alongside Karlheinz Stockhausen. He is probably most well known for his composition *Lux Aeterna* which was used by Stanley Kubrick in *2001: A Space Odyssey* (1968). His use of sketches in both electronic and instrumental music – as well as his taste for non standard notation – offers an interesting framework to compare the role played by sketches in his composition process. In this section we present two case studies. The first focuses on the sketches produced during the composition of the piece *Volumina* (1961/1962). *Volumina*'s final score is written in non-standard notation, and we look in particular at the reasons underlying the choice for an alternative representation. It is important to note that we were not able to access the full extent of the archives for this study, nor were we able to reproduce all the sketches observed for this study. We thus make a case out of the available materials.

The second study explores the sketches used for the elaboration of the electroacoustic piece *Artikulation* (1958). *Artikulation* is an electroacoustic composition for four channels. The materials used for this study have been published along an aural score [52]. The sketches and notes reproduced in this document are an except of the 110 documents produced throughout the composition.

4.2.1 *Volumina*

This study compares an except of the sketches drawn for the composition *Volumina* (studied from the document [53]) and the final version of the score. This piece has been chosen for its unusual notation developed in the sketches, which remains in the final score. This notation is made of geometrical shapes, such as triangles and rectangles, but also some more abstract drawings. The shapes are often filled with different textures. The musical interpretation of the various shapes and figures is thoroughly explained in the preamble of the score. The score, which has been studied at the British Library ([51]) is not reproduced here due to copyright issues. We examine in this case study the motivation underlying the development of this notation and how a taxonomy of graphical objects emerged during the sketching process.

Volumina is a composition for a single instrument, the organ. It is thus meant to be performed by an organist, usually trained to perform music written in standard notation. In comparison with standard notation, the notation developed for *Volumina* enables a wider range of interpretations. As we shall see, the development of *Volumina*'s notation aims at manipulating dimensions of music that would be problematic using standard notation.

The sketch of *Volumina* (figure 4.1) is drawn on plain paper, thus there are no predefined dimensions. The vertical axis is used to represents pitches in their absolute notation (hand written on the left hand side as "C, C1, C2", etc.). The vertical space is separated in three parts: the upper part represents the right hand staff, the middle part represents the left hand staff, the bottom part represents the pedal staff. Below the pedal staff, an additional space is kept for comments. Each part contains a pitch scale on the vertical axis starting with the lower C and ending with D1 for the pedal and A3 for the hands. These represent the pitch scale in which the organist will perform. The horizontal axis implicitly represent time, although there is no explicit legend. The numbers "32" and "33" at the bottom of the sketch refer to consecutive measures, but the duration of events is not clearly defined. The sketch does not match with the movement 32 and 33 of the final score but with the movements 35 and 36.

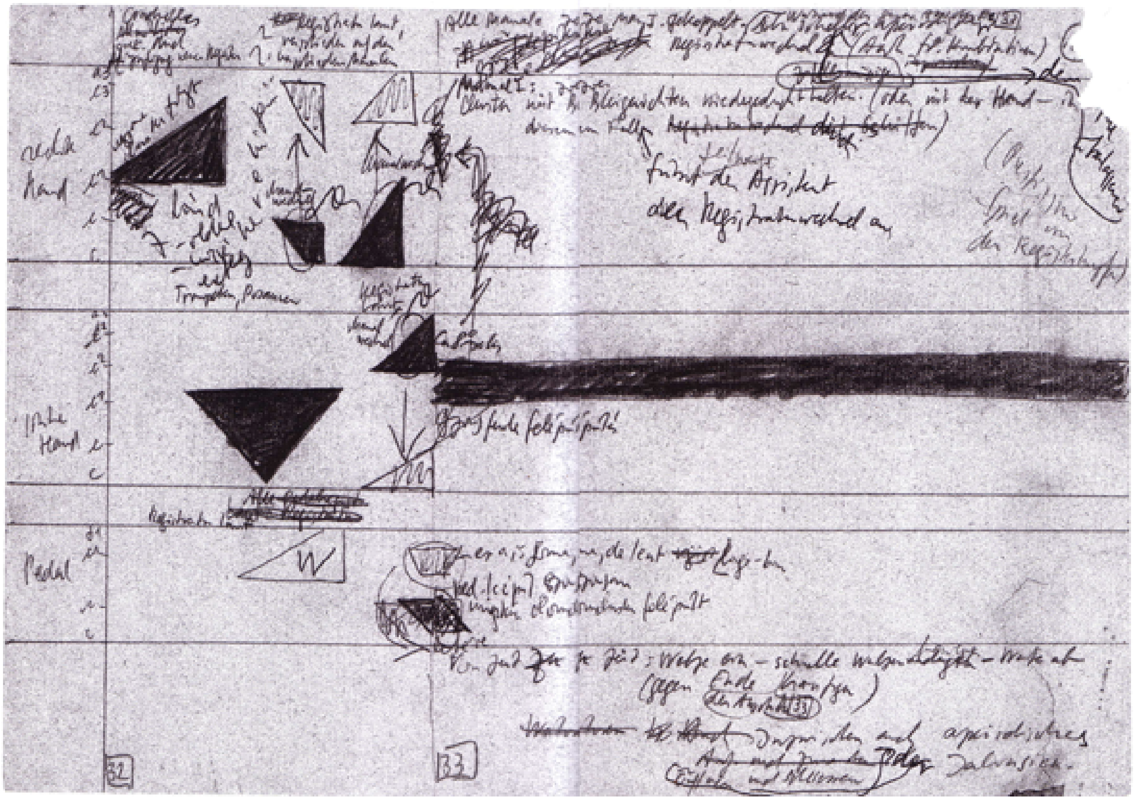

Figure 4.1: A sketch of the piece *Volumina* by György Ligeti. Extracted from [53], Reproduced by kind permission of Schott Music Limited, London.

In this sketch, Ligeti uses plain geometrical shapes, four triangles, one four-side figure and one rectangle. These shapes define a pitch-time-space in which cluster of sounds will be played; the wider a shape is at a certain time on the vertical axis, the higher the density of notes played will be. The large scale used to represent pitch presumably serves a practical purpose, that of defining precisely pitch boundaries. However, the scale in this sketch appears ambiguous and it is not clear at what pitch (or scale of pitches) an event starts. This sketch suggests that Ligeti explores the development of sound clusters within defined ranges, which have different duration, different progressions and different play modes. From this sketch, it is not clear how the organist will have to play these clusters, and the sketch suggests that the interpretation will be partly free. The constraints developed for this sketch focus on time aspects (although without precise measures), on which keyboard notes are played and finally on the pitch scale. In comparison with the other sketches of Ligeti presented in [53] (see figures 4.2 and 4.3), the sketch of *Volumina* is much more ambiguous, in particular regarding time and pitch aspects. In fact, the five other sketches in [53] have sequences were pitch and rhythms are approximately defined (the tempo is missing though).

The characteristics of this sketch falls into all of our information categories. The emergent property that occupies the most space is that of pitch. The vertical axis serves the purpose of defining it, and all graphical elements drawn onto the sketch are implicitly linked to the pitch scale. An other emergent property defined in that sketch is that of texture, represented by the colour of the shapes or their texturing. The sketch also present a spatial relation, the vertical axis defining a pitch dimension and the horizontal axis defining the time dimension. Both relations are vague: the pitch scale does not allow knowing precisely the boundaries of each object. The time scale is referred to in term of measures, but there is no mention in the sketch of how long a measure lasts. The measure '32', although gathering more shapes than the following measure is given less horizontal space, suggesting that its duration is shorter. Third, the sketch present functional relations between objects, indicated by the several arrows. These arrows link shapes to other similar shapes, seemingly indicating a revision of their original position. Finally, the background knowledge is illustrated by the numerous textual annotations, which serve several purposes. On the left side, these are precision for the pitch range. On the horizontal axis, the numbers '32' and '33' indicate a measure of time, in relation to the whole piece. We speculate[1] that the short text annotations close to the shapes are precisions of the musical play mode for the graphical textures, or could be precisions about the functional relation between two shapes. Numerous annotations written with different pencils could be mnemonics written at different moments that indicate succesive revisions of the sketch.

By comparing the sketch of *Volumina* and the final score, we observe that some aspects remained but some other disappeared or evolved. For example, the basic geometric shapes evolved into more textured shapes. Curves replace straight lines, and textures are added to the filling of certain shapes. The corrections made with a red ballpoint pen in the sketch are considered in the final score ; for example, the four triangles that were assigned a new position (indicated with arrows on the left part of the sketch, the new positions are indicated with shapes roughly filled) appear on the final score where they have been relocated on the sketch. The pitch scale disappears in the final sketch: the shapes are assigned specific scales identified by different textures or contours. According to the final score's preamble, the scales are chromatic, diatonic, pentatonic, or, in the case of triangles, an all-note (*Allmählicher*) clustering. The lack of a pitch scale on the

[1]We did not have access to a translation of the text.

final score suggests that interpretations will not be identical from one performance to another, as the interprets chose the notes he/she wants to play within a designated scale. It is also unusual, in the sense that sketches usually tend to be more vague than the final result. In the case of pitch (and in this case only), the final score is less precise than the sketch, as pitch indications are missing in the final score. Textual precisions on how to perform this piece are gathered in a 5-page preamble.

Another dissemblance between the sketch and the score concerns the nuances. Indications of nuances are lacking on the sketch, but are very precise in the final score. Ligeti was not concerned by this aspect to the extent that he would draw it. This suggests that either the nuances were not considered as a problem to solve with sketching, or that the composer had a clear representation in mind of how nuances would be addressed in the final score.

Besides the four-page preamble which gives indication movement-by-movement, some contextual indications are added to the final score that were not in the sketch. For example, the long rectangle in the sketch that became two textured rectangles (one for the right hand keyboard and one for the pedal keyboard) is assigned a specific indication:

> Gewebe: schnelle, kontinuierliche, aperiodische, sehr dichte, labyrinthische Bewegungen in unregelmässigem Rhythmus, mit beiden Händen über den gesamten umfang der Manuale. Auch clusters ad lib. (mit Handfläche, Arm, Ellbogen). [2]

The fact that this information appears only on the final score indicates that the technical aspects of the interpretation are not central either to the elaboration of the piece. Similarly, the texturing of the shapes, which also appears in the final score but is not present in the sketch suggests that the rhythmic patterns were not a major concern in the sketching part. In contrast, the pitch scales, which were indicated in the sketch, disappear in the score. This primary interest for pitch scales suggests that the harmonic content might have been amongst Ligeti's primary concern at the moment of the sketch. The reason why the pitch scale have been removed seem to be for usability purposes, i.e. the scale was not giving enough precision on the dynamic boundaries of a given cluster. From the sketch to the score, the only information that persists is the distribution of the cluster amongst the right hand, the left hand and the pedal. The graphic shapes have slightly evolved, either in shape or in texture. Noticeably, the textures of the final shapes

[2] Structure: quick, continuous, aperiodic, very dense, labyrinthic movements in irregular rhythm, with both hands over the whole range of the keyboards. Clusters ad lib as well (with the whole hand, arm and elbow).

are more sophisticated, as to represent a metaphorical sonic event. For example, lines undulating intricately within rectangles illustrate a particular play mode (linked to previous quote). This metaphorical representation is ambiguous to read for a performer: unlike standard notation, which has a relatively straightforward interpretation, *Volumina*'s notation favours multiple interpretations. Overall, the attention given to some sound dimensions in the sketches (e.g. pitch), and the lack of representation of others sound dimensions (e.g. nuances, rhythms) suggest that the composer might have not considered the latter dimensions as problematic for the development of the piece, or that their development did not need intermediate representations before the final score was written.

We now turn to a study of the five other sketches presented in the document [53]. These sketches were elaborated during the composition of pieces of various instrumentation.

4.2.2 Five acoustic sketches

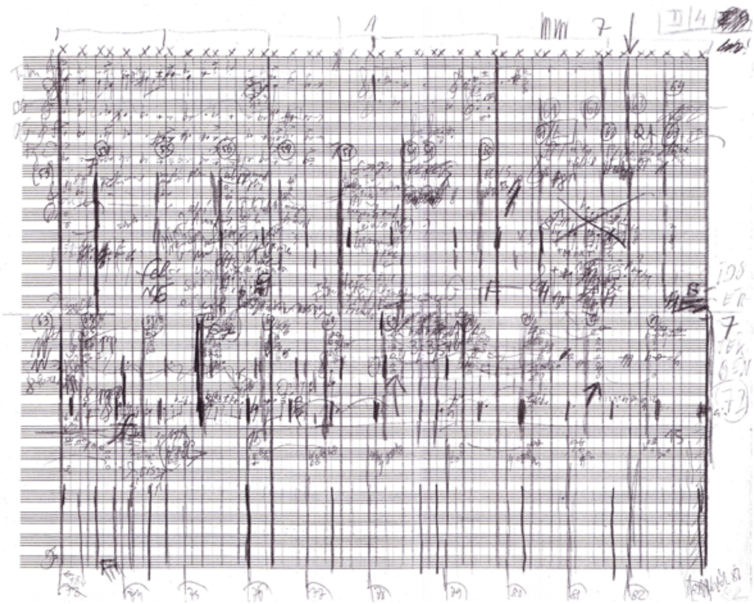

Figure 4.2: A sketch of the piece *Requiem* by György Ligeti, numbered #3. Extracted from [53]. Reproduced by kind permission of Schott Music Limited, London.

A common aspect of these five sketches is that they all have been revised after a first draft. This is particularly striking in the *Requiem* (figure 4.2) where strokes were added after the first sketch was made in order to separate, underline or set aside certain sequences. The use of colours also recurs in all sketches[3]. In the sketch of *Requiem*, green and red ballpoint pens were used to

[3] A colour copy of the sketches could not be obtained

add precisions after a pencil was used to sketch the whole part. This use of pencil to write notes and ballpoint pen for additional precisions also recurs in all sketches.

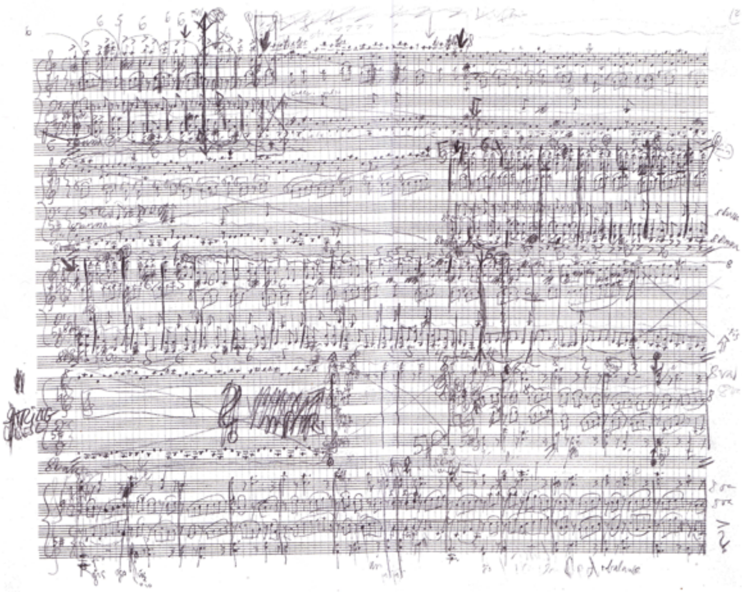

Figure 4.3: A sketch of the piece *Konzert für Violine und Orchester* by György Ligeti, numbered #3. Extracted from [53]. Reproduced by kind permission of Schott Music Limited, London.

In the *Konzert für Violine und Orchester* (figure 4.3) Ligeti uses seven different colours to separate different moments in time. The strokes he used to link the notes between different staves is also present in the other orchestral works. In these sketches, the apparent role of the strokes is to support the elaboration of vertical harmony. In fact, the large vertical space used in *Volumina* could not be used in an orchestral score, and this for practical reasons: if the pitch for every instrument was extended to half a page, the vertical representation of a single measure would take at least twelve pages. Therefore, the exploration of harmonic contents such as realised in *Volumina* could not be easily sketched with several instruments at once.

None of the five other sketches published in [53] uses a non standard notation. The common aspects of these sketches concern the use of colours to separate or identify events, the re-editing of parts of the pieces, and the scribbling of side notes, probably used as mnemonics for details to be considered in the final score. There is not enough sketches in the document, however, to study in more details the development of structural aspects. In terms of information categories, we observe that both sketch reproduced in figure 4.2 and 4.3 present numerous spatial relations that take the form of vertical coloured bars, probably used to disambiguate the vertical relation that notes have one to another. To the vertical bars also correspond numbers that refer to successive measures (sketch 4.2). The vertical bars also serve a functional role, that of highlighting relations among the notes. Other functional relations include arrows that point at group of notes, brackets that distinguishes six groups (on top of the score), and local circles around groups of notes. We note in both sketches several references to background knowledge under the form of textual annotation (capital letters, numbers, validation marks). Several numbers are written inside and on the margins of the sketch. Emergent properties can not be clearly observed in this sketch, for the representation uses formal notation. However, the sketch presents evidences of several revisions (invalidation, grouping, emphasis on parts, etc.). Moreover, the depicted elements that fall in the information categories of spatial relations, functional relations and background knowledge underline the cognitive role played by intermediate representations: in this case, they support the revision of the piece by allowing identification of parts of the score, grouping and separating or numbering.

The sketches studied for the following composition, *Artikulation* are part of a more complete set of sketches, which allows the analysis to focus on different aspects of the processes.

4.2.3 *Artikulation*

Artikulation is an electronic music piece composed on four channels of audio in 1958. Ligeti had composed only two pieces of elctronic music, *Glissandi* (1957) and *Artikulation*. The latter, which was documented in [52], present a facsimile of part of the 110 sketches used during the composition process. Interestingly, the document was principally published in order to present an “aural score” designed as to offer a visual aid to the listening of this piece. The notation developed is arbitrary but attempts to represent similar events in a similar visual way (see figure 4.4). Since, this kind of “aural score” became a consistent practice in electroacoustic music, mainly for analysis or multi-channel diffusion. The Acousmographe software was specifically developed at the *Groupe de Recherches Musicales* (GRM) to address this task.

The document reproduces 15 of the 110 sketches developed by Ligeti. Most of these contain numerical data in relation with the electronic equipment Ligeti was using to generate sounds. According to Wehinger, the piece is largely based on experimental and empirical methods. The sketches were thus used mostly as mnemonics for numerical combinations to experiment with the hardware. Ligeti ([59]) described the structure of the piece : “[...] The overall plan was a gradual, irreversible progress from the heterogenous disposition at the beginning to the complete mixture and interpretation of the contrasted characters at the end”. We study how this idea took

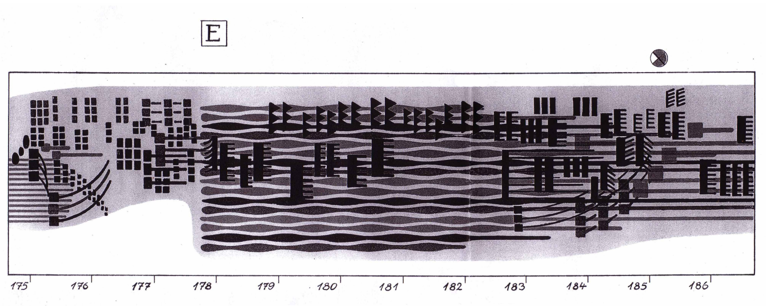

Figure 4.4: Excerpt of the aural score of György Ligeti *Artikulation* designed by Rainer Wehinger. Reproduced by kind permission of Schott Music Limited, London.

form on a medium for which no notation existed, and the role of intermediate representations in this process.

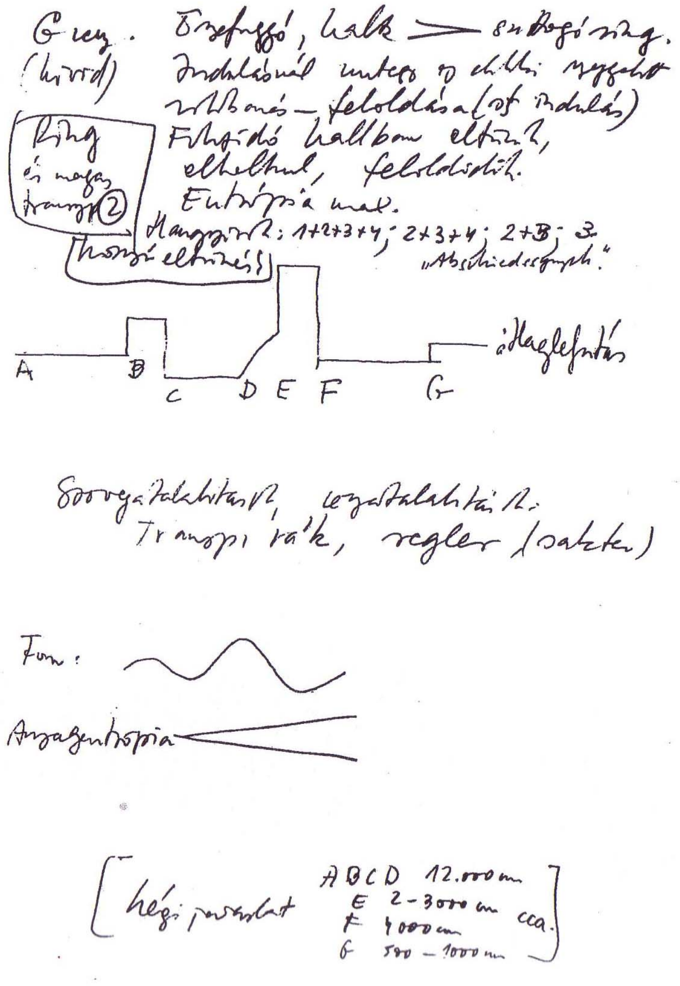

Figure 4.5: Structural sketch (#12) of the piece *Artikulation* by György Ligeti. Reproduced by kind permission of Schott Music Limited, London.

It is not known whether the sketches are reproduced in a chronological order or not. The first four sketches reproduced in [52] were developed to reference 42 sound materials recorded on tape. The next two sketches represent numerical data used in relation with the equipment and the tapes. In contrast, the next three sketches (inconsistently numbered 8, 9 and 12 in [52]) present structural information. The analysis accompanying the sketches specifies that the piece contains seven parts from "A" to "G", which is shown in figure 4.5. The parts are represented along the horizontal axis. A single line evolves along the parts on the vertical axis. Rainer Wehinger, who interviewed the composer, reported that the "part A is subdivided into twelve sections and comprises more than two third of the whole piece". It means either that the diagram sketched in figure 4.5 does not represent time on the horizontal axis, or that the sketch was revised later on.

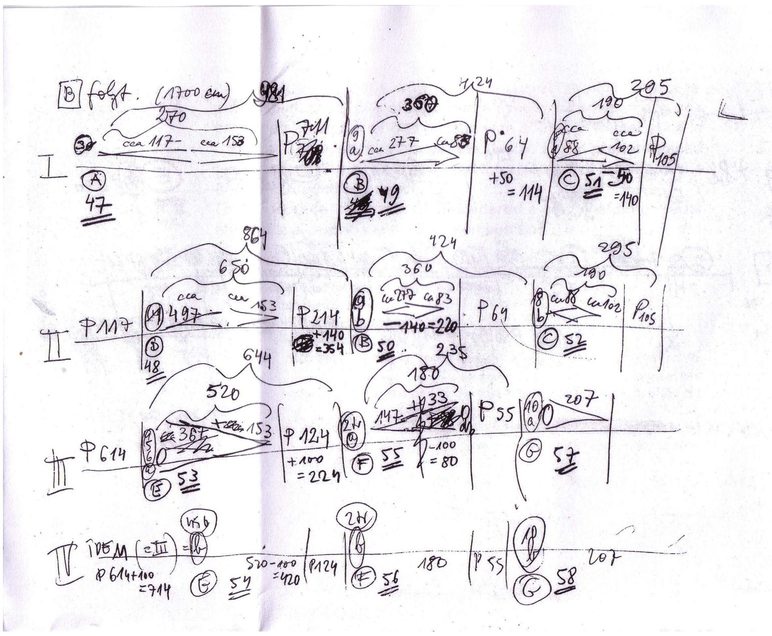

Figure 4.6: Structural sketch of the piece *Artikulation* by György Ligeti. Figure 8, extracted from [52]. Reproduced by kind permission of Schott Music Limited, London.

The sketch reproduced in figure 4.6 seems to represent structural information of the piece. The four channels of audio are represented with Roman numbers from I to IV. The overall aspects are reminiscent of an instrumental score, with the separation in staves and the use of symbols that belong to traditional notation. The various numbers written on the piece are probably references to sounds, sketches or pieces of equipment. Variations of amplitude are drawn in each section, with numbers that possibly specify a volume. The references to circled letter from "A" to "G" suggest that this representation refers to the parts of the piece schematically decomposed in the diagram in the upper part of figure 4.5. Overall, the large number of references and numerical data suggests that this sketch was drawn when the composer had already referenced a large number of sound samples. A second sketch (sketch 9) is described by Wehinger as completing this one. In this sketch, not reproduced here, two large circles letters "C" and "D" suggest that the sketch represents a development of the parts C and D. Numerical values are represented along a line, according to a seemingly serial process. The possible role played by the sketch 9 is to precise the symbolism used in sketch 8. The high-level representation used in sketch 8 is arguably intended to allow the composer to embrace the structure in one visual image, while individual parts are more precisely defined elsewhere. The sketches thus supported the representation of the structure, as well as noting details for individual parts.

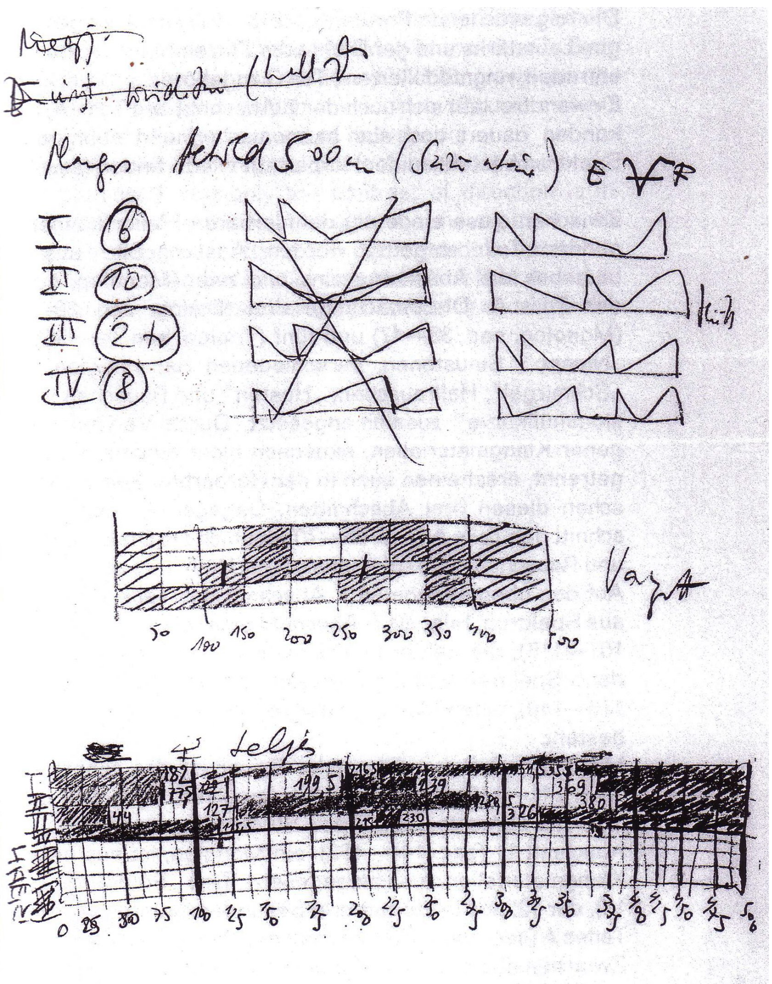

Figure 4.7: A sketch of the piece *Artikulation* by György Ligeti. Reproduced by kind permission of Schott Music Limited, London.

The sketch reproduced in figure 4.7 was produced as a development of the parts E and F of the composition, which is indicated on the top right corner of the page. This sketch shows on the top four lines of envelopes, preceded by Roman numbers from I to IV that identify the four channels of audio. A first set of four envelopes was drawn and further scribbled off, as to set aside the idea – presumably – after it was tested out. The second set remains untouched. This sketch represents numerical data that have been used to try the system, or to clarify an idea. Two tables complete this page. Both seem to be alternative representations of events that develop in time. The second of these tables (bottom of the page) is seemingly a refinement of the first table (in the middle of the page). The first table is relatively vague. The table is measured on the horizontal axis by numbers increasing 50 by 50, from 0 to 500. There is no notation for the four rows of the table, but it seems to implicitly represent the four channels of audio. Cells are marked so as to indicate events to happen in time for each audio channel. The bottom table seems to be a refinement of the first one. The table is more accurately drawn and the number of rows and columns have doubled. The Roman numbers are indicated for each row from I to IV, which is also doubled for the four rows at the bottom (these are not used). The time scale increases 25 by 25, still from 0 to 500. The cells are marked again, and the overall aspect is roughly conserved, although many revisions occurred. The time at which the cell ends and starts is specified by the end or the beginning of each cell (e.g., the first event in the third row ends at 44, a new one starts at 127, etc.). This table does not give an indication of what the textured cells represent, which could be indicated by the first sketch. Roman numbers associated with circled numbers could correspond to a given sample of the 42 sonic materials collected. This sketch exemplifies a process of multiple representations of the same event using various levels of precision.

The three sketches reproduced for the piece *Artikulation* illustrate the broad range of cognitive purposes served by intermediate representations. In figure 4.5, we argue that the several references to a background knowledge (text, numerical annotation, capital letters), associated to a vague, unrevised plan of the piece serve the purpose of planning the work and decomposing it in coarse tasks. This is suggested by the capital letters associated to the main depicted element, and their association to numerical values in the bottom annotation. These values are presumably frequency ranges or specific numbers used to control a given device. The written text at the top of the figure is a textual illustration of the successive envisaged states. The second sketch reproduce in figure 4.6 is a more informed representation of the structure of the piece, and again serves the purpose of planning, but at a finer granularity. The spatial relation on the horizontal axis is that of time, whereas the vertical axis decomposes the space in four lines, one for each channel of the piece. The vertical decomposition allows organizing event or each channel by building a functional relation between the lines in a manner reminiscent of musical scores: simultaneous events are represented by similar positions in the horizontal space. However, this representation is not precise, which indicates that the representation serves the purpose of planning events rather than precisely organizing them. The depicted elements of this sketch are mostly numerical or building on formal music notation (the ‘$< >$’ signs used for *crescendo* / *decrescendo*). The lack of diversity in the signs indicates that this sketch is rather use to offload the complexity onto an intermediate representation rather than exploring possibilities. The few numerical revisions suggest that the numbers were tested with a given system and corrected onto the sketch after the experimentation. Finally, the sketch reproduced in figure 4.7 present successive diagrammatic representation that developed to address specific aspects of the piece. The decomposition in four parts recurs in all three representations. The first representation on the top shows envelopes that evolve over time (horizontal axis). It is not known whether these envelopes apply to volume or another sound parameter. These envelopes are vague and do not contain information of scale for either axis. The next two diagrams represent time on the horizontal axis, and the four channels on the vertical axis. The shading of the cells in the first of these sketches is refined in the bottom sketch. This can be deducted from the position of the cells which are shaded in black in both tables, whose position according to the scale defined at the bottom is similar. However, the bottom sketch is a refinement of the first one, where the emerging property refined is that of time. The table is drawn bigger and the scale is decomposed in finer steps (25 instead of 50). The position at which each black cell finishes is now specified with a numerical value. The information contained in both diagrammatic representations is not equivalent, which shows that these two diagrams were drawn in search of a *solution* to a particular problem that involves three perceptual inferences, that of time (horizontal axis), channels (vertical axis) and the arrangement of numerical values (shaded cells). This is consistent with the observations of Larkin and Simon which argue that the advantage of diagrams is mainly computational [45]. The use of diagrammatic representations in the course of a composition process reveals that composition often involves local problem-solving activities that are better solved with diagrams than in the head only.

4.2.4 Conclusion

The case of *Volumina* suggests several hypotheses. First, that Ligeti created this notation to represent perceptual features in a manner that facilitates visualizing the interactions between them and their organisation over time. The initial idea that developed on the sketch was mainly concerned by a distribution of notes within clusters to be played on the three keyboards of the organ. By developing this representation, Ligeti was able to focus on particular aspects of the piece (timbres, pitches and their evolution over time) without committing to the details of realizing it using standard notation. Second, the sketch was intentionally vague: the technical details were not to take over the elaboration of the structure (or the development) of the piece. Third, the initial sketch reflected the primary ideas and helped to validated or invalidate them: the pitch scale disappears in the final score, but harmonic and performing precisions are added, represented by textured shapes. Fourth, the elaboration of the final score would not have been possible without first having experiment the ideas on the sketch. Fifth, a certain amount of details (or constraints) seem to be required to sketch musical ideas, but they do not all need to be represented. Regardless of the importance of certain parameters – such as nuances and rhythms – in the final composition, it was not necessary for Ligeti to represent them in the first stages. Sixth, the final score presents graphical aspects which are more complex than the event they represent: for example, the texture of the rectangle event in the movement 36 is of a greater complexity than what it represents. This was probably added as a visual metaphor of what the composer heard, and wanted the organist to play. This contrasts with traditional notations where there is a straightforward mapping between the representation and the sound events. This is reinforced by the textual indication which make explicit that the clusters should be played in a "labyrinthic" manner. In this case the metaphorical representation serves the purpose of being more or less freely interpreted.

Overall, the sketches developed by Ligeti for *Volumina* seem to serve the purpose of freeing the composer from the constraints associated with standard notation, while still enabling the development of a musical structure. Ligeti's idiosyncratic notation remains in the final score, meaning that the resulting piece could not be obtained with standard notation. The central role played by sketches in the elaboration of this composition indicates that sketches can be key to the exploration of unconstrained musical structures. Sketches also facilitate the combination of sound dimensions, such as pitch, time and density that are intertwined within shapes.

The use of colours is mostly characteristic of the five acoustic sketches. Colours are used as functional relations to separate or identify parts of the composition, as well as for re-editing and annotating the draft. The overall density of information we can observed in the sketches of Ligeti's acoustic composition is, in comparison with the sketches of *Volumina* or *Artikulation*, much higher. The sketches of acoustic music also go into more details. For *Volumina* and *Artikulation* the sketches are vague in the first case and partial and fragmented in the latter case. The acoustic sketches, in comparison, lack few details in regards of the final score.

The editing of sketches as observed in *Volumina* has commonalities with the editing the acoustic sketches, in particular with the sketch in figure 4.3. In *Volumina*, geometrical shapes are moved to different parts of the sketch, indicated with arrows and the contours of the shape at the new location. In the sketch of *Konzert für Violine und Orchester*, we observe a similar kind of editing. Parts of the screen are scribbled off and annotations seem to indicate mnemonically how this part will be further filled. See for example the annotation "STRINGE___" at the beginning of the second system, or "STRING CRESC" at the left of the fourth system. This kind of editing, similar to a "copy and paste" does not appear in the sketch of *Artikulation*.

For *Artikulation* and *Volumina*, we argue that the motivations behind the sketches are plural. First, sketches develop in order to cope with an unfamiliar setting for which no notation pre-exists. In *Volumina*, the notation develops along with the composition process. In the case of *Artikulation* no notation consistently emerges (for there is no need to communicate), but time representations are sketched in both examples reproduced in this study, seemingly to support a reflection on the structure of the piece, and to support local problem-solving. Second, sketches develop to explore ideas using a progressive commitment to the details. Sketches are re-used to develop ideas in more depth (see e.g. figure 4.7).

4.3 Study case 2: Samuel Freeman

At the time of the study, Samuel Freeman was a composer studying for a Master of Arts by research in Music Technology at the university of Huddersfield. Freeman was then interested in live forms of composition, where the sonic materials to be rendered are to be processed in real-time, with or without a performer. The initial specification of the project that we report here was to produce a composition for 8 channels of audio. A total sequence of sixty pen and paper sketches were produced in the course of this composition. Here we consider the developments across the first six of these sketches.

4.3.1 *Octorgan*

The circle at the top of the sketch on figure 4.8 represents a spatial arrangement for eight numbered speakers. The lines between them represent possible pairings of the speakers. The form of the lines – solid, dashed, undulating – is used only to distinguish the identity of the pairings not their form or auditory qualities. The middle line in figure 4.8, produced next, represents a possible translation of the initial spatial arrangement into a sequence of pairings that could be rendered on a stereo channel. The final two sketches (bottom) represent a mapping of the four pairings into a three-dimensional auditory display.

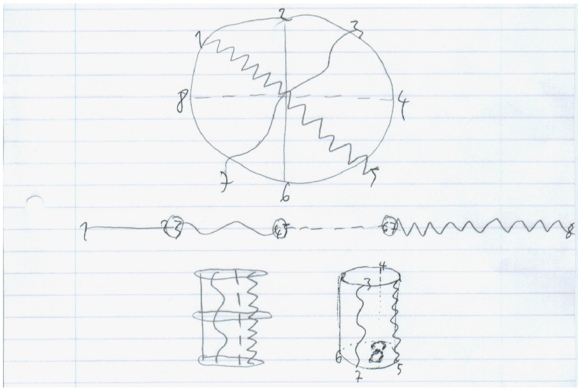

Figure 4.8: Freeman sketch 1

The starting point for Freeman's composition is thus an exploration of possible spatial configurations for displaying 8 channels of audio. This occurs prior to any consideration of what audio will be presented in the different channels.

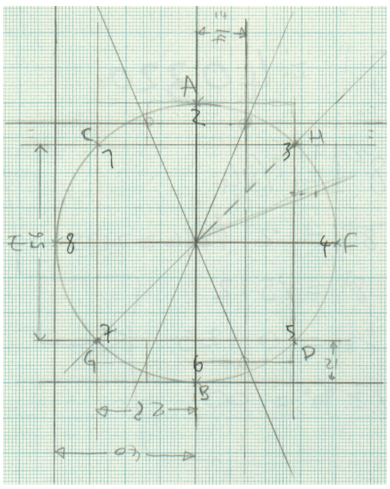

Figure 4.9: Freeman sketch 2

In sketch 2 (figure 4.9) the circular speaker array recurs but Freeman's primary concern here is with the numerical relationships that can be constructed from the geometry. The circle is drawn with a diameter of 8 cm on graph paper. The speakers are treated as geometric points. Some of the angles are bisected, chords drawn across the circle and extended into secants to find points of intersection. The distances between some of these lines are noted in pencil. This sketch is focused on finding a set of interrelated numbers, indirectly anchored in the original concept of 8 channels, that can be used as numerical parameters in the composition.

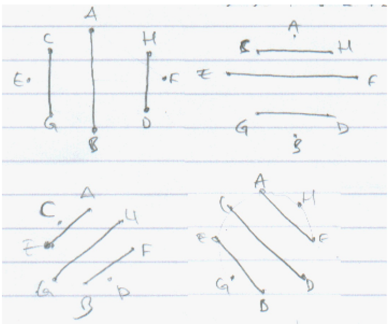

Figure 4.10: Freeman sketch 3

The next sketch in the sequence returns to the pairings of speakers (figure 4.10). The lines have now evolved from being 'graphical labels' for pairings of speakers to become maps of possible locations between speakers where sounds will be projected. The four panels in sketch indicate how different configurations of these spatial arrangements will be simultaneously overlaid. This drawing emerged in part from a consideration of how such an auditory display could be implemented in Max MSP. Although ostensibly spatial this sketch thus doubles as the architecture for a proposed three-dimensional panner.

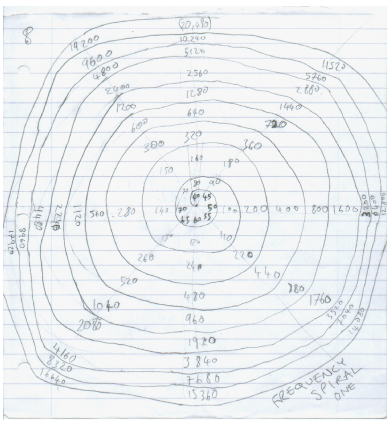

Figure 4.11: Freeman sketch 4

In sketch 4 (figure 4.11) two innovations occur. For the first time a musical space, consisting of frequency intervals, is drawn. In addition a spiral structure is introduced. Here Freeman is calculating the pattern of intervals needed to construct 'nontaves' (as opposed to octaves) in which eight stepwise increases in frequency lead to a doubling – i.e. a repetition of the same note on the ninth step. The radii represent eight notes that get higher as we move outwards along the spiral.

In sketch 5 (figure 4.12) the frequency space is then superimposed onto the spatial array created by the speakers. Graph paper is used to ensure an accurate mapping of frequencies to co-ordinates. This sketch also doubles as an architectural drawing in the sense that the pairs of values it specifies it were converted into a look-up table in the Max MSP program.

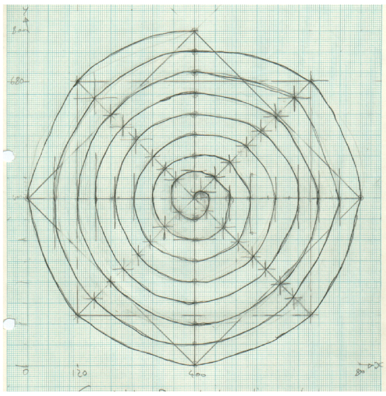

Figure 4.12: Freeman sketch 5

The next drawing (figure 4.13) was produced as part of a process of reflecting on the overall architecture of the composition up to this point. Here Freeman abstracts away from the details of the mappings he has created to consider the overall structure. The speaker positions are now represented by the double lines. Interestingly a 'figure- ground' reversal has occurred with the segments between the speakers - not the lines between them - highlighted as shaded areas.

At this point in the development of the composition a prototype Max MSP system was built and tested. This revealed that although sounds could be rendered at positions on the circumference of the circle it was much more difficult to discriminate between locations within the circle. As a result of these problems with the perception of location in the rendering the focus of the composition switched to mapping possible sequences of channels.

Sketch 7 (figure 4.14) shows a series of drawings that explore variations in sequences of channels (speakers). The lines across the circular array of speakers now indicate order of playing.

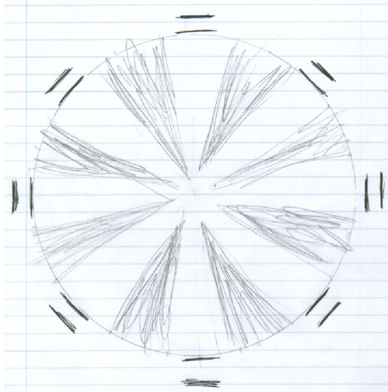

Figure 4.13: Freeman sketch 6

In some cases these patterns are annotated by numbers that the sequence of steps around the circle that generates the pattern (e.g., 1,2,1,2 in the centre of the page). This eventually led to the development of patterns that repeated after 8 or 16 steps and which became lists of integers used by the program.

It is useful to consider one further sketch produced for this composition (figure 4.15). It is not clear exactly when it was produced and it is not an integrated part of the sequence described so far. Rather it was produced "in parallel" when the problems with the prototype were identified. This drawing resulted in part from frustration at being too "hung up on the numbers" and a desire to for some "less concrete" representation of the piece. At this point the composer had produced a complex Max MSP system that was, in his opinion, musically uninteresting. In response to this figure 4.15 was produced in an attempt to sketch the aesthetic abstractions, textures and transitions over time that the composer was seeking to create.

Each musical event is represented with a specific colour, a form and a text. The text refers to the composer's personal music references with adjectives such as "small mysterious" or "large complex". The colours – which were added later in photoshop – code the spectral progression and in conjunction with the letters provide a cross-reference between the forms and the text. This drawing was subsequently used to guide the structure of the composition for the rest of the piece.

4.3.2 Conclusion

The sketches developed by Freeman involve a variety of different semantic frames. Although initially concerned with spatial relationships, Freeman's successive sketches explore the space of geometric-numerical possibilities, the frequency or 'nontave' space, the temporal space and,

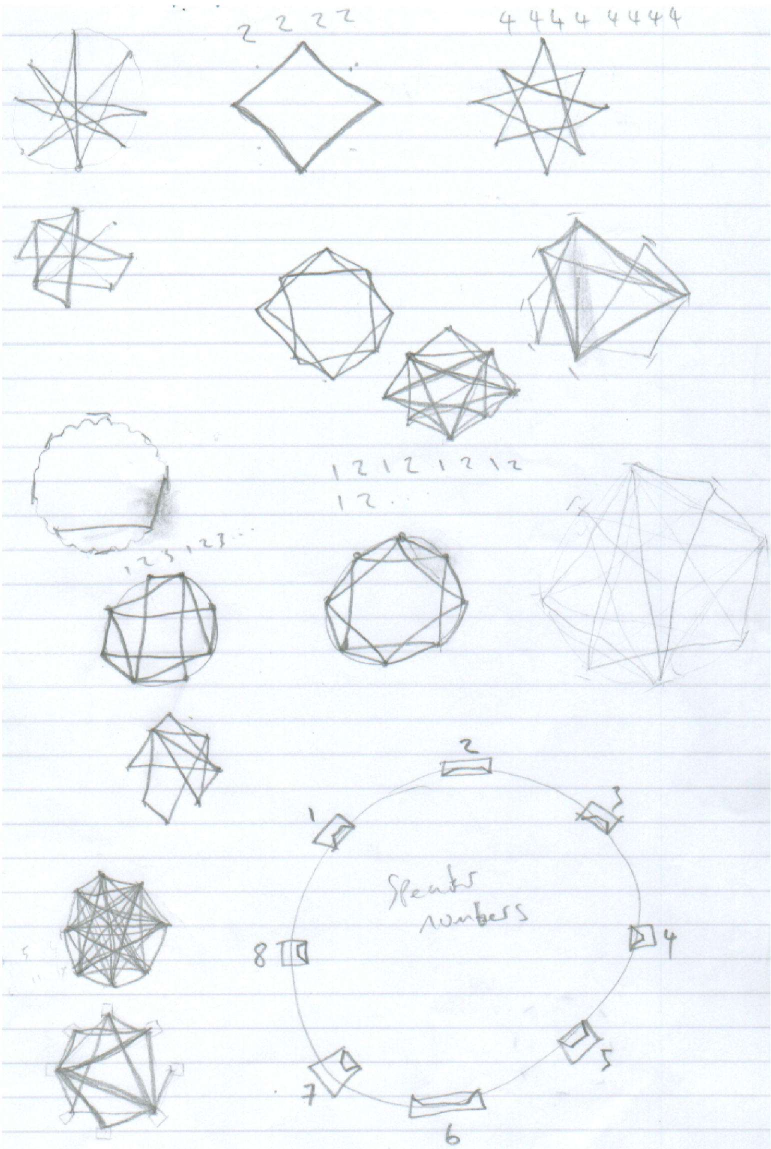

Figure 4.14: Freeman sketch 7

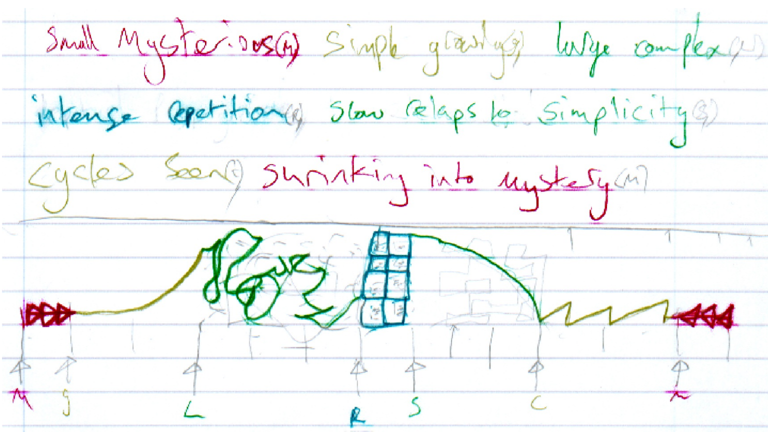

Figure 4.15: Freeman textures and transitions sketch

in figure 4.15, the aesthetic space of the composition. In all but the last of these variations the pictorial devices of circles and chords between points recur but with different interpretations. For example, the lines between points on the circle begin as markers of identity, then change to encode numerical relationships, then spatial vectors, then musical vectors, then temporal sequences (cf. Neilson and Lee, [57]).

This reuse of the circle and line arrangement highlights the influence of medium on the form of the sketches (cf. Tversky, [85]). The two-dimensional structure of the page naturally affords planar shapes and it is interesting that the three-dimensional shapes considered in sketch 1 (figure 4.8) do not recur. It seems likely that the affordances of pen and paper themselves constrain the kinds of creative solution that emerge.

A third point highlighted by this case study is the way the sketches switch back and forth between these different semantic frames as the composition proceeds. In fact, individual drawings sometimes combine aspects of different semantic frames in a single sketch (e.g., figure 4.9, figure 4.12). This entails that, for example, the x and y axis cannot be given a consistent interpretation. In addition to switching between semantic frames the drawings also switch between different levels of detail. Sometimes dealing with specific sets of parameters, sometimes providing an overview (e.g. figure 4.8, figure 4.12 and figure 4.15). This movement between semantic frames and levels of resolution suggests a simple 'monotonic' view of progression from underspecified sketches to progressively greater levels of detail is incorrect. For Ligeti, the semantic frames evolve rapidly from underspecified drawings to a structural sketch of the piece (sketch 8/110, figure 4.6). The following sketches develop into experiments to fill parts of the structure. The corrections progressively brought to structural sketches suggests that the structure is constantly refined during the process.

A final point highlighted by the case study is the practical work done to reconcile the representations of the basic concepts and ideas in the sketches with the kind of input formats suitable for the realisation (e.g. figure 4.10 and figure 4.12) . Although Freeman's initial concern with numeric spaces originates from the remit of composing for eight channels it evolves into an exploration of possible parameters for the program (e.g., figure 4.9, figure 4.13). In the case study this acts as a constant and sometimes frustratingly restrictive influence on the development of the composition, leading at one point to a switch to an abstract aesthestic space (figure 4.15, and also Ligeti's figure 4.6). Noticeably, the aesthetic space represents the evolution of the structure over time. The scale is, however, not fixed: sonic events of higher complexity are likely to occupy more space on the horizontal axis than sonic events of lower complexity, regardless of their respective durations. Moreover, a precise representation of time at this stage does not seem to be a major preoccupation for both Freeman and Ligeti, since they both started to represent other aspects of the piece.

4.4 Study case 3: Dennis Báthory-Kitsz

Dennis Báthory-Kisz (1949) "has composed more than 700 works, including sound sculpture, solo and chamber music for the instruments of classical music, electronic music, stage shows, orchestral pieces, dance music, opera, interactive multimedia, sound installations, and performance art events"[4]. The sketches studied in this section are part of a series of sketches that have been produced throughout a year of work. The composer provided 18 sketches developed for 16 compositions, as well as the scores of the compositions corresponding to the sketches. These compositions are part of a series of commissions entitled "We Are All Mozart", a project for which the composer had to create 100 musical pieces.

In contrast with the other case studies, Báthory-Kitsz developed at most only one sketch for a composition, except for one composition for which he developed three sketches. Interviewed, the composer gave two reasons for this. First, he was constrained to write these pieces in a short period of time (around three days for a piece). "The reason that I sketched some (a departure from my usual practice of creating a piece in final form) was because numerous pieces were being formed at once in order to deliver them when due". Sketches were developed as mnemonics for the elaboration of a piece, and we can suppose that in order to get organised, the composer needed to be able to see his notes at a glance. Second, Báthory-Kitsz being a composer of 45 years experience, argued that "[Were I less experienced,] I would probably still sketch more extensively just to overcome the shortcomings of the software (and not get locked into software limitations)". Noticeably, sketching is not a dominant practice in his composition processes in general. Overall, Báthory-Kitsz developed 32 sketches for 30 compositions out of 100, i.e. 70 compositions have not been sketched. These sketches were mostly drawn for instrumental compositions, although the commission included electroacoustic pieces. Báthory-Kitsz reported : "I do not sketch most electroacoustics because it is so hands-on. I may jot down notes to recall

[4]Wikipedia: $http://en.wikipedia.org/wiki/Dennis_Bathory-Kitsz$, accessed the 01/02/2010

as I am working, but the architecture is almost always in the head or embedded in the software data, from photographs through algorithmic output." As we shall see for the first example, *The Nine Rabbits of Valladolid* (sketch in figure 4.16), the sketch is used solely as a mnemonic. However, further studies of Báthory-Kitsz' sketches show that they can serve other purposes, such as local-problem solving, planning, or accommodating perceptual features together.

4.4.1 *The Nine Rabbits of Valladolid*

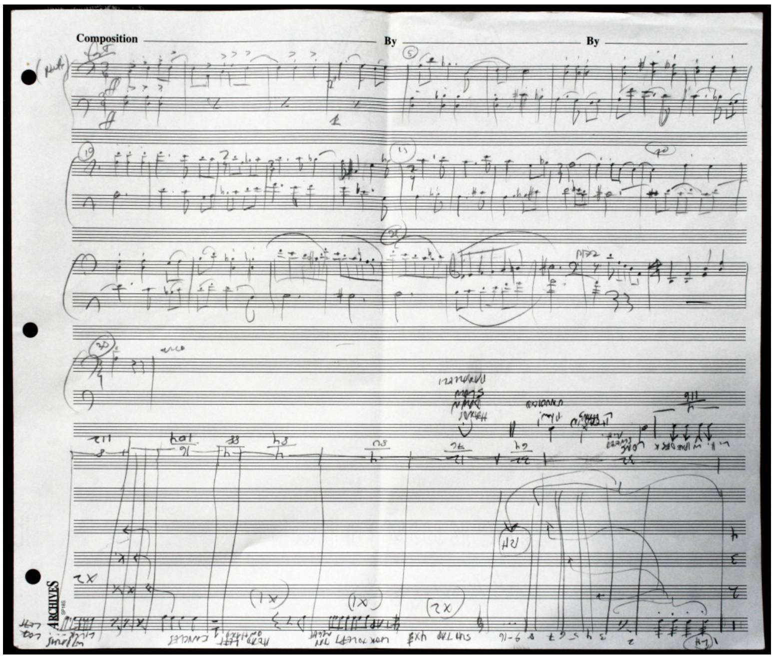

Figure 4.16: *The Nine Rabbits of Valladolid*, cello duo, 2007, sketched in the upper part of the page and *Drumbing*, four percussionists and a table, 2007, sketched upside down at the bottom of the page. Full score written with Finale. Reproduced with the kind authorisation of the author.

Báthory-Kitsz compares his sketches to Post-It notes. He uses them as mnemonics for ideas that arise when he is likely to be distracted, but also as technical references or calculations. Figure 4.16 illustrates how these two processes occur in Báthory-Kitsz's practices. The page contains two distinct sketches drawn for two separate compositions. The sketch drawn at the top represents notes written in traditional notation. The sketch contains all the details of the final score, except for the tempo at which it will be played. However, the metrics are already defined, as well as the nuances and the orchestration (two cellos). Even the play mode (*pizz*) is indicated on the sketch.

The first page of the final score (reproduced in figure 4.17) is almost identical to this sketch. The differences are highlighted with red ovals. These differences concern a few notes, the tempo

Figure 4.17: First page of the score of *The Nine Rabbits of Valladolid*, cello duo, 2007. The red ovals indicate the differences with the original sketch. Reproduced with the kind authorisation of the author.

of the piece, and (at the bottom) a change of clef, which is usually done to facilitate the reading of the score by the performers. There is no major - structural change between the sketch and the score. Moreover, there is no evidence that the four pages that complete the score use any material sketched out. On the contrary, Báthory-Kitsz seemed to have a precise idea of the composition at the moment he wrote the sketch. The composition was further developed with a music notation software, following closely the idea developed in the sketch.

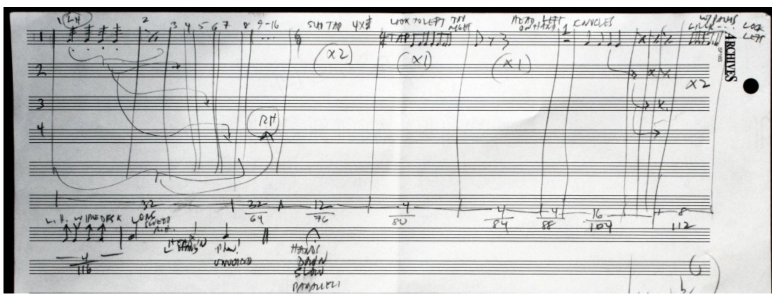

Figure 4.18: Sketch developed for the piece *Drumbing*, for four percussionists and a table, 2007. Reproduced with the kind authorisation of the author.

In contrast, the sketch developed at the bottom of the same page and presented upside down resemble more of an attempt to explore the structure (reproduced in figure 4.18). This sketch was produced for the piece *Drumbing*.

4.4.2 *Drumbing*

Drumbing is a piece for four percussionists, a table, and a few objects. The sketch of *Drumbing* contains mostly structural information and most details recur in the final score. However, very few notes are written down, and the sketch is further extended to an 11-page score. In the sketch, the horizontal axis is used to represent time and the vertical axis is used to separate the four percussion staves. Numerical data is written above and below the staves ; short words are also written. The numerical data refers to the successive position in the score.

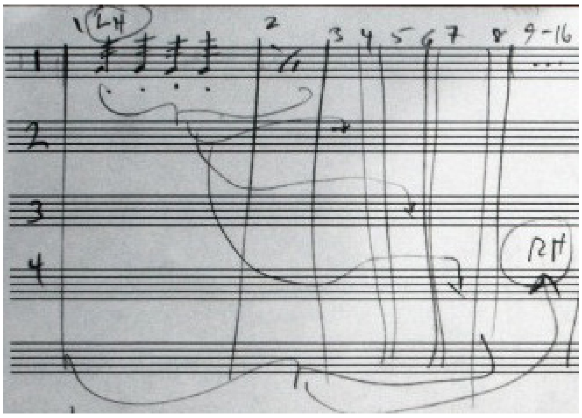

Figure 4.19: Detail of the first 16 measures of *Drumbing* (see fig. 4.18). Reproduced with the kind authorisation of the author.

Figure 4.20: Detail of the first 16 measures of the score of *Drumbing*. The red oval shows the how the motive sketched is repeated in the score. The orange rectangle circumscribes the second motive repeated in the measures 9 to 16. Reproduced with the kind authorisation of the author.

The first 16 measures (detailed in figure 4.19) occupy a third of the representation. This part is more detailed than the rest of the sketch. A short motive is written in the first measure of the stave numbered “1”. Arrows indicate where this motive should be repeated in the staves numbered 2, 3 and 4. The schematic arrows must represent a kind of "copy and paste": in the final score, the motive written in the first measure of the first staff is repeated as shown on figure 4.20. In a similar manner, the large brace at the bottom of the eight first measures is linked to the following eight measures by an arrow, illustrating another sort of "copy and paste" between the measures. In the final score, this schematic representation develops into a new motive which is added in a similar manner to the first eight measures. This is illustrated in figure 4.20: the orange rectangles circumscribe the repetition that occurs in the measures 8 to 16.

The rest of the sketch is less detailed, and the final score also presents many dissimilarities with the data sketched. Báthory-Kitsz explains that: "The first part, because it was slower in its additive character (doubled measures of additive rolls from 1-16), and because it was setting up the 'punchline', so to speak, of the end as well as the other sections, is closer to the sketched structure. But you can see that I was already anxious to get to entering the information, and moved away from the details. It also still has an irregularity foreshadowing the subsequent sections (built in with the pair of 6/4 measures) and then two measures (instead of one in the sketch) at 27-8 and a deviation by the addition of measure 29."

Further links can be observed between the sketch and the final score. Some structural modifications were brought, however, when the final score was written. This indicates that the sketch of *Drumbing* is used as a mnemonic but also doubles as an overview that supports the elaboration of the piece, as a reminder of the structure. The drift from the sketch to the final score occurs when the composer is committed to the details of the piece. However, the structure of the final score remains very similar to the original sketch. Báthory-Kitsz added: "Once underway, I took *Drumbing* slightly off its square course. The last movement is a good example: mm96-99 set up the expectation of 100, which is not met because measure 100 is the same as 99. Only then does the additive process continue, again repeating. So they are two blocks of 5, not 4. The next three blocks are four (106-9, 110-113, 114-117) followed by a group of 3. Then a block of four, a pause, and the end. It comes up short of the structure as well as organizing it differently. "

In contrast with the sketch reproduced in figure 4.16, the sketch of *Drumbing* represents the composition overall, but the drift between the sketch and the score is also greater. One of the differences between the two compositions is their instrumentation: in one case, there is an instrumentation that the composer is familiar with (*Nine Rabbits of Valladolid*, two cellos), and in the other case, there is a less common setting (*Drumbing*, 4 percussionists and a table). The two cases suggest that a few parameters might be of influence in the sketching activity. Overcoming difficulties, an unusual setting, defining abstract processes or specific calculations, even the moment at which an idea strikes the composer seems to interfere with the particular shape of a sketch. The composer reported that he considered his sketches as “[...] mnemonics, as most of the piece has been worked out conceptually. Where work is being done, it is usually architectural or numerical, or sometimes physical.[...]There are no particular revisions except overscribbling. Sketches are mostly limited to a page or two, and many serve as highly incomplete mnemonics for the eventual pieces. Some are what can be considered technical references only (numbers of items, beats, ratios, scales...)”

4.4.3 *Starry Night*

It is useful to consider one more sketch designed for the composition *Starry Night*. It is a piano piece. The sketch is represented in figure 4.21. The composer describes this sketch as a “full sketch”, meaning that the sketch represents the overall musical idea developed further in the score. This sketch contains two main parts and annotations on the margins. The first part, on the top half of the page, represents a piano staff, identifiable with the G and F clefs. The sketch goes across two lines and is separated in six parts. The first part represents a cloud of points with no representation of the duration, tempo or precise pitch. An arrow links this part to an annotation “sustain low under cloud of stars”. In the final score, this develops into a merging of the five lines of the staves into one (see figure A.19 in annexes, third system of the final score). The second of these six parts contains a unique drawing with the annotation “coalesce”. The drawing is an arrow that points at the next part. The next part starts with a reminder of the two clefs (G and F) and contains another cloud of points, similar to the first part. There is no arrow or annotation to explain this part, but the next part (4 of 6) seems linked to it. The part four contains a text description only “crossing arpeggios”. It is linked by an arrow to another sketch in the bottom of the page, completed with a note “big clouds - 4 layers each hand - tuplets”. Next to the text, a sketch of a staff with clouds reminds us of the clouds of points developed in the parts 1 and 3. This sketch is completed by the text “remove stems & beams”. This part is explicit in its intention to organise the clouds as tuplets, which organisation was decided later (see the evolution of the rhythm of the notes in the first system of A.21). Back to the top sketch, the second line starts again with a representation of the clefs. The fifth part contains points again, but this time they are organised. Four pairs of notes are represented on each staff, aligned to represent the progression of a 4-note chord. The last part of the sketch starts with the number "8" written on the top of the G staff and the bottom of the F staff. In this part, the idea is represented by a text "Wide chords (octave)" and "get less frequent". The numbers, along with the text, express the idea that the G staff will be played an octave higher while the F staff will be played an octave lower.

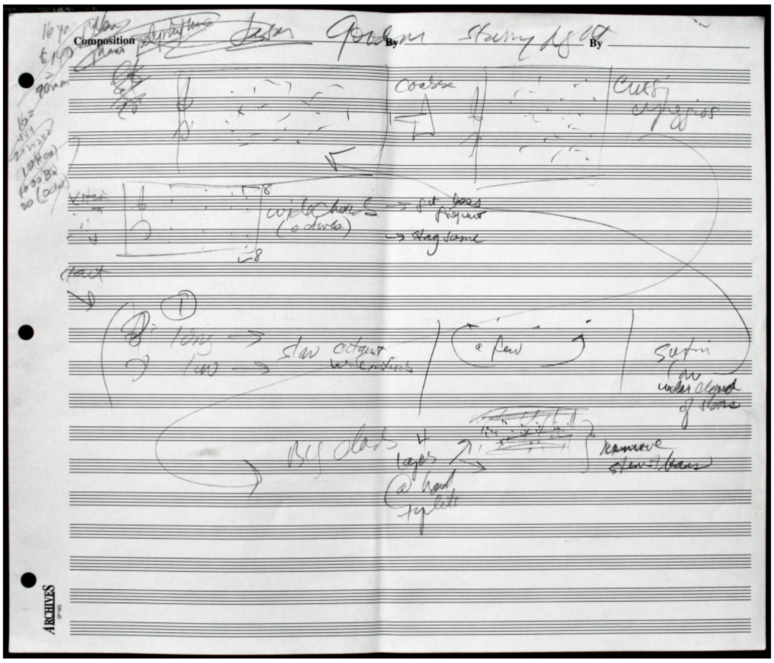

Figure 4.21: *Starry night*, piano, 2007. "Full sketch of a piano piece, with sketches of the aleatory."

On the central part of the sketch, where arrows link the parts 1 and 4 to further developments, two additional sketches are developed that are not explicitly linked to a specific part of the top sketch. These sketches seem independent. The first of these two sketches, represented on the left, represents the two clefs followed by a text. The manner in which the text is aligned indicates that the meaning of the text applies to each of the clefs. "long ->" for the upper clef, "low ->" for the lower clef. This is followed by a text vertically positioned so as to apply to both staves "slow, octaves & wide intervals". The next sketch represents three points circumscribed by double sided arrow with the comment "a few" inside the circumscription. Further comments are written on the margin and scribbled off. The composer specified that these comments were written for a different composition.

The composer reported that the top sketches have been drawn first, which represent an overview of the piece. Parts of the piece were refined and developed in the middle-page sketches. The vagueness of this sketch suggests that it serves as a mnemonic for ideas that Báthory-Kitsz had partly developed beforehand. The text in particular plays a mnemonic role, specifying tasks for the realisation of the piece. The further developments of parts of the sketch also suggests that the representation supports the development of an organised form and facilitates the work on the structure with a rough hierarchical approach. This is characteristic of drawing rather than text – the overall display represents an overview of the piece, the text specifies parts of it. The overall sketch is decomposed into parts which are developed below the first sketch. This hierarchical approach is characteristically a top-to-bottom hierarchy (see conclusion): first the overall representation, second a development of the parts, third, details of some parts, although these were mostly achieved during the realisation of the piece. Its role as mnemonic arguably doubled with a more architectural role, the composer referring to the sketch to realise the piece bits by bits.

4.4.4 Conclusion

Overall, Báthory-Kitsz' sketches seem to serve different purposes. They are either a more or less precise draft of the first measures that is used as a mnemonic, as in *The Nine Rabbits of Valladolid*, or an externalisation of high-level concepts, as observed in the two other studies. This externalisation plays the role of accommodating perceptual features together, in order to facilitate computational operations or planning. Amongst all the sketches provided by the composer, seven are a draft of the final piece: *Low Clouds and Evening Wind* (figure A.1), *The Nine Rabbits of Valladolid* (figure A.2), *Fanfare:Heat* (figure A.3), *Loss of Innocence* (figures A.4 and A.6), *Toccata: Tides of Wales* (figures A.4 and A.5), *A Partial Summer* (figure A.7) and *Candles of Red Sky* (figure A.11).

The eleven remaining sketches show more condensed information, less related to standard notation. They are: *Drumbing* (figure A.2), *Sequenza Nova* (figure A.8), *An Fold-in Round* (figure A.9), *Starry Night* (figure 4.21), *Running the Traction Line* and *What to Do, Farmer Gray?* (figure A.12), *Return to Nineveh* (figure A.13), *Scalar Rainbows* (figures A.14 and A.15), *XLII: Adeste Hendecasyllabi* (figure A.16), *Morning in Nodar* (figure A.17) and *She Who Saves* (figure A.18).

4.4.4.1 Emergent properties

We consider here all the sketches provided by the composer, as opposed to those described only in this case study. This allows to get a more quantitative understanding of the representation of emerging properties, whose representations across the sketches vary.

Time is mostly represented on the horizontal axis (50%, 10 sketches out of 20, figures A.1, A.2 (top), A.6, A.7, A.9, A.10, A.11, A.12, A.13, A.18). Four sketches (20%) represent time by a succession of numbers that represents the successive parts (figures A.2 (bottom), A.3, A.4 (bottom sketch), A.16). Six sketches (30%) do not represent time in an explicit manner (fig A.4 (top sketch), A.5, A.8, A.14 (mostly text), A.15, A.17). Overall, 70% of the sketches represent time in one way or the other.

Pitch is represented in most sketches. The sketches in which no pitch notation appears are the sketches reproduced in figures A.8, A.14, A.15 and A.16. Noticeably, three of those do not explicitly represent time either. These sketches gather ideas expressed with textual descriptions, being used as mnemonics, and further directly developed with Finale. Overall, pitch is represented in 80% of the sketches.

The other dimensions that are represented are rhythm (55% (11/20), figures A.1, A.2 (top and bottom sketches), A.3, A.4 (bottom), A.5, A.6, A.7, A.9, A.11, A.16), sound transformations (2 sketches, figures A.11 and A.13), space (2 sketches, figures A.8 (top sketch) and A.17) and playmode (4 sketches, figures A.8, A.12, A.13 and A.17).

4.4.4.2 A hierarchical approach

We observed in the sketches an approach at various level, the elaboration of the structure followed by the elaboration of the parts, and finally revision and editing.In most of the eleven sketches that show condensed information, Báthory-Kitsz uses a hierarchical approach from the overall structure to the details of the parts, that we name "top-to-bottom". This contrast with the first category of sketches that have the opposite hierarchy: a "bottom-to-top" development where the structure, which is probably thought of beforehand, emerges along with the writing of the details of the piece. The top-to-bottom hierarchy is particularly explicit in the sketches that the composer considers himself as "architectural". As reported in the study of *Starry Night*, the composer starts with a vague representation of the overall structure, separated into several parts. These parts are further developed, either with another sketch or with textual description. Few revision appear on the scores, once the structure is in place. Arrows play an important role in this hierarchical approach to create a visible link between a sketch of reference and the development of its parts.

4.4.4.3 A distinction between drawings and text annotations

We distinguish the roles played by the drawings and the textual descriptions. Drawings consistently support the elaboration of a vague idea at the structural level, whereas text is mostly used to specify parts of the structure. Text is also used as a mnemonic that describes the relationship between the sketch and the score, as observed e.g., in the composition *Starry Night* (figure 4.21). Annotations are consistently written in the sketches, being mostly mnemonics for the details of a given piece, low level data that serve a specific calculation for the notes written in the program. An example of this low level data is the sketch reproduced in figure A.9.

4.4.4.4 Coffee breaks

A final point was raised by the composer regarding his use of sketches. Báthory-Kitsz reported that an important reason for drawing sketch was that ideas do not necessarily strike when he is in front of his computer, but could appear when he is away from his desk, while having a coffee break, for example. Moreover, he reported that the experience of staring at a computer was not particularly pleasant to him, hence, he would rather elaborate on the idea for a piece remotely from the computer. This seems to explain the diversity of his sketches, which are either vague and structural or very close to the final result. In the first case, sketching facilitates the reflection on the overall structure of a given piece. In the latter case, the composer seems to sketch as a substitution for the computer.

4.5 Study case 4: Kevin Austin

Kevin Austin (1948) is a composer of instrumental and vocal composition, and electroacoustics (live, on tape, and improvised), and multi-disciplinary works. He teaches composition at Concordia University, Montreal, Canada. The composition studied, *Involuntary memory* (2008), is a piece for twelve channels of electroacoustic and voice. Ten sketches drawn in the first stages were provided by the composer, plus another three of the score. Prior to sketching, Austin reported having a precise idea of the concepts he wanted to explore in this piece: "[...] the first sketch in many ways was a way of tying together many existing strands, ideas and thoughts". The sketches are used as a medium between these concepts and the music, which double in some cases as exploratory sketches to cut down the complexity.

4.5.1 *Involuntary Memory*

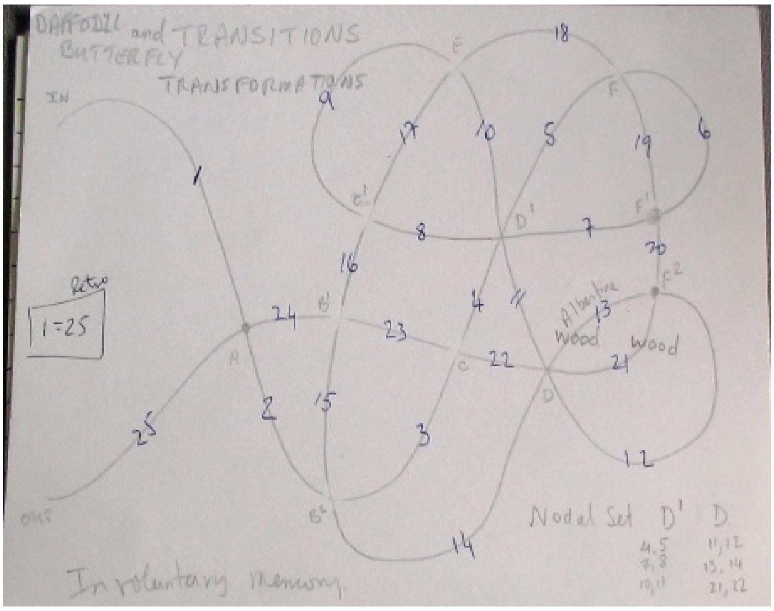

Figure 4.22: First sketch of *Involuntary Memory*, Kevin Austin

The first sketch, entitled "Daffodil and Butterfly / Transitions / Transformations" evoked to the composer the petals of a daffodil or a butterfly in motion. The sketch consists of one continuous line drawn over the whole page, which intersects with itself. The trajectory follows a path which starts on the top left. This is specified by the annotation "IN" above the beginning of the stroke. The trajectory ends further down on the page, with the annotation "OUT". The path is represented as a graph with many crossovers, identified with successive capital letters from "A" to "F^2". The curves between two nodes are labelled with successive numbers from 1 to 25 that became the sections of the piece. The sketch contains additional annotations that concern the instrumentation ("wood") and the text ("Albertine").

The sketch is further refined with coloured pencils (figure 4.23) so as to indicate the range, register and instrumentation. Additional numbers are added to the curves as indications of rhythm (e.g. 2:3, 4:7, etc). Time is represented along the evolution of the line. Two annotations on the right hand side of the sketch ("fast" and "slow") indicate that the vertical space is used as a dimension for the graph to be interpreted. In a similar manner, the annotations "simple" in the left side and "complex" in the right side indicate that the horizontal space will be used as a dimension for the complexity of the music.

Below the sketch of the path, series of letters are written that represent the successive nodes of the graph. These letters are embedded in rectangles placed in a manner that remind the interface of digital audio workstation, where sounds are represented over time as rectangles. This diagram represents a distribution of events (the rectangles) over time (the horizontal axis). It helped the composer to find the time location of his materials. This sketch constitutes the reference for further work carried on paper. At this time, the verticality and horizontality were assigned sonic dimensions which are developed in later sketches.

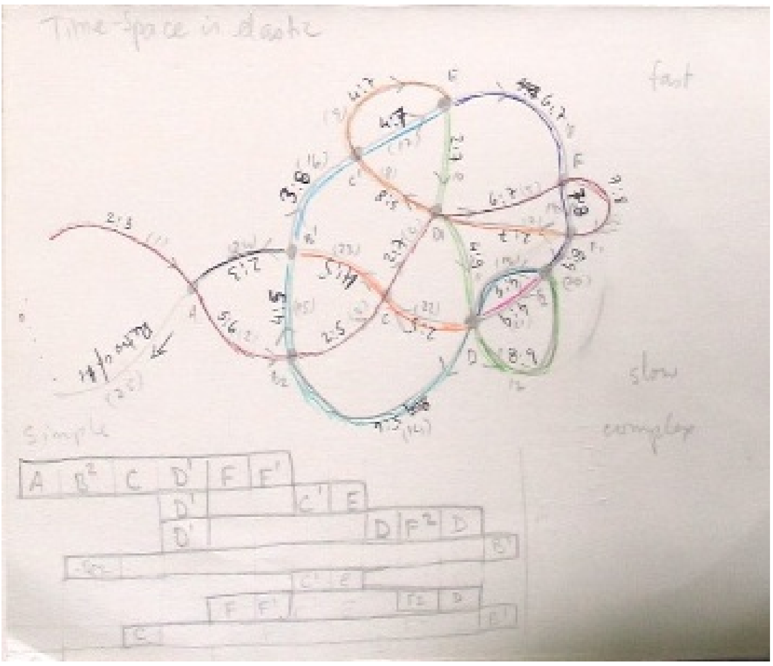

Figure 4.23: Sketch #2. Elaboration of the first sketch.

Chronologically, the next drawing (not reproduced here) is a text that was selected and fragmented. The segmentation of the text supported the generation of the melodic part. The page reproduced in figure 4.24 is composed of two sketches elaborated successively. The top sketch is a study of the possible interpretations of the vertical and horizontal space. On the top a diagram composed of two double-sided arrows indicate that the vertical axis is to be mapped into "pitch" (meaning "pitched" instruments, such as a highly pitched cymbal) towards the top and to "noise" (for e.g. a crash cymbal) towards the bottom. The horizontal space goes from "res" (for resonant instrument, such as a gong) to "dry" (for e.g. a wood block). The composer reported that some details were examined during this process, and this sketch helped to make some emerge and let some other aside.

This diagram further turns into a more precise diagram with the words "res" and "dry" now affected to the vertical space. The horizontal space is decomposed in three parts for the instrumentation, "metal", "skin" and "wood". Below the diagram, textual description are added as mnemonic for concurrent ideas.

Below this diagrammatic sketch, Austin has drawn a refinement of the first shape, which he describes as "another view". The strokes of the original path are now drawn with a ruler. The segments are still numbered, from "1" to "25". This graph was drawn in order to affect instrumental tone to the various parts of the graph, indicated by the words "skin", "metal" or simply designated by letters "m" or "w". The other information drawn in the second sketch (numerical data, spatial information, see figure 4.23) do not recur. The composer explained that there was no need to represent part of ideas that were already settled.

The next page of Austin's notebook represent a work on the metric structures. It contains three part, two of these are reproduced in figure 4.25, the last part which contains a table filled with numerical data represents further work on the metric structures and is not reproduces here. The original graph is drawn again in the first part, but this time only the marker of the nodes are indicated on the graph. This drawing was developed as a simplified version of the first sketch as a reminder for the sections of the piece. Below the graph, a table put in correspondence the nodes with values which are used to define the metric modulation for each node. The resulting metrics are reported in a table in the right side of the graph. These values were probably added to the second sketch of the piece (see e.g. the ratio 2:3 for the segment finishing in the node "A" or the ratio 5:6 for the node finishing in the node "B" in figure 4.23).

The next two sketches illustrate the consistency of the process developed by Austin for *Involuntary Memory* (figures 4.26 and 4.27). As we have seen, the first sketch has already been

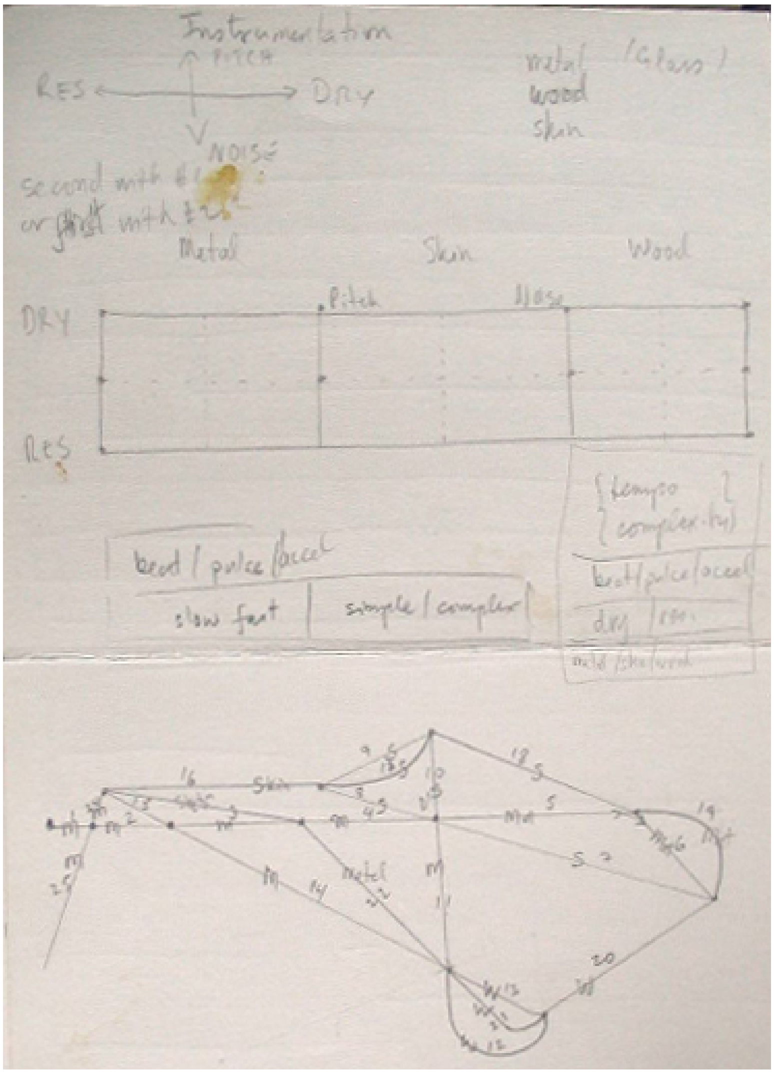

Figure 4.24: Sketch #4. “A modification of the first shape and sketches about instrumental tone colour”

re-used to define the instrumentation (sketch 4, figure 4.24) and the metric structure (sketch 5, figure 4.25). The second sketch (figure 4.23) also presented possible interpretations of the vertical and horizontal space, and it also reinforced the relationship between time and the trajectory of the line. The two sketches were drawn to precise how the timeline unfolds as well as how the instrumentation develops.

The horizontal axis represents time, the vertical axis represents MIDI note numbers. The colours are used to identify which family of percussion is represented in a given part of the graph. The metal percussion are represented in orange, skin percussions in blue, and wood percussions in green. The nodes distinguished in the second sketch are reported at the beginning of each stroke. The vertical space is decomposed in four parallel lines, which distinguishes MIDI note numbers. The horizontal axis is also segmented with parallel lines drawn with a ruler. These

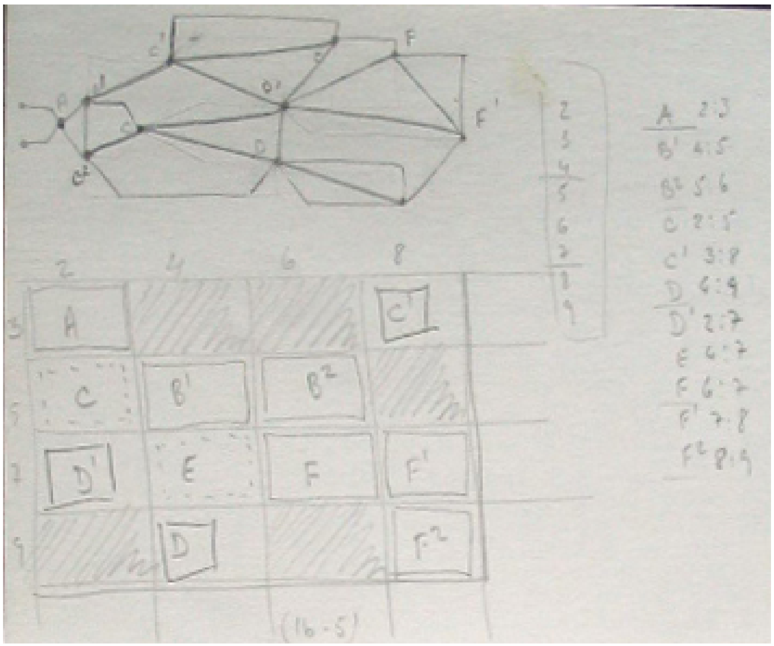

Figure 4.25: Sketch 5, top part. "Refinements.Work on metric structures "

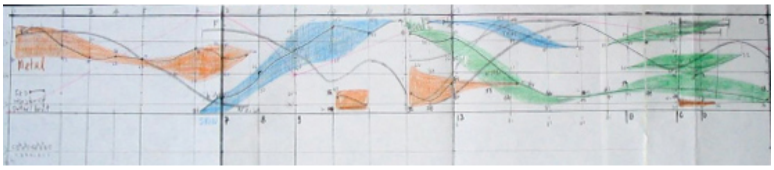

Figure 4.26: Sketch 6, part 1. "A transcription of the second image into a time line form."

lines correspond to the 25 segments identified in the first sketch.

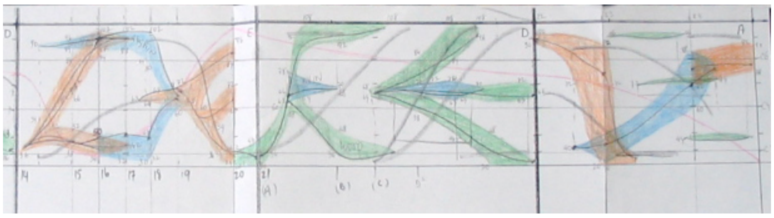

Figure 4.27: Sketch 6 part 2. "This was converted to a pencil score and this pencil score was expanded into Finale"

The next step in the composition process was to convert all the points in the graph as MIDI note numbers as represented in figure 4.28. In this example, the parts are decomposed into smaller parts, e.g. the seventh segment is decomposed in five parts, for the instruments of each class. These five parts are again decomposed in smaller events, noted from "1.1" to "5.3". Noticeably, some parts are decomposed a step further, such as "4.1.1", "4.1.2", etc. The tempo (60) is indicated in the top of the sketch. The number of notes is also indicated (23). The latter results from the length of the segment in the graph combined with the tempo determined for the segment. The composer specified that the realisation of the piece implied slight distortions of these ideas.

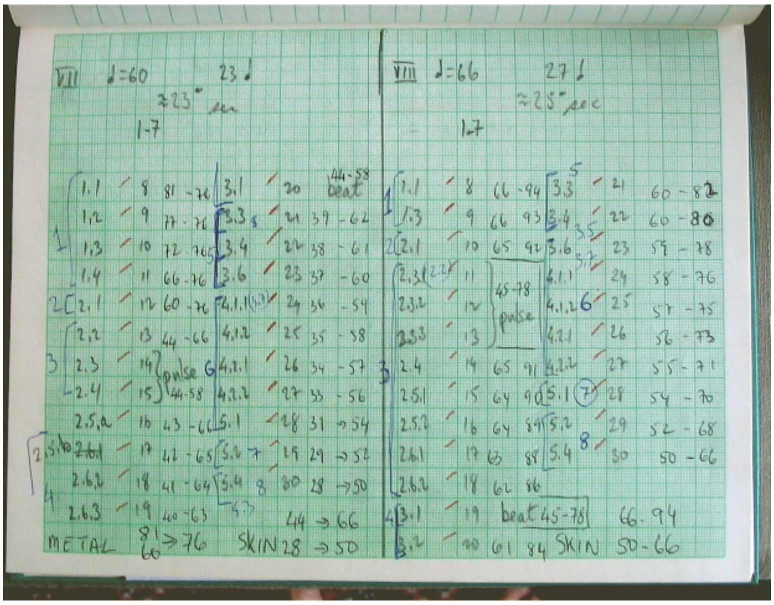

Figure 4.28: “This is the “note data” template for sections VII and VIII. This will be messaged into MIDI note numbers for the MIDI files to control the sampled instruments in Finale”

From the note data, the score was then written by hand (see figure 4.29). There is no particular revision or traces of edition in this sketch. However, a few annotations are made with coloured pencils. The comments in yellow are reminders of the structure, the marks in red have been written after the notes were verified. When he used these values with a program, Austin was able to assess more accurately the results and introduced a few changes.

Figure 4.29: Excerpt of the hand-written score of *Involuntary Memory*

The last step in the process was to enter the notes into Finale (see figure 4.30). Noticeably, the resulting score was not used in order to be played by performers, but to generate the electroacoustic part of the composition using a sampler. The MIDI note numbers of each of the twelve staves were used to build independently the twelve channels of audio, which were to be rendered on distinct loudspeakers.

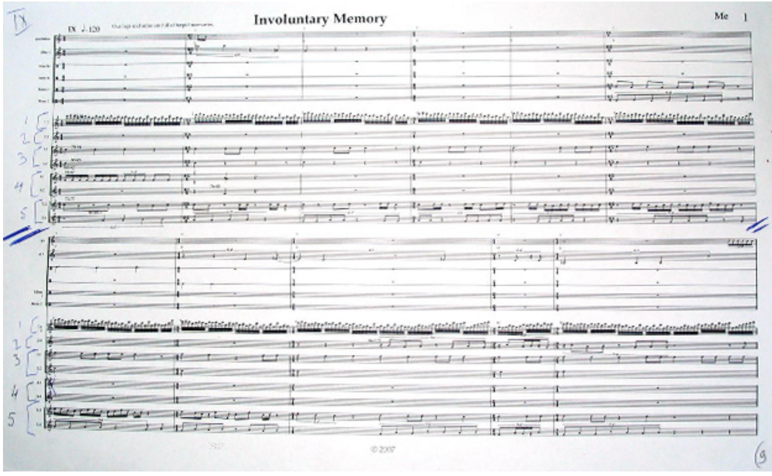

Figure 4.30: Edited score for *Involuntary Memory*. "Each line was broken down for note data"

4.5.2 Conclusion

The approach developed in this composition is consistent throughout the sketching process. The first image is used to generate most of the data reported in the final score. The sketch is refined four times during the process so as to represent the various dimensions of the composition. First, the sketch is refined so as to represent most of the information (figure 4.23). The additional sketches focus on certain aspects of the composition. The second refinement (figure 4.24) affects the family of instruments (metal, skin, wood) to specific parts of the graph. The following sketch (figure 4.25) represents the graph so as to explore the metric structure of the piece. The last refinement (figures 4.26 and 4.27) develops the temporal structure, the evolution of the instrumentation and their pitch over time. This part involves a precise multi-dimensional system where the time is represented on the horizontal axis, the pitch on the vertical axis, the instrumentation being identified by colours.

4.5.2.1 Dimensionality

The representation of musical dimensions varies in the successive sketches. In the first four sketches, time is represented along the path, and finally unfolded on the horizontal axis in the last sketch. The sketches reproduced in figures 4.23 and 4.24 developed as an exploration of sonic dimensions, particularly how these would be represented on the vertical and horizontal axes. This further determined how timbres were affected to MIDI note numbers. The use of tables and diagrams in the sketches 2, 4 and 5 characterises an exploratory work on the dimensions of the main sketch (representing the butterfly journey).

4.5.2.2 Hierarchy

As observed in other case studies, the sketches follow a hierarchical development. However, the main idea appears clearly from the beginning, as suggested by the clarity of the first sketch. The first sketch generalise the idea developed throughout the composition process. The composer's concerns go from the overall representation to the detail of the note in a top-to-bottom approach. No major development on the structure was made after the composer started to get committed to the details of the piece (i.e. the notes).

4.6 Discussion

The case studies have highlighted that in music composition, as in other forms of creative design, sketching plays an important role in facilitating the development of ideas. It appears that this is partly because people start out with relatively underspecified concepts of what they wish to achieve. Another role of the sketches is to act as a mnemonic for ideas striking when composers are not in front of their computer. Following Green (1989 [31]) it seems that sketches provide a suitably underspecified representation that helps composers to avoid premature commitment to the concrete details of a piece. Analysis of the case studies highlights several similarities and dissimilarities between sketching processes. The aim of this discussion is to extract the key properties of sketches from the case studies. First, we study the use of multiple sketches. Second, we examine the music events that the drawings are meant to represent. Third, we review the dimensions drawn in the sketches. Finally, we present a categorisation of sketch properties.

4.6.1 The use of multiple sketches: a cycle of 'sketch, inspect, revise'

In the early stages of music composition, most composers who draw sketches develop multiple versions of their sketches. In the samples studied in this chapter, but also in others studied at the British Library (e.g. Xenakis or Elgar sketches), sketches are not drawn once and for all, but developed and revised. Ligeti developed 110 sketches for the piece *Artikulation*, Freeman developed sixty sketches (of which we reproduced six) and Austin drew more than ten. This suggests that sketching music supports a process that evolves along with the representation. Design ideas are projected onto the paper and compared to the original idea the composer had in mind. The design idea is usually refined either on the same sketch or in a separate paper (see e.g. Freeman's case study). When multiple sketches are drawn, they usually show evidences of revision and editing (see e.g. figures 4.1, 4.2, 4.8, 4.22, 4.31). The emerging properties of the sketches, as well as their spatial and functional relations differ from one sketch to the next, showing evidence that the successive representations serve the purpose of clarifying the focus, or in some cases that the representation itself suggested new relationships (see e.g. Freeman).

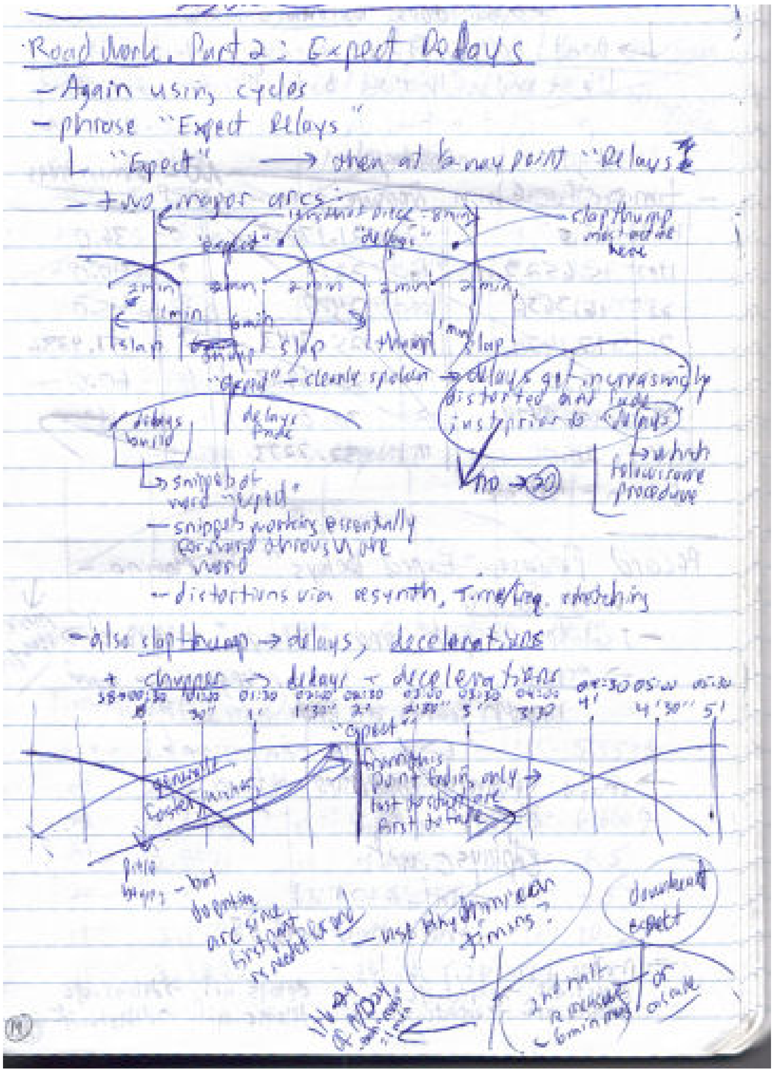

Figure 4.31: Sketch of *Expect Delays*, David Mooney, 2002. The structure on the top described as "two major arcs" is extended and refined at the bottom of the page. A time line is added, the next drawing focuses on one arc of the two drawn in the drawing at the top.

Some sketches show that ideas vaguely drawn in a sketch are further developed in a separate page. See for example the development of the design idea in Austin's case study. In this case, the main depicted element recurs across the sketches (the journey of the butterfly), while other parts are removed or left aside. The spatial relations evolve so as to represent various dimensions, successively time, instrumentation, transformations, and time again. Noticeably, the first sketch group all these dimensions together in a vague manner. Following Larkin and Simon, and Suwa and Tversky, the reason for this is to accommodate the interdependence of dimensions to facilitate the computation. The original sketch serves as a reference most of the following sketches, which noticeably develop two dimensions at a time, that of instrumentation over time or pitch over time.

However, the development of ideas varies from one composer to another. Whereas Austin or Schwarz started to draw the overall structure and then developed the details, Ligeti or Freeman elaborated the overall structure in parallel of the design of details (see Ligeti's sketch 4.6 and Freeman's *transition sketch* 4.15). Noticeably, Báthory-Kitsz uses both approaches. In the first case, Austin and Schwarz reported having a specific idea prior to sketching, which was developed straightforwardly. In the latter case, the structural ideas emerged during the sketching process.

The general pattern suggested by this analysis is that the use of multiple sketches is key to the development and refinement in the design of musical ideas that build on an interdependence of musical dimensions. The successive sketches are linked, for most of them. Design ideas are sometime explored further in following sketches. This is the case for Ligeti, Austin and Mooney. Alternatively, the representation itself can be reproduced, but to explore a different design idea. This is the case for Freeman, where a circular shape would be reproduced in several sketches to represent successively space and then frequencies. These developments follows a dialectical process of 'sketch, inspect, revise' observed in architecture sketches by Schon and Wiggins (1992) [69] or in a more musicological manner as a validation / invalidation cycle described by Xenakis and Delalande [91]. We now turn to the details drawn in the sketches, in order to examine whether some of these details recur.

4.6.2 Representation of musical events: why sketches are vague?

In music analysis, the representation of musical events occupies an important place. Kevin Austin, who teaches composition and analysis at Concordia University, Montréal, frequently asks his students to draw representations of what they perceive in a musical piece. Hans Tutschku, who teaches acoustic and electroacoustic composition at Harvard University, asks his students to draw a representation of their own pieces in order to facilitate the diffusion of the music when reproduced on several loudspeakers[5]. As we have seen with the representation of *Artikulation* (figure 4.4), the representation of musical events can also be intended as an aid to the listener. The role of graphical representation in support of the analysis of music is significant of the need of decomposing musical events into a form that is de-correlated to an abstract hearing. The goal of such representations is to provide a visual representation of events that can not be easily accessed from memory only. To bridge the gap between the representations intended for music analysis and those intended for composition, it is useful to consider one more sketch, which was developed long after a composition started. *Distance Liquide* (2007) is an electroacoustic piece for eight channels composed by Hans Tutschku while in residency at the Groupe de Recherches Musicales in Paris. After he had composed approximately seven minutes of the piece, Tutschku felt that he had lost track of the direction of the piece. The sketch reproduced in figure 4.32 was drawn to provide the composer with an overview of the piece, as a structural plan he could see at a glance.

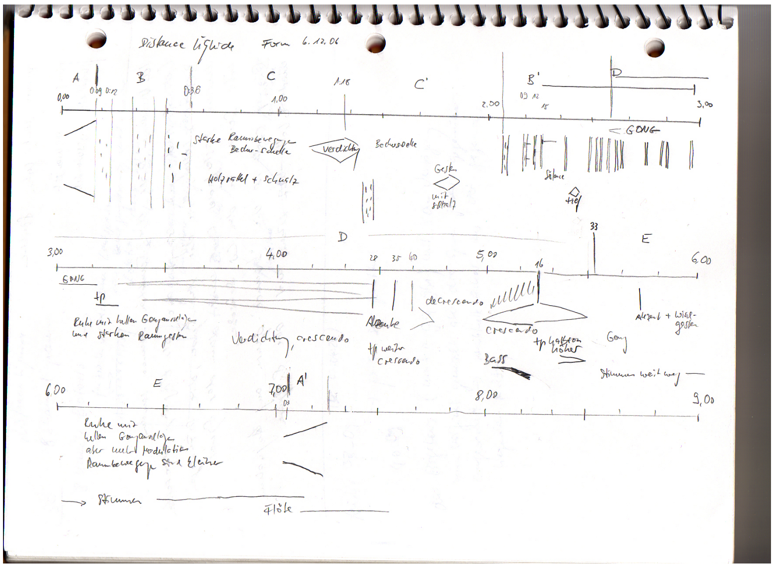

Figure 4.32: Sketch of *Distance Liquide*, Hans Tutschku, 2007. This sketch was drawn as a representation of the structure in order to give the composer an overview of what was composed.

The sketch of the intermediate state of *Distance Liquide* consists of a timeline that is spread out on three rows on the same page. Time is specified above each row. Letters are also written above each row that distinguish the sections of the piece. Musical events are represented so as to illustrate amplitudes (crescendos and decrescendos), textures (the three vertical rectangles at the beginning of the representation), timbres or instrumentation (textual description e.g., *Gong*,

[5] Personal communication with Kevin Austin (September 2008) and Hans Tutschku (August 2008)

Flöte,etc.).

Although the composer had at hand various representations of what was already composed, e.g. the representation in Pro Tools as well as spectrogram representations, he felt that a less precise representation was needed in order to refine the structure. He reported two reasons for this: first, that he needed to think about the piece outside of the studio in order to provide himself with some distance from the piece (this sketch was drawn while the composer was having lunch); second that the process of drawing this sketch was more useful than the overall representation it provided. The composer reported that once he had drawn this sketch, he knew how to complete the piece[6]. In this case, the representation of musical events does not have to be precise, as the process of representing them in time was reportedly more helpful than the sketch produced. This is consistent with an observation given by Báthory-Kitsz in a personal communication: a sketch does not necessarily reproduce all the processes or events in a given piece, but rather helps to sort out an isolated problem, while the main idea develops in the composer's mind and is then realised directly in software.

The representation of musical events differs according to the different contexts of music composition, which have different means of realisation. Ligeti's *Volumina* is a piece for organ (i.e. to be interpreted by an organist), Freeman's *Octorgan* is to be interpreted in real time by a computer, Austin's *Involuntary Memory* is for twelve channels of audio and voice or instrument. Báthory-Kitsz' compositions involve various instrumentation. The constraints inherent to the instrumentation play a role in most cases, but not all. Ligeti's drawings integrate the three keyboards of the organ, as well as an unusual scale for the representation of pitch. For Freeman, the first drawing is a representation of the setting of eight speakers in which the piece will be played. In these two cases, the set of constraints drawn at the beginning play a key role in the development of the sketches. For Ligeti, the sketch representing the three keyboards remain in the final score. In Freeman's case, the space for the eight speakers schematically represented as a circle recurred in the following sketches, representing successively a timbral space, trajectories of sound in space, or numerical values to be used with Max/MSP. For Báthory-Kitsz and Austin, the relationship with the constraints seem less important and are mostly represented as textual notations (see e.g. the instrumentation on the first sketch of Austin, figure 4.22).

A key property of the sketches, hence, is the integration of *some* constraints related to the

[6]The final piece last 13 minutes, i.e. 5 more minutes than what the sketch represents

means by which the piece will be realised. Although the chosen constraints vary from one composer to the other, the use of space shows similarities, which are studied in the next section.

Another common aspect of these case studies is the vagueness of representation. For Ligeti, the final score shows many more details than the sketch, in particular the nuances and indication related to the interpretation. For Freeman, the drawings evolve from a vague representation of the scenic space to successive representation of concurrent aspects of the sound ; e.g., Freeman represents a timbre space but ignores temporal aspects. Austin refines his primary sketch five times to explore different aspects such as time (figure 4.23), instrumentation (figure 4.24), metric structures (figure 4.25), and all parameters together (figures 4.26 and 4.27). Báthory-Kitsz draws either structural sketches (e.g. figure 4.21) or more precise sketches, almost identical to the final score (e.g. figure 4.16). The reason for the last sketches is practical. The composer reported that he would sketch as a way of getting started when he is not in front of his computer. The sketch written for *Nine Rabbits of Valladolid* is almost identical to the final score, whereas *Drumbing* and *Starry Night* are vague and exploratory. This vagueness is sometimes disambiguated in further sketches, which suggest that the initial sketch plays the role of facilitating the development of interdependent dimensions.

The design concepts, in most of the case studies, develop without commitment into the details of the realisation. Additionally, there is no straightforward mapping between the ideas represented and the real world, which is clearly shown by the use of the circle in Freeman's drawing to represent frequencies or space with the same shape, or Austin's timeline that doubles as a diagram of timbres. This indicates that vagueness – a contrasting function between pen and paper and computer programs – effectively supports the elaboration of musical composition by facilitating switches between musical dimensions and the representation of interdependent perceptual features.

A final point highlighted by the case studies is the hierarchy in the development of the sketches. Two approaches coexist in the case studies. The approach mostly used starts with a representation of the global aspect of the composition. Sections are identified and explored in further sketches. In some cases (e.g. Ligeti's *Volumina*, Austin's *Involuntary Memory*), a few more sketches are drawn that go successively to smaller scales, from the global aspects to the local aspects. In Bathory's *Drumbing* and *Starry Night* as well as in nine other sketches provided by the composer, the same global form is drawn but without refinement. The second approach consists of the opposite hierarchy, this is exemplified by Freeman's *Octorgan* and 45% of Báthory-Kitsz' sketches. Details of the piece are first represented, and the overall structure emerges along the exploration of the details.

4.6.3 Accommodating the multi dimensions of sound

Musical composition builds on various dimensions of sound, such as timbre, time or pitch. During the elaboration of a composition, these dimensions are often decomposed into smaller dimensions. For example, timbre can be explored according to quasi unlimited dimensions of spectral distribution, roughness, noisiness, harmonicity, etc. (see e.g. Schaeffer (1966) [68] or Bregman (1994) [11]). Time, which probably constitutes the major dimension for the elaboration of musical structures, can also be decomposed in several dimensions such as *micro*, *meso* and *macro* where the organisation of sonic structure follow e.g. global rules for each scale (see e.g. [7]). Pitch, which is traditionally scaled at 12 notes per octave can be decomposed in smaller steps (e.g. a quarter of tone). Given the importance of these dimensions in music composition, it can be expected from the sketches that they represent and attempt to accommodate these dimensions together. Manipulating high-level concepts that combine several dimensions (such as pitch and timbre over time) is problematic on the auditory domain only, which naturally drives composer to project their concepts on a visual medium. A 2-dimensional planar paper allows the representation of two or three dimensions at the same time, but to represent more is not easy with hand drawing. In the sketches studied, dimensions of sounds are combined in various ways.

Ligeti, in the sketches of *Volumina* represents time on the horizontal axis and pitch on the vertical axis. The vertical axis is separated in three parts, one for each keyboard of the organ. Another dimension is used and coded by the filling of the shapes. It corresponds to the play mode for each event, e.g. the density of notes played within a geometrical shape or the scale in which they must be played. In the final score, an additional dimension is represented, the nuances.

In the case of Freeman, the first sketch seems to indicate that dimensions play a key role in the design of his musical ideas. The first sketch represent a 3-dimensional view, which is further simplified in a 2-dimensional view. For this composition, Freeman has to deal with 8 channel of audio. Space, in this case, is the dimension with which he gets started. With the original circular shape he used in the first sketch, he represents different aspects of sound, such as frequencies and rhythmic patterns. Time is represented by the trajectory of a spiral. In the sketch reproduced in figure 4.15, Freeman adds the dimension of time on the horizontal axis, in a similar manner than to Ligeti. Various colours illustrate the successive parts of the composition. Although these successive parts evolve on the vertical axis also, what their evolution represent is not clear from the sketches.

Báthory-Kitsz represent various dimensions, most commonly pitch (80%), time (70%) and rhythm (55%). He sometime represents play modes (20%), space (10%) and sound transformations (10%).

Austin uses the space of the paper in a similar way to that of Freeman. The first dimension represented is time (along the trajectory of a single line, figure 4.22). Further explorations associate the vertical space with the pace of the composition, the horizontal space with degrees of complexity (figure 4.23). In the next drawing (figure 4.24), the vertical and horizontal axes are used to distinguishes the family of instrument to be used. In figure 4.25, the space is used to elaborate metric modulations. Finally the last sketch uses the horizontal axis to represent time, the vertical axis to represent pitches and colours to represent families of instrument.

Overall, it appears that the use of multi dimensional diagrams is a recurrent property of the sketches analysed. Amongst the dimensions drawn, time, pitch and rhythm are the most commonly represented. A key aspect of these representations is that they allow to switch from a given dimension to another, without changing the diagram itself. A diagram developed to explore e.g. frequencies, could be further used to organise e.g. rhythms or spatial trajectories. Pen and paper enable a form of free association between dimensions that seem to be integral to the way they are used.

4.6.4 Categorisation of sketch properties

For the clarity of our argument, we regroup the properties observed in the case studies in different categories.

- Representation of musical dimension, in particular time, pitch, rhythms or timbres. These representations are idiosyncratic, but the combination of these dimensions in diagrammatic representations recurs.

- Vagueness and ambiguity of representations. This is particularly identifiable in the first sketches that are drawn without artefacts such as a ruler or millimetre paper. Further sketches, however, sometime explore sonic dimensions in a non-ambiguous manner.

- Multiplicity of sketches. Most composers - but not all - develop series of sketches in order to develop an idea or specify a part distinguished in a sketch drawn earlier.
- Re-use and reinterpretation of the sketches, or part of them.
- Revision and edition. This happens mostly at an advanced stage of the composition process, when the composer commits to the realisation of the piece. Confronting original ideas with their sound result often suggests revisions of the original sketches.
- Development of a graphical semantic. The vagueness and ambiguity reported earlier doubles with idiosyncratic ways of representing sonic events, which sometimes turns to a graphical semantic used to identify sonic events.
- Distinction of the structures in smaller sections. Most of the first sketches are a projection of the overall structure of a piece. This overall representation is decomposed into parts that are clearly identified.
- Integration of original constraints. Sketches contain indications that specify the musical dimensions to be considered in a given piece. These indications can be textual (e.g., references to timbres) or graphical (e.g., the representation of a space).
- Textual annotations. These are mostly mnemonics but also serve the purpose of separating and identifying parts of a piece, or refer to the calculation of low level data such as MIDI note numbers, frequencies or space relationships.

Properties of sketches for composition are problematic for computational music systems that aim to provide interfaces that support music composition. In contrast, programming languages require as clearly defined a syntax and semantics as possible. However, the external representations that provide the most effective support for creativity seem to exploit under-specification of their syntax and semantics. It appears that vague representations of musical dimensions and dynamics of shifting or combining semantic frames are a key part of the process of composition. The process of managing these dynamics must be accommodated in the design of interfaces.

Implementing these properties in a computer program is problematic in regards of the expectations usually associated with the use of computer programs. Whereas composers do not expect a sketch to produce sound, they expect a program to react to their actions. The properties of sketches differ in nature with the properties of computer programs ; to support composition with the functions of pen and paper within a computer program requires an accommodation of these properties with the expectations of the users. The process of sketching with a computer program is likely to change the initial process of sketching, hence changing the end result. The manner in which the implementation changes the process needs to be addressed, once the design of such a program is defined.

Chapter 5

Informing the Design

"Pen, paper, and mechanical instruments were my first doors to music..."

Horacio Vaggione, [12]

This chapter discusses the design of a computer program that integrates the key features of sketches observed in the previous chapter. The design is informed by a critical comparison between the features of existing music software and the features identified in paper sketches. A key aspect addressed is the representational gap between the sketches and the tools used to compose music. By looking back at the case studies, we note that whereas Báthory-Kitsz most often represents sonic events in relation with standard notation, a link can not be drawn between the sketches of Freeman or Austin and the representations offered by contemporary computer programs. The aim of this chapter is to review the available functions of existing programs in contrast to the functions of paper-based sketches and identify how to support the latter in a computer program.

The first section analyses the role of existing programs dedicated to music composition. We first discuss the paradigm of standard music program exemplified by *Logic Pro* and *Pro Tools*, and then review programs that aim at representing music through alternative paradigms. In section 8.2 we describe requirements and the rationale behind the design choices for a novel program incorporating the above features. Subsequently, we present three successive versions of the program that led to the prototype of the Music Sketcher.

5.1 Analysis of existing programs

5.1.1 Logic Pro and Pro Tools

Logic Pro and Pro Tools are Digital Audio Workstations (DAW), that are commonly used for multi-track recording, editing, and mixing of music. They represent at the same level sound files and music notation (MIDI), which allows, for example, to write parts of a song using MIDI and to record other parts with live instruments. The use of MIDI facilitates in particular the prototyping of instrumental music: composers can use a keyboard connected to the computer to generate MIDI events that are recorded by the program in real-time. These events contain information used to control the duration, pitch and volume of notes. When these events are linked to a MIDI *instrument*[1], it allows writing the score of an instrument using a direct input from the keyboard. The improvement in the quality of sound samples and MIDI playback encourages many composers to release a final product where not all the instruments have been recorded live.

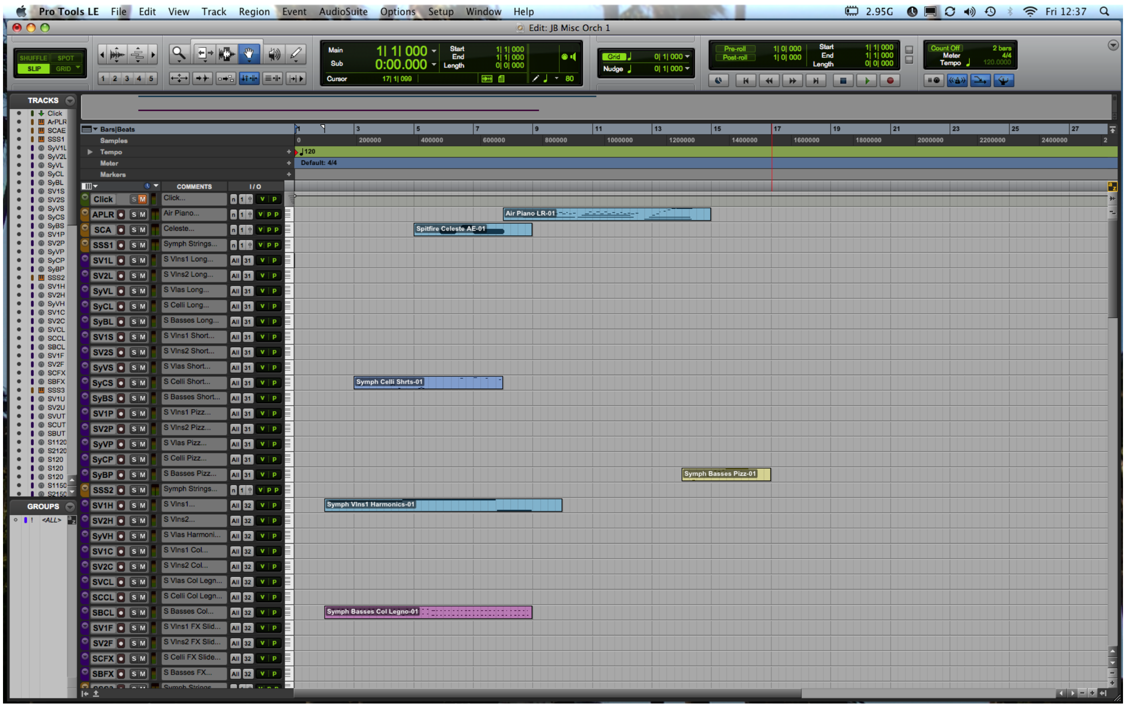

Figure 5.1: A template loaded in *Pro Tools*

The representation of sound in Pro Tools is similar to all professional DAW: sounds are identified on the tracks as rectangles whose length represent the duration of the sound. The waveform envelope can be seen inside the rectangles, which informs the user of the evolution of

[1]A MIDI instrument is a virtual instrument that uses sounds samples that are controlled by an external MIDI device or directly within the software.

the sound's amplitude over time.

In order to give a more concrete account of how these programs are used, we have asked the composer Dru Masters to explain how he uses these programs. Masters is a composer of music for TV programs, who works mainly for the BBC and ITV. He gave us an example of his use of Pro Tools when scoring music for TV. We reproduce here a transcript of this interview.

Dru Masters: "To give you an example, well, I need to load this orchestral template, which takes a bit of time. I can't show you a picture with it because it would probably crash, as I'm currently working on this template. This is a really quick way of working. I haven't been working with templates before because the old G5 is just too slow, but now I've got this thing (a Mac Pro). You'll see up here, that's the contact memory service (a indicator of the use of the RAM dedicated to the storage of sound samples) so, there's already 1.1 giga bits loaded and it will be about 3 or 4 gig when it finishes. The memory management is a lot better now. But also I can open up about a hundred and twenty tracks on this, so it's all there. I'll show you an idea. It's very instant. To be able to play a keyboard instead of a mouse, I mean the keyboard is the interface that composers are used to. The mouse is an inconvenience that we try to avoid, because it's a pain, literally. We now need to wait for all the samples to be loaded."

Figure 5.2: Dru Masters in his studio in London, July 2009. The keyboard at the front is used in conjunction with Pro Tools. The laptop is not part of his usual setting, it was used for the experiment described later in this thesis.

Dru Masters: "(5 minutes later) So here, I've got a default sound, a piano sound, which doesn't work properly in ProTools, it works better in Logic. So if I select that track I can play strings (the composer gives an example, using the keyboard to play strings). I've got a huge number of sounds, here's a celesta, here I've got contrabasses, etc. Ok let's say I start with *col-legno* basses (he clicks to select the track), I need to take that off (click again) and press record (a scroll bar starts moving across the screen, the composer plays on the keyboard and record twenty seconds of his interaction with the basses)."

Dru Masters: "Ok. so now I can very quickly record something with harmonics. (He selects another track with harmonics sounds, press record on that track and start playing. The sound recorded previously is played back and the composer adds the harmonics to the track). You get the idea. And then, same thing, so we got this cello (the composer selects a cello library to a track, plays back the two tracks previously recorded and adds the cello part). Obviously, I'm not working with a click, which is gonna let me out of sync but, well. What could I bring in now? I don't have any brass here, but, what else do we have? Hm, OK, here's a celesta. (The composer adds three or four notes of celesta over the recording). Let's listen to it now. You can see how that might work in the context of something that needs to be quickly done. So now I'm going to add some piano at the end of this. (He quickly adds a piano melody at the end of the recording). And then, quickly, go back to, hem (he goes back to the beginning of the piano recording and add some double bass sound). It's very quick to get something together. It's how I tend to work. If I want to bring in sixteen new instrument tracks, I just create sixteen new instruments, here we are, and then on the first one the track) I go to the mixer (a mixing-desk representation of the track) and I'll put in a... *atmosphere*[2]. Here we go. So now I can have a... (he chooses a sound from the plugin, tries it and goes on to record the new sound over the beginning of the composition)."

Dru Masters: "It's slightly work in progress, just to see how many instruments I can bring in on this. There's some great sort of cheat sound that I sometimes use. It's the closest I get to cheating really. (The composer looks for a new sound to add and records it on top of the composition, which now lasts around a minute and has seven different instruments overlapped. He goes on adding orchestra strings at the end of the composition.) It's very instinctive, but obviously it goes faster if you got sounds to hand. So if I suddenly want anything, any new sound I just go here. What should I add? Name a sound."

Jean-Baptiste Thiebaut: "What about bass clarinet?"

[2]The composer used a plugin called Atmosphere, from the company Spectrasonic. This plugin is a synthesiser, which generates pitch sounds when controlled by the keyboard.

Dru Masters: “Ok bass clarinet (he looks for the sample library and loads it into the system. He records the clarinet over the composition). I don’t think that they have pitch bend on this? Well, a little bit, but you can always change that (by editing the MIDI score). It’s pretty quick because I know my library and the presets and I can sort of load stuff very quickly and then just try something and very quickly get a sketch of some music that sounds quite professional but whether it’s real composition or whether it’s proper in terms of musical ideas, I don’t know. That’s how I tend to work.”

Jean-Baptiste Thiebaut: “I can see how complex this can become. So you now work with Pro Tools, but you have used Logic before. What made you change your mind?”

Dru Masters: “I’ll give you an example. This is something I’ve done for a string quartet (he loads the recording). One of the reasons why I like working with Pro Tools is that it now got *Sibelius*[3] built in so I can go straight to print out the score. Whereas before, I was working with Logic and I had to export MIDI files, import them in Sibelius, correct all the problems, print the score and then I have to export all the audio from Logic into Pro Tools to record it and then export all the audio back into Logic if I wanted to add any MIDI parts and export all back again into Pro Tools. So now I can just work in Pro Tools and I have all in one.”

Jean-Baptiste Thiebaut: “If you had to do a string quartet again, or compose anything outside of your commercial commissions, how would you envisage the work?”

Dru Masters: “I think, something I’ve always envisaged as a child, in a sort of, you know, something that is not based on any kind of physical reality, I always imagined how amazing it would be to have like a dictaphone where I could sing into it the trumpet part, and it would just play back as a trumpet. I think that the interface, because it’s all about speed and, for me, I think for most composers that I know who work in TV and films, it’s about speed of creation and everything in the interface is getting in the way of you actually getting some of your ideas down. Every time I have to move the mouse to click on the chord and remember that I haven’t put the track into ‘record ready’ it’s just like, one more thing that’s really holding me up. So an ideal environment would be one where you could actually capture something quickly, like sing ideas and then it would pitch, follow your pitch, understand it and transcribe it. I think that Melodyne can do that. As a tool from pitch to MIDI it’s brilliant. I mean the more you make these things easy the more people can compose, which isn’t necessarily a good thing (laugh)

[3] Sibelius is a notation tool used to write instrumental scores.

because someone with no ability could sing a line and then become a composer. But then again you can argue that I could be a best composer if I didn't have to rely on my piano playing ability, which is limited. On another front, there's a compromise for the sound because the result you get with the keyboard is not great with the attack and release of the sounds. I feel I'm very limited in terms of what I can really achieve."

A screenshot of the session appears in figure 5.1. It appears from this interview that Digital Audio Workstations aim at facilitating composition in a precise context: in this case, the composer reports that prototyping is eased by the software providing that he uses a keyboard, possesses a large sample library and the computational means to process these samples at once. The complexity of the interaction, which seems necessary to accommodate all the functions that the composer needs, seems to also have its shortcomings, as explained by Dru Masters in the last paragraph. We argue that beyond this observation, it is because of the complexity of the program and its dependency to precise instructions that it cannot, in its current form, support the activities observed on paper sketches. Indeed, the commitment to the piece as reported by the composer in this activity appears to be rather more 'hands-on' than the vague processes observed in the sketches.

We now turn to a review of exploratory programs that diverge from the paradigm of DAW by building on different means of representations.

5.1.2 Open Music

Open Music is a program developed at IRCAM[4]. This program was designed as an attempt to overcome the problems of Digital Audio Workstations in terms of their adequacy to fulfill the needs of contemporary music (see Assayag et. al. (1999) [4]). Open Music provides algorithms to generate complex symbolic structures. To manipulate symbolic representations, the program encapsulate bits of MIDI data in blocks that can be connected one to another to create interactions between them (similar in that to the patch representation of programs like Max/MSP or Pure Data, discussed earlier). A particular tool, 'Maquette' allows representing the blocks on a time line, which enables using the program in a similar manner to that of sequencers. Recent developments of Open Music have integrated the representation of sounds (as opposed to MIDI data only) within the same environment: blocks of MIDI data can be connected to blocks of sounds to operate various kind of transformations. The main function of Open Music is to allow a variety

[4] Institut de Recherche et Coordination en Acoustique Musicale: http://www.ircam.fr

of operations on the symbolic representation, thus facilitating the generation of composition or parts of composition with algorithms.

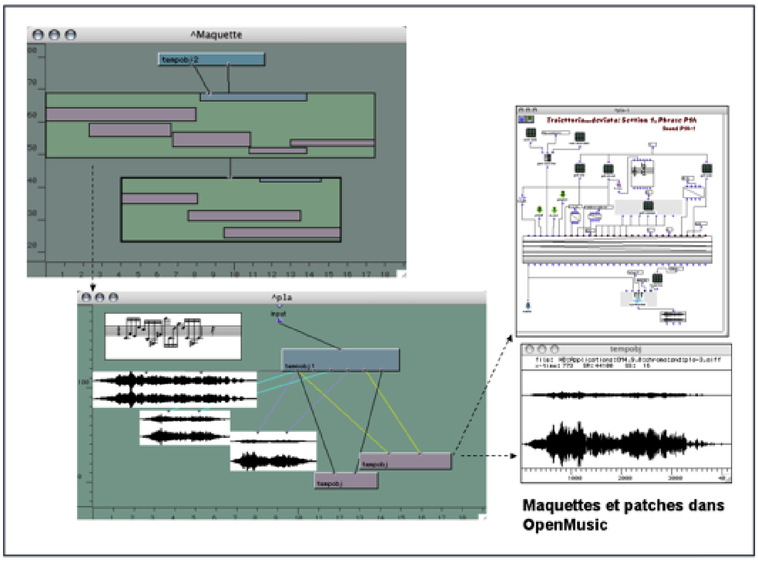

Figure 5.3: Screenshot of Open Music and the Maquette interface

The figure 5.3 shows how the Maquette relates to the objects (the rectangles) which contain either symbolic data (notes) or sound samples. Several functions are provided to link these blocks together. This program, designed in conjunction with composers at IRCAM, addresses specific needs for the generation of algorithmically-driven scores. The patch representation facilitates the development of interconnections between sequences of the piece, which appears to be a useful feature in support of exploratory approaches of composing. Changing the parameters of the relationship between two objects create unexpected results. The main disadvantage of this approach with regards to paper sketches, is the commitment to numbers to characterise the relationship between objects. The program allows a flexible use of constraints to generate complex structures, but through the use of a precise semantic (that of the programming language Lisp). In contrast, paper sketches develop an unconstrained, vague semantic, where diagrammatic representations allow switching between representations of perceptual features. The difference in functions from paper sketches to the functions of Open Music is exemplified by a study of Philippe Leroux's work at IRCAM observed by Donin and Theureau (2007) [23] where paper sketches are reproduced along examples of the composer's use of the program Open Music. As observed with Digital Audio Workstations, it appears that the functions of paper sketches are complementary to that of Open Music.

5.1.3 The UPIC system

The UPIC[5] system was developed at first as a hardware device that included a drawing table linked to a 64-oscillator synthesiser. The original idea was formed in the early sixties by Iannis Xenakis who composed instrumental music using an architect table to assign pitches and dynamics to the instruments (see e.g., the original sketch for *Metastaseis*[6]). Xenakis pioneered the use of graphical interfaces for music composition by introducing free-hand drawing to control sonic events with the UPIC in 1976. The UPIC system allows controlling the pitch and dynamics of a synthesised waveform. On the main drawing board, time is represented on the horizontal axis, while the vertical axis controls pitch. An intensity envelop can be drawn separately for each line of the board. A waveform can also be defined separately for each line drawn on the main board. The notes are thus drawn on the main board and their envelopes and timbre can be defined individually, enabling users – paraphrasing Xenakis [91] – to create something alike a full orchestra. Another feature allows users to change the time scale of the score, which could be rendered in e.g. 2 seconds or 1 minute.

From a compositional view point, the UPIC system has many disadvantages. First, the result is constrained to the timbres that one could define with only 64 oscillators. Although all audible timbres could virtually be synthesised without a limit of oscillators, their drawing represents an obstacle – complex timbres are difficult to draw by hand. Second, the UPIC system developed apart from the other music programs that are used nowadays to realise a piece (e.g., Protools, Logic or Cubase), which prevent interoperability. Third, the direct mapping between the drawings and the sonic result prevents multiple interpretations by the system and therefore constrains the drawing to the manner in which the mapping is done. These constraints, as a whole, limit the impact of the UPIC system in the support of the first stages of composition: although free-hand drawing facilitate early representations, the constraints of the mapping limit the possible outcomes and the lack of interoperability prevent re-uses of the graphical score in a different environment. Rather, it is used as a sound design tool to create original timbres. We now turn to a more recent program called IanniX, whose development was inspired by the UPIC system.

[5]UPIC stands for Unité Polyagogique Informatique du CeMaMu
[6]Xenakis produced the electroacoustic piece *Légende d'Er* with the UPIC

5.1.4 IanniX

IanniX is a program developed by company *La Kitchen*[7], for which development started in 2001 with Adrien Lefevre. The initial concerns of this program were to address the question of time, represented in most computer programs on the horizontal axis with a fixed, linear progression. Vaggione (2001) [86] argued that the representation of time in computer programs should follow the various time scales at which the composer operates ; Dahan (2005) [21] argued that horizontal representation of time - which prevail in most sequencers - constrain the construction of parallel dynamic events that could evolve at their own speed rate. To address this problem, IanniX allows users to control multi-dimensional, abstract objects that can be parameterised to run concurrently with various behaviours. An example of these objects is illustrated in the figure 5.4.

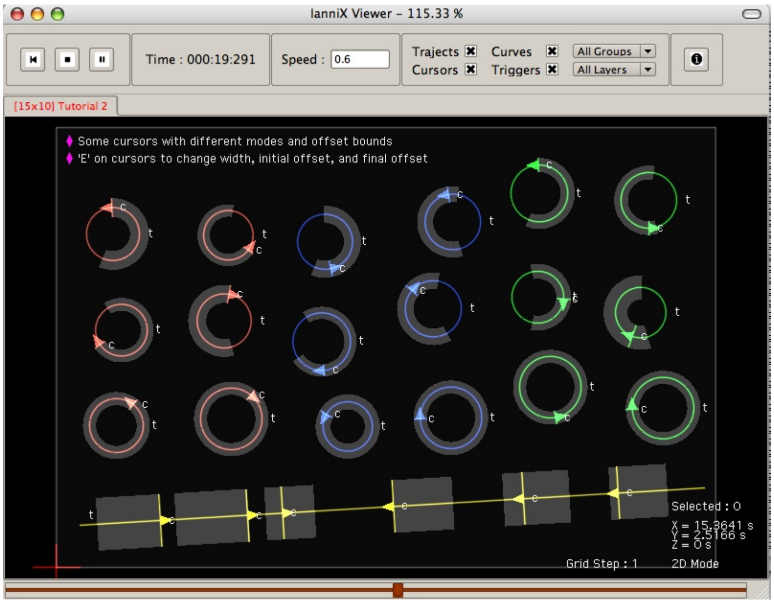

Figure 5.4: Interface of IanniX, version 0.650b

Although inspired by the UPIC, IanniX does not offer the flexibility of free-hand drawing. Instead, the graphic interface is constrained to the use of circles and lines. It addresses the problem of interoperability, for its goal is precisely to communicate with other programs (IanniX does not produce sound itself). Communicating control data from IanniX to other programs occurs in real-time, which facilitate the construction of parallel sound objects but does not facilitate representing the whole structure, for it offers an instant view of the state of the control parameters, as opposed to representing time information. As we shall see in the case of Metasynth and OpenMusic, a virtual montage room seem to be required to facilitate the representation of the

[7]The company closed down in 2007, but the Iannix project program can be found on Sourceforge: http://sourceforge.net/projects/iannix/

structure.

5.1.5 Metasynth

The primary intention of the program Metasynth is sound synthesis. Its interface allows a range of graphical manipulations (including the use of images) to control a frequency additive synthesis. In contrast with the UPIC, Metasynth offers instantaneous audio feedback of the drawing. The graphical functionality of the program enables users to create sounds, but these are constrained in timbre by the additive synthesis method used to transform images into sound. The time is represented on the horizontal axis, while the vertical axis represent the pitch. The vertical axis is scalable, supporting the representation of linear, logarithmic or harmonic scales. In order to produce a sound, the drawing is interpreted as a spectrogram (the system maps the vertical data to pitches, the horizontal data to duration). Several functions are available to support understanding the relationship of the drawing with the sound rendering. These functions are either graphical (e.g., 'blur' or 'contrast and luminance') or expressed as sound transformation (e.g., 'invert pitch' or 'add harmonics'). Using these functions modifies both the graphical display and the sound result. Metasynth also offers a 'montage room', which enables manipulating recorded sounds in a timeline using the same paradigm as developed in most audio workstations.

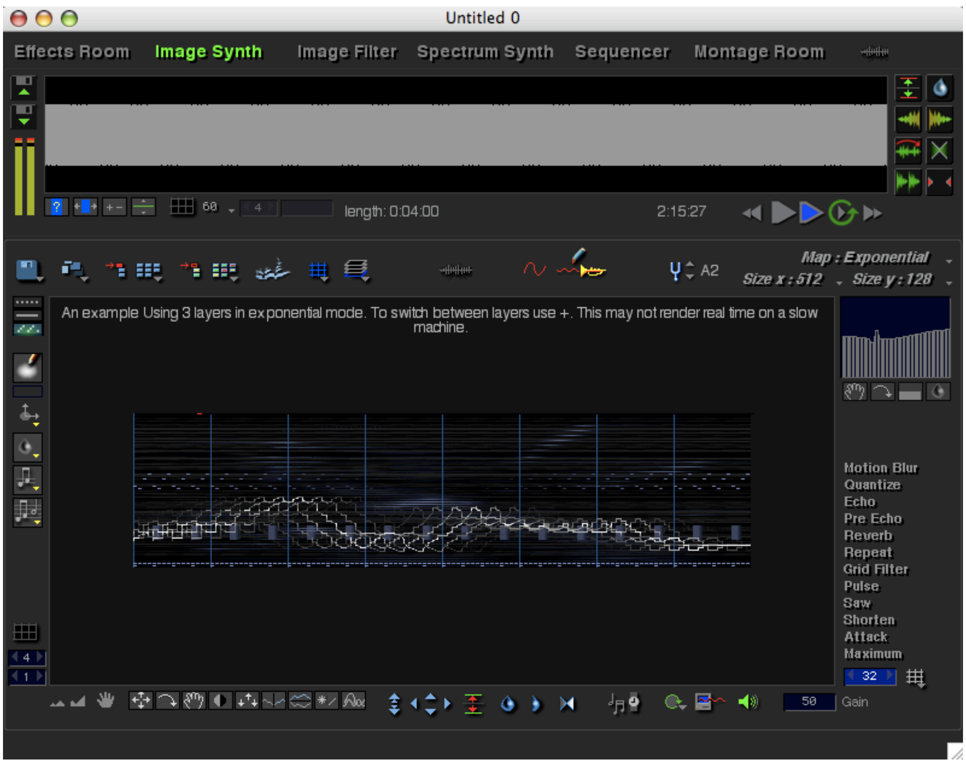

Figure 5.5: Metasynth screenshot

Observing how composer would sketch a composition with Metasynth would however be difficult, for the direct relationship between images and sound does not facilitate representing abstract relationships or vague intentions: every action in Metasynth has a direct impact on the sound outcome, whereas it was observed in paper sketches that drawing plays a more representational role, where mappings are intentionally vague or not represented. Observing composition processes with Metasynth would not allow distinguishing what is drawn as the representation of a musical intention from what is drawn to match the constraints of the program.

5.1.6 Hyperscore

Hyperscore was designed to simplify the approach to traditional forms of composition. This program facilitates the elaboration of complex structures using a 2-step approach. The first step enables people to define motives and to associate them with given colours. The second step allows people to "paint" a score by the means of the predefined colours, presented in a way similar to a colour palette (see figure 5.6). The horizontal axis represents time, while the vertical axis allows to controls variations for the motive.

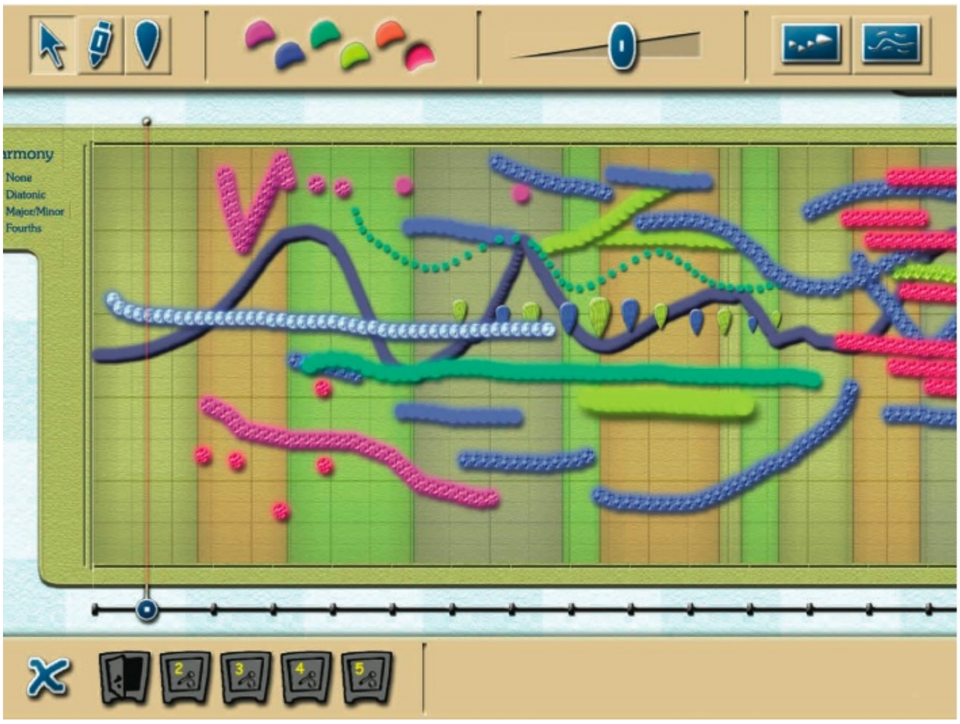

Figure 5.6: Hyperscore screenshot

The distinction between melodic motives and musical movements is handled in a way that reminds us of the *micro / meso / macro* distinction, which is an important concept to electroacoustic composition (see Roads (2002) [64]). In Hyperscore, the *micro* scale consists of the smaller elements (MIDI notes), the *meso* scale consists of the motivic scale and the *macro* scale refers to the space where the *meso* motives are combined and organised. The vertical axis represents different constraints in the *meso* space (the pitch of the notes) and in the *macro* space (complex constraints on the harmonic content). This change of representation, also a feature of Diemo Schwarz's CataRT ([71]), facilitates switching between semantic representations, a feature that is commonly found on paper-based sketches (see e.g., the case study of Freeman).

Hyperscore presents an interface that allows hand drawing in support of composition. The pitch axis doubles as an harmonic space, which bridges one of the gaps between paper-based sketching activities and the computer based realisation of music pieces. However, as pointed by M. Farbood in [26, 25], this program would improve greatly if it used sound samples rather than MIDI. Moreover, the harmonic constraints of the program limit the results to traditional classical music, which limits musical creativity to specific genres of music. Not surprisingly, most of the compositions made with this program are within the Pop/Rock/Hip hop style, as a result of a highly constrained mapping system.

5.1.7 *The Sketcher* and the *Music Sketcher*

The program *The Sketcher* has been developed by Dahan, and a user manual is published in Dahan (2005) [21]. The aim of *The Sketcher* is to provided electroacoustic composers with a workspace that abstracts away time and frequency paradigms of representations. The software itself has not been released and no evaluation of the program could be found.

The program *Music Sketcher* has been released in 1998 by a team of developers at IBM. The program "takes a top-down approach in that it lets the user arrange phrases or riffs into larger musical structures"[8]. The description further claims that the program is a sort of precursor of Apple's GarageBand. The program has been retired from the IBM website and we have not been able to evaluate it.

These two programs – although unreviewed – illustrate the need for different approach to music composition by means of different representational paradigm. We have coincidentally called our program the Music Sketcher (see Thiebaut (2008) [84]) to distinguish it from Dahan's The Sketcher. At this time, we were not aware of the existence of IBM's Music Sketcher. Within

[8] The full description can be found here: http://www.ibm.com/developerworks/java/library/j-camusic/#resources. Website visited the 25th of August 2009.

the scope of this thesis however, we will still refer to our program as the Music Sketcher. A different name will be chosen if the program is eventually released.

5.2 Critical analysis of representations in music composition

The programs reviewed above have shown different strategies for the representation of sounds and their organisational, structural or transformational parameters. In these programs, the processes observed on paper sketches are under represented. In particular, we observed that the use of free hand drawing in programs like UPIC or MetaSynth fails to support the early stages of composition, and is used instead towards the design of sounds within a constrained environment.

This review is not exhaustive, other programs could have been discussed in more depth such as Audiosculpt, the Musical Sketch Pads [76] or previous work on musical interfaces ([79, 8, 83]). We have chosen to review these programs as they are representative of the most widely used (Pro Tools and Logic), or present novel paradigms for music representation. From the sample studied, we argue that the manner in which representation is designed do not support specifically the issues of indeterminacy and vagueness, which are integral to the way paper-based sketches are used for music composition.

Drawing on the above review, we propose four areas of improvement for a musical application in support of the early stages of composition:

- Visual support for music creativity could be enhanced if initial representations could be successively re-interpreted. For example a representation of pitches over time could be re-interpreted as a spatial locations over time, or as a timbre map. This is consistent with the kind of re-interpretations of sketches of composition seen in the studies of Austin and Freeman, and with the kind of figure-ground reversals seen for sketches in other domains (see e.g., Suwa and Tversky (1997) [77] , Neilson and Lee (1994) [57]). The underspecified semantics of paper-based sketches suggests an equivalent feature in music programs: a certain degree of ambiguity or vagueness that supports the exploration of musical structure.
- High-level constraints of *intelligent mapping* may impose too precise a context, such as e.g. algorithmically-driven strategies with Open Music, traditional classical music for Hyperscore or harmonic sound synthesis with Metasynth. The mapping between graphic events and sonic events must remain a feature of music programs, but the way it operates should be left to the user in order to avoid predefined effects and support a variety of associa-

tions. This must be accommodated with the need of composers to handle a certain extent of *complexity*.

- A certain degree of indeterminacy must be considered, by providing means of representation that do not necessarily have a direct impact on the composition but rather consist of a means for the composer to represent processes or structure for himself or herself.
- The use of drawing is underused in regards of its importance in the first stages of composition. Drawing provides a quantity of information that could be used to control or represent sonic events. The information that can be extracted from drawing is e.g. the width of the stroke, the successive coordinates on both vertical and horizontal axes, the successive directions of the pen, the overall length or the colour of a stroke.

5.3 Designing the *Music Sketcher*

Not all aspects of paper-based sketches are relevant to our design, nor it is possible to create a program that reproduce the exact same experience. The details of texture, the feel of the paper and the fact that it can be crumpled have not been observed as playing a central role in our case studies. Moreover, drawing on a computer is only loosely analogous to drawing on paper although graphic tablets offer a more intuitive control of drawing than mouse based input. The most fundamental issues for user-interface design is that the user understands the mapping between the gesture and its representation on the screen (see e.g., Nielsen (1994) [58] on the visibility of system status), and more precisely in our context, that it facilitates the computations that are facilitated by the use of pen and paper.

Music Sketcher must thus exploits the analogy to paper sketches and attempt to reproduce the same sort of control over the drawing. We do not expect to obtain the same graphical results with the Music Sketcher as we observed in paper drawings, rather the Music Sketcher must attempt to reproduce some of the key functions of sketching. One potential problem with the analogy is that programs have different functions to that of paper. By engaging with a computer program, composers naturally expect a process of action/reaction where the limit to their actions is limited to the set of possible reactions. In comparison, a sheet of paper does not react - although it has physical properties that we can interact with. This difference – *reaction vs reflection* – leads the user to be driven by the possible results rather than by the process itself of *doing*. The implementation of the Music Sketcher is driven by these observations and its interface aims at being as little constraining as possible.

Vagueness, as we pointed out earlier, is an important feature of sketches as it facilitates the development of ideas without premature commitment to the constraints inherent to their realisation. While drawing, the composer does not, in general, focus on the specific tools he or she wants to use but rather on higher level concepts, often of a structural nature. Although vagueness is a characteristic of most sketches, there are little commonalities in the way it is expressed. Vagueness has been observed in the representation of several dimensions of music: time (Austin, Freeman, Ligeti, Bàthory-Kitsz), pitch (Ligeti), space (Freeman) or timbres (Austin, Bàthory-Kitsz, Ligeti). This highlights a challenge in the design of our program. How to accommodate vague representations in a program when direct mappings are considered – following Nielsen (1994) – as a prominent usability heuristic. Paper sketches are vague, for they do not need to be precisely drawn to express an intention. In contrast, using a computer program requires precise instructions. Designing a system that facilitates both vagueness and precision poses a challenge for which exploratory, heuristic methods are appropriate.

5.3.1 From observations to design

We have characterised that the early stages of music composition are not supported by existing composition software. The design of our program will follow an exploratory approach, where we attempt to propose analogue functions to that of pen and paper within a computer program. Several arbitrary choices will be made and tested using a formative evaluation. Our exploratory approach is similar to a "trial and error" method, where we evaluate different settings and features in terms of adequacy to the with the task to be done (engaging with a composition process). We set out the preliminary functions of the software as follows:

- Drawing using the mouse or a graphic tablet
- Erasing, moving and rotating the strokes drawn
- Define other interpretations of the time line than the horizontal axis
- Define a mapping between the strokes and the sound rendering
- Allow for the sound to be exported to an other application
- Allow multiple sketches

5.3.2 Getting started: an empirical approach

In order to define an empirical framework that would facilitate iterations in the program, we needed to consider basic requirements and the technological means for developing them. We choose to get started with a simple design that allows drawing by hand and allows associating sound samples to the graphical elements. The rationale behind choosing sound samples instead of notes was motivated by the review of the program Hyperscore, which imposes a precise relationship between the drawings and the notes. Using samples, in contrast, allows different interpretations of a single graphical element, providing that it can contain sounds easily changeable. The first prototype was developed using Max/MSP with which we had designed three interfaces for musical purposes (see Sedes et. al. (2003) [72], Thiebaut (2005a) [80] and Thiebaut (2005b) [79]). In particular, our experience in developing the program Pompiloop[9] with Max/MSP/Jitter was a strong incentive to re-use the same environment. Further iterations in the program however required switching technology, for certain functions could not be implemented with Max/MSP. We present hereafter a succinct account of three successive versions of the Music Sketcher and emphasise in particular the rationale that motivated the iterations of the program.

5.3.3 First prototype

The first prototype was developed within the environment Max/MSP. The interface was developed with the Javascript User Interface object (JSUI). The audio processing was developed using the MSP library of objects.

The drawing interface is represented in figure 5.7. Drawing on this surface can be done with the mouse or with a graphic tablet. It was not possible to use the pressure of the pen on the tablet to control the width of the stroke. The reason for this is that there was no simple way for Max/MSP to get hold of the pressure parameters of the graphic tablet. This was a factor that motivated changing programming environment later on. The graphical operations available at this stage were a global zoom (in and out) of the sketch and translation of individual strokes.

The main focus at this stage was to develop a strategy for the mapping of time, which was the prominent dimension drawn in the paper sketches. A sound engine (not reproduced here) was developed, which used the velocity at which a stroke was drawn to control the speed rate at which the sample would be played. The overall duration was decided by the cumulated length of the stroke. Using Max/MSP for the user interface however rapidly posed some problems to support

[9] Pompiloop is a composition software for children from age 5 to 11: http://www.pompiloop.com/

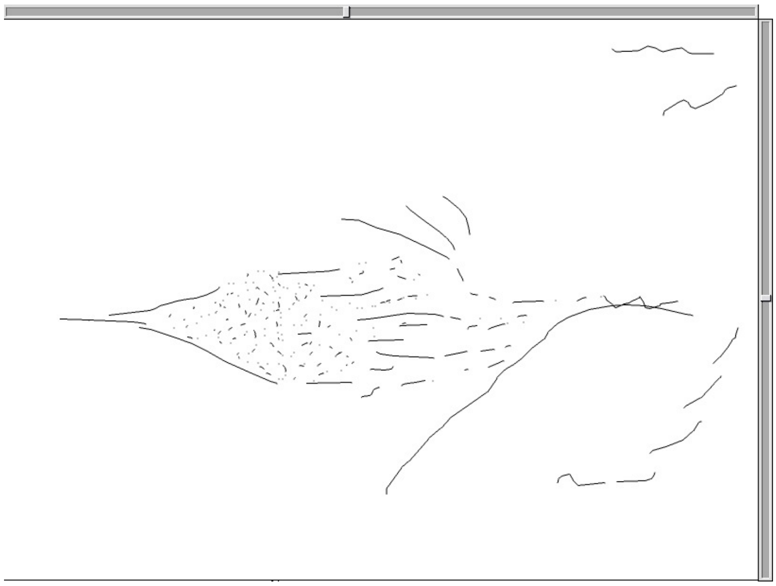

Figure 5.7: Drawing interface of the first Music Sketcher's prototype. The drawing can be scrolled vertically and horizontally.

user interaction. With javascript, it appeared that desirable functions such as drag and drop (to associate a sample to a stroke, for example) could not be implemented. In order to evaluate our mapping strategy for the interpretation of time, several additional functions should be developed. These functions were listed as follow:

- Allow drag and drop of a sound sample onto a stroke
- Map the pressure of the graphic tablet to the width of the stroke
- Overcome the limitations of the graphical display
- Enhance user interaction: allow rotating strokes, switch easily from a 'selection' mode to a 'drawing' mode
- Facilitate the re-interpretation of the sketch (by e.g., offering different mappings for interpreting time)

Driven by an empirical approach, we thus decided that implementing these functions would facilitate observing the adequacy of the mapping of time. As we pointed earlier, attempting to find an adequate strategy for the representation and interpretation of time was motivated by the recurrence of representations of time in paper sketches. Rather than attempting to solve all problem at once we decided to focus on that dimension first, before considering other dimensions (e.g., pitch, timbre). Having done a few projects within the programming environment Processing (see Bokesoy and Thiebaut (2006) [8] , Thiebaut (2007c) [82]), we naturally turned toward this environment to implement the functions mentioned above.

5.3.4 Second prototype

The second prototype thus aimed at integrating new features to the program in order to ease observing the adequacy of the time mapping, and also facilitate further developments. When re-developing the program, we encountered a problem of a new nature. Although Processing facilitates the design of graphical interfaces, its ability to deal with sounds is limited in the sense that the libraries available for it do not offer the same granularity of control than Max/MSP. In order to deal with time accurately, we needed a precision that was not possible to obtain using Processing. This problem was overcame by bridging the new prototype with a sound engine developed in Max/MSP. Bridging these two programs was made possible using the protocol Open Sound Control (OSC), which allows sending and receiving information in real time to and from the ports of a given machine, using either UDP or TCP protocols (for more details, see Wright and Freed (1997) [90]). We used OSC to communicate information from Processing that could be received and treated in Max/MSP. This bridge was hidden to the user, who never has to interact with the sound engine. This solution is not ideal however, for synchronizing events poses some other problems of representation in the main interface: when an instruction is sent from Processing to Max/MSP to render a sound transformation, it occurs independently from Processing and synchronised information must be sent back from Max/MSP to Processing in order to refresh the display.

Figure 5.8: Interface of the second prototype in Processing.

The features described in the previous section were added. At the bottom of the screen, the button "load sounds..." allows choosing a directory which contains sounds files. Once the files are populated in the rectangle at the bottom, the user can drag a file to a certain line or point to affect the sound file to a stroke. When the mouse hovers over the stroke, the colour of the stroke changes to red so that the user know to which stroke the sound file is affected.

The interaction is facilitated with the use of buttons represented at the top of the screen (figure 5.9). These buttons allow accessing the following features:

Figure 5.9: Tools palette.

- Pen item: (default option) clicking on this button places the user in drawing mode. In this mode, the user can draw events on the screen using either the graphic tablet or the mouse. The width can only be modified using the graphic tablet.
- Rotation item: the second item in the tools palette enables to enter the rotation mode. Rather than specifying a specific rotation with a given angle, the program allows to use the pointer to rotate the whole screen.
- Pointer item: the third item in the tools palette enables to select a stroke and move it across the screen.
- Curvy line item : the fourth item allows to apply three different mappings over the time dimensions. These mappings are accessed by clicking successively on the button (the button is a three-state button). By default, the duration of a sound event depends on the overall length of the stroke. The next interpretation allows using the horizontal axis to calculate the duration of a sound. The last interpretation uses the evolutions on the vertical axis to control the duration of each sound. In addition, the sketch is rendered from top to bottom (as opposed to a left to right rendering in the two other cases). In the last two cases, the representation is modified in order to reflect the manner in which time is interpreted (see figure 5.10).

Changing the representation is required to reflect the changes in order to keep intact the visibility of the system status. However, the changes in the graphical display can cause confusions: if the drawing follows a graphical *reasoning*, changing the representation may affect this reasoning.

We let this representational issue aside to focus on further developments. The reason for this

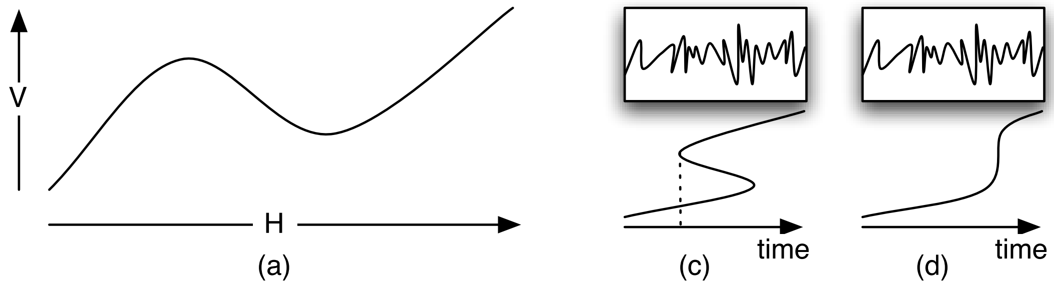

Figure 5.10: Mapping of the curved line (a) when the vertical axis (V) is chosen to represent time. The dashed line in (c) shows how two points can correspond to a single moment in time. (d) shows how the interpolation is calculated to address the problem.

was that at this stage, the prototype was not advanced enough to be evaluated. Thus, instead of evaluating an incomplete set of features, we decided to address an other salient feature of paper sketches: the representation of pitches. In order to address the problem of mapping pitches to the drawings, we have chosen to map the vertical evolutions of the lines to change the pitch of our sound files[10].

The mapping from the variation of a stroke to pitch present some issues, which are common when numerical data is mapped to signal data. In order to intervene on the sound as precisely as possible, we developed a single program which interpolates the successive variations of a line and write the corresponding values into a signal buffer. This buffer will then be able to be read at the signal rate (44,100 sample per second in our case). The program we have developed builds on the existing Java package *buf.op* developed for Max/MSP. We provide an array of values to the *external* object[11]. The interpolation considers the time between two points of the line and calculate the intermediate values accordingly. The interpolation is calculated for every line in the drawing. The buffers are dynamically filled when the data is received in Max/MSP. A *poly* object is used that allows to have multiple instance of the same object (see figure 5.11).

Each sound object is assigned a departure time. An event starts when the departure time equals the value received by the object "receive chrono". The "chrono" value measures time at the sample level and can be increased or decrease in order to shorten or lengthen the duration of the whole composition, having an impact on the whole sonic result. Another feature of this sound engine is that each sound is assigned a duration which is linked to the length of the corresponding

[10]When the representation is in vertical mode, the horizontal variations are used to change the pitch
[11]Within Max/MSP, objects can be written in Java or C language and used within the graphical environment as objects. They are commonly called externals.

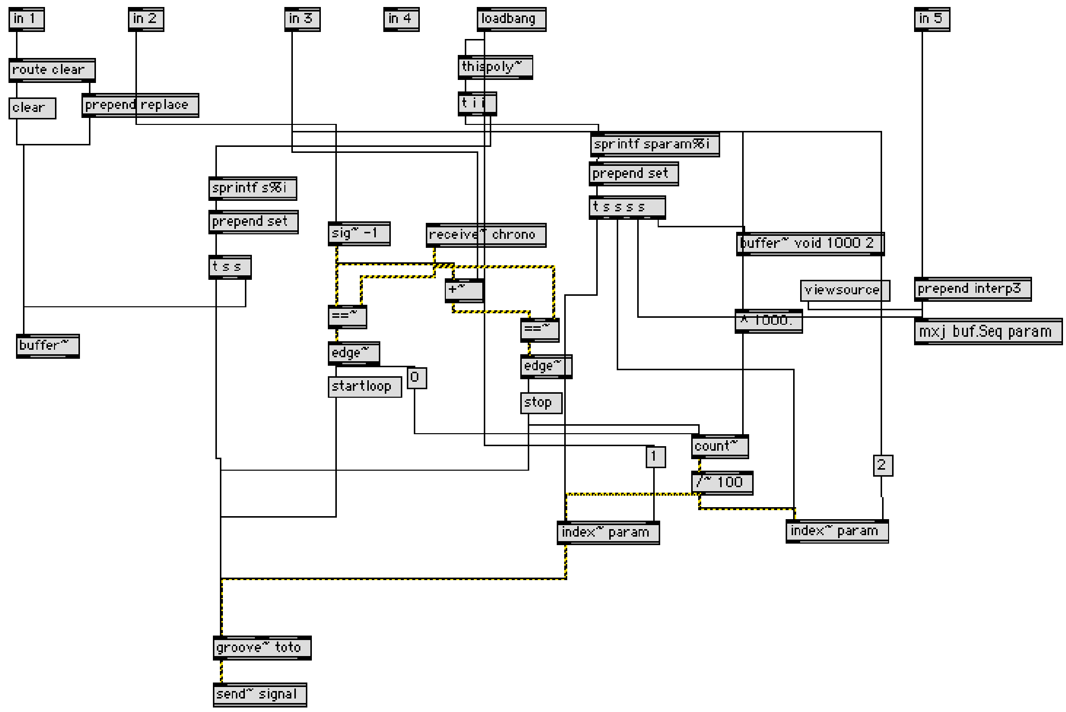

Figure 5.11: Max/MSP sound engine that renders the sound from the Music Sketcher. In the prototype, this allows to have up to 40 sound objects simultaneously active.

stroke. If this duration is longer than the sound file attached to the event, the sound will loop until the duration is reached. If the duration is shorter than the sound file, the sound will stop when the duration is reached.

At this stage, the program was presented at the International Computer Music Conference 2008 in Belfast (see Thiebaut, Healey and Bryan-Kinns (2008) [84]). Informal discussions with composers and researchers during the conference highlighted the limitations of the program in terms of interaction and representation. The main misconception observed at this stage was the automatic pitch mapping, which did not appeal to composers and regarded as too constraining. The multiple interpretation of time was also criticised, for it changes the representation, which appeared to be not desirable. The lack of available graphical operations was also noted. From the informal feedbacks we received and our own appreciation of the program, we elaborated a new set of features that should be available before a formal evaluation could take place. These features are as follow:

- Representation of time: develop an alternative way to facilitate multiple interpretations of time. This must remain consistent with the visibility of the system status, while modifying the overall drawing as little as possible. Any modification should be reversible, in order to be able to get back to a previous representation

- Representation of pitch: leave the choice for the mapping to the user: the aspect of the stroke could illustrate an intention without having any effect on the sound
- Allow other types of transformations (than pitch) that could be controlled by the coordinates of the stroke
- Editing operations: implement a function of copy and paste, reintroduce the zoom (which was let aside in the second prototype), allow colouring the strokes and modifying them locally
- Playback operations: double the audio feedback with a visual feedback, using a cursor that moves from left to right on sketch
- Distinguish local and global actions: enable operations at the stroke level and at the sketch level
- Address interoperability: this is a key issue to address, for our program focuses on the early stages of composition. We assume that further development should be made in a different environment. The Music Sketcher ought to facilitate communicating with those environments, in a similar manner to that observed on paper sketches: these are used as a first step towards composing, which ultimately occur in an audio workstation. Audio workstations present several advantages for the realisation of musical pieces that this program will not attempt to compete with. The sonic events that are defined over time should be exported in a format readable in a digital audio workstation.

A final point highlighted by the presentation of the program at the ICMC conference concerns using the graphic tablet. We had the opportunity to use a Wacom PL 400 (see figure 5.12), which is more sophisticated than most graphic tablet, in the sense that it reproduces the display on a shielded LCD screen, which can be directly manipulated with the pen. This facilitates the drawing, for the sketch is displayed below the pen as opposed to displayed on a remote screen. During our presentations, however, we couldn't use the graphic tablet, for practical reasons: the tablet is not easily transportable and requires some time to install. Each time the system was demonstrated informally, we used a mouse or the trackpad of the program. After some time, we completely abandoned using the graphic tablet, not because we thought it would not be useful, but because it was easier to demonstrate the system without carrying the tablet to every meeting. We noted that discussing the features of the program did not require drawing accurate sketches. For this reason, we have chosen not to use the graphic tablet in further developments of the program. Another reason for not using the tablet in further versions of the program was that we considered that observations with the most usual setting (the mouse) would characterise processes that would equally be observed with a graphic tablet, whereas the contrary would not necessarily be true. We argue that observing composition processes with a graphic tablet would not ease distinguishing the characteristics of sketching on a computer in an ideal case from the characteristics that could be observed in most common cases (i.e. when using a mouse).

Figure 5.12: The graphic tablet allows to draw directly on the screen.

The list of functions described above posed some novel technological constraints. Although Processing has been useful for the rapid design of a graphical user interface, the efficiency of the graphical rendering and the design of menus and buttons are limited. Switching technology appeared inevitable for several reasons. First, there was a need for an appropriate file management system, which Processing does not provide. All the classes of the project can be accessed from tabbed panes, but there is a limited number of those panes that can be displayed at once. Switching easily from one class to another started to be difficult after we developed more than 15 classes. Second, integrating Java classes in Processing was not always as simple as with the Integrated Development Environment (IDE) NetBeans. We observed this when we worked on the communication with a digital audio workstation, which implied re-using third-party classes, which always needed to be adapted to run in Processing. At this stage, the Music Sketcher contained 21 different classes. We thus decided to continue the development of the Music Sketcher in Java, and to keep using Max/MSP as sound engine.

We now turn to a description of the elaboration of the third prototype and present the final version that was further used for the formative evaluation.

5.3.5 Third prototype

Most developments decided toward the end of the last prototype were incorporated directly in the new Java version of the prototype. We describe these in the second part of this section. However, addressing the interoperability problem was not straightforward. It is worth reporting here the progresses in the development of a module able to communicate information to a Digital Audio Workstation (DAW).

5.3.5.1 Addressing interoperability

There are two main reasons for communicating with a DAW. First, to facilitate further compositional work in an environment known to composers. Second, to provide an alternative representation to that of the Music Sketcher and allow switching back and forth between the representations as the composition progresses. With these requirements in mind, we looked for the technological means to develop this. In the Music Sketcher, we know what the sounds are, when they start and when they end. This is all that we need to communicate to a DAW.

Our first step was to look at Logic Pro, which was the environment with which we planned to communicate. We aimed at understanding how the sounds were represented in the project files. It rapidly appeared that the binary format of the files would not reveal the manner in which sounds are represented within Logic. We noted, however, that Logic was able to import and export AAF files. AAF stands for Advanced Authoring Format, and is an open source format for the interchange of audio visual materials (see the Advanced Media Workflow Association for more details [1]). To understand how Logic encoded AAF files (and thus read from them), we created a session with Logic, added a few sounds to it, and exported the session as AAF. Surprisingly, this file was again a binary that could not be simply hacked. We thus looked at the AAF documentation, which indicated that AAF file can be represented either as XML text files or in a binary format. A tool exists that allows converting the binary format to XML and reciprocally. This tool is written in C++ and needed to be compiled on the machine that was using it. We thus downloaded the whole AAF project, compiled the tool (*aaffmtconv*) and used it to convert the binary AAF file exported from Logic to an XML file. We won't get into the details of the XML description of media contents in AAF, but in short, the granularity of details in these XML goes well beyond what we expected. We thus started to hack the XML representation and developed empirically an engine able to create an XML file and to encode it to the format that Logic was able to read, by calling *aaffmtconv* from Java. The class developed for this purpose was called CompositionXML[12]. At this stage, we were able to create a composition with the Music Sketcher and export it as AAF, and re-open it in Logic. It appeared, however, that opening an AAF file from Logic took a long time, which increases depending on the number of sounds described in the file. The reason for this is that Logic stores sound samples in a cache, to allow rendering them more quickly. This is not compatible with the instant communication that we wished to achieve between the two environments.

We then started to look for a solution that would quicken the process of importing sounds back and forth. Although most professional products can import AAF files, it would not have worked in a quicker manner than with Logic. Too many steps are involved: exporting the session as AAF, opening the targeted program, locating the file from the hard drive and import it in the program, which is inevitably followed by a conversion of the AAF format to the proprietary format of the DAW. What we aimed at was to allow the user to click on a button, which would allow all the selected samples to be imported directly in a DAW. The choice of a DAW that would allow this was then drastically reduced, for the only way of doing this was to modify the source code of a DAW. Two open source DAW exist (to our knowledge), Audacity and Ardour. We chose Audacity for the practical reason that it has a strong and responding community of developers, which include colleagues from the Centre for Digital Music at Queen Mary. The Music Sketcher was already communicating with Max/MSP using OSC, thus we naturally thought of using the same protocol to communicate with Audacity. Our contribution to the program Audacity has been to integrate an OSC function to it[13], so that it could receive messages from any program on its network and take appropriate action upon reception of those messages. Typically, we wanted to be able to load sound samples in Audacity at a given timecode (which was determined in the Music Sketcher). The main challenge was thus to develop a thread-safe function that could receive messages and add new sounds on request while managing synchronisation with the user interface (so that updates of the UI would not be intertwined with the communication). We are indebted to Gÿorgy Fazekas from the Centre for Digital Music at Queen Mary for his help on the development of the solution. The second step was to act upon reception of those messages. We developed new functions in Audacity to be able to create a new track and add a sound to it.

[12]CompositionXML should be made available after this thesis is finished as an open source Java class.
[13]For this we used Ross Bencina's *oscpack* library, developed in C++.

5.3.5.2 Implementation of the functions in Java

The static and customised buttons on the top of the sketch in the previous version were replaced by a floating bar (see figure 5.13), which eased further addition of new buttons as the development went.

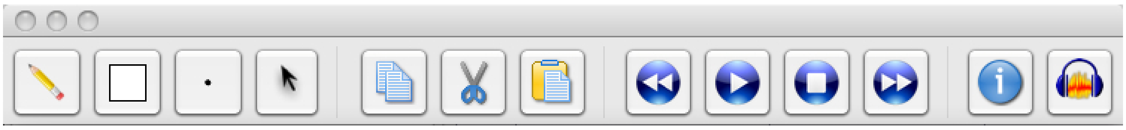

Figure 5.13: Menu bar of the third prototype of the Music Sketcher

The function available from the menu bar are:

- Pen selection: this allows the user to draw on the screen
- colour chooser: this button opens a colour chooser which changes the colour of the pen
- Size selection: this button allows changing the size of the stroke
- Mouse: this allows to select a stroke or a group of strokes on the screen and to move them or edit them (see following functions)
- Copy: this allows copying the stroke(s) currently selected onto a buffer. This function also respond to the key command 'cmd+C'
- Cut: this allows deleting the stroke(s) currently selected and to copy them into a buffer. This function also respond to the command 'cmd+x'
- Paste: this allows pasting the content of the buffer onto the screen. This function also respond to the command 'cmd+v'
- Rewind: this allows moving the cursor to the left by a hundred pixels
- Play: this allows playing the whole sketch. This function also respond to pressing the space bar
- Stop: this allows stopping the playback and moves the cursor back to the left origin
- Forward: this allows moving the cursor to the right by a hundred pixels
- Inspector: this button opens an inspector and loads the settings of the selected stroke or group of strokes
- Export to Audacity: this allows exporting the selected objects into Audacity

Two developments need to be described in more depth. First the role of the inspector. Second, how the sound rendering is managed within and outside of the Java Virtual Machine.

5.3.5.3 The inspector

The role of the inspector is to control precisely the mappings associated to each stroke and to support editing functions at the stroke level.

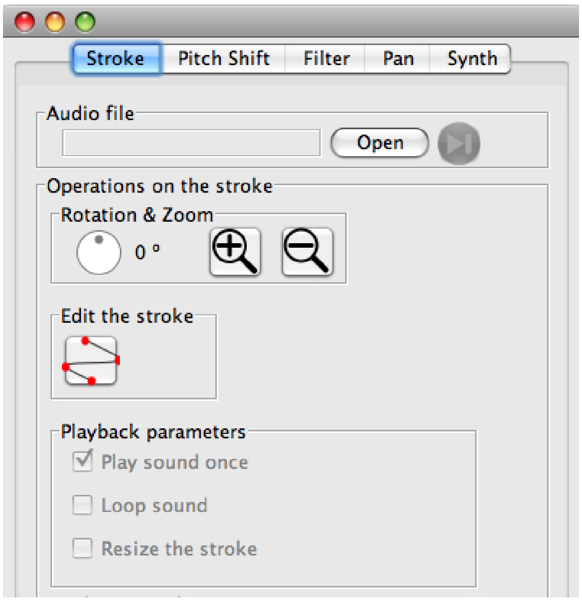

Figure 5.14: Stroke inspector

The functions available from this window are grouped in four submenus. First, the 'Audio file' box allows associating a sound to the stroke (by pressing the Open button). A sound can also be associated to a stroke by dragging a sound file onto the stroke. If a sound is associated to the stroke, its name appears on the text box on the left and the sound can be played by pressing the icon on the right.

The 'Rotation & Zoom' menu allows rotating the stroke by clicking and dragging the knob. The magnifier with the signs '+' and '-' allow changing the size of the stroke.

The button in the panel 'Edit the stroke' allows editing the points of the stroke by clicking and dragging the point across the screen (see figure 5.15).

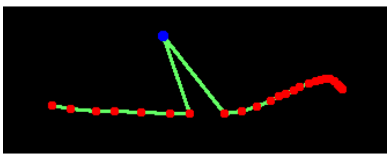

Figure 5.15: Editing a stroke

Finally, the panel 'Playback parameters' allows modifying the stroke according to the feature of the sample that was associated to it. 'Play sound once' is the default option, and indicates that the stroke should not be changed upon the particularities of the sound. 'Loop sound' calculates how many times the sound can fit in the length of the stroke (the distance in the stroke corresponds to a certain amount of time). If the stroke lasts longer than the sound, a marker shows where the end of each loop is located in the stroke. ‘Resize the stroke’ changes the size of the stroke to match the length of the sound, i.e. the stroke can be either expanded or reduced depending on the length of the sound.

5.3.5.4 Sound rendering: a mixed approach

Relying on Max/MSP to process all the sound rendering became problematic towards the end of the second prototype. We noted then that in order to give a feedback to the user when the sounds were played, synchronizing information between Max/MSP and our application posed some unnecessary complications. We thus developed a sound engine able to play back the representation directly in Java using the Java Sound API. When the user presses the ‘play’ button, a cursor starts moving horizontally across the screen. When the cursor encounters the extreme left point of a stroke, the sound associated to it is played. Each sound is played on a separate thread in order to be able to play several sounds simultaneously.

The transformation of sounds still uses Max/MSP and is processed independently. The interface for applying effects is accessed from the stroke inspector (see the tabs in figure 5.14 ‘Pitch Shift’, ‘Filter’, ‘Pan’ and ‘Synth’).

5.4 Conclusion

The successive iterations in the program have highlighted a challenge in the accommodation of our design rationale with existing technologies. Our “trial and error” approach to the problem facilitated progressing towards a solution, by developing successive prototypes of the program. The iterations in the program were made possible by the numerous informal exchanges with Pat Healey and Nick Bryan-Kinns who supervised this work, and also with composers and researchers at the ICMC conference in Belfast or professional developers of music tools (in particular Emmanuel Favreau, developer of the *GRM Tools* and Brian Clevinger, developer of Native Instruments’ *Absynth*). We gathered from these meetings the lists of features that could enhance the user interaction, which were presented above.

The third prototype was finished in March 2009. This prototype was developed accordingly to the hypotheses formulated in our critical analysis section (8.2). In order to verify our hypotheses, we need to proceed to an evaluation of our program, in terms of usability (to enhance the user interaction) and in terms of the adequacy of the program to the initial requirements (reproducing the functions of paper sketches).

The next chapter describes the setting and results of usability tests that build on formative evaluation. We also present the re-iteration of the program that followed the tests.

Chapter 6

Formative Evaluation

We proceed to a formative evaluation in order to detect usability issues and evaluate the matching of the program with its initial requirements (see previous chapter "Informing the design"). The formative evaluation involves four expert composers to test the program. We observe how composers use the program and interact with features that differ to that of most compositional environments. Following the testing, an interview took place to evaluate in which manner the difference of representation affects their experience of composition. Interviews allowed to collect comments on the ease of use and suggestions for improvements. This chapter describes how the tests were designed and ran. We then report a list of usability issues, classified as misconceptions, conceptual mismatches and missing functionalities. Finally, we present the iterations in the program that followed the formative evaluation.

6.1 Design of the evaluation

The methodology used builds on formative evaluation, which has been used by Lee [47] to evaluate multimedia applications. Formative evaluation is naturalistic in nature, which is particularly suitable for a more qualitative understanding use for composition. As pointed out by Coughlan and Jonhson [18], creative output can not be measured quantitatively, as its value can be defended from a wide array of equally valid opinions. It is rather the processes involved to achieve creative results (considered so by the participants) that need to be observed. For this purpose, qualitative approaches are usually preferred to quantitative studies (see Marshall [54] and Creswell [19]).

As described by Weston et al. [89], formative evaluation is particularly useful to evaluate the matching of a design with its requirements:

> "The purpose of formative evaluation is to validate or ensure that the goals of the instruction are being achieved and to improve the instruction, if necessary, by means of identification and subsequent remediation of problematic aspects."

A formative evaluation builds on expert users to analyse an interface. In our case, the experts are professional composers. In four similar settings, we observe composers interacting with the program and collect their advice on the adequacy of the program for their particular needs. It was not expected from the composers that they would interact in a similar manner with the program. Would it have been the case, a heuristic method or a cognitive walkthrough would have been more appropriate, as these would have focused on the efficiency of the program to perform given tasks. Music composition is a creative and exploratory process which cannot be reduced to a series of tasks. The formative evaluation allows to identify different scenarios of use of the program. Comparing the processes involved in each approach allows to identify the processes that recur. These tasks sometimes differ to that offered by traditional environment of composition.

The role of the usability test is to ensure that the program matches its design rationale and to improve it where necessary. This test allows to confront the implementation of the Music Sketcher, whose design was based on observations of composition practices, to a direct engagement of the composers. This allows us to identify problematic aspects and iteration on the development of the program. We collected suggestions of desired features in an interview that followed the test. Each report of the tests includes a transcription illustrated with the drawings and a transcription of the discussion (in annexes).

6.1.1 Setting up of the test

The test must ease the observation of processes that can be observed in composition in general, and in paper-based sketches in particular. Typical processes that happen then are drafts of the global form, problem solving for parts of the composition, offloading computational operations and exploration of concepts which have little to do with the semantics of composition (e.g. musical concepts that can not straightforwardly be expressed as "notes"). The specificities of the program and the fact that composers are not familiar with the environment favour the exploration of what is possible to achieve rather than composing straightforwardly with the Music Sketcher. For this reason, the composers were asked to explore the program and compose a short musical movement using most of the features offered.

The tests were run with four experienced composers of different backgrounds. After introducing them to the program, the composers were asked to explore the software and its possibilities. The dimensions observed during the studies were based on Lee's evaluation of interactive multimedia software:

1. User satisfaction (To measure the user's perceptions, feelings, and opinions of the system.)

2. Performance Effectiveness (To quantitatively measure the ease of using the system, either by speed of performance or error rate.)

3. Flexibility (To evaluate the degree to which the system enables a user to achieve his or her goal.)

These criteria were, however, used as a general framework for the observation rather than strict rules. Lee's model suggest a rather quantitative approach, whereas we noted that a qualitative approach would allow richer observations of the processes involved. Thus, although the three points enumerated (user satisfaction, performance and flexibility) were observed, the method used to observe them differed. The user satisfaction was assessed in the interviews and through observations of their use of the system. The performance effectiveness was considered in two steps. First, by observing the functions of the Music Sketcher with regards to music composition, second by comparing how effective the system was at reproducing the functions of pen and paper. Finally, the flexibility is evaluated in similar terms to Lee's description, i.e. to which extent the program facilitates the first stages of composition. In order to evaluate this, we compared the processes that occurred with the Music Sketcher to those that occurred using paper sketches.

The tests also included a debriefing where suggestions of re-development were collected. These suggestions were of mainly two aspects. First, of a usability nature, e.g. raising concerns about the appropriateness of a given interaction with the system. Second, suggestions of missing functionalities. The suggestions of the second nature completed the analysis of composition processes and suggested revisions of the original design rationale.

6.1.2 Description of the study

The studies took place in the composers work environment. All the equipment were provided apart from a pair of speakers available in the studios. The equipment consisted of a laptop with the software installed, and a mouse and keyboard to interact with the program. The study was video taped. The first stage of the study consisted of an explanation of the program (approximately 20 minutes). The composers were then given 90 minutes to explore the program. A 30-minute discussion followed the study, which was also video taped. The interview questions focused on the usability problems that occurred during the course of the study. The composers were asked to describe what went wrong and how they expected the system to react. Finally, the composers were asked to elaborate on the functions that would like to have had access to.

The study was given the approval QMREC2008/29 from the ethics committee at Queen Mary, University of London.

6.2 Usability issues

Usability issues are understood here as three types of problems related to the use of the program. First, we consider distinct misconception in the program with regards to achieving certain tasks. Second, we report the conceptual mismatches between the design and the users' expectations. Third, we consider the missing functionalities. This section is thus decomposed in three parts. Each usability problem is illustrated by examples from the study and extracts from the transcriptions or by a reference to when it has been reported in the transcript which are reproduced in annexes (e.g. 0:05:37).

6.2.1 Misconceptions

6.2.1.1 The matching of sound samples and their graphical representation

Allocating sounds to the strokes has been a usability issue throughout the study. The original design of the Music Sketcher allowed associating a sound sample with a stroke drawn on the board (see figure 6.1). The association can be done with a drag and drop of the file from the hard disk onto the stroke, or by clicking an open menu in the stroke inspector. The main usability problem occurred because composers did not remember that they had to allocate a sound to a stroke.

This happened with KN. The composer had drawn several strokes and then remembered that she had to allocate sounds to them (0:02:30 - 0:02:55). Forgetting to allocate a sound to a stroke has however been consistent throughout the study, and sign of discouragement would occur when she forgot those, because of the several steps involved to allocate a sound to a stroke. Another

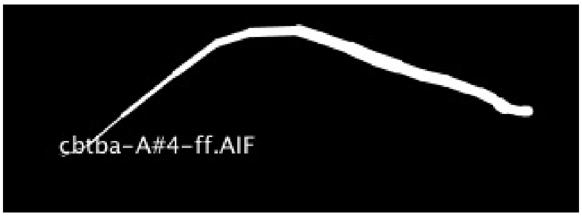

Figure 6.1: Example of an association of a sound sample to a stroke, 0:05:01

issue with the allocation is the fact that when browsing the sample library, it is not possible to listen to the sample. One has to wait for the sound to be allocated before playing it, which does not ease the use of the program. It occurred again at 0:17:40.

A different problem occurred with DM. The composer asked why a short stroke could contain a short sound or a long stroke could contain a long sound (0:47:25). It also occurred with MG, who suggested that a time stretch could be developed to automatically change the duration of a sample depending on the length of the stroke (0:07:08, 0:18:00).

The issues raised here are first, that the composers expect a stroke to produce a sound, even if no sound is affected with it and second, that the absence of mapping between the length of a sound and the stroke is not intuitively understood.

6.2.1.2 Sound transformations

Sound transformation raised several issues. First, that operating on a sound transformation would not immediately be considered when playing back the whole sketch (there is a need to save the sound first). Second, that saving a sound takes as long as the sound lasts (KN 0:07:35, 1:11:30, DM 0:34:20, 1:08:45, 2:06:13, MG 0:05:08), and that no other operation can happen in the meantime. The transformed sound is played back in real-tim during the save operation, which was not always desirable (KN 0:15:30). In addition, no notification is given when the task of saving the sound is finished (DM 0:29:11).

The filter transformation caused issues in the interpretation of the representation (KN 0:21:00). It was confused with a low pass filter. To understand the process, the composer chose a noisy sound to hear the transformation and understood the effect after 2 minutes (0:23:20).

Straight lines generated a bug in the transformation process (DM 0:41:00 to 0:44:00, RH 0:28:38 and 1:03:20).

Max/MSP crashed after a transformation was tried out with a particularly flat stroke (RH 0:31:09)

The synthesis tool was not desirable in its current form (RH 1:24:35: "Personally, I would never use the synthesis, but that's a personal aesthetic that I have").

6.2.1.3 Graphical editing features

Copy and Paste put the stroke (or group of strokes) at a location on screen which sometime would be outside the visible area (KN 0:34:30, 0:45:48) .

The difference of representations between Audacity and the Music Sketcher was problematic, as every sound was exported on a different track on Audacity. As a result, Audacity would display more than 60 tracks where each individual sound was difficult to locate (KN 0:41:03).

The software crashed when playing back the whole sketch (KN 1:01:00). This was due to the large number of strokes played back. The number of strokes also had an impact on the selection tool and the playback, which would randomly generate undesired sound artifacts.

Drag and drop: DM tried to drag and drop a group of strokes from one sketch to another but it didn't work (0:14:25).

Working on the edit points was reported as quite slow (DM 0:18:00) or not intuitive: it would have been easier for the composer to be able to remove points or erase parts of the stroke (RH 0:43:20).

Confusion with pen and selection tools. When a composer tried to select a stroke, the system was in drawing mode, so he ended up drawing a new stroke on the canvas (RH 0:27:00, was also observed with the other composers).

6.2.1.4 Using Audacity

Exporting too many sounds made Audacity crash, because of the numerous tracks that needed to be created. There is a need for a concatenation of sounds on the vertical level to avoid Audacity crashes (KN 0:39:02).

6.2.1.5 Browsing sound samples

The composer consistently reported that browsing without having the ability to preview the sounds was a problem (RH 0:17:44). More generally, the composers would have like to be able to listen to the sounds before they associate them to a stroke (DM 0:18:00).

6.2.2 Conceptual mismatches

6.2.2.1 The representation of time

The representation of time has been an issue at various levels.

First, to understanding how the representation works (KN 0:03:30, RH 0:10:27). The Music Sketcher uses a left-to-right representation of time, but without formal cues of time such as ruler or a grid, the composers did not understand immediately that the horizontal axis was a time axis. Two composers reported that the representation felt too ‘random’ (RH 1:42:50, DM 1:28:45) to support organizing the sounds together.

Second, to having an idea of how long the sounds really are (KN 0:06:30, DM 0:46:00,). In particular, the composers pointed out that if two sounds have been allocated the same sound but have a different representation, the difference would not be reflected in the stroke. At 1:18:10, KN reported that it was an issue to be able to allocate an hour long sound to a tiny stroke. Although the option ‘resize the stroke’ allows to extend or shrink the stroke to match the sample duration, the composers would not want to always check whether the sound duration matches its representation.

6.2.2.2 The representation of sounds

There was confusion as the characteristics of the strokes are meaningless if no effect is applied to them. The composer expected an instant impact on the sound (MG 0:11:37).

6.2.2.3 Graphical editing features

Zooming in/out was an issue as well as a feature. It has been an issue because the composer was expecting the whole sketch to shrink or expand, but in fact the strokes can only be expanded or reduced. This changes the moment at which the sound will start, which the composer considered as a feature as it allow to change the pace at which events would occur (KN 0:52:10).

The rotation tool was misleading: the composer expected that the sound would be modified as a result of the graphical transformation (DM 0:02:25, 2:06:13).

Looping the sound: the composer expected that he could move the markers to change the loop points (DM 0:09:30).

‘Resize the stroke’ was misleading: the composer assumed that he could loop the sound after resizing the stroke (DM 0:09:44).

Zooming: the feature was confusing as it applied to a stroke instead of the whole sketch (DM 0:10:08). It was also confusing because the composer thought that it would make the note last longer (DM 0:40:00).

6.2.3 Missing functionalities

6.2.3.1 Undo

No undo function was implemented. All composers reported that it would ease the use of the program (KN after having copy and pasted strokes, 0:11:20, 0:44:03, 0:45:48, DM 1:26:30, RH 0:15:30).

6.2.3.2 Control of the gain

The lack of control of the gain for the sound was problematic. The composers reported that controlling the gain could be done in various manners:

- Mute the sound rendering when saving a sound (KN 0:15:30, DM 1:26:00)
- Mute strokes when playing back the sketch (KN 0:26:30)
- Controlling the gain (KN 0:27:30, 0:56:06). Elaborated on this at 0:29:16, 1:26:30 and 1:29:40: suggest that the vertical axis could control the amplitude of the sounds, quiet at the bottom, loud at the top. But admitted that it would constrain the drawing. Also reported by DM (0:38:00, 1:46:32) who suggested to develop a breakpoint envelope in the inspector to control the gain (1:54:45). Controlling the volume of the sounds (RH 1:20:25)
- Use the thickness of the strokes as a way of controlling the amplitude (KN 1:31:00).
- Display information on the sounds in the inspector, with a breakpoint envelope to control the gain (KN 1:32:00).

6.2.3.3 Transformations

Synthesis and effects : it was suggested that the stroke could control an additive synthesiser (KN 0:31:20). More effects, like reverb (DM 1:01:10) or pitch transposition (DM 1:06:00), supporting multiple peaks for the filter (DM 1:23:00). RH reported that pitch shifting was not very useful in this manner as it is was not particularly reflecting the way he uses music software. He would have preferred to be able to adjust the tone of a given sample, although this would have defeated the point that the stroke was used to control an effect (0:37:00). Also suggested performing time stretch on the samples (0:17:00).

RH suggested combining the sound transformations together (0:35:00, 0:58:20) and having a more instantaneous feedback but also a correlation between the drawings and the sound rendering. 1:23:50. He suggested also having more sound transformations: multichannel (0:59:12), EQ and reverb (1:24:22), granular tool (1:29:30)

6.2.3.4 Group operations

The ability to copy and paste groups of strokes appealed to composers, but they suggested that more group operations would be useful. In particular:

- Export a group of strokes as a single sound (KN 0:38:02, 1:26:00, DM 1:47:05)
- Apply the effect to a group of strokes (RH 0:26:01)
- Listen to a group of sounds, as opposed to listen to the whole sketch at a given horizontal position (KN 0:06:30, 0:44:45).
- Globally apply a transformation, such as a pitch effect to a group of strokes (KN 0:10:00).
- Use side workspaces to elaborate on sound textures and be able to import these as a single sound/stroke (KN 0:48:03).
- Group items to recolour them (DM 1:46:32).

6.2.3.5 Zooming

It was suggested that zooming in and out the whole workspace should be possible (KN 0:52:40, DM 1:25:10, 1:46:32).

6.2.3.6 Representation of time

To cope with the lack of references to time in the workspace, it was suggested to display a ruler to have a sense of the overall duration (RH 0:52:30). The display of this ruler should be optional (KN 1:28:10).

In order to give a better feedback with regards to the duration of sounds, sound samples should be imported as flat strokes, whose length would match their duration (RH 0:41:10, 1:01:46)

6.2.3.7 Browsing samples

Browsing the samples: there's a need for quicker access to the samples and being able to listen to them while browsing (instead of having to allocate a sound before being able to listen to it) (DM 0:28:00). The composer also reported that it would have been easier if he was able to use his own sample library (DM 0:54:00). Having a browser window where one could listen to the samples and import them with a drag and drop (RH 0:40:30)

6.2.3.8 Editing features

Editing the strokes: the composer suggested that he would like to join strokes together and delete parts of the strokes. It was suggested to select a group of points to drag them all or simply delete them. (1:03:00 DM) RH suggested to fine tune the samples by combining the strokes 0:16:24.

Visually being able to shorten the sound samples or play only a part of them (DM 1:24:53, RH 0:25:35)

6.3 Results of the formative evaluation: impact on the design

The usability issues raised in the case studies often match from one case to another. This is the case for the representation of time, undo, the control of the volume, the browsing of the sound samples, the saving of the sound transformations, the zooming (which changes the location in time) and the matching of the length of the strokes with the duration of a sound.

6.3.1 Representation of time

The representation of time was problematic, mainly because of the lack of cues given by the sketch as of when a sound event starts. Although this has been a deliberate choice in the design of the program, the composers reported that it would be good to be able to switch to a timeline view.

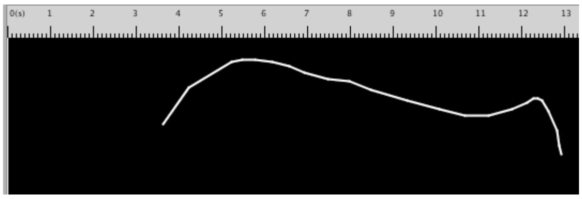

Figure 6.2: Indication of time: implementation of the ruler

The figure 6.2 shows an example of how a ruler can be added to the Music Sketcher in order to allow a finer control of the events in time. The ruler also allows moving the cursor by clicking or dragging onto it.

6.3.2 Undo

The problem of not having an undo function occurred when the composers drew accidentally on the sketch or deleted a stroke. This has been pointed as a high priority feature by all composers. An *undo* class was created to memorise the following actions in an infinite array:

- Draw a stroke
- Cut
- Paste
- Move

- Delete
- Group
- Ungroup
- Add a sound to the sketch

All undone actions can be redone, unless an action is added to the array. In this case, the list of *redoable* actions is discarded. As in most programs, *Undo* can be reached with the key command 'cmd+Z' and also from the 'Edit' menu. *Redo* can be reached with the command 'cmd+Y' and also from the 'Edit' menu.

6.3.3 Control of the volume

Controlling the volume of the individual strokes has been raised as a high priority feature by all composers. Not being able to control the gain is problematic for mixing the sounds together. Several possibilities have been suggested to tackle the problem. A combination of these suggestions has been developed: a breakpoint envelope allows editing the volume throughout the stroke, and the size of the strokes is mapped to the volume of the sound.

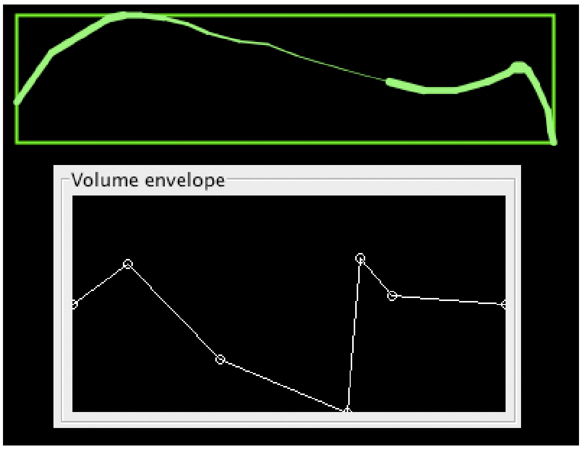

Figure 6.3: Volume controller and visual feedback

The figure 6.3 shows how the control of the volume operates with the breakpoint envelope and how the width of the stroke correlates to that volume.

6.3.4 Browsing sound samples

It was reported that browsing through the samples library occurred via too many steps. First, the composer must draw a stroke, open the inspector, click on the 'open' button and finally choose a sound sample using the Java *awt* file chooser. This file chooser does not allow the playback of sounds, and the composers have to choose a sound before they can play it back in the Music Sketcher. It was suggested that first, the sounds should be available from an inner browser, and second, that the sounds should be played back in this browser. Another useful feature suggested was the ability to drag and drop a sound from the browser onto the sketch. This could either be done onto a stroke, thus affecting the sound to it, or if it was dropped onto the sketch, then it would create a flat stroke whose length would match the duration of the sound.

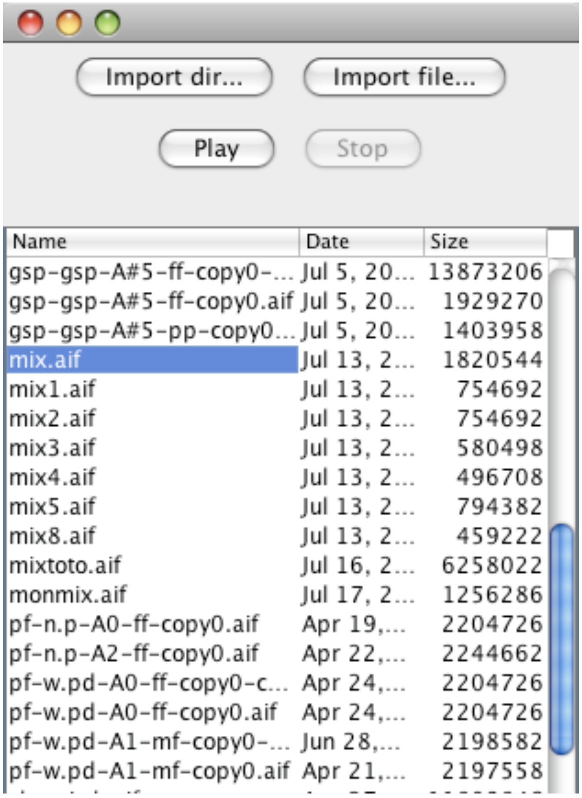

Figure 6.4: Inner browser

The browser was designed accordingly. The sounds can be imported in the browser using the buttons ‘Import dir...’ to import a directory containing sounds, or ‘Import file...’ to import a specific file. The sounds can then be played within the browser by pressing the ‘Play’ button. The list can be sorted by name, date of modification or size (in bits). Finally, the files can be dragged and dropped onto the sketch area.

6.3.5 Saving the sound transformations

Once a composer has explored a sound transformation, which is listened to using a ‘preview’ button, the transformation has to be saved and a new sound sample must be created and named. The transformation then applies to the sound in real time, which has been reported as too long (it takes as long as the sound sample lasts). This problem could not be solved using Java to process the sound transformations, as the processes should have been redeveloped in Java instead of MSP. The solution to this was to display a progress bar when the sound was saved, which indicates when the recording is finished. Also, the progress bar is run in a separate thread in order to let the user carry on further actions while the recording is not achieved. The transformation is saved in a temporary file, which is renamed when the action is finished.

6.3.6 Zooming

In the original design, the zoom function applies to a stroke, or a group of strokes, as opposed to a global zoom of the time line. The aim of this 'local' zoom is to allow for changing the representation locally. However, the result of this operation is inconsistent: the extreme left point of a stroke – which determines the anchor point for the sound rendering in the time line – was moved when the stroke was zoomed in or out. It was reported that the anchor should be kept identical when zooming occurs in order to keep the moment at which the sound will be played identical. Also, it was reported that a global zoom was desirable, in order to expand or reduce the overall time line.

The local zoom function was then adjusted to reflect these observations. We also developed a new function to manipulate the overall representation, which zooms in or out all the strokes and changes the scale of the ruler accordingly.

6.3.7 Time matching of a sound sample with a stroke

The matching of the duration of sound samples with the length of the stroke has been reported as problematic in different ways. We argued in the original design rationale that the drawing should be constrained as little as possible. However, would a stroke be constrained to match a sample duration, this stroke would be either expanded or reduced. In the original design, several functions were designed to allow different relationships between the size of the stroke and the sound sample. These features are available as check boxes in the inspector (see figure 6.5). The default operation ('Play sound once') does not change the length of the stroke. The second operation allows for the looping of the sound. This means that if the length of the stroke is greater than the duration of the sample according to the overall distance-time scale, the sound will be looped as many times as it fits in the stroke. This function reveals time markers that indicate where the loop points are. The third operation allows for adjusting the size of the stroke to match

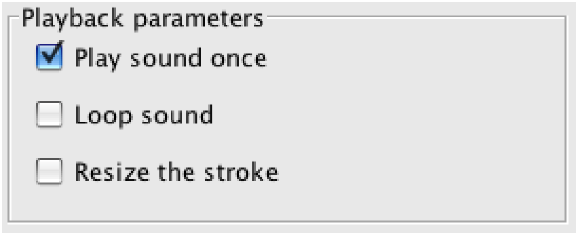

Figure 6.5: Menu for the mapping of the strokes

the duration of the sample it contains.

The representation of a sound within a stroke was ambiguous as a short stroke could contain a long sound and vice versa. This has been solved by making the matching function more clear and accessible. A right click onto a stroke (or a group of strokes) displays a menu that offers to 'Reveal the length of the stroke' . This is also available from a 'Stroke' menu available in the menu bar. Finally, the text of the previous check box was changed to 'Reveal the length of the stroke'.

The composers reported that they would like to manipulate the sample duration using its representation. It appeared that offering a graphical manipulation of this would be a good solution, but a lack of time prevented developing this. Instead, it was suggested to the composers that they could mute certain parts of the sound by manipulating the volume envelope of the sound.

Finally, the menu 'Playback parameters' was made more explicit and renamed to 'Sound mappings', and the check box 'Play sound once' was removed to avoid confusion.

6.3.8 Group operations

A greater flexibility for group operations was suggested by the composers (see subsection 'missing functionalities'). In the original design, group operations consisted of: multiple selection, moving, copying, cutting, deleting, pasting of strokes. These functions were consistently used throughout the studies, in particular to aggregate sounds together. The multiple selection could easily be lost whenever the user clicked onto the sketch and that no stroke belonging to the group could be found. To solve this problem, we implemented a group function that allows linking strokes together. Once the strokes are grouped, they can be ungrouped as well, or integrated into a larger group. Clicking on a stroke that belongs to a group selects all the strokes of the group, which is illustrated in figure 6.6.

The group/ungroup functions are accessed via a pop up menu (right click on the sketch) or via the 'Stroke' menu.

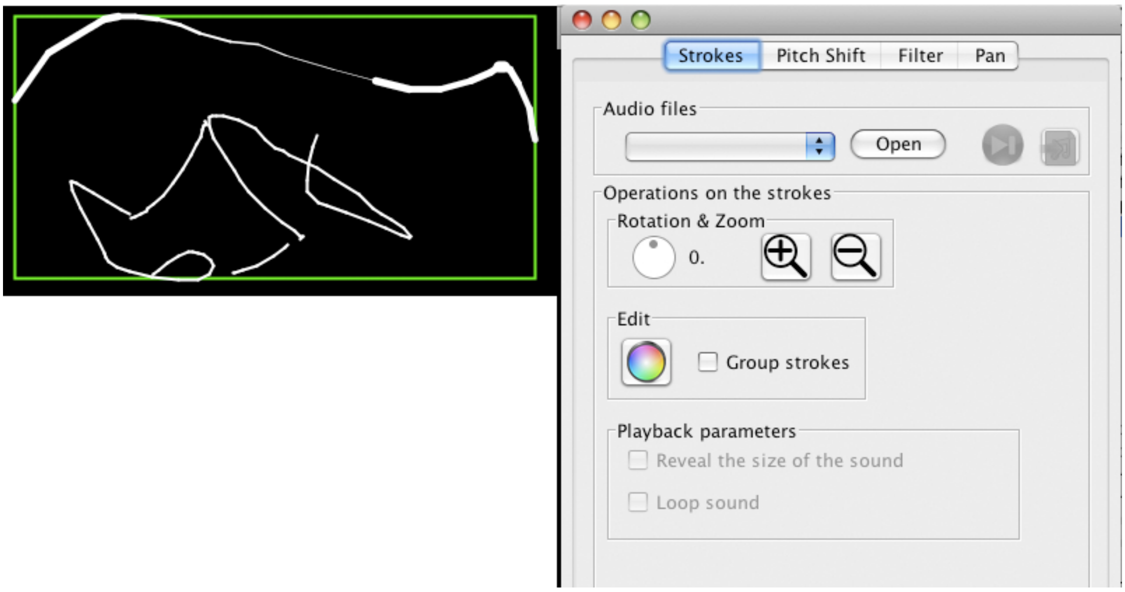

Figure 6.6: Group of strokes and the inspector

Specific functions were implemented for the group, as shown in figure 6.6 (see the inspector on the right). Rotation and zoom apply to the whole group. The colour of all strokes can be changed, and the strokes can be grouped or ungrouped by clicking on the check box 'Group strokes'. The result of a given group can also be listened to (player icon button) or saved in a new file. When the mixed result of a group is saved, the file is automatically loaded in the browser, in order to ease the re-integration of the mix into the sketch.

6.3.9 Sound rendering

Overall, the sound rendering was problematic only when a certain amount of strokes needed to be played altogether. This can also be observed in several DAW: in order to avoid reading from different locations on the disk simultaneously, the sounds to be played are loaded on the RAM. If the RAM is overloaded, the rendering might become jittery. In the first design of the Music Sketcher, each sound was read in a different thread, as it has been an easier way to manage the rendering. This proved to be not efficient, i.e. highly consuming in terms of RAM and CPU and the sound result was jittery when more than 8 sounds were played at once. A solution to this was to create a single thread to play all the sounds, as opposed to creating a thread each time a sound needed to be played. The thread loads the sounds as they have to be played and releases them from the RAM when the playback is finished. The playback of the sound occurs in a critical region.

6.3.10 Minor usability issues

Many minor usability issues were reported and fixed:

- Saving a sketch should change the title of the sketch, and the save operation should concern the active sketch as opposed to saving all the sketches opened in a session.
- When a stroke is copied, its colour is lost.
- Editing the strokes should allow to remove or add a break point. Also, editing the points in a stroke works inconsistently. An example of this is that the breakpoints would disappear when the user clicks outside of a break point, but dragging the stroke would drag a point which is not visible.
- Moving a stroke that contains little break points is difficult, the user has to drag it from its extremities.
- Transformation of flat strokes does not work or crashes the sound engine.
- Changing the colour after it has been created should be possible.
- It is not possible to mute the sounds.
- The playback should be controlled at any time with the space bar to play and stop it.

6.4 Conclusion

The formative evaluation allowed us to identify various usability issues, but also supported efficiently designing the solutions. The qualitative approach of the usability testing allowed us to gather comments on the efficiency of the functions to realise a task but also – in some cases – how a task could be facilitated if the function was different. Overall, the feedback from the composers facilitated understanding their needs in terms of representation, as well as the understanding of how well the Music Sketcher answered those needs. We present in the following chapter a review of their evaluation that focuses on their use of the Music Sketcher as a representational tool. Besides the results gathered during the usability tests, a second evaluation with a revised version of the program is presented.

Chapter 7

Analysis of Composition Practices with the Music Sketcher: Case Studies

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The work presented in this chapter was carried out after major changes were made to the program, following the results of the formative evaluation (see section 6.3). We observe in this chapter how the Music Sketcher impacts the early stages of compositional processes, and contrast our results with the case studies. In particular, we explore critically the processes involved in the design of a musical composition. The Music Sketcher has been designed to bridge the gap between sketching activities and the realisation of a composition. We analyse the extent to which the program bridges this gap. Finally, we examine how the change of medium (from pen and paper to computer) affects the processes involved in the first stages of musical composition by observing the differences and similarities between pen and paper sketches and those that develop with the Music Sketcher. We illustrate our analysis with four case studies involving composers using the software.

7.1 Methodology

Unlike many of the processes analysed in cognitive studies, musical composition is not a well-defined problem. In mathematics and cognitive science, a well-defined problem consists of a problem where a) the initial state is known, b) the means for the realisation of the task are known, c) the finite state is known. If a given problem does not satisfy all three conditions, it is considered as ill-defined. If we consider musical composition at large or ‘in the wild’, we can argue that none of these three conditions are satisfied: a) there is no common initial state to approaching a composition among composers, b) there are no common means to realise a composition and c) the finite state largely depends upon the composer's appreciation. Scaife and Rogers (1996) [67] argued that to understand the interplay between internal and external representations, empirical studies have to focus on the externality of graphical representations, as opposed to the observed or inferred internal representations. Distributed cognition provides a useful vocabulary to describe this interplay, by considering both the subject and the artifacts (e.g. representations) used throughout a given process. Nabavian (2009) [56] provides an account of applying distributed cognition to joint music composition. He distinguishes the system formed by collaborative musicians and technological artifacts from that of Hutchins system formed of two pilots and cockpit (1995b) [40]. He argues that an ill-defined system such as joint music composition is an *open system* (following Perry and Macredie [62]). Nabavian focuses his study on the processes themselves, rather than the outcome, for "the outcome of the previous session is not the creation of a physical product but the shaping of the musicians' cognition (i.e., changes that take place in their knowledge about the composition in the course of the session)."

In a similar manner with individual composition, we aim at understanding how the composer's cognition co-evolves with the successive representations, and the dynamics between them. Observing this interplay can not be measured in terms of outcome, but rather chronologically, by observing how the external representations evolve and inferring the internal representation of the composer. To be able to keep track of the external representations and support inferring about the cognitive processes, we propose two complementary methods. First, to use a camera to record the experiments in order to keep track of the interaction and transient information (i.e. verbal and gestural cues). Second, to keep a chronological record of the representation and a log of the interactions with the program.

The task given to the composers must facilitate the observation of these processes, we thus ask the composers to compose a short musical piece with our program. A brief description of the program is given at the beginning of the task, which does not cover the whole range of functions of the program. There are two reasons for not presenting all the functions to the composers. First, because there are too many functions to be remembered at once. Second, in order to encourage interactions between the composers and the observer, which would give cues about the composers' intentions.

7.2 Case study: MG2

This study reproduces a series of sketches that were drawn during an experiment with the Music Sketcher, to whom we shall refer using the initials MG2. The sketches are reproduced chronologically, in order to give a precise account of the evolution of the drawing. We identify in this study several processes supported by the graphical representation of the Music Sketcher.

This case is not representative of all processes, it rather shows the methodology used to collect data. Reproducing the full extent of a study is needed to understand how the processes unfold. We use this case as a reference to identify processes, and compare in further sections their occurrence in other studies.

The session occurred in the composer's office.

7.2.1 First part: presentation of the program and exploration

The composer took part to the formative evaluation of the program. He had used the previous version of the program and was familiar with its functions. In the first part of the study, the composer was introduced to the new features of the program. In this first part, learning the software doubles with exploration of possible musical outcomes. This can be seen in the screenshots 1 to 7. We reproduce the verbal communication to give an account of the context in which these drawing were produced.

0:01:30 "There is now a sound browser inside the software"

0:01:35 "Ok, so I can import a folder of sounds?"

0:01:40 "Yes"

0:01:55 "Very good. Thats a very good addition"

0:02:20 "From the browser, you can also drag a sound onto a stroke, or if you drop the sound directly onto the sketch, it imports the sound and create a flat stroke. Also, you can edit the stroke more easily now."

0:02:40 "Ok that's good. Because that was quite annoying before"

0:03:05 "There's a global zoom also, and I kept the local zoom which is a kind of discontinuous function"

0:03:30 "Ok, I see"

The composer tries these functions

0:04:40 "So, the next step would be to attach a modulation to these shapes, right? How do I

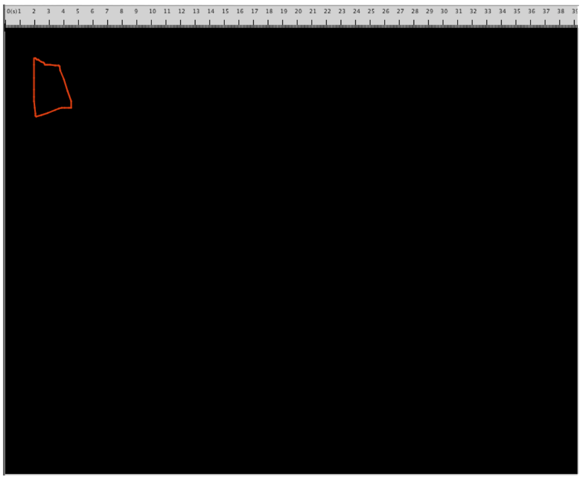

Figure 7.1: MG: Snapshot 1 - 0:02:00

apply that, is there an apply button?"

Figure 7.2: MG: Snapshot 2 - 0:04:00

0:05:19 "You can preview the sound by clicking this button or apply the modulation by saving the sound, here by clicking this button"

0:05:25 "Oh, yes, 'save as', of course"

The composer went on to save the sound and listen to the transformation. Interestingly, he wasn't interested in hearing a preview of the sound

0:06:12 "Ok. I like it. I remember that I had annoying requests, it had to do with copy and paste. So I can copy and paste? Can I change the scale of this"

0:07:00 "Yes, but it doesn't change the sound, unless you apply the effect again"

0:07:14 "Ok so now I have a micro version of my sound. (Listens). Ok, so I've scaled it but I was expecting the time resolution to change, but it's not. How can I change that?"

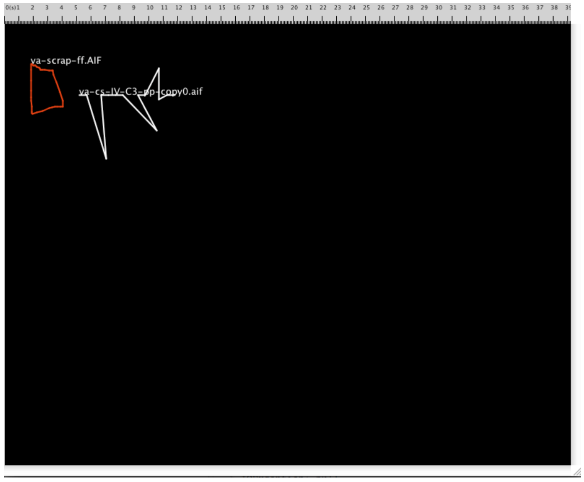

Figure 7.3: MG: Snapshot 3 - 0:06:00

0:07:50 “Well you cannot really do that. But you can reveal the length of the sound in the stroke, that would expand or shrink it.”

0:08:30 “I see. It seems much easier to use than the first time.”

The composer went on choosing another sound and drawing another stroke

Figure 7.4: MG: Snapshot 4 - 0:08:00

0:09:55 “So I can now start thinking broadly in composition terms, I can create a composition”

0:10:00 “Yes, please do. Oh, by the way, there’s a volume envelope in the inspector.

0:10:10 “Oh yes I’ve seen that, how does it work?”

0:10:20 “You can drag the points and the whole envelope applies to one stroke. It’s revealed on the stroke as you change the volume. The thickness of the stroke changes.”

0:10:40 “So what is the scale?”

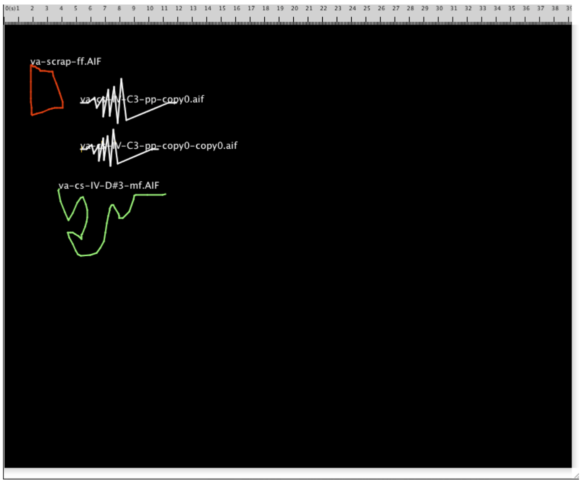

Figure 7.5: MG: Snapshot 5 - 0:10:00

0:10:50 “Well, it’d be 0, 1 and 2”

0:11:00 “Ok, I see”

After drawing several strokes, the composer erased most of them, keeping only two. He then listened to the sketch.

0:12:20 “So, the stroke itself here, does the volume automatically apply?”

0:12:25 “Yes”

0:12:35 “So I presume that the time scale is over the entire sound?”

0:12:40 “Yes”

0:12:45 “That’s very useful. Not as extreme as I would like, but that’s very good.”

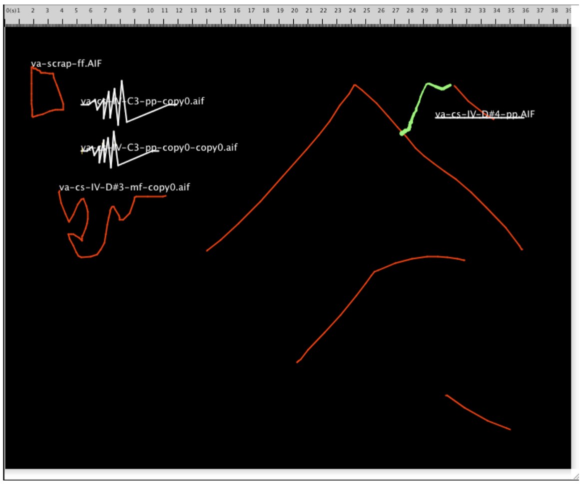

Figure 7.6: MG: Snapshot 6 - 0:12:00

0:13:39 “So if I don’t like this I can just undo”

0:13:45 “Yes, or you can just erase the stroke”

0:14:13 The composer went on applying an effect

0:15:10 “It’s really nice that when you delete a stroke it automatically select the next stroke available, it’s like it knows what I want to do next”

Figure 7.7: MG: Snapshot 7 - 0:14:00

0:16:19 “Did we talk about eradicating Max/MSP from the equation at all?”

0:16:30 “Yes, we did, but I couldn’t implement all the transformations in Java”

0:16:40 “Have you look at Ollie Bown’s Beads library for Java? It would allow you to do exactly what you want to do”

0:16:50 “Oh yes, you mentioned that last time, didn’t you? I have been too busy unfortunately but I’d definitely look at it”

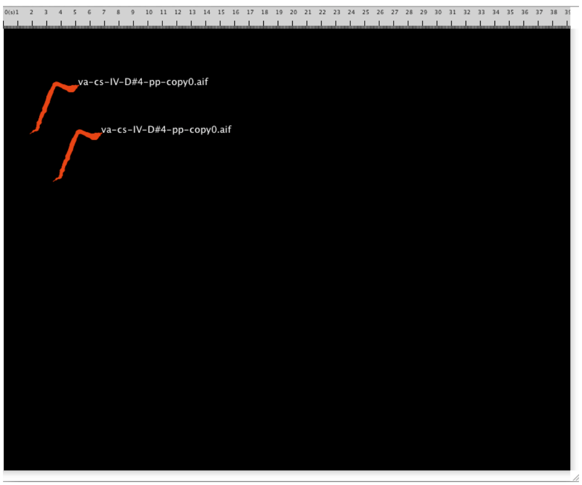

Figure 7.8: MG: Snapshot 8 - 0:16:00

0:17:00 “That’d be good, it does all the things you want to do, granular synthesis, time shift, etc.”

0:17:30 “Ok, what was I going to do.. Change the pitch of that.”

The composer works on the same stroke, with a sound of flute.

7.2.2 Second part: re-use of elements and accumulation

In this part, the attention of the composer is more focused on the sound results than on graphical explorations. Most strokes drawn in the first part were erased to keep only one, which was copied and pasted onto the screen (see figure7.9). Each stroke was then processed with a different sound transformation and subtle changes in the volume envelope were made (see figure 7.10). This stage was followed by further graphical exploration (see figure 7.11) and elimination (see figure 7.12). The composer wanted then to listen to the sounds and imported the next sound as a flat stroke (see figure 7.13). After a few modifications on the envelope, the stroke was copied and pasted four times, each time with a slight shift in its location in order to create a textured element (see figure 7.14). In the next stage, the composer moved the group closer to the group drawn earlier in order to assemble these two movements (figure 7.16). The following operation consisted of editing slightly one of the stroke of the second group, in order to apply an transformation to it (see figure 7.17 and 7.18).

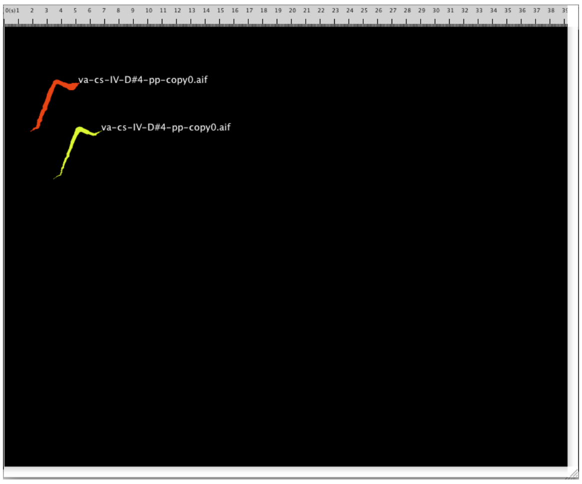

Figure 7.9: MG: Snapshot 9 - 0:18:00

0:20:57 “Oh that’s interesting. When I step back, it retrieves it. (inaudible)”

The composer tries effects on the strokes.

0:22:30 “So... I can change this. Let’s get rid of all this.” He erases the strokes

0:23:12 “That’s interesting. The stroke is very thick. Because there’s a lot of variation involved” The composer went on editing the points of a stroke and recorded a pitch transformation

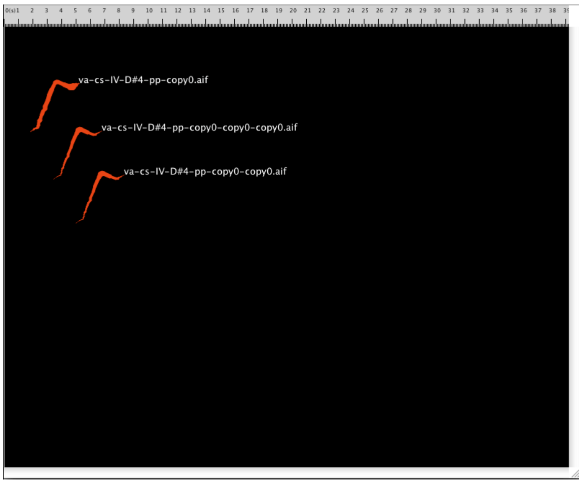

Figure 7.10: MG: Snapshot 10 - 0:20:00

without listening to the preview.

0:24:45 “Right, this stole my settings. When I came back to it, it didn’t apply the setting that was there. It’s a little thing” The composer wanted to get back to a process for which he had set parameters earlier, but he couldn’t find it in the inspector.

Figure 7.11: MG: Snapshot 12 - 0:24:00

0:25:42 The composer listens to the whole sketch after saving a new sound. “That’s more like what I wanted. Let’s try some more shapes. That’d look like a sound I like. As a composer I can hear things in my mind that I want to now add but I can’t draw those things, I don’t know if I can”

0:26:39 “You can try”

0:26:41 “Yes, I can... (inaudible). I need to have a look at your percussion section. ‘Super ball’, what’s that? (he listens to it). “That’s gorgeous, that’s a lovely sound. But that’s too much.

Figure 7.12: MG: Snapshot 13 - 0:26:00

I need something with... some little needle... maybe one of those..." He listened to a sustained sound of cymbals and chooses it. "All right, so I want to create a gesture" He went on to change the volume envelope of the sound and listens to the result. "That's more what I wanted" He tries pitch transformations. "All right, this is a nice element". However, he doesn't save the transformation and goes on using the filter effect. "I'd expect to find a... The filter's not what I would call (inaudible) but I guess it's fair enough. But also it means it's incredibly silent."

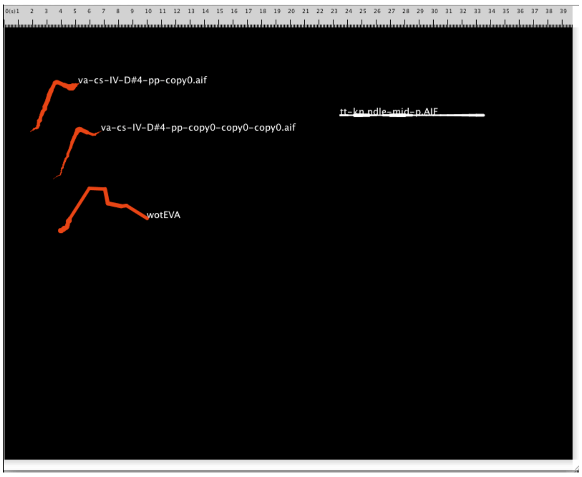

Figure 7.13: MG: Snapshot 14 - 0:30:00

0:31:07 The composer copy and paste a stroke several times.

0:31:17 "You can also create a group and copy and paste it"

0:31:20 "Create a group by selecting them all, right? So now I do what, press 'g'?"

0:31:34 "Hem no, you click on this 'group strokes' "

0:31:41 He listens to the result. "No, I want to ungroup now. Here we go." Here the composer wanted to adjust the location of the strokes in order to change the texture created by the accumulation.

0:31:50 “You can switch from one stroke to the next by pressing ‘Tab’ ”

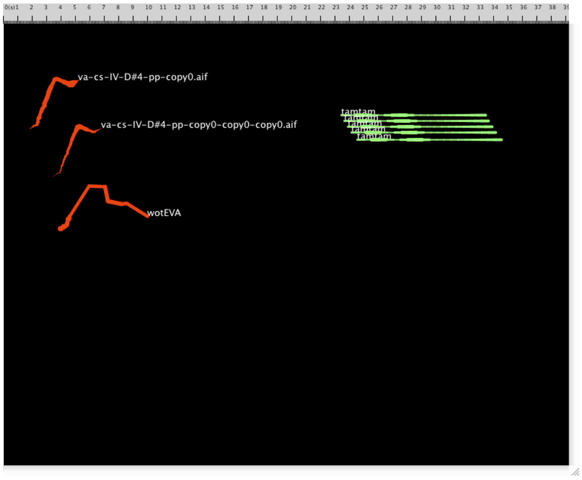

Figure 7.14: MG: Snapshot 15 - 0:32:00

0:32:01“Ok (trying it). That’s great. So if I... change that (he applies a transformation to one stroke in the group). Will it crash it?”

We then spent two minutes solving a problem that occurred when sounds were not renamed with an ‘.aif’ extension.

0:34:00 The composer listens to the group of strokes and moves them across the sketch to listen to the impact on the overall composition.

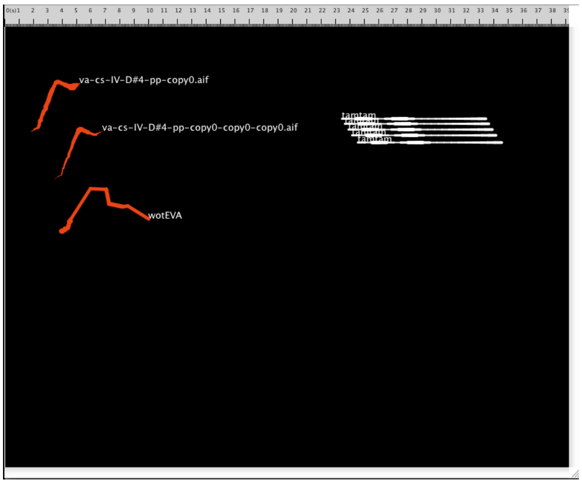

Figure 7.15: MG: Snapshot 16 - 0:34:00

0:36:00 “I hate concentrating on details like names when I’m thinking about sounds (referring to the bug that just happened).”

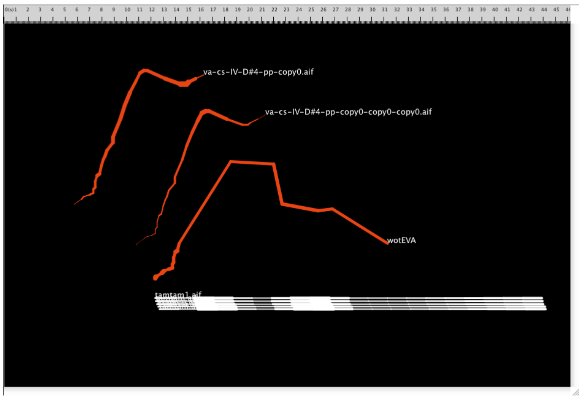

Figure 7.16: MG: Snapshot 17 - 0:36:00

The composer applied new transformations, sometimes without listening to the preview. The composer spent the next four minutes moving the strokes across the screen and edit the volume envelope of the sounds.

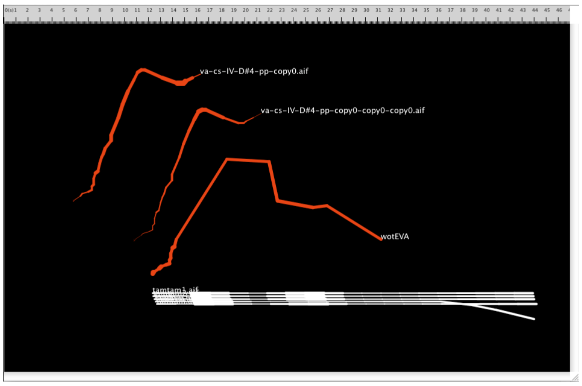

Figure 7.17: MG: Snapshot 18 - 0:38:00

0:40:00 “All right. That’s more like it”

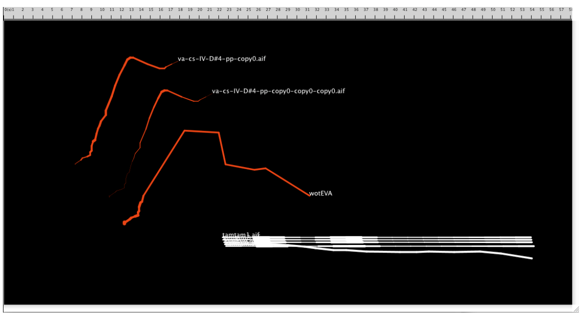

Figure 7.18: MG: Snapshot 19 - 0:40:00

0:40:30 I noticed that the composer wasn’t using the function of mixing a group into a new sound: “There’s something I might introduce you to. You have a function that plays a group once it is selected, or export it as a new sound”

0:40:55 “Just as that? So I’ve got a gesture. Can I group the strokes like this and then shift them all?”

0:41:10 “No you can’t”

0:41:15 “Ok so if I try exporting this... I can’t even spell it (typing the name of the new sound)”

7.2.3 Third part: group, mix and further graphical editing

This third and final part shows how grouping and mixing can suggest novel representations, and how the piece evolves not only from the intention of the composer but also with the support of the graphical representation.

After the last figure (7.18), the intention of the composer was to apply a transformation to the movement he created. To do so, he first copied and pasted the whole group (see figure 7.19) before being introduced to the ability to export the whole group as a mixed sound. The group was then mixed and re-imported into the sketch (see figure 7.20. The composer then erased the group and started to edit the stroke that contained the mix (see figure 7.22). The next intention of the composer was to balance this mix with percussive sounds. To do so, he first drew several short and thick strokes close to the stroke containing the mix (see figure 7.23). He then browsed the samples library to find percussive sounds. Different sounds were added separately to each stroke (see figure 7.24). The composer used the rotation tool to change the positions of each individual stroke and listened to different outcomes it produced (see figure 7.27). This suggested to the composer to try doing a reversal of the movement by copying and pasting the group and apply further rotation to it (see figure 7.28). To finish the movement, he re-imported the first movement and applied a transformation to it, again by using the rotation first (see figure 7.30). The role played by the program in the development of this process was that of suggesting developments in the composition. First, by reducing the representation of the whole group to a straight stroke, the composer faced an impoverished graphical representation of the composition, although the content of the piece was intact. When drawing the cluster of points, the composer had in mind adding ‘something percussive’. The first manifestation of this intention was to draw short strokes, which also balanced graphically the drawing. The composer used the representation to get started with the development of a vague intention. The vagueness of his intentions was reinforced by the fact that the sounds that were assigned to the strokes were not heard individually before being assigned to the strokes. The composer used the sounds of vibraphone and randomly assigned different pitches to individual strokes. The actions that followed were not directed toward changing the sounds assigned to the strokes, but mostly graphical. The rotation played two roles: first to reorganise the cluster over time, second to create a ramp in the flat stroke that was used to control a pitch transformation. The second group, although a copy of the first group, thus sounded differently.

0:42:17 "So I can now delete that (the group that was exported) and move this mix there"

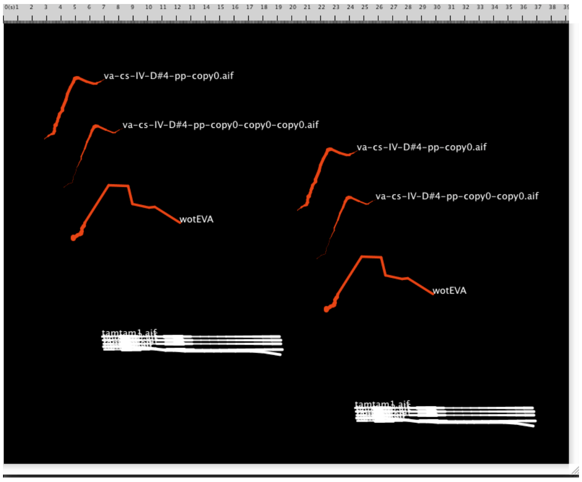

Figure 7.19: MG: Snapshot 20 - 0:42:00

The browser encountered a bug and importing the mix didn't work. We restarted the software with an identical setting.

0:43:10 "Here it is (the mix sound). So, in a way, it's better for me to get rid of all that (he deletes the strokes that he incorporated into the mix). I bring my sound here, the one I've created. (he listens to the result). It doesn't have all the sounds. It's ok. Oh I see, it's because it's not named aif"

0:44:03 "Yes, that's probably true"

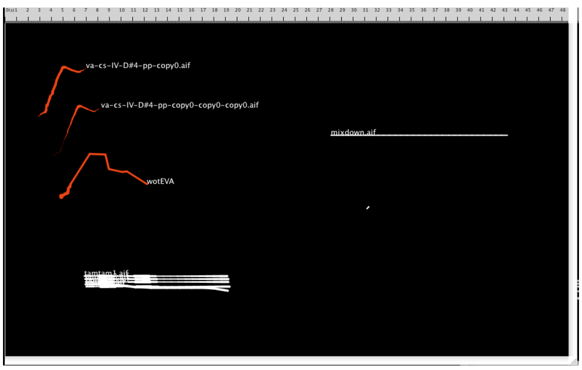

Figure 7.20: MG: Snapshot 21 - 0:44:00

0:44:15 “So we can do this (rename the sound), and that (re-import the new sound) can’t we?”

0:44:20 “Yes”

The composer played the sketch again and all the sounds were finally there

0:44:51 “Let’s try to mix this down. Like this. Ok”

The composer imports the mixed sound onto the screen and listens to it.

0:45:20 “Ok. That’s it. I’m going to try another gesture. The transformation would be... Let’s try it like this (he starts editing the stroke and then affects a sound to it).”

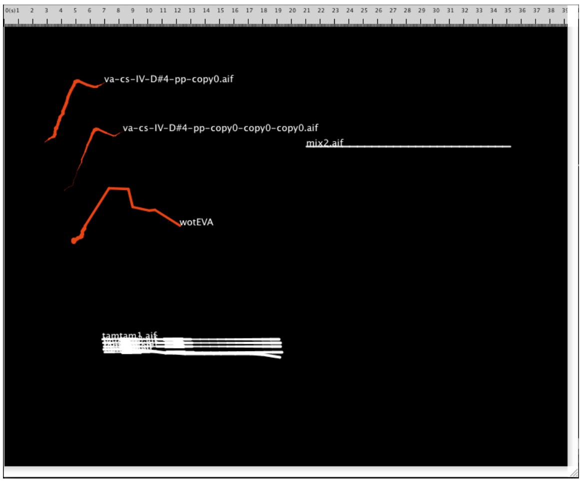

Figure 7.21: MG: Snapshot 22 - 0:46:00

0:47:22 “You know what would be nice. When you are trying to redraw a stroke, it’s annoying to have to reposition every segment. Is there an easy way? If you could just do this (he illustrates ‘this’ with a movement of the mouse on the stroke) and it would edit all of the points in the stroke?”

0:48:01 “I could have used Bezier curves but it’s much more complicated to calculate all the interpolated positions that are used to control the sound transformations”

0:48:20 “Yes, sure.” The composer then listened to a pitch transformation of the whole mix. “That’s more what I wanted”. He then record the sound. “That’s fine. Then.. I want to add something percussive.”

0:50:50 “I’m just thinking, I know this is silly but I’m wondering about the level of graphical representation. I’ve got loads of elements there (graphical elements), so if I import something which... is like that... from the percussion section... I can just do this... (he imports different sounds to the different short strokes drawn on the sketch)”

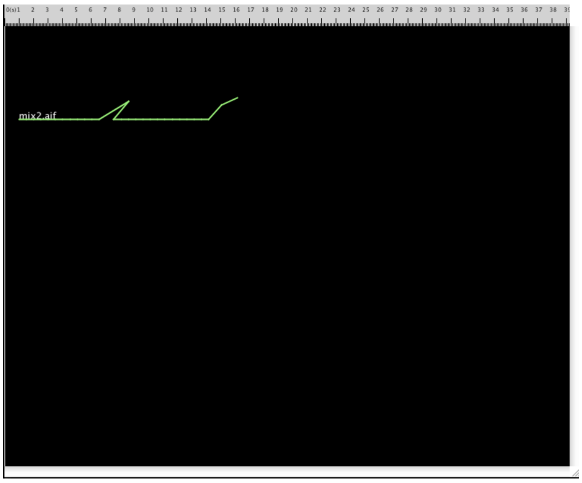

Figure 7.22: MG: Snapshot 23 - 0:48:00

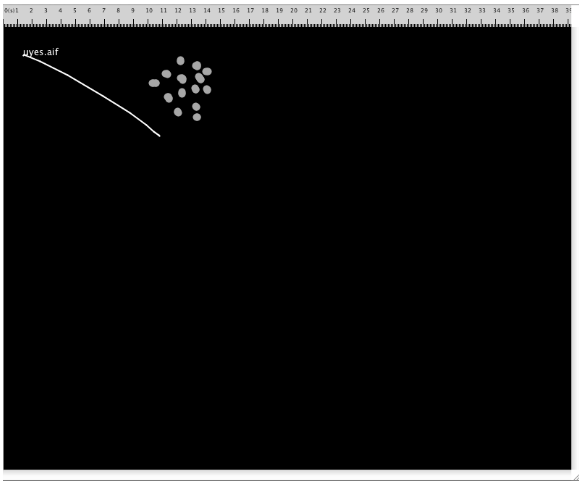

Figure 7.23: MG: Snapshot 24 - 0:50:00

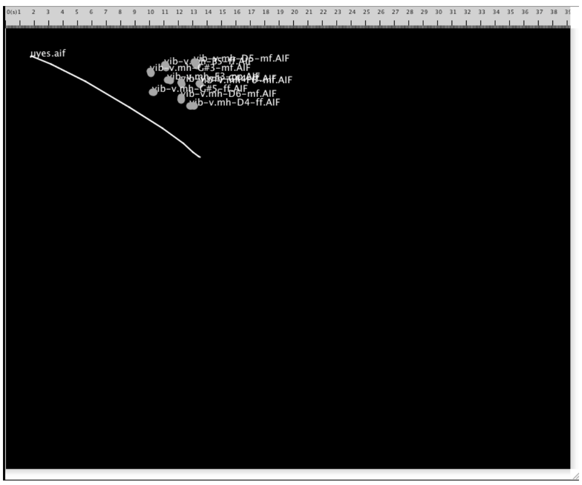

Figure 7.24: MG: Snapshot 25 - 0:52:00

0:54:34 “That’s a nice little cluster.”

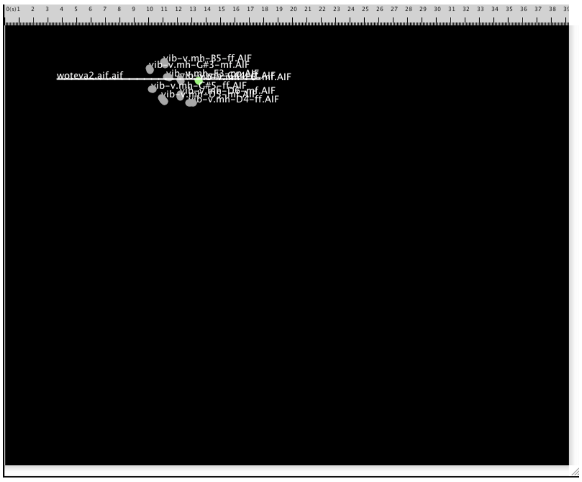

Figure 7.25: MG: Snapshot 26 - 0:54:00

After playing this first sketch, the composer spent some time adjusting the position of the strokes. In order to see the elements more clearly, he exported the small elements as a mix, but the mix was saturated so he returned to the previous representation.

Figure 7.26: MG: Snapshot 27 - 0:56:00

0:57:02 “Can I edit the volume of the whole group?”

0:57:10 “No, I was about to develop that but I ran out of time”

0:57:20 “Ok (laugh). That’s all right, it’s one of those things that, you know, I’m thinking of the sounds, I’m not thinking about the shape. The shape... I’m trying to push the edges of what this is, yes. What it does, it does really well but in terms of, as a compositional tool, going beyond the sketch is kind of needed”

0:57:55 “Yes, I but I wonder where should this stop? Should there be boundary to what it does?"

0:58:10 "Well, in a way, you don't want it, do you? If you start working with something, you don't want to have to then think about it in a different way too early. You want to get lost in the... process. Without having to transfer your representation from one software to another. In an ideal situation anyway."

Figure 7.27: MG: Snapshot 28 - 0:58:00

0:59:10 "Ok. I'm quite interested into... Oh that's really nicely done!" The composer applied the rotation to the cluster of strokes and observed: "So now I can have my sequence in retrograde".

1:00:17 "Ok, that's the first cluster and then Im guessing that what I can do is to take the whole thing, copy and paste it and then rotate it to a 180 degrees would that be interpreted as a pitch change? Yes, that's excellent. Really really cool. I wonder... So I now have a compositional structure. Let's try... (he applies a pitch shift to the long stroke below the group and save it as a new sound). I really like the idea that you can take large sections and just transpose them, transform them as large sections . And I try to using this as a kind of symbolic notation. " He then listened to the whole sketch

1:02:28 "Ok, and then I would do this (copy and paste the long stroke below the second cluster)". He recorded a pitch change without listening to a preview of the transformation. He then listened to the whole sketch.

1:03:54 "Great. I think that this notion of being able to totally reverse everything and then create transformations in very simple way by rotation is really strong. That's a very good compositional tool. Because it kind of allows you to transform sounds in a very intuitive way. Does

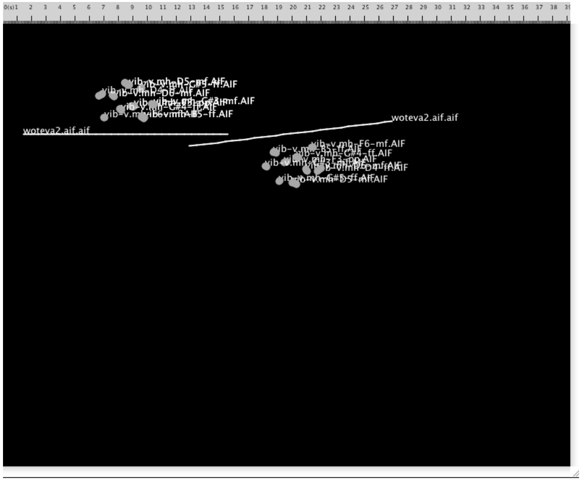

Figure 7.28: MG: Snapshot 29 - 01:00:00

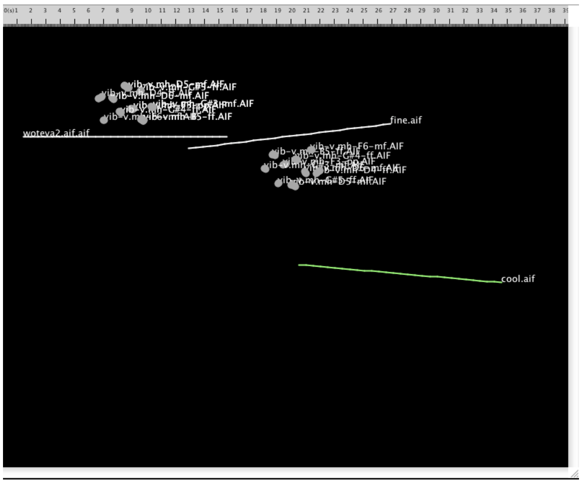

Figure 7.29: MG: Snapshot 30 - 01:02:00

it always rotate from a central point?"

1:04:35 "yes, it rotates around the centre of the stroke or the group of stroke"

1:05:18 "The zoom function is not that flexible. It's still good though. I'm just thinking visually... (inaudible)"

1:06:06 "Ok, let's have the whole piece. (he presses play)"

He then save a different transformation and listen to the sketch again.

1:09:10 "Ok, that's it, that's my piece. It's called... *Liquid prison entry*. It's really nice, exactly what I wanted. You could spend a few hours working in this environment and do something more complete"

1:11:41 "So, are you satisfied with this composition?"

1:11:50 "Yes, I'm happy enough. To be honest I'd like to be able to control the sound a bit

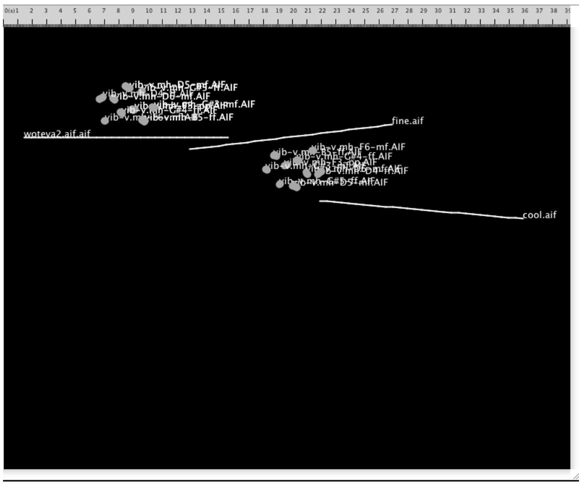

Figure 7.30: MG: Snapshot 31 - 01:09:00

more. When you do a pitch shift, because of the nature of the processing, you introduce a bit of noise, and that's always a compositional issue. I quite like pitch shift, but I think some people would find it difficult to work with. I really think it's a great idea for a tool. It's much better than it used to be. It's easy, it's fun to use. I like it. I really like the rotation and I feel like you should do all the processing in Java"

1:13:15 "Yes, I agree, relying on Max for the sound transformations is a bit of a waste of time. Do you think that importing sounds as flat strokes is a good thing? Especially when you mixed down a group with original strokes and then import back the sound as a flat stroke, do you think that having kept the original representation would have make a difference?"

1:14:20 "Yes I think it would be nice to be able to see my original gesture. It would act as that sort of metaphor for it. Having said that, it's not that much of a barrier for me cos I'm used to this kind of representation, I'm used to not looking at all after a while. So I can imagine that this have that stuff in it. But if I get back to it after a few days I think I would have forgot that. I guess it would be very difficult for you to make a visual representation of the shape that you could save alongside your file, so when you drag it in, if it had a shape you can just see that it was the shape that produced that sound. Even if it is a bitmap. Something like that might be useful, in terms of the relationship between how the composer is cognitively aware of the effect the shapes have and the sound output.

1:15:15 "Yes, it's something I haven't realise before, cos the export function was not there before. In fact, you were self conscious that well, it's too bad, the shape is not there anymore when you imported the mix back, that the original intention was lost. It makes sense to keep track of the representations you draw for yourself, because if you import too much of those, you would end up manipulating straight lines, which is not very different from audio workstations"

1:16:09 "I think that's it. And you end up doing very coarse manipulation. I think it's fine where you are at the moment. But if you don't work over it and come back after a week, you'd be like 'huh?' You want to save that element of the program, if you can, cos it's kind of at the core of it. You want to have a kind of score and a mark that says 'this was the shape that produced that sound' . And if that was recursive, you could separate the transformations from the process."

1:18:10 "It's come off a long way, and I can really see how it addresses your initial questions. It is fun to use. There's one element which I think would be good, the kind of gestures I like to make, I'm not sure whether this makes these gestures really simple. That kind of frenetic, overloaded, slightly mentally-ill kind of approaches that I like to take, you know everything is kind of moving a lot. I'm pretty sure that it's very hard to do that kind of work in this. I don't think it's an issue that you need to address, you don't need to address my aesthetic"

1:19:15 "There might be some common ground in the practices of composers, if not the aesthetics."

1:19:38 "I think what you've done, aiming at considering certain approach to composition, you've hit the target, in some ways. If I'm thinking that way, composing that way, it works very well."

1:19:52 " 'You have to think that way', that's probably the problem yet to solve"

1:20:01 "Like you say, you want to aim at helping those people who'd you think... You got users , you want to give them a usable tool, and I think you are doing it. That's my view. What I'd like to be able to do is to expand or compress ideas. I'd like to have, generally speaking, so for example I've written pieces in music that are 45 minutes or an hour in length and then I would just shrink all that material down to a few frames and then play back, time compressing, play it back a few seconds and pick up frames from that and use that to make a piece. So I tend to do things at that level of intensity. It's that 'fierceness' that I think I would struggle to achieve. But again that's not necessarily a problem cos I can't think of any composer who works that way, so that wouldn't be a barrier in most cases"

7.2.4 Discussion

In this case study, we have distinguished several processes that highlight the role of representation with the Music Sketcher. During the learning phase, the strokes were drawn with very different aspects, in order to understand how the system would render those differences. The graphical exploration supports learning the program more than the task of composing. After the learning phase (from 0:18:00 to 0:41:15), the sketch developed in a process that intertwined graphical exploration and sound-driven validations or invalidations: the composer edited or added new strokes, and then kept only those that match its intentions. The graphical exploration is characterised by the re-use of graphical elements (see figures 7.10, 7.14). In the final part of the study, the representation played a different role, that of suggesting new developments in the composition. This occurred after the composer exported a mix of what he had already composed and faced a new situation, that of having an empty sketch to the exception of the flat stroke representing the mix (see figure 7.22). The composition process was then characterised by three graphical operations: grouping, copy and paste and rotation. A group of short strokes was drawn by the representation of the mix with no specific idea about the sounds that they would contain (00:48:20 "I want to add something percussive", see figure 7.23). After the sounds were found and affected to the stroke, the composer copied and pasted the whole group in order to proceed to a pitch transformation (1:00:17, see figure 7.28). The rotation was used to control the pitch transformation of the flat stroke and to reverse the occurrence of the percussive sounds (1:03:54: "Great. I think that this notion of being able to totally reverse everything and then create transformations in very simple way by rotation is really strong. That's a very good compositional tool. Because it kind of allows you to transform sounds in a very intuitive way.").

The processes observed in this case study allows formulating two hypotheses about the role played by the Music Sketcher in support of music composition:

- Vagueness: drawing arbitrary shapes supports refining vague ideas. In the process, we observe an interplay between the evolution of the representation and the inferred intention of the composer until a movement is considered terminated.
- Re-representation and re-interpretation: editing functions of copy, cut and paste facilitates exploring possible outcomes and suggests novel developments by means of re-interpreting existing shapes

We discuss these hypotheses in the next two sections by comparing MG2's cases with the other case studies.

7.3 Supporting vagueness

We have observed that vagueness plays an integral role in the design of musical sketches when these are drawn on paper. The sketches drawn with the Music Sketcher allowed observing contrasted results with regards to vagueness. We examine in this section how vagueness is sometimes observed in the process of expressing musical ideas and in contrast, how the vagueness of representation sometimes seems to inhibit the expression of musical ideas.

In KN's study (see full transcript in B.1), the vague drawings were drawn in support of vague intentions. During the exploration of the functions of the program, vague drawing occurred first as a way of understanding how the program works (see figure B.1). In this group of strokes, little evidence is given to when a sound starts and finishes: grouping them together served the purpose of creating sound textures by an accumulation of sounds. But rather than organizing these strokes in a determined order, the composer moved and accumulated those randomly and was looking for unexpected results. Although this appeared to be a way of understanding the mechanisms of the program, this process of drawing without having a clear idea of a musical outcome recurred throughout the study. The next group of strokes reproduced in figure B.2 was drawn after the composer reported that she was tempted to 'draw flowers and things', which seems to be consistent with the dialectic of 'seeing-as' and 'seeing-that' described by Goldschmidt (1991) [29] in architecture sketches. The composer draws the strokes to represent an intention (the representation is *seen as*) but the representation becomes in turn *propositional* (see Takano (1989) [78]) when the composer builds on the representation to advance in the process of expressing the intention (the representation allows *seeing that*). A similar process can be observed in the drawings of MG2 (see the previous section and figure 7.31): the musical *intention* is represented first and further refined and tested with different sounds.

This dialectic of 'seeing-as' and 'seeing-that' can be observed in the successive sketches drawn by MG2 in the third part of the study (see the development of the sketches in figures 7.23 to 7.30). The cluster of strokes drawn in figure 7.23 follows the vague intention to "add something percussive (0:48:20)" (the *seeing-as* phase). Assigning sounds to the strokes enabled *seeing-that* (0:54:34: "That's a nice little cluster"). The composer then acted upon the representation.

Representing an intention in these cases does not correspond to a pre-determined musical fact, but rather consists of a first step towards defining it. MG1 (in the formative evaluation, see transcript in section B.3) gave a detailed account for this, referring to the program as facilitating

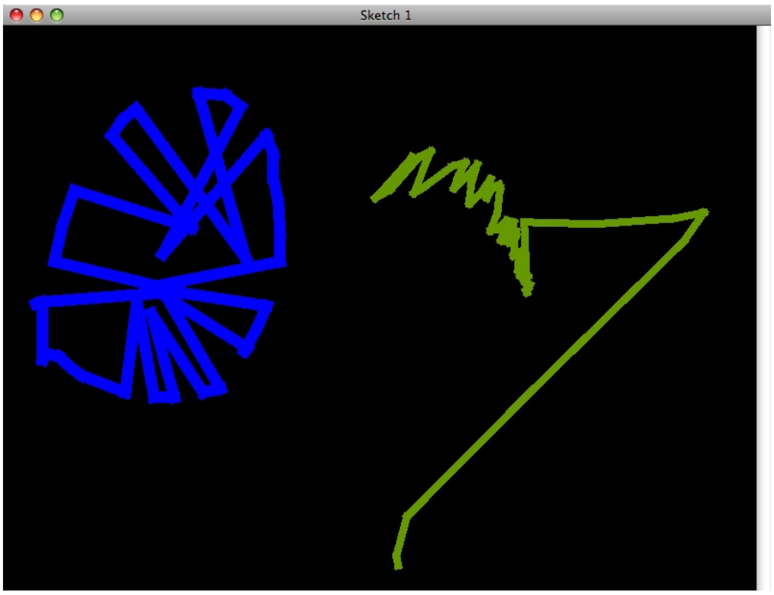

Figure 7.31: Exploratory sketch 1

an "open-ended creative approach" (0:48:00) in which the drawing act as "some sort of a refined marker for the process I'm engaging with". KN also gave an account of how vague intentions are part of her approach when composing: "What I like about this immediately is that I can copy and paste it (the stroke) because it makes me think immediately in terms of textures. Oh, I realise that I now need to allocate sounds to them." (0:02:30). In this case, *thinking in terms of textures* reveals that the representation supports the process of creating these textures which are not yet defined *in the head*. This is particularly striking as the composer had not yet assigned sounds to these strokes, but already engaged in the process of designing an intermediate representation for the idea she had in mind.

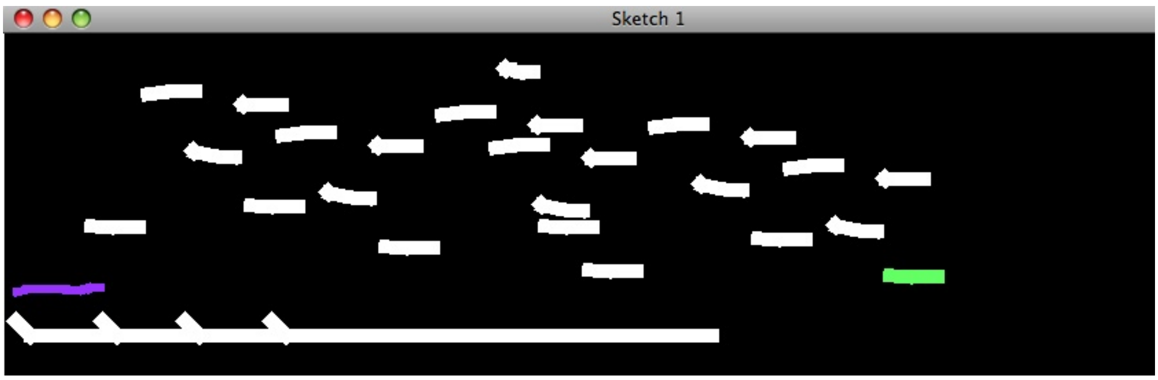

Figure 7.32: RH, Final sketch

In contrast, two other case studies tend to show that representing an intention first – as opposed to acting upon the representation of sound samples – is not always desirable. RH reported that the lack of cues of time was problematic (1:42:50), that it felt 'random'. The composer reported that getting started with a composition using the Music Sketcher would take longer than using the environment he was used to compose with. The reason for this is that the representation of sound events does not facilitate a precise 'fine tuning' of the sounds as desired by the composer (see RH transcript B.4 0:16:34, 0:31:09). The drawings of the composers (see figure 7.32) also reflect that a precise representation of time is sometimes needed to be able to develop the composition. The continuing line at the bottom at the drawing consists of six identical sounds that the composer attempted to organise in synchronicity with the rest of the sketch. Performing this task took considerable time (from 1:05:45 to 1:13:27) in comparison to what it would have taken using a standard DAW. In a similar manner, the composer DM reported that the vagueness of the representation did not facilitate his composition processes. The composer also reported that the representation felt too random (see the transcript B.2, 1:28:45). The final sketch (figure B.13) present similarities with that of RH's final sketch: most strokes are flat, and are drawn in order to clearly identify the time at which the event start. In these two approaches, the dialectic of *seeing as* and *seeing that* is underused. Most often, the composers were deceived rather than inspired by the way their drawing was interpreted. In both cases, what is 'in the head' of the composers does not need to be vaguely interpreted to be further refined. It rather appears that a precise representation is needed for the development of their composition.

Vagueness thus appears as satisfying certain approaches, and as a discrepancy in other approaches. The reasons for this are consistent with our findings in paper sketches. Vague representations participate to the elaboration of processes where the end result is unclear, whereas a similar degree of vagueness is not desirable to achieve intentions that are well formed in the head of the composers. To the difference of paper sketches however, the Music Sketches does not offer the same flexibility in accommodating both vagueness and precision. Whereas paper sketches are sometimes drawn on millimetre paper to facilitate certain mappings or representation of precise information (see e.g. Freeman and Austin), the Music Sketcher does not ease switching between precise and vague representations. The formative evaluation led to improvement in the representation of time (with the time ruler and the ability to reveal the length of the events), but it appears that offering a dual view of the initial drawing and a representation of sounds in the form of a sequencer would be beneficial to accommodate both approaches.

7.4 Re-representation and re-interpretation

We have observed that paper sketches of composition are characterised by successive iterations that re-use parts of previous sketches or present evidence of revision and edition. Following Zhang and Norman (1994) [92], successive representations allow to *anchor and structure cognitive behaviour* and also *change the nature of a task*. We question in this section whether this is also characteristic of the music sketches drawn with the Music Sketcher. Looking at the evolution of the sketches, their editions or revisions, we observe their role at anchoring and structuring the compositional process, and their influence on the task itself.

To draw an analogy between paper sketches and the sketches drawn with the Music Sketcher, we must acknowledge the constraints of each system, for they play a role in the evolution of the drawings. We observed that the function of erasing in the program facilitates using the same space to develop the composition, whereas the development of a composition on paper sketches most often uses successive sketches. Following Zhang and Norman, these successive representations act as anchors to the cognitive process. In contrast to paper sketches, drawing and erasing plays a role in understanding the functions of the program rather than solely anchoring cognitively the state of the composition. In the case study of MG, the first fifteen minutes were spent drawing strokes that were further reduced until one remained. It is clear that early representations with the Music Sketcher play a role in understanding the functions of the program, which has little to do with the processes we aim at observing. However, a graphical form emerged and persisted from this exploration of the functions, which plays a role in anchoring the cognitive process. This is further characterised in the case study reproduced above when the composer reported that the shapes of the strokes helped in remembering the sound associated to them (MG, 1:14:20). A similar process of elimination was observed with RH (see B.4). The emergence of graphical forms and their role at anchoring the cognitive process can also be observed in the sketches drawn by KN (see B.1). The composer reported thinking of group of strokes as 'textures' (0:02:30), which further supported structuring the process (0:35:20 "Oh this is really nice, because I can build up a texture very quickly that's got lot of iterations of something by just playing around.").

Re-representation took several forms. In the case of KN, RH, MG1, copy and paste was used extensively to build aggregate of strokes (see e.g. figures B.5, B.22 and B.18). These aggregates sometime turned into an identified new sound. The frequency of observation of this was reduced after the formative evaluation, when we implemented the ability to export the sound from a group of strokes into a new sound. This function allowed composer to re-use the sound outcome of an aggregate by importing it back to the sketch. Figures 7.33 and 7.34 illustrate how this occurred with the composer RH in the experiment.

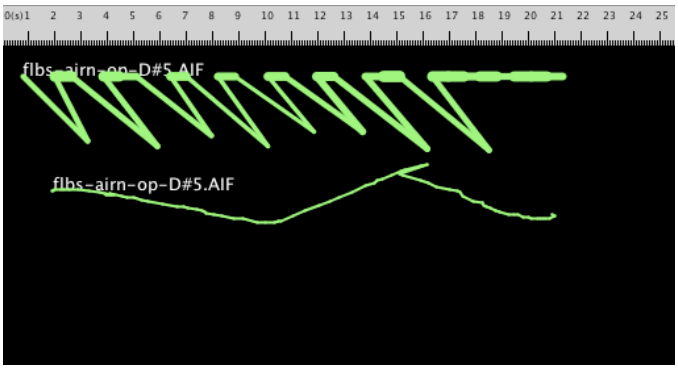

Figure 7.33: RH, material for the first group

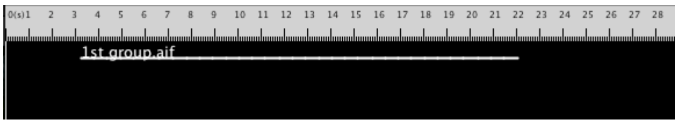

Figure 7.34: RH, first group

Re-interpretation was also observed in MG2's case study. In this case, importing the mix back into a clear sketch suggested entirely new developments (see figure 7.23). These new developments built again on re-representation when the composer copied and pasted the first aggregate and rotated the copied aggregate (see figures 7.23 to 7.28). The re-representation was followed by a re-interpretation of the sketch.

We highlighted a divergence between the role of paper sketches that act as a representation for the self as opposed to representations within a program that sometimes double as a way of understanding its functionalities. Representation with the Music Sketcher also serves the purpose of expressing vague ideas, refine them and suggests novel developments in the composition. Of particular importance, the ability to erase, copy and paste plays a role in developing local aspects (e.g. aggregates or textures), whereas rotation and importing back mixed sounds suggest new functions for the drawing (e.g. reversal).

7.5 Categorisation of digital sketch properties

Observing the final sketches developed during the formative evaluation (see figure 7.35) allows to notice that each of them developed a unique semantics. The composers have made different choices to represent the sonic events. The final sketch a), for example shows a variety of undulating lines that are often grouped. Here, it is rather the grouping that represent a sonic event rather than a single line. The composer reported thinking of these groups as *textures*. Some of the groups contain the same lines, rotated and accumulated in different manner. They also have been associated different sounds, and the composer was able to memorise easily the content of each group. The final sketch b) is formed of three groups and two long, complex strokes. Although the strokes contained in the groups have been reduced, the single strokes are very large and easily identifiable one to another. The complex forms of the strokes illustrates the motivation of the composer to create complex transformations, each of the five different strokes used to generate the whole sketch having a very different aspect.

The final sketch c) is much more minimalist, and this is the only sketch where no stroke has been copied and pasted, even though some of the strokes would be assigned the same sound sample. The dissociation of the strokes was made using different colours as well as the lay out, the vertical distribution doubling with the horizontal axis to emphasise the time location.

The final sketch d) contains almost identical strokes in two groups. The strokes are not undulating nor are dissociated with colours. In this sketch as in sketch a) the strokes have been assembled so as to create an evolving texture over time rather than a succession of individual movements.

One of the properties of the sketches built with the Music Sketcher is the tendency to illustrate aspects of the sounds. This happens either by grouping (e.g. a), b) and d)), by the use of colours (e.g. a), b) and c)) or by a dissociation of the drawing itself, sometimes in an illustrating manner (e.g. a) and b)). The sketches a) and b) combine the three approaches, whereas c) and d) use only one each. However, the sketches c) and d) make use of the space in a more precise manner, almost like attempting to recreate the context of a traditional composition software.

The representation of time for each stroke occurs on the horizontal axis for the sketches c) and d), whereas the strokes drawn in the sketches a) and b) are not attempting to represent time. The Music Sketcher interprets time on the horizontal axis, thus making any inner representation of time redundant.

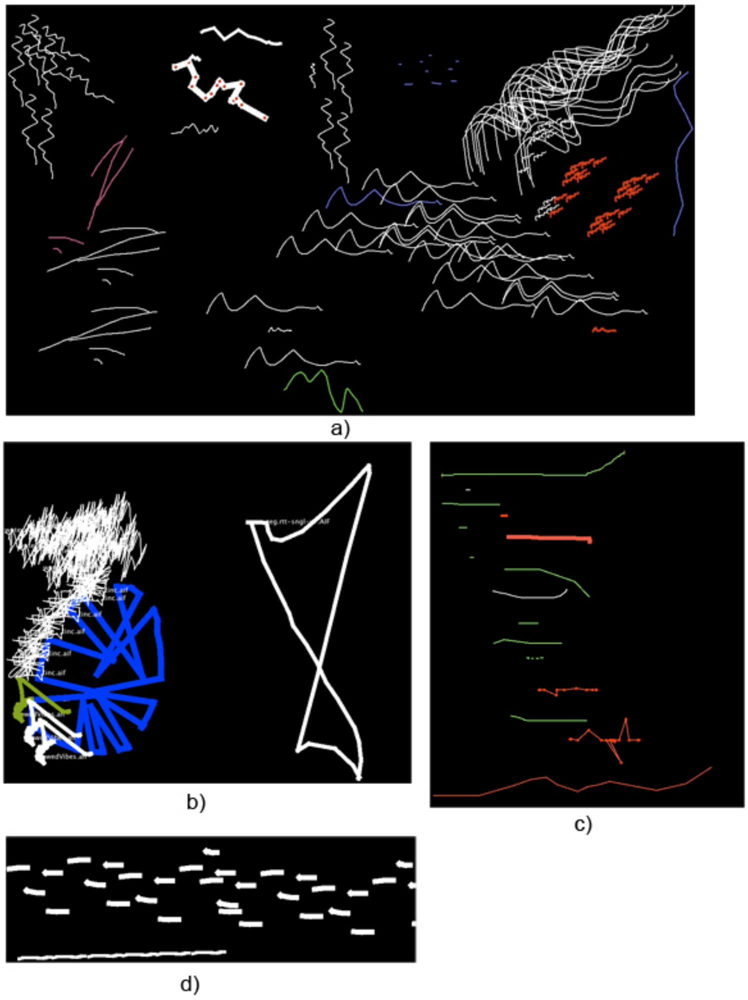

Figure 7.35: Final sketches of study 1 (a), 2 (c), 3 (d) and 4 (b)

7.5.1 Supporting exploratory tasks

Sketching on paper is often observed in support of exploratory tasks. The reason for this, as observed by Suwa and Tversky [77] in their study of architecture sketches, is that sketching facilitates the development of *unanticipated relations and features that suggest ways to refine and revise ideas*. The cognitive process involved is comparable to the process observed by Kirsch and Maglio [43] in their study of the tetris game: the action of rotating the pieces serves the purpose of seeing the world differently rather than directed to a direct solving of the problem. In the case of music sketches, creating a representation of the world arguably serves the purpose of nurturing a reflexive process to develop and refine ideas. The representation of the world drawn on paper – an ephemeral medium – enables exploring musical possibilities , and is part of the wider creative process of music composition. The sketches drawn with the Music Sketcher are no exception to this, as we shall see in this section.

In the first stages of all experiments, the composers have gone through an exploratory phase. Although we argue that exploration is mainly supported by the ability to sketch, it must not be ignored that the composers were also novices in the use of the tool. Thus, their exploration in the first stages can be the result of an exploration of the software, as much as an exploration of their own drawings in the reflexive manner observed in paper sketches. To distinguish these kinds of explorations, we consider the drawings that were produced in the later stages of the studies.

Graphical exploration is illustrated by the series of sketches reproduced in figures 7.31, B.14, B.15, B.16, B.17. The composer (MG1) was self-conscious about his exploratory activity and reported: "What is really interesting with this is that I can mess about and make a sound. You can just think irrationally and get the results that you like, which is something that you really want to do when you're composing." (0:48:00)

Overall, MG's case suggests that the goal of drawing is – at first – rather vague. However, it is the action of drawing that provides ways of seeing the world in a manner that facilitates further development in the piece, and ultimately its emergence. A similar graphical exploration can be noticed in the cases of KN and RH (see figures B.3, B.7, B.8 and B.9 for KN and 7.32 for RH).

In contrast, graphical exploration did not occur in the cases of DM (see figure B.13) and PS (see figure B.24). DM explained that in order to facilitate his process of exploration, he expects from a software to offer some 'pulse-based' functions (DM, 1:47:15). Rhythm being an important aspect of his work, he spent most of the time of the study trying to overcome the lack of precision in the representation of time. The representation reflects this: most strokes are drawn as flat lines and are spatially distinct, which facilitate seeing where the sounds would start and end. In the case of PS, the reason for little graphical exploration is different. PS reported that he usually tried not to look at the representation of sounds, that he finds misleading (PS, 1:17:25 "I think it compromises my hearing"). The final state of the representation is almost identical to what the composer had drawn in the first five minutes of the study. Throughout the study, the composer assigned various sounds to the strokes and operated transformations but made very little changes to the representation itself. The composer reported that the Music Sketcher provided 'a much more comfortable way to work than Logic' (PS, 1:07:50), as he considers that the representation of sounds interfere with the way he thinks of them. The representation with the Music Sketcher, in contrast, remains more vague, which allowed him to progress in the composition without modifying the initial representation.

Overall, it appears that exploration is consistent in the initial stages of composition. The contrasting approaches taken by the composers highlight a challenge in accommodating them within a single representational paradigm. Graphical manipulation in support of exploration was observed in a majority of cases, but a more precise representation of time appears desirable in support of rhythmical exploration. This suggests that switching between different representational paradigms would facilitate exploration in the first stages of music composition.

7.5.2 Matching of digital sketches and paper sketches

The matching with the functions of pen and paper is explicitly articulated in this account of the composer MG (0:48:00): "I like the fact that I can take sections I developed in this preliminary area and put them together in different ways and reorder them. I'm thinking of these strokes in term of transformations as opposed to in terms of representation of the sound. I did something and I remember doing that. It works as markers for the things I did. It feels quite intuitive in terms of elements. It's like a kind of record of your practice in composition. You make your own representation of the sounds. "

The sketches drawn with the Music Sketcher are similar in many aspects to the sketches drawn on paper. Some dissimilarities have been observed too, and it is disputable whether these occur because of the difference of medium (pen and paper as opposed to a computer) or because of the ability of the Music Sketcher to render a sound output.

The most striking similarity between these sketches is the development of an idiosyncratic graphical semantic. It has been observed in the paper sketches that this graphical semantic served the purpose of identifying the sonic events. It is for the same purpose that the composers used colors or specific shapes with the Music Sketcher. Another similar aspect is the distinction of small sections. With the Music Sketcher, this takes the form of small groups distinct from the composition that are built to create specific textures. In paper sketches, the distinction of small parts consists more of parts of the structure that are isolated to be further refined or developed. The outcome of these processes are different, but the processes are noticeably similar. Another common aspect is the re-use and reinterpretation of the sketches, or part of them. With pen and paper, this often takes the form of a refinement of a rough structure or part of the structure. With the Music Sketcher, the process is facilitated with the copy and paste function. As it can be seen in the sketches a), b) and d), numerous strokes were copied and pasted, some of them (sketch a) being rotated or altered. In the study that led to the design of the sketch a), the composer did use side sketches to create small groups that she would later import into the main sketch. This matches a process observed on several paper sketches. Revision and edition also occurred in all digital sketches, which was also observed in paper sketches. Revision and edition with the Music Sketcher are facilitated with the instant feedback generated, but also by the ability to remove a stroke and the function of copy and paste.

The properties of paper sketches that do not recur in the digital sketches analysed are: the representation of musical dimensions, the multiplicity of sketches, the integration of original constraints (such as indications that a given axis would determine e.g. a timbre space), and textual annotations. The representation of musical dimensions is not facilitated by the Music Sketcher in the sense that every stroke can have its own mapping. Also, the instant sound feedback favours an immediate commitment to the piece, which does not encourage the composers to build abstract structures to represent the piece, as it has been observed in paper sketches. The multiplicity of sketches also do not recur. The composer of the first case study did use side sketches to create short movements, but the main sketch was not refined in a different sketch. Rather, editions were made in the main sketch. It is likely that the possibility of erasing strokes allowed to achieve similar tasks without having to draw new sketches. This is facilitated in a software as opposed to paper. The integration of original constraints was not observed in the digital sketches. This occurred in paper sketches with Ligeti's *Volumina* where the vertical axis was set for the pitch and textures would indicate different play modes. It was also observed in Austin's *Involuntary Memory* where the segments of the main drawing would correspond to specific timbres. Such conceptual manipulations were not observed in the digital sketch, because the Music Sketcher gives an importance to the strokes themselves rather than to their spatial layout. Finally, textual annotations are not facilitated in the Music Sketcher, which has been reported as a disadvantage in the case studies. The textual annotations observed in the paper sketches concerned mainly indications for the instrumentation, local problem solving or reminders.

Chapter 8

Conclusions and Future Works

By taking a technological stance on observing composition practices, we 1) show that the use of pen and paper can play a key role in the development and refinement of musical *ideas*[1], 2) show that existing technology do not support similar functions to those found in (1), but rather encourage a premature commitment to the realisation of a piece, 3) establish a theoretical framework for the analysis of music sketches drawing on musicology, situated cognition and distributed cognition, 4) design and refine, using a formative evaluation, a software that provide similar functions to that of pen and paper in the context of composition.

The four intended audiences for this thesis are the human computer interaction (HCI) research and practitioner community, the cognitive science community, the computer music community and the musicology community. To our knowledge, this is the first technological study of composition used to inform the design of a computer program. Chapters 2 examines the evolution of music notation in history and questions the role traditionally given to music representations in musicology. Chapter 3 discusses a theoretical framework for the study of intermediate representations of music, which provides insights to HCI designers and computer music researchers for the study of *open systems*. Chapter 4 presents four case studies and discusses the characteristics of music sketches from a cognitive science perspective. Chapter 5 informs the design of a program based on the previous observations and provides insights to the community of designers for bridging the gap between analytical findings and the development of a program to address those findings. Chapter 6 presents a formative evaluation of the program. We highlight the challenge

[1]We understand *idea* in the Deleuzian sense, see chapter 3, section 3.2.1)

posed by the evaluation of software aiming at facilitating creative outcomes, in comparison to more traditional methods (e.g., heuristics). Chapter 7 explores the characteristics of the representations produced with our software and compare those to the findings of chapter 4. It is hoped that this retrospective and longitudinal analysis will impact iterative designs of programs that aim at facilitating creative outcomes.

The remainder of this chapter is structured as follows. Section 8.1 gives an overview of the contribution of each chapter. Section 8.2 aims to analyse critically the methodological aspects and the evolution of the scope of the thesis throughout its development. Finally, section 8.3 presents the works envisaged beyond this thesis.

8.1 Overview

Music representations have co-evolved with music composition practices and technologies. This co-evolution is illustrated by the initial development of notation as a means to record music, which in turn impacted music composition by providing a formal way to offload memory processes and to develop abstract relationship on the medium itself (see e.g., the example of geometry in Bach's music and statistics in Xenakis' music). These observations provide the basis of this thesis and narrow its scope to the study of representation. Chapter 3 reviews studies of representations in composition rom the theoretical viewpoint of musicology and distributed cognition. We established that distributed cognition provided a useful but also in some respects limited framework for an analysis of representations in composition. By focusing on processes, cognitive studies allow identifying analytical issues, which constitute the basis for the design of a computer program aiming to answer those issues. Chapter 4 studies the paper sketches produced by four composers of the 20th and 21st century. These case studies characterise the fact that paper sketches play a role in support of music composition, especially in the first stages of composition. Particular characteristics were identified and compared to the features of currently available computer programs supporting composition. Chapter 5 begins by reviewing existing programs and present an analysis of their functions with regards of the findings of chapter 4. Building on this analysis, we inform the design of the Music Sketcher. Three iterations in the development are presented, which led to a prototype that could be formally evaluated with expert users. Chapter 6 describes the method and the results of a formative evaluation intended to identify potential misconceptions in the design of the program form a user perspective. The formative evaluation involved four expert composers, who used the programs and provided criticisms of its adequacy to their practices of composition and helped identifying usability issues. The formative evaluation led to a last iteration to the program. Chapter 7 presents a retrospective analysis of the role of the representations built with the Music Sketcher and compares their characteristics to that of paper sketches. We show that vagueness and re-representations – two key characteristics observed on paper representations – characterise the composition processes that evolved using the Music Sketcher.

8.2 Critical reflection

8.2.1 On the methodology

In chapter 2, we set out the hypothesis that early representations are not necessarily traceable in the final result, yet playing a key role towards defining it. In chapter 3, we discussed that there was no pre-existing methodology for observing the role of representations in music composition processes. In order to understand the dynamic interplay between what is in the head of composers and the representations of music, we needed to observe the early, intermediate representations to final musical works. Studying the early stages of music composition 'in the wild' challenges the methodologies used in the field of musicology, which traditionally approaches composition processes in a teleological view, looking for the recurrence of early motives in the final piece, but tend to ignore the artefacts used to compose a piece when their impact can not be directly observed. In order to observe the characteristics of early representations, we examined early, chronological drafts of compositions. To define a framework for our study, we established a descriptive vocabulary, which was obtained mainly from reading van Sommers (1984) [87], Larkin and Simon (1987) [45], Green (1989) [31], Goldschmidt (1991) [29], Schon and Wiggins (1992) [69], Hutchins (1995a,1995b) [39, 40], Goel (1995) [28], Scaife and Rogers (1996) [67], Suwa and Tversky (1997) [77] and Nabavian (2009) [56]. A contribution of this thesis is in the methodology set out and followed. It allowed us to describe adequately the mechanisms involved in sketching music. In order to give a better account of the challenges faced in this thesis and the choices made for the methodologies, it is useful to discuss critically the scope of this thesis.

8.2.2 On the scope of this thesis

The scope of this thesis is the characterisation of cognitive processes observed in the early stages of music composition *and* the iterative design of a program to address these characteristics. The scope of this thesis was however refined several times in the course of the past four years. The original motivation was a personal need for better interfaces to music composition. As a composer and computer scientist, it appeared naturally that computer programs could be used to manipulate images to make sounds, which led to several research publications and artistic productions (see [80, 79, 81, 83, 82, 84]). At the beginning of this thesis, the rather large scope envisaged was thus the design of a computer program that facilitates composition by means of graphical manipulation. The diversity of approaches in computer programs for representing and composing music, as observed in chapters 2 and 5 show that representational paradigms, in general, are not facilitating graphical manipulation for music composition. In particular, the paradigm of digital audio workstations – the sort of programs that is the most widely used – builds on the practices of music studios (e.g., the multi track representation) and supports a hands-on approach but fails to facilitate the high-level and conceptual approach to composition that can be observed, for example, in paper sketches (see chapter 4). To motivate the design of a program, we needed to identify more general aspects that are problematic for music composition at large and characterise the cognitive processes involved. At this stage, the scope of this thesis was narrowed down to the study of representations in the early stages of music composition. The case studies of chapter 4 allowed us to characterise the cognitive processes involved in the early stages of composition. As discussed in the previous section, an ad hoc methodology was adapted from a range of studies to facilitate the observation of processes that we aimed to incorporate into the design of a program. This design was informed in chapter 5 and evaluated in chapter 6. It appeared that our primary motivation to compose with graphical means should be reconsidered. We observed that sketching on paper was a recurring activity in the first stages of music composition, but composers ultimately commit to computer programs that we can not aim at competing with, for these programs allow composers to realise diverse operations that are also integral to modern composition processes (e.g., scoring, support of MIDI, plugins, etc). The design scope of our thesis was thus refined to designing a program to bridge the gap between sketching activities and later stages of commitment using a DAW. This consideration brought about the importance of facilitating the communication of music representations between applications, which is discussed and partly addressed in this thesis. Overall, designing the Music Sketcher posed several challenges. First, to turn the processes observed on paper sketches into computerised functions. This brought about challenges for choosing an appropriate technology but more importantly to choose the appropriate design. The formative evaluation has shown that numerous design choices needed to be changed (e.g. the representation of time or group operations). This highlights the difficulty to 'get the design right' on the basis of observations. The second challenge highlighted by the design of our program was to provide a similar experience to that offered by pen and paper, yet enhancing this experience by providing an audio feedback. Changing the medium – from paper to computer screen – affects the experience of composition. Although this is partly shown in the discussion of chapter 7, some factors remain unaddressed, such as the difference of context between e.g. sketching a composition on paper while having lunch and sketching on a computer screen in the context of a study. Our work thus has limitations in terms of analysing the impact of these external factors on the study. Finally, the rationale followed for the design of our programs has excluded *de facto* building on different paradigms to that of hand drawing. Several other approaches could be considered in support of the early stages of composition, by, for example, considering the role that tangible devices (e.g. a keyboard) or portable recording devices such as imagined by Dru Masters in chapter 5 could play in the early stages of composition.

8.3 Future works

The evaluation (chapter 7) has raised some important questions, which we intend to address in future works. The recent developments in portable devices such as touchscreen phones highlight new possibilities for interaction and sketching. These devices could be a more appropriate target for our software than computers. In the case studies, the composers reported that sketching a composition often begins in unplanned situation, e.g. when the composer is travelling or having lunch. Whereas it may be difficult to sketch on a laptop while having lunch, a handheld device seems more appropriate. The evaluation chapter raised another area of improvement: bridging the gap between our tool and professional programs to facilitate switching between representations (a practice observed on paper).

Vagueness and re-representation are characteristics of the early stages of music composition, and we have shown that these characteristics can be successfully integrated into a computer program. This finding may be of importance for the design of systems that intend to facilitate creative outcomes. To our knowledge, all design fields benefit from dedicated software (e.g. Photoshop for graphical design, AutoCAD for architecture and house design, 3ds Max for 3D design or Digital Fashion Pro for clothes design). But it is questionable whether these programs support the development of vague ideas or facilitate re-representations. This thesis constitutes a basis for improving the adequacy of software dedicated to creative tasks, in particular where the early stages involve informal drawing. Creative practices constitute an important part of human activities and largely relate to the use of tools and technology. We argue that by looking at creative practices from a technological stance and understanding the role of equipments and artefacts as part of the creative dynamic, we can inform the design of systems that will facilitate the engagement into creative practices beyond music composition. Future works include the testing of this argument in other creative practices such as architecture or advertising.

Appendix A

Dennis Báthory-Kitsz

A.1 Sketches

Figure A.1: *Low Clouds and Evening Wind*, piano, 2007. "It is being written in complete form; only the passages at the bottom of the page will be expanded when put into Finale notation software."

Figure A.2: *The Nine Rabbits of Valladolid*, Cello duo, 2007, sketched in the upper part of the page and *Drumbing*, four percussionists and a table, 2007, sketched upside down at the bottom of the page. Full score written with Finale.

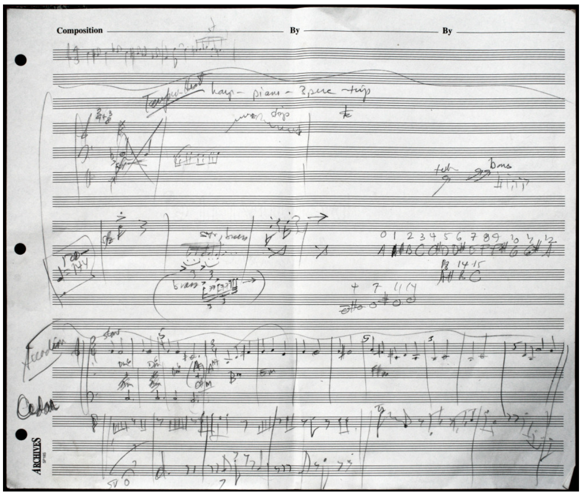

Figure A.3: *Heat: Fanfare*, large orchestra, 2007. “Three pieces on a single page. What’s interesting is the middle one. This is a full 6-minute fanfare for large orchestra, and that is the entire sketch – from there it was written out.”

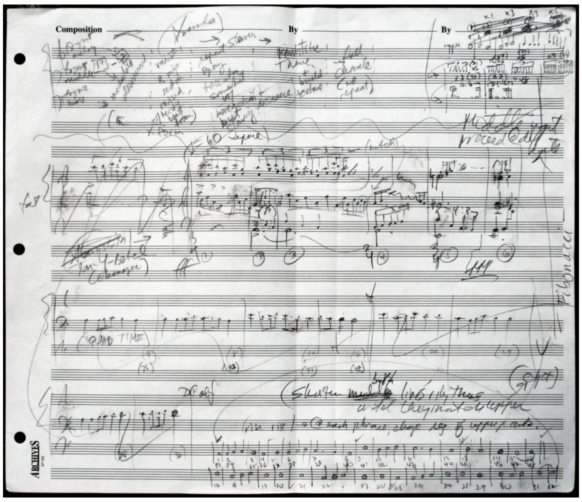

Figure A.4: “The top sketch is the description of an organ prelude (*Loss of Innocence*, organ, 2007). The second is more fully sketched, mostly to get the math in place and the note order worked out (*Toccata: Tides of Wales*, organ, 2007).”

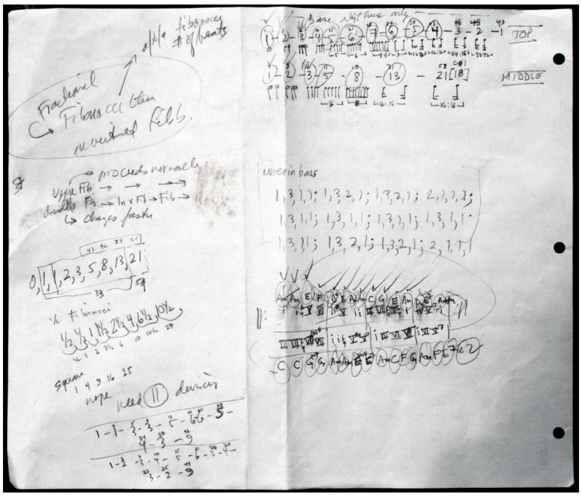

Figure A.5: “Remaining work of *Toccata: Tides of Wales*, organ, 2007.”

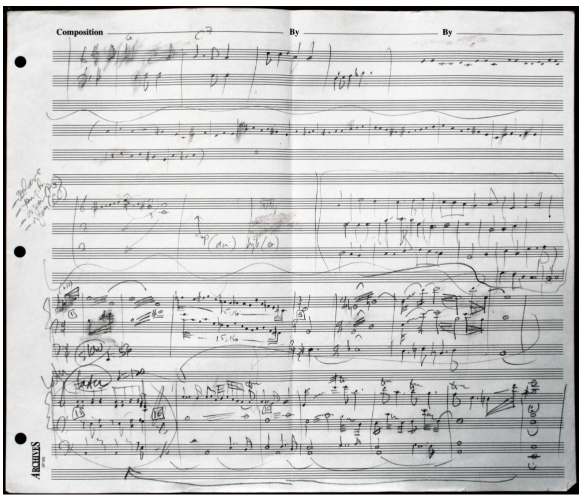

Figure A.6: “Remaining work of *Loss of Innocence*, organ, 2007.”

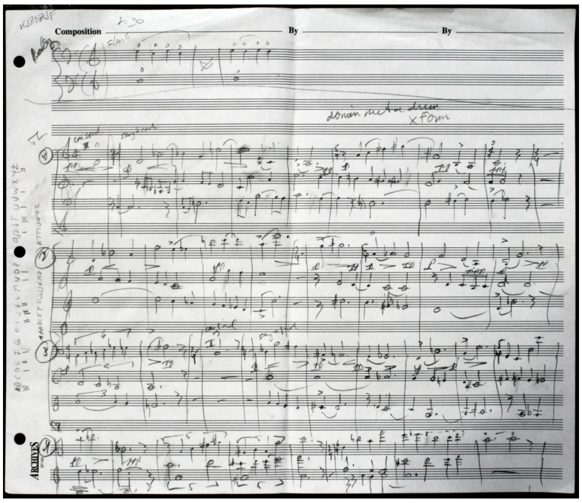

Figure A.7: *A Partial Summer*, cello duo, 2007. "Only two measures were sketched (the top one) before the piece was written out in final form. The bottom is the only measures of a piece that was abandoned."

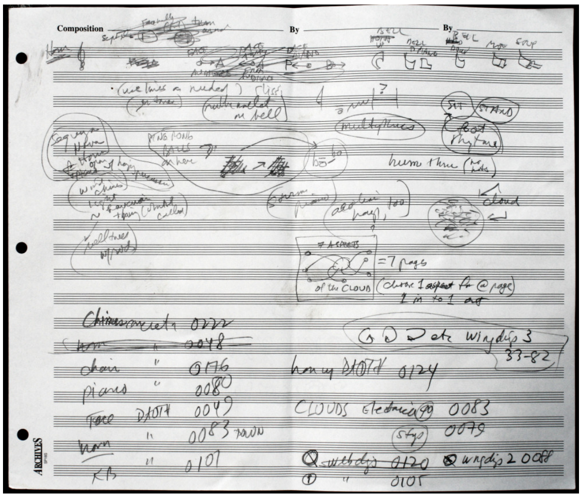

Figure A.8: *Sequenza Nova*, horn, 2007. "The page shows positions, architecture, a central image sketch, and font characters. The finished score was done directly in Finale without further sketches."

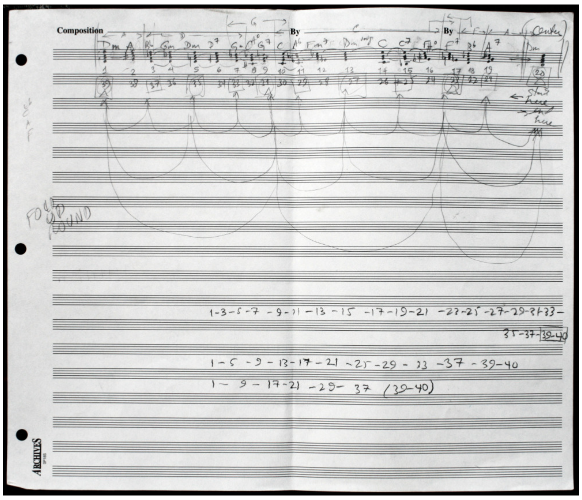

Figure A.9: *An Fold-In Round*, for seven to fourteen voices, 2007. "It is also structural – chords and jumps. It is a very long round that can be sung by jumping measures in various combinations."

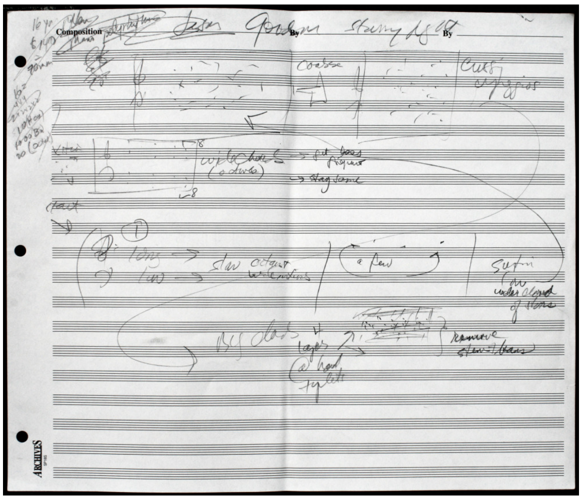

Figure A.10: *Starry night*, piano, 2007. "Full sketch of a piano piece, with sketches of the aleatory."

Figure A.11: *Candles of Red Sky*, Theremin and voice, 2007. "It is the second page as composed, with almost no sketching."

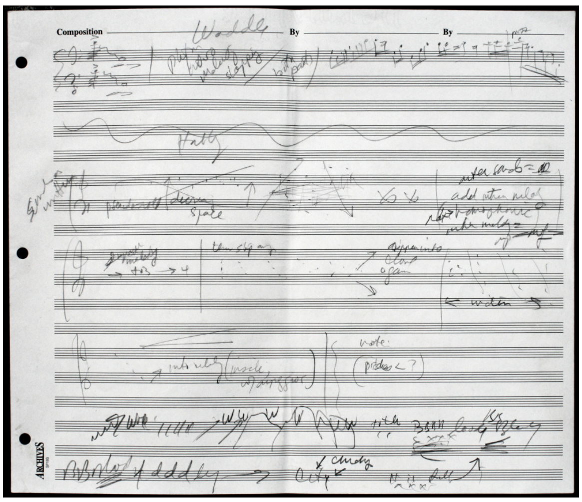

Figure A.12: *Running the Traction Line*, cello and contrabass, 2007 and *What to Do, Farmer Gray?*, marimba, 2007. "[This] represents sketches for two pieces, a double bass and cello duo, and a marimba piece. The second sketch is more architectural."

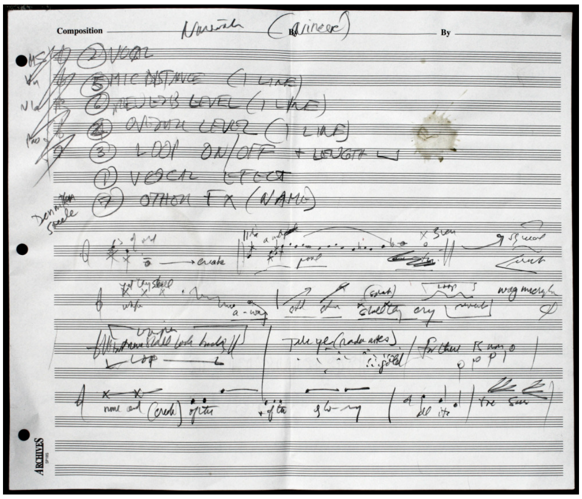

Figure A.13: *Return to Nineveh*, vocal and effects, 2007 “[This] is the first page of a vocal piece with effects, with no sketching other than a remind of what the effects notation is.”

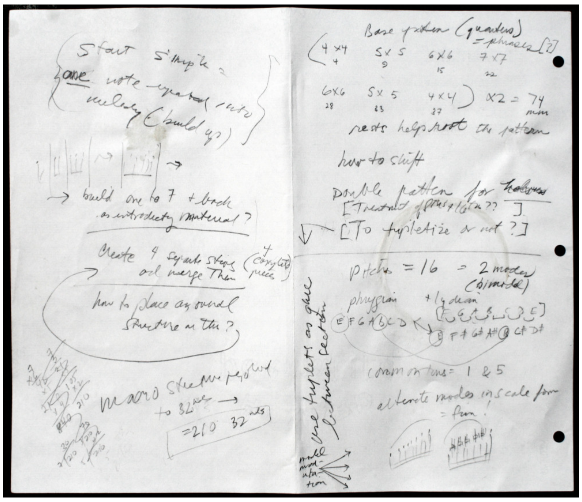

Figure A.14: *Scalar Rainbows*, piano, 2007 “[the two following sketches] are the shapes of a longer and more complicated piece. Once underway, there was no intermediate sketch.”

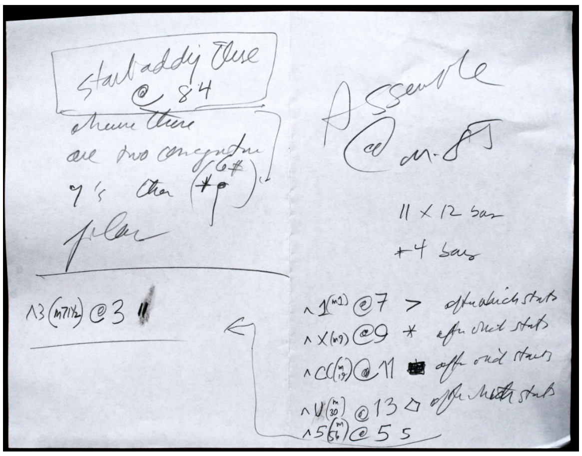

Figure A.15: *Scalar Rainbows*, piano, 2007.

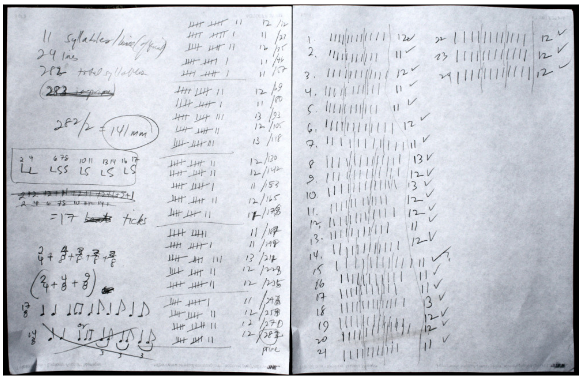

Figure A.16: *XLII: Adeste Hendecasyllabi*, voice and piano, 2007 “[This sketch] is the rhythm scheme of a Catullus poem that was analyzed to create the basic shape of the music. There is also a melodic sketch on one page (not included).”

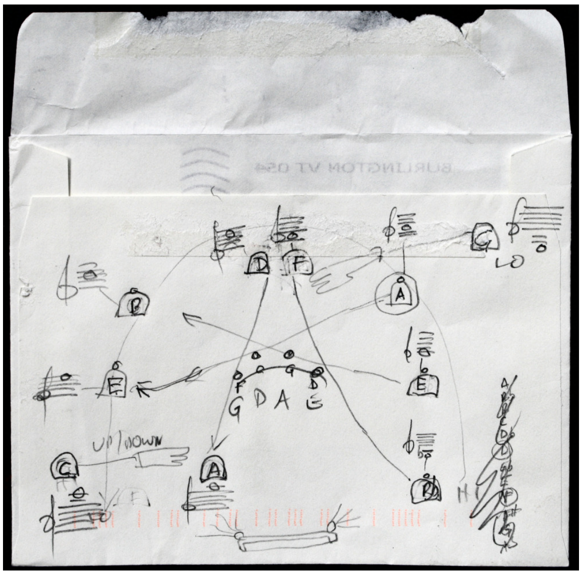

Figure A.17: *Morning in Nodar*, eight bells, 2007 “[This sketch] is really and truly sketched on the back of an envelope. It is the bell pattern for control strings connected to a double-bass bow.”

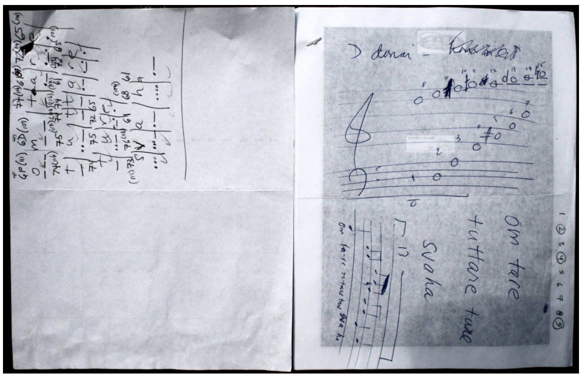

Figure A.18: *She who saves*, voice and two horns, 2007 “[This sketch represents] the notes for a piece for two natural horns and soprano. Hidden in the rhythms of the horns are the Morse Code characters that represent the text, so decoding the rhythms also reveals the text.”

A.2 Scores

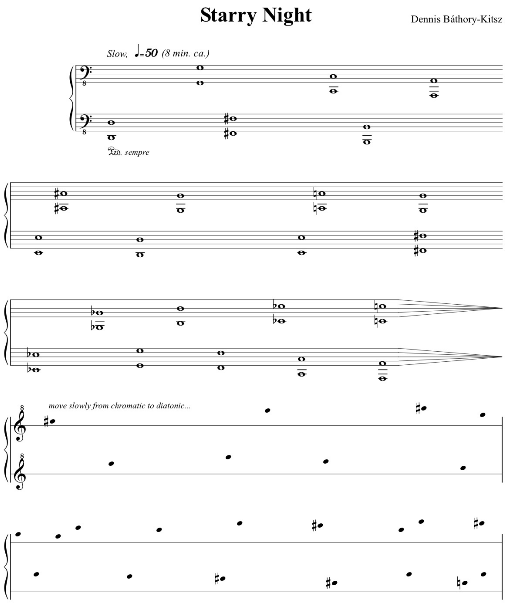

Figure A.19: *Starry Night*, piano, 2007, page 1

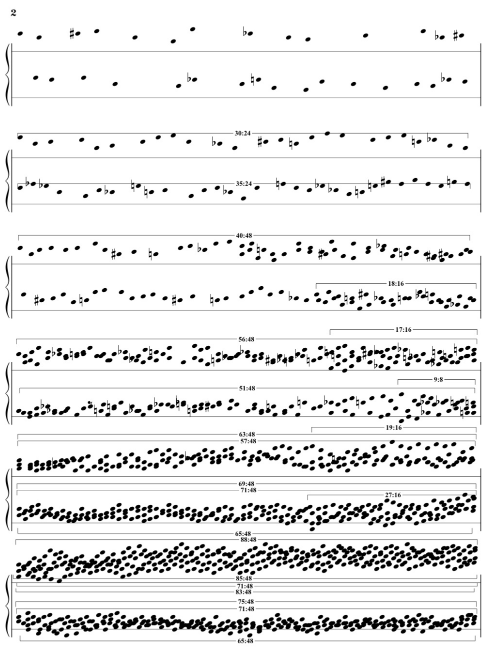

Figure A.20: *Starry Night*, piano, 2007, page 2

Figure A.21: *Starry Night*, piano, 2007, page 3

Appendix B

Evaluation transcripts

B.1 KN

B.1.1 Transcript of the study

0:02:30 "What I like about this immediately is that I can copy and paste it (the stroke) because it makes me think immediately in terms of textures. Oh, I realise that I now need to allocate sounds to them."

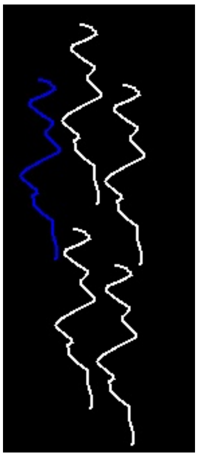

Figure B.1: Group of strokes #1, 0:01:20

0:02:55 After being explained that she could allocate a sound to a group of stroke, the composer went on to chose a sample to allocate to the group of strokes that she drew (see figure B.1). She went on to play the sketch

0:03:30 "That's very cool. One thing though. It's not confusing I'm sure. I'll get use to it, we got time going this way (pointing at the horizontal axis) and time going that way (waving a finger along the stroke) but that's where the events starts isn't it? So that's ok. So it doesn't really matter in which direction I draw it. So if I think in terms of lengths of events... It's tempting just to draw flowers and things (laugh). But I guess I'll get over that or maybe it's just my problem."

0:04:10 She went on to draw a second group of strokes (see figure B.2). She then looked in the sound library for a sustained sound to allocate to the group of strokes.

Figure B.2: Grouping of strokes #2, 05:01

0:05:20 "Can I listen to the group as it is?"

0:05:35 The composer would have liked at this stage to listen to the whole group only. It was possible by using the playback option for the whole sketch, but the feature she suggested was more specifically for a given group.

0:05:52 Pointing at two different strokes in the same group, which all share the same sound, she asked: "What is the difference between that one and that one?"

0:06:21 "It doesn't make a difference. If you change the length or change the points of the stroke it can make a difference if you apply an effect."

0:06:31 "Ok, I understand."

0:06:40 The composer went on trying an effect.

0:07:02 "You would need to save the sound with the inspector to apply the effect. It doesn't work as a VST plugin where the effect would play as you go".

0:07:25 "Oh ok, so I can preview a sound effect but it doesn't load automatically the sound to the stroke"

0:07:32 “Yes exactly”.

0:07:35 The composer went on to record a sound transformation

0:07:45 “You need to wait for the recording to be finished before you go further”

0:08:10 The composer went on to record several other transformations for the group represented in figure B.2, so they all contained a different sound.

0:09:21 She went on to play back the group “That’s so fun.”

0:09:40 “What I’d like to be able to do is to globally transpose, say, that one (the group), the whole thing as a group because I do that a lot, make a texture and then I would transpose it or filter it *on mass* almost like subgrouping in a mixer. It would be very nice to be able to do that. I can’t, can I at the moment?”

0:10:15 “No”

Figure B.3: Exploratory sketch 1, 12:49

0:10:25 The composer went on to copy and paste the second group she drew and listen to the accumulation of the textures.

0:11:20 “Oh, I can’t undo!”

0:11:30 She went back to the first group and copied and paste the group twice, resulting in figure B.3. She then saved the whole session and opened a new sketch

0:13:04 "So, to pan the sound from left to right, I'll need to move that (a vertical bar) to the top"

0:13:13 "Yes. But you'd have to save the sound"

0:13:20 "Haha! (disappointment)"

0:13:45 The operations now occured on a group that she copied and pasted (first group with vertical lines, figure B.1).

0:14:25 "I'll tell you something now on the interface that I'm noticing I'm doing. Because that's a square (the colour choser button) and it's over there (to the left), I associate this with a stop button, so I'm tempted to go over there to stop things."

0:15:30 "Is there a way to stop that playing while it's playing back? When you've done something it plays back each time I noticed. All of it. I think that might be a bit irritating if you use it seriously because quite often the sound would be very long for instance. And also if you're fiddling away seriously with the piece you'd be playing the same sounds over and over again, you'd have to hear it again each time. I wonder if you need it to be honest."

0:16:40 "So yo can draw lines, but not shapes, isn't it?"

0:16:48 "Yes"

0:17:40 "So that, what influence would that have on the pitch shift?" (she drew a wave). She wondered until I told that no sound was associated to the stroke. This behaviour recurred.

0:20:20 "I now wonder what that shape does, sonically. What the filter would do is just a band pass filter. So if I play this... Ok. So the filter, is that a moving filter, no it's not is it?"

0:20:30 "Yes it is"

0:20:35 "Because from the way it looks I thought this was the low cut (the bottom bar) and that would be the high cut (the top bar)."

0:20:42 "It's a fixed band but the centre is interpolated, so these are the limits of the frequency range"

0:21:00 "It's a little confusing because it looks liks it's a fixed band, but I can hear it. Hm, I'm not sure."

0:22:00 "So I can change the sound by just choosing another right?"

0:22:10 “Yes”

0:22:20 She went on to chose a sound to check how the filter work by browsing the library to get a sound with noise.

0:23:09 “So that, would be a very narrow filter” (she changed the Q to be very narrowed).

0:23:18 After listening to the result: “Got it.”

0:23:30 She then change the Q and listens to the result. “It’s nice”

0:24:10 She created a new group with a wavy line on the horizontal axis and copied it several times. The sounds contained are different for each stroke. She transform the sounds in the strokes and listens to the whole group.

0:25:40 “So why the play back cursor moved back to the beginning?”

0:25:50 “That’s a bug”

0:26:00 “Oh ok”.

0:26:15 “Can I mute any of them? If I want to listen to these but not those?”

0:26:25 “No, you can’t, but you can copy and paste them into a new sketch to listen to them separately”

0:26:32 “Oh yes, that would be the way to do it. I really want to do that”.

0:27:00 She created a new sketch and copy pasted the group in the new sketch (see figure B.4).

0:27:10 “Now, can I change the volume for those?”

0:27:15 “No you can’t”

0:27:30 “(Laugh, disappointment). I really want to do that, it’s very important because I want to balance them against this (pointing at the main sketch). So I would like to have a volume controller. So, I’m stuck.”

0:28:00 She went on to accumulate the strokes that she edited in the side sketch (figure B.4) to the main sketch (figure B.7).

0:28:20 “Having no control over the dynamics is an issue isn’t it. I’d like to be able to bring the volume of a group down. I can’t make those quieter if I need to. I do like the way that having a visual sketch interface makes you think of how things relate to each other much more though. I think it’s something very important. Mixing in so much software, I can see how that relates to that, it can make it

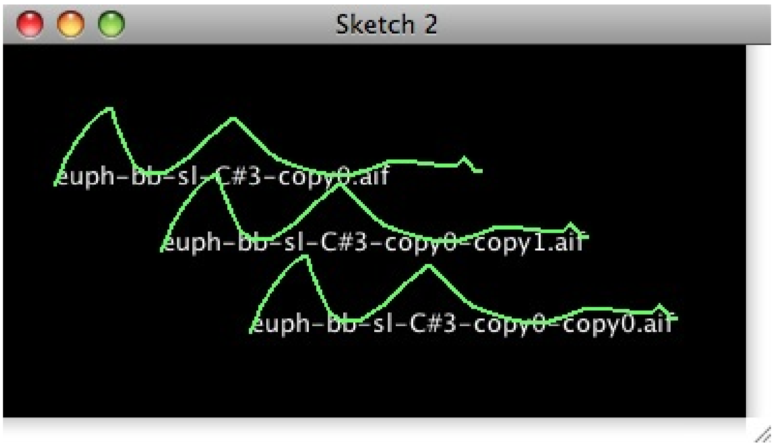

Figure B.4: Side sketch 1

explicit, it's really nice."

0:29:20 "I think you could have loud on the top and quiet at the bottom, and where you put things would control the colume I don't know"

0:29: 32 "It might constrain the drawing though, what you think?"

0:29:40 "It might, that's a problem, but you have to get control over the dynamics somehow"

0:29:45 "Would you like to have some kind of synthesis?"

0:29:50 "Yes, that'd be nice. For me I feel that things 'aliens' and I'd like to be able to draw the sort of sound, the kind of waveform and see what it sounds like, so it would be great actually. I know you can do that in Max MSP, you can draw your shape and fill your wavetable, but, for people who don't have any real grounding at all in synthesis, it could be quite a nice way to do additive synthesis, to be experimenting with aggregates of synthesised timbres."

0:31:20 "So, if I assign a sound, it plays the entire sample, right? If I was to assign to that (a stroke) a long sound it would play the sound all the way through, right? Because it would be nice to have a little bit of it."

0:34:30 The composer went on to edit a group in a separate window (figure B.5). The copy and paste action put the strokes outside of the frame as it kept the original coordinates of the strokes on the main sketch, which were far on the right.

0:35:10 Once the position problem was solved, she listened to the group of sounds.

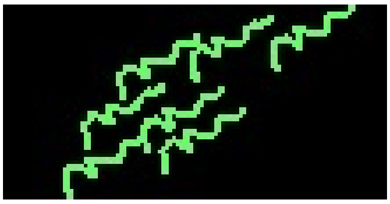

Figure B.5: Side sketch 2, first draft

0:35:20 “Oh this is really nice, because I can build up a texture very quickly that’s got lot of iterations of something by just playing around.”

0:35:40 She went on to build aggregates of the same sounds, as can be seen in figure B.6

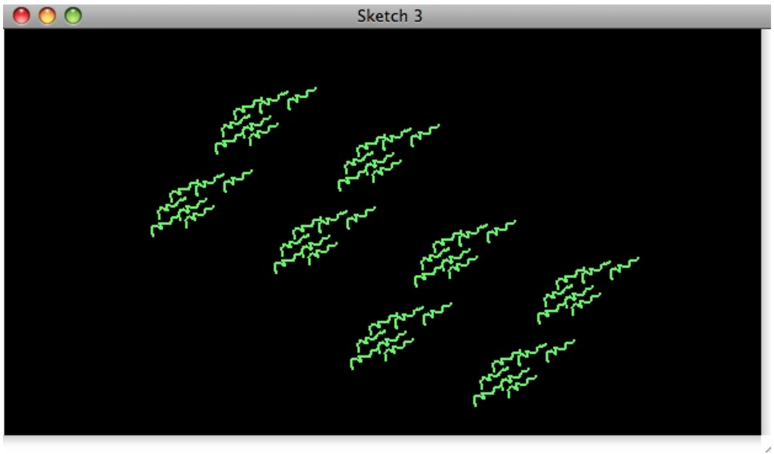

Figure B.6: Side sketch 2, second draft

0:36:10 She selects the whole aggregate that she edited in the side sketch.

0:36:35 “If I want to save that as a sound?”

0:36:43 “That’s not possible yet...”

0:36:50 “Ha! Because what I’m thinking, and it’s probably why you’re here, because I can’t at the moment transpose a group in you interface, I want to save that, bring it back, do stuff, and that would be very useful. And, you know, you can do that in Protools obviously, but I detest Protools. So I can’t... What’s ’Export as AAF’?”

0:37:20 “That ’s an interchange format that Logic can read. But it caused some usability problems so the program is now communicating with Audacity instead”

0:37: 34 “Right. That’s great. I think it’s great that it communicates with Audacity because it would be very good for people who are starting out composing or not used to working with sound, and then Audacity is open source so it's just wonderful. People who are not composers would like this. So how do I save my finished piece? I need to open it in your software!"

0:37:57 "You can export it in Audacity"

0:38:02 "Ok"

0:39:02 Exporting the 48 sound files of the sketch B.6 eventually crashed Audacity. The program had to be relaunched. The second time worked, but the sound exported were the original ones. The difference of representation between the Music Sketcher and Audacity was disturbing:

0:41:03 "So where am I in the session? I can't tell. It's just a black hole"

0:41:14 "Maybe you should zoom out?"

0:41:44 "Oh. No, thats time shift. Looks like it's here"

0:41:56 "(sic)I'll undo something. It's not like it, is it?"

0:42:30 Audacity wasn't eventually able to play back the aggregate.

0:43:20 "That would be very good to record all that (referring to figure B.7)"

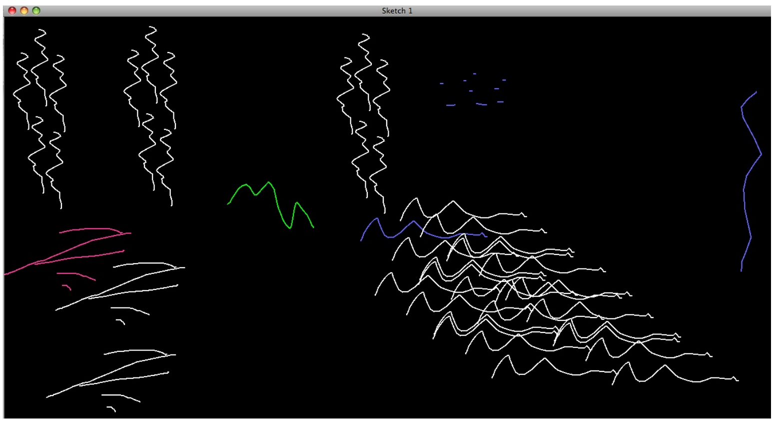

Figure B.7: Exploratory sketch 2

0:44:03 "Oh. I can't undo."

0:44:45 "I want to hear that" (she moved the cursor to the point to play back)

0:44:52 The composer went on to copy and paste, but the paste did not go where expected.

0:45:02 "Oups"

0:45:09 "You can delete the selected strokes"

0:45:48 “Right. I want an eraser, that’s what I want. Photoshop for sounds...”

0:46:01 She listens to the whole sketch.

0:48:03 “I think, what would thrilled me, would be to have my main stage as it were, then several small ones (sketches) where I put gestures or shapes that I might used, that I’ve made, a little library almost. Would be fun. So that maybe you had a panel opened with all your windows in miniature of the things you made earlier. So you can easily copy and paste them in the main stage. That’s how I tend to work. I have a lot of things that I might slot in later and edit. So I could pick and chose from here (points at the side sketch) to here (the main stage).”

0:49:10 “It’s great, and it’s fun. And that’s important you know, that it’s enjoyable to build something quite immediate and although you’ve explained a few things to me about what one has to do, it’s fairly intuitive. And there’s certain things that I’m expecting that don’t happen yet but that’s just because you are in the early stages, isn’t it?”

0:50:03 “Can I shrink all this, zoom it in and out?”

0:50:15 “Yes, if you select all the strokes and go in the inspector, you can zoom them all.”

0:50:37 “Right, so when I zoom out, I change the piece. Because this is the time and it has changed. So that’s not zooming in the sense of display term.”

0:50:45 “No, it’s a destructive zoom”

0:52:10 “But that’s nice, because you’re dealing with time and you’re making things slower and faster but it is a different thing and I can see that... But I’d like that, I think that’s good. You don’t often get that do you, with software. But what I’d like also is to make things smaller so I can get more on the page and keep going for a longer piece, because this is not very long. But let me just test what this would sound like. This should be much faster now. That’s a really nice thing, although that’s not what I expected at all I really like it. That’s my favourite thing, I can change time!”

0:52:40 She went on to zoom even more. “Let’s see if I can break it (laugh).”

The following actions were used on groups of strokes, mostly using the zoom. This

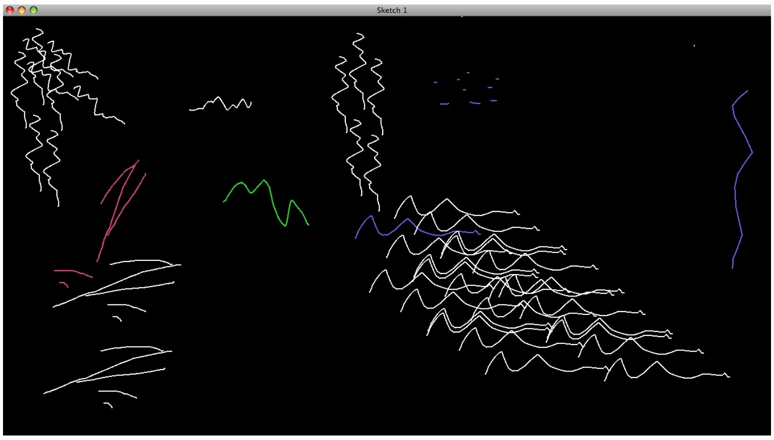

Figure B.8: Exploratory sketch 3

result in the sketch represented in figure B.8.

0:56:06 The composer felt stuck as she could not control the gain of the samples.

0:57:20 "What I would love to be able to do is to select a whole group, say, that little texture there - cos now I'm thinking in terms of textures - and that's very helpful that it's visually represented. I'd like to bump it up or bump it down. I mean it becomes bit like a conventional software then. But I'd like to be able to make it like this, add something like that there (points at a group of strokes)."

0:58:05 "The other thing I'd like to do is to play the first half second, getting just a bit of it." (58:05)

1:01:00 The composer went on to explore the loop possibilities. She played the sketch back. The software crashed but the composer was able to save the sketch and reopen it. Due to a file corruption, she opened a previously saved sketch to carry on the experiment. She then opened a new sketch to develop new textures.

1:11:30 "(Laugh) Its a problem." Saving a sound takes as much tim as the sound lasts, which caused waiting for 30 seconds to carry on doing any action before it was finished.

1:13:00 "What does rotating do to the sound?"

1:13:10 "Nothing"

1:13:15 "Because what would be nice would be to reverse the sound. What I don't understand is that it doesn't do anything. Because that would sound the same as that (she rotates a stroke)"

1:13:25 "I think every visual change should have a sonic correlation, because that 's why you using the software for."

1:16:30 "I really want the space bar to be stop/start, because it's the way it usually works" (1:16:30)

1:17:05 "I can break it in front of your very ears (laugh)" The composer aggregated several strokes and wasn't able to stop the playback.

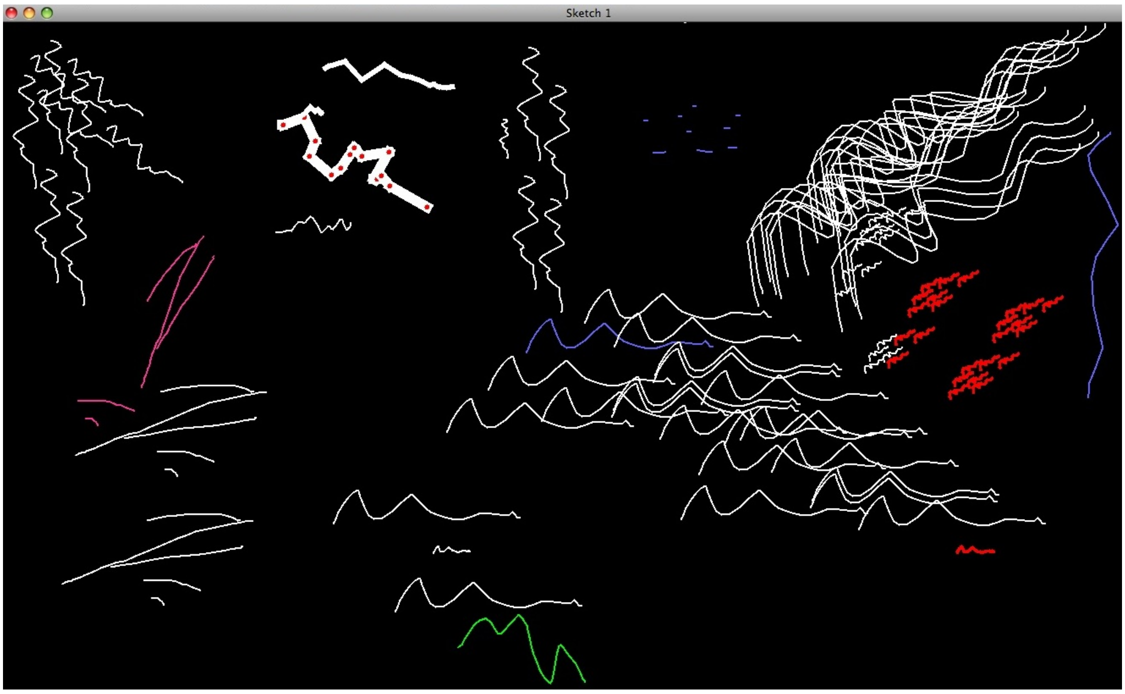

Figure B.9: Final sketch

1:18:10 "The thing is, visually, it's not what I'm hearing, cos these are long sound (short strokes)"

1:18:17 "Yes, you can load a one hour long sound on tiny stroke. But is that an issue?"

1:18:30 "I think for me it is. Because I suppose I'm used to thinking of a score, which I'm beginning to think that this is, as something which represents durations in some way, as well as other things. But especially durations of sounds. But this isn't a score. It's a way of placing things in time. But the thing is, when you do a shape, a mark, it has implications, and it's very hard not to think of a short stroke as a short sound."

1:19:30 "On the inspector, if you select a stroke, you can resize the stroke to match the size of the sound."

1:20:30 “Oh ok. ’resize the stroke’. So that would... Ok. But they don’t start at the same point in time now, do they. Because, they’re up here, and that would be very important to keep the time for those.”

1:22:20 “You need something that everyone can understand. ‘Show real length of the sound’ could be more appropriate to explain this.”

1:23:00 “You need to anchor the initial point otherwise you lose what you made (when doing a zoom or resizing the stroke).”

B.1.2 Interview

“What do you think would be most important to develop, you mentioned operations on a group, control of the volume, save a group as a sound?”

“Yes. That would be great. Because I can see the limitations that you always going to have that you can’t keep building up textures, there’s going to come a point where you run out of memory. So to mimise the effect of memory usage, you would want to export a group as a sound and bring it back in, as you would do in any sound editor. And it would also be useful visually cos you don;t have a group displayed as a single thing.” (1:26:00)

“What would be the biggest priority?”

“Volume control, definitely. You can’t orchestrate without being able to control that. Grouping is almost as important, but maybe less.” (1:26:30)

“About the ruler?”

“I think you need something to measure time. You need some sense of proportion. I don’t like time rulers much in Protools and things because you do start to think in seconds, which I think is a problem. So if you do something much more imaginative just with,well, proportions. I don’t know, you could chose how long you wanted your piece to be before you started even. And then if would show you when you’re half way through, or third without saying you’re three minutes in. [...] I guess it would be all right if you just choose whether you had it or not. Then if you didn’t want to see the time in seconds you turn it off.” (1:28:10)

“And also, I don’t know about the vertical axis, whether there could be some use for it? It could control the gain for example, with the loud sounds on the top and the quiet sounds on the bottom” (1:29:40)

"If you had your controller for the volume in the inspector, you wouldn't be able to tell from the sketch whether a sound is quiet or loud. You will need to go back there (the inspector) to check."

"The thickness of the stroke maybe?"

"Oh yes, that would work very well. That would be an obvious correlation." (1:31:00)

"Information on the sound would be very important. Also, maybe a breakpoint envelope in the inspector would be good."

B.2 DM

0:02:25 The composer started by drawing an almost straight line. Using the inspector, he allocated a sound to the stroke and played it back using the play button in the inspector.

0:02:55 When presented with the rotation, he asked: "Can I play the sound now?" expecting the sound to be modified. The possibilities of transformation were then explained and he tried out the pitch effect on a stroke.

0:04:31 The composer was satisfied with the interface: "This is really interesting in itself. How many times I just wanted to get sounds to go woooot (crescendo). And trying to do that, just simply, I mean you can use the pitch shift but it's quite hard to get something that just do that"

0:04:56 "That didn't seem to be time shifting in the way that a pitch shift would. Pitch shift would speed up the sound."

0:05:10 The filter was then introduced

0:05:25 "So these two lines determine the frequency range which is going to be your band pass filter, and this (pointing at the horizontal bar) which you can drag too is just the Q factor."

0:05:38 "So I can see the Q going from a bell to... whatever that is."

0:05:45 "That's the frequency range. So you can see the numbers there."

0:06:02 The composer tries the effect. "I like it."

0:06:10 "So it would go from 224 to 3000 hz.The exact peak would be varying If you set up a very high Q, the bandwidth would be very precise, very narrowed."

0:06:24 "Sure."

0:07:01 “The last effect is a simple pan. You can constrain the left and right by dragging these two lines”

0:07:06 “Ok.”

0:09:01 “That’s about it for the transformations. So, now about the play back. If you click on this, you can loop the sound and that would indicate where the sound would repeat (showing the markers that appeared on the stroke).”

0:09:15 “And I can move these around to have more loops?”

0:09:30 “Hm, no, it’s just an indication of when the sound repeat. A way of having he sound repeating more would be to extend the size, by looping for example.”

0:09:40 “So that’s ’resize the stroke’?”

0:09:44 “Yes. ’Resize the stroke’ makes the stroke match exactly the length of the sound.”

0:10:00 “Right. So I want to go back to ’loop’ (click on the ’loop’ check box) and then move the loop... hmm. that’s because of the... So I want to, I need to make it bigger like that (click several times on the magnifier button. That’s it, yes. So that’s not zooming in and out that’s actually making the stroke bigger or smaller. And that (’resize the stroke’) puts it back to what it was originally.”

0:10:30 “Yes.”

0:10:32 “It’s sensible.”

0:10:45 “There is one thing which is, well, noticeable in the representation of time. If you just draw a stroke and associate a sound to it, you wouldn’t have a matching of the length of the sound with the stroke. So a small stroke can contain an hour long sound. Unless you resize the stroke to match its length, or loop a sound that is short in a big stroke, it would repeat.”

0:10:56 “Sure.”

0:11:00 “So sometime the matching of the time might be lost.”

0:11:06 “Ok. So if I want to hear that now looped, can I click on it here? (the loop checkbox)”

0:11:12 “Hm, no I think it would be looped only once (pointing at the markers).”

0:11:19 “Ok. So if I keep doing that (clicking on the magnifier) I will then eventually more than one loop? oh yes, get you.”

0:11:28 “If you go back to the sound effect, you can save the sound.”

0:11:32 “Ok.”

0:11:35 “So, that would be ’Save as’ and you define a new name, when you’re happy with the transformation.”

0:11:42 “Ok. Does that save the transformation or the whole sound with the transformation?”

0:11:48 “That would create a new sound and affect it automatically to the stroke. So the next time you play the stroke that would play this sound”

0:11:56 “Ok. So if you don’t save it there, then when you save the sketch it won’t save all of those parameters with it?”

0:12:30 “It would save them with it, but when you play back the sketch it doesn’t play them as VST plugins, so you need to save the sound. The thing is also that I’m using Max/MSP to do these transformations so at the moment it’s all real time so when you save a new sound you need to wait until it’s finished to be loaded with the stroke.”

0:12:45 “Right. So I need to do that for each sound as I go. I need to save that somewhere. So I’ll end up with a large number of saves.”

0:12:57 “Yes.”

0:13:00 “Ok. Cool. And then, presumably, you can just keep drawing on this canvas and this is time chronologically that way (pointing at the horizontal axis)?”

0:13:15 “Yes.”

0:13:18 “And can you extend or contract that?”

0:13:24 “Yes. You can also open new sketches.”

0:13:29 “Ok.”

0:13:31 “So you can have some small sketches on the side to kind of make some new movements and then when you’re happy you just copy and paste them in the main sketch.”

0:13:40 “Hmm.”

0:13:42 “So the way of doing that would be to go to File (showing) and New Sketch, then resize it and put it there.”

0:13: 48 “Ok. But why would I want to work on two at the same time?”

0:13:54 "Hm I don't know, if your main composition is there for example, you might want to just try some other ideas."

0:14:03 "Can I copy and past things from that one to the other one?"

0:14:10 "Yes you can do drag and drop and apple-c apple-v."

0:14:17 "Oh fantastic. So I could take that idea (dragging the stroke) and drag and drop it into that (the other sketch)?"

0:14:25 "Oh no, drag and drop wouldn't work, but copy and paste."

0:14:45 "So when it's pasted in it it's pasted with all the parameters? (doing it) Oh yeah."

0:14:54 The composer selected the stroke he just pasted and the inspector was updated accordingly, notifying him that the parameters were in place. He then closed the window containing the new sketch.

0:15:02 "It didn't warned me to save."

0:15:07 "Hm no. The whole sketch is one 'thing'. No matter how many sketches window you open, they're going to be saved in one session."

0:15:15 "Ok. So I've closed that 'sketch 2' window, does that still exist somewhere, can I open that up again or have I just lost it?"

0:15:25 "You lost it"

0:15:40 "It doesn't matter. Although in Logic, you can do the same thing. If you close that window it would close if it's been save. If it hasn't been saved then it will ask you but it's quite annoying, you just go and click on the red button at the top and it just... close"

0:15:54 "So, all of these things (referring to the palette) ... Why would I use the colours? Just so I can see what things are?"

0:16:00 "Yes, if you want to dissociate the strokes."

0:16:07 "I see."

0:16:41 The composer went on to draw a new stroke and associate a sound to it, and then play it back and apply an effect.

0:17:10 "So if I click on that (the cut button) I can get rid of that? (doing it) Hm, yeah."

0:17:22 The composer then clicked on the edit stroke button.

0:17:27 "So I can change these completely. Can I delete them or can I just drag them?"

0:17:35 "You can just drag them at the moment."

0:17:46 “But you can cut, so that would be the same thing.”

0:17:52 “No, it would cut the whole stroke, not the edit points.”

0:17:58 “Oh I see. What would be great is if you could join two strokes together. And also if I could delete parts of the stroke like in a drawing program. It would be nice to be able to modify the strokes more than just by doing that (dragging the points) cos it’s quite slow. Or to be able to select from that point to that point. If you could just do that, deleting those points but keeping those. But I’m saying that and I did not even try the software so I might change my mind after using it.”

0:20:00 “And what the point do (the size button)?”

0:20:09 “That’s the size of the stroke.”

0:21:04 “Would I use this button (Audacity button) to play the whole composition?”

0:21:11 “No, that button sends the whole composition to Audacity. The sounds are positioned in Audacity where they are.”

0:21:18 “I never used Audacity. What does it do?”

0:21:29 “It’s a sound editor. It’s used for recording. It’s open source, which is why I choose it”

0:22:30 “I could do with something like that. Cos I often need to edit the front of something, like edit the space at the front. I used to use Peak but I don’t have it now and I generally have to go to ProTools and it’s such a pain to cut the front of something.”

(interruption. chat not related to the study)

0:27:10 “Ok. I’ll just get rid of that and start again.”

0:27:40 The composer erases the strokes and start drawing. When browsing to find a new sound the composer reported: “Can you have a preview for the sounds? Cos it takes some time to add this (the sound) and then have the preview.”

0:28:15 The operation in the music sketcher requires the composer to chose a sound without being able to hear it, load it to the stroke and then hear it. The composer suggested that preview should be available when browsing.

0:29:13 The composer drew an almost horizontal line and then started to play with the transformations. Given that the evolutions of the stroke were very subtle, there was not much difference when he tried out the transformations. He then started to edit the points.

0:31:34 “You need to save the sound if you want the effect to apply when you play the sketch back.”

0:31:40 “So I need to..”

0:32:00 “Yes, select it.”

0:32:06 “Can I save it (the transformation) from anywhere or do I have to save that (the other transformation) as well?”

0:32:15 “If you want both effects to apply, you need to save them one after the other.”

0:32:21 “Ok. Shall I put that in my folder?”

0:32:25 “Yes.”

0:32:29 “You need to wait for the process to be finished before you can interact again.”

0:32:38 “I guess it slows down the creative process if you cannot... So how do I know that it’s finished?”

0:32:45 “You can act again.”

0:34:20 “Ok. So I need to save that as well.” He went on to process the sound.

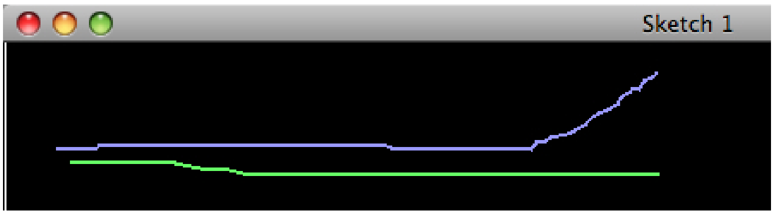

Figure B.10: Draft 1

0:35:10 The composer went on to draw a second line, below the first one (see figure B.10). He associated a sound to the last stroke and transformed it, and then played the whole sketch.

0:35:40 “Undo would be quite handy. Does it matter if they (the strokes) are at a different height?”

0:35:48 “No it doesn’t change anything.”

0:35:52 “How can I change the amplitude?”

0:36:00 “Hm. you can’t. It is something that I will do.”

0:36:06 “That would be very handy.”

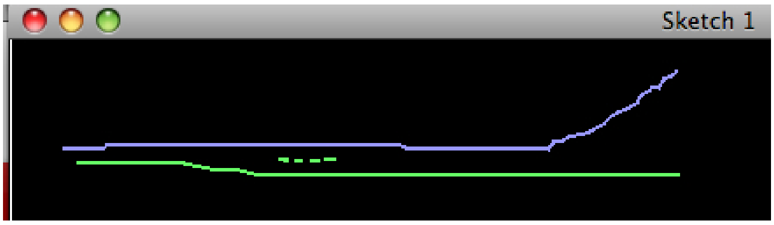

Figure B.11: Draft 1. Incorporation of short percussive sounds

0:38:00 By then the composer had drawn 4 small strokes and added the same sounds to them all. He drew them very short and wanted to assign a percussive sound to them (see figure B.11).

0:38:20 “So I can;t just do a drag and drop copy?”

0:38:26 “Hem, no.”

0:38:32 “And I can’t zoom on this. “

0:38:45 “If you zoom them, you would make them bigger.”

0:38:56 “I can’t zoom in to move these closer together?”

0:39:05 “If you select them all, you can then zoom them all.”

0:39:14 “That changes the strokes doesn’t it. I want to zoom in on that area to make it bigger so I can work on that area.”

0:39:30 “The magnifier would do that, to some extent.”

0:39:35 “Would that not make the notes longer?”

0:39:50 “No, it wouldn’t affect the sounds but it changes the time at which they start.”

0:40:40 “(trying this) I see”

Between 0:41:00 and 0:44:00 a bug was noticed. The composer tried to apply an effect on a stroke that was completely horizontal which proved not working when applied to an effect. The bug to correct is when the lower value of the stroke is the same as the higher value. It then generates interpolated values that are equal to 0 and not usable by the program to do the expected effect.

0:45:00 “It’s nice that you can move things around like that.”

0:47:00 The composer went on to add more strokes and allocate sounds to them. He moved the strokes and listened to the sketch systematically after that to hear the result of the action.

0:47:14 “So that one is quite long even though I’ve only made it a short stroke. It’s quite a long note. It just plays the note whatever.”

0:47:25 “Yes if you want to see how long it would be you can click on ’Resize the stroke’.”

0:47:30 “Oh I get you. I see. Interesting.”

0:47:35 “If you don’t resize the stroke, you might have this ’mismatch’ of representation.”

0:47:45 “Yes.” The composer did not resize the stroke.

0:48:00 “So, that’s going down but the sound is not going to change because I haven’t done anything with the pitch shift or anything. So I’ve drawn that stroke to look like it’s moving down, but what’s my purpose in doing that, is there any?”

0:48:15 “It could be that you want to remember a specific sound.”

0:48:30 “I see, yes, it’s a way of remembering that it’s going to go that way.” (48:30)

49:00 to 54:00: chat non relevant with the study

0:54:12 “It’s quite tricky cos I don’t know your samples. I guess if I had my own samples library as well, it would be easier to create something.”

0:54:27 “Would you like to use your own sound library?”

0:54:34 “No that’s fine cos I don’t know the individual samples that way. I know the samples library but the individual samples would take me longer (to browse).”

0:55:00 “I think the most fundamental thing initially is the ability to change the amplitude. That’s the one thing that would be really good right now.”

0:55:30 “I like the fact that I sort of know I want a little ’wooop’ - and I don’t know what it is cos I don’t know the samples - but I know I want something doing that. It’s nice to actually be able to go and do that.”

0:57:00 At this stage, the composer had 10 strokes on the sketch (see figure B.12).

0:57:00 to 1:00:00: non-related chat

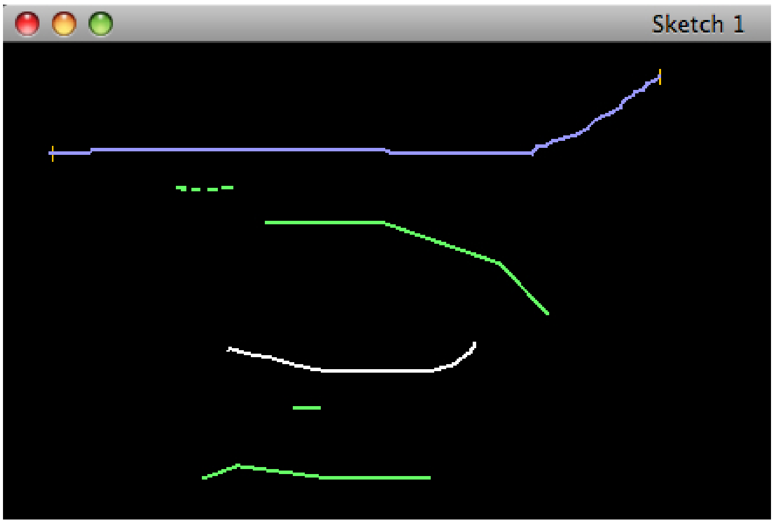

Figure B.12: Draft 1. 10 strokes

1:01:10 "It would also be nice to be able to put some effects. It would be nice to put some reverb on the snare or something. I suppose it depends what you're trying to use this for. And I suppose that's the key, isn't it. If you're using it as a way of trying out some ideas, then, it's a quite and easy way to do. I mean I'm trying to be more creative by drawing all these things but actually I don't really need to. What I need to be doing is probably, in some ways, have the labels (display the labels) so that I can see where everything is. Then, there my sound effect is coming in (placing the first sound at the top left corner) and then I know I'm gonna want like a low double bass note and then a subtle glockenspiel sort of pigging in. And then - I can't remember what that is - yeah, that's the double bass pizz, and then the bartok pizz and then we've got the double bass coming out, flute, and then the snare coming in (he moved the stroke as he talked)... So if I'm using the sketch pad thing like that then it makes total sense to just be able to do it like that. Cos it doesn't really matter, cos the idea I guess is that you export it and then you can mix it, or export it and then rework it in another program. If your idea's that the sketchpad is just a sort of, say, I'm gonna want some things coming here , and then some violin coming in."

1:03:10 "I think what would be great is if the pitch, or things, was controlled by the visuals. Because it's what my instinct was. My instinct was if I do that (draw a stroke bending at the right edge) the note would bend out at the end. And also that the length of the sample would be controlled by the length of my stroke. Let's say here, I want a loads of snare drums doing 'de de de de de de dem', it would be great if I could go, rather than just to have to do one, to go 'de' 'de' 'de' 'de' 'dem ' (he draws a small stroke each time) and then select the whole lot and say I'd like you to be (he opens the inspector and notice that he can import a sound for all the strokes)."

1:04;15 "You can."

1:04:20 "Ok. You see, that's great (laugh). It works. Perfect."

1:04:25 He went on to listen to the sketch that he re-organised while talking.

1:05:00 "So if I select all of those, I can move them with the arrows?"

1:05:10 "Yes, you can move them quicker by pressing control."

1:06:00 "And hm. That would be great if I could alter the pitch. I know these are pitch notes, but in terms of being able to write something quite musical, it would be great if I could just, say, copy that note, paste it and hem tune it upper note."

1:06:10 "You could do that using the pitch shifter, if you define the threshold to be the same for both low and high."

1:06:15 "I see."

1:06:20 He went on to play the sketch but the sound wasn't modified.

1:06:30 "You have to save the sound before the modification is considered."

1:06:35 "Oh yes. I forgot."

1:08:45 The composer saved the sound and got stuck when he tried to interact while the sound was still recording.

1:10:05 "Getting the process in the background, is this something that you can change? Cos you don't want to sit here waiting for that to finish before you hear it."

1:10:30 - 1:14:00 We discussed the software Max/MSP

1:16:02 "Can I change the colour afterwards? It would be good to do so."

1:16:10 "No you can't at the moment."

1:16:20 The composer went on to allocate a new sound to a stroke and was satisfied with an effect.

1:18:00 "Nice. You can't make sounds that easily with Logic, could you? It's really cool, cos I don't mix in more 'acousticky' or orchestrally type of stuff but also...

It's a great idea I mean in terms of the sounds, that sounds fun."

1:18:30 - 1:22:00 irrelevant chat.

1:22:00 The composer went on to add more sounds.

1:22:20 "It's quite quick and intuitive once you get used to how it works and understand what it can do. It would be nice if you could multiple peaks (referring to the filter)."

1:22:30 "The time is just over the whole length of the playback, is that right? It follows the shape that you've got?"

1:22:38 "Yes it follows the shape but you can have multiple mappings."

1:22:46 "So if I go down there and then up here (editing the points on a stroke) it will go up and down to follow that?"

1:22: 52 "Yes."

1:23:00 The composer tried the new shape with the filter and was satisfied.

1:24:10 "Cool. Now I'm gonna save that."

1:24:53 "It would be nice to take, say, that flute note and make it shorter. I can't do that , can I? It still plays the sample even if I make the stroke shorter. It would be nice to be able to change the duration or an envelope maybe."

1:25:06 "That's were a zoom would be quite handy cos I can't see, I copied everything on the same line and I can't see which one is the last one."

1:25:30 "You can hide the labels if that helps."

1:25:40 "Good point."

1:25:50 "What would be nice as well would be to mute sounds. If I could temporarily mute it without having to destroy it. You could do that with undo as well."

1:26:22 He listened to the sketch. The discussion that followed took over the study, so the sketch in this stage was the final sketch. See figure B.13.

Figure B.13: Final sketch

B.2.1 Interview

1:27:50 "Great sounds. I just don't know how you could get these sorts of sound easily in something like Logic. I'm sure you can, get a synth up and you could make it and maybe use some kore or something to do it but that's a very easy way to make good sounds. Really handy (referring to the filter effect and the interface). I mean in terms of ease and speed of just sketching out musical ideas it's quite and interesting and creative way to do it but I'm not sure how quick it is at the moment, I think in some ways it's almost slower than something like Logic where it's timeline based and it's really quick to get instruments up. And to control them because they're locked in on a grid whereas... It could be nice where you can lock or not lock."

1:28:38 "What do you mean?"

1:28:45 "Well, at the moment what you've got, there's no rythmic structure as such because it's a bit random, it feels a bit random to me. I mean I feel like it's in time but if I want to make it more in time or if I want to make that... Obviously I can explore that and then I can probably do that. Maybe that's the point because it's a sketch pad, not something to put... It'd be nice to be able to click on the grid like you can do in Logic, where you can turn a grid off. Also with Pro Tools you can snap things to the grid, or even have a grid that you can physically line up with. Having a grid view that you could switch on or off."

1:29:37 "From a sound design point of view, I think this seems like a tool that would benefit sound designers a lot but I would imagine that most sound designers work to picture, so that would be great if you could work to picture."

1:29:58 "Picture?"

1:30:01 "Yes, for example in Logic you can move the cursor around and you know where it corresponds to in the picture."

1:32:10 "Being able to create sounds like these for example (the last one he drew, at the bottom of the sketch), just to be able to that, a sound that just goes 'fiouuufff' is really hard to find a way of doing that and making a unique sound just using a sample. I think that's really interesting and really useful and unique in some ways. I'm sure there's other ways of doing it but it's really quick and a neat way of doing it. I think for more musical stuff it's not easier than doing it into something like Logic, so I wouldn't necessarily jump to it and go 'I'm going to sketch out some ideas on this first and then go into Logic'. I might do if I got quicker on it. Also depending on what sounds I got available. An other interesting thing to be able to do post production stuff on tracks, use the filter on the whole thing."

1:33:40 The composer then started to explore the possibilities of sound design of the program.

1:44:50 "If you were to give priorities to the things you'd like to have the most, how would you rate them?"

1:45:12 "I think that there's a group of things which are equally important. So I think that being able to zoom in so you can draw your curves more accurately and move things around more accurately. And being able to control amplitude. Those two things are equally important and at the top. Maybe amplitude more important than the zoom. And maybe having a grid where you can snap the strokes to. Snapping not being that important. Perhaps more control parameters on the filter. Oh, and really high priority I think being able to work on the length of the notes because that makes it almost unusable for some sounds because you just, like the flute sound was way too long so that would be very important. Also, use the scissors to select an area and delete it or even split the notes in two samples. But it would be great if you could just snip a sample in half and have two separate notes from there. And the other thing, quite low priority, would be to group items together and recolour them, so I could for example group all strings in together and give them a colour."

1:46:32 "If you would group strokes, would you like to be able to save mix of these sounds as well?"

1:47:05 "Yes, that would be fantastic."

1:47:15 "Is this a place to create sounds or a place to create compositions, because I was thinking of it as a place to create compositions using sketching and if you're creating compositions that are not particularly pulse-based then it's quite easy. But if you want to do stuff that is more fluid, which is my kind of work, although I'm interested in this sort of things, most of my work needs a pulse or a tune or some rhythm or something an that's where it gets a bit more complicated because you need something that you can work to with a grid. But that might just be me. But it's fantastic that you can do things like this cos you have much more control over these sounds"

1:48:45 The export in Audacity did not import the transformed files but only the sound originally affected to the strokes.

1:52:15 "Being able to mix things in Audacity is great. What would be great is if you could control the amplitude with a different curve. In Logic you can have several curves for a sample, have a curve for the volume, one for the pan, etc. It's a bit of a pain in Logic because if you move the sample, it would ask you whether you want to move the automation as well, and there's some inconsistencies, see (he demonstrated the problem), so that would be great to have something like that in your software."

1:54:28 "I was thinking of representing a break point envelope in the inspector to control the volume. Do you think that would be useful?"

1:54:45 "Yes, that would be great."

1:55:30 "I think it's got great potential, it's really cool, its just really different. And sound wise, what you can do with it is fascinating. I can see how easy it would be easy to write more routines to do different things to the sounds. So you start off with the concepts and then if someone wants to move the sound another way you can just add another subroutine."

1:57:30 "I hope my comments are not too negative. I work in a very commercial world and I like quite commercial music. I like avant garde music and experimental music as well, but I don't tend to make it very much. Sometime I do, but generally that's not what people come to me for so I don't concentrate on it very much. My comments are driven by my needs so I appreciate that people might have very different needs than I do."

2:05:00 "it would be great to be able to label sounds, because their names are not particularly explicit. Would be good to be able to rename the flute for example."

2:06:13 "I'm not sure about the rotation. It would be great if the effects could happen instantly because it is annoying to wait for the saving to be finished before you can work again, especially if the sound is very long."

2:09:00 "I think that you have to look at who you are competing with. Because there's no point in you competing with Logic or Protools cos they're so well developed. What they don't do, with all of those programs it's a real struggle to do sound design, proper sound design, where you can manipulate sounds in a controlled way and I think that does seem to give some of these options. And I think being able to do that, and also the whole idea of just sketching an idea and then exporting it and sorting it out somewhere else is a great idea. So I think these are the strength and there would be things that would appeal to me, because I would probably still end up writing a lot of my stuff with Logic or Protools but if I needed a sound that just did something, you know, strange or filtered in a certain way being able to do it in that, would be great. And just quickly visually doing it and then just importing it back into Logic would be very good."

B.3 MG - 1

The composer started to draw a stroke and associated a sound to it.

0:01:02 "So I'm not listening the sound as it is?"

0:01:03 "You are. The stroke itself can control some sound effects. If you go to the tab there, you can control the pitch from, say, minus 5 semitones to plus 3 semitones and transform the sound according to the evolutions of the stroke"

0:01:45 "I see (trying the effect). So if I were to... Yes I understand."

0:02:15 "So for example (clicking on the screen)..."

the composer went on to apply the effect with different configurations

0:03:02 "I understand"

0:03:35 "So that's pitch shift. So I can save that and then import it into the system"

0:03:45 "Yes"

0:04:00 "That's nice, I'm really enjoying this."

The composer tried several transformations

0:04:43 "Nice. I 'm gonna save the sound now"

The composer pressed the save button and carried on interacting with the software.

0:05:08 "You need to wait for the recording to be finished"

0:05:15 "I see. Ok"

The composer tried the synthesis effect

0:05:25 "Hilarious. I'm not sure I quite understand... Oh I see!"

0:05:45 "Yes, it's a wave synthesis"

0:06:10 "But it doesn't use any of the source sound for the wave table, is that correct?"

0:06:20 "I'm not sure what you mean?"

0:06:30 "It doesn't use any of the sound source from that... piano?"

0:06:40 "No"

0:07:08 "All right. I'm going to try that with this filtering. There's no time stretch?"

0:07:12 "No"

0:07:28 "Ok, do you mind if I start from the beginning?"

0:07:30 "No, sure"

0:08:20 "That controls the width of the stroke. It does not effect the sound. Would you have suggestion for what it could do?"

0:08:30 "It could be an indication of the overall volume, for each sound. Because each one of these sounds, that I draw, they're going to play at the same time right? So you want to have some way of indicating the volume. That would be interesting. Because then you would have a sense that when you're sketching that this is a big thing. First thing that come to my mind."

0:09:00 "What's this?"

0:09:04 "Just the colour. So when it's green, it means that the stroke is selected, you can see it in the inspector"

0:09:25 "Ok, so that's the inspector..."

Once the composer felt confident with the program, he deleted the strokes drawn to start working on his composition. The first two shapes that he drew are reported in figure **??**.

0:09:50 "Ok, so I'd like to have a short sound. Can you preview the sound from this (the browser)"

0:10:05 "No"

0:10:10 "That's ok" (He started to listen to the sounds he integrated)

The shape drawn on the left was originally circular, but the composer modified the points to create this movement and explore the transformations that would result of this new shape. The second shape was drawn having in mind possible transformations (0:09:35). The composer associated sounds with the strokes and operated a series of transformations. At 0:10:27, he was satisfied with these two. For the second shape (green shape in figure **??**), he also used graphical transformations (rotation and zoom out) to explore different outcomes in the sound transformation. The final form of the stroke that he would use untl the end of the session is shown in figure B.14.

0:10:25 "Does it matter when I do this? (rotating the stroke)"

0:10:30 "No"

0:10:38 "Is there any way I can change how long...It basically lasts the same length of the sound, is that right? (nod) So this is a very long sound"

0:10:48 "Hem, no. If you resize the stroke, it would make the stroke as long as the sound

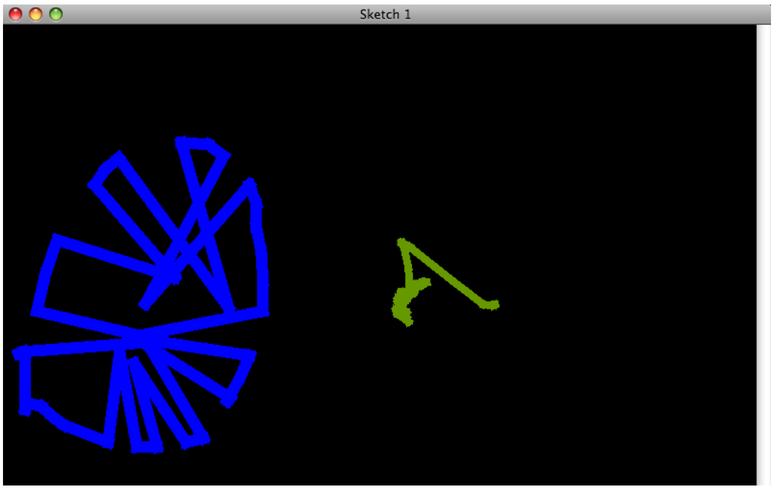

Figure B.14: Exploratory sketch 2

actually is. So this is a rather long sound"

0:10:57 "Ok. That's all right"

0:11:30 "So, the rotation, is it purely visual?"

0:11:37 "Yes, it doesn't impact unless you use the effect, because that changes the coordinates of the stroke"

0:12:17 "Interesting (trying successive pitch shift effects). Ok."

0:13:17 "If you press tab, you can switch from one stroke to the next"

0:13:30 "I see. Interesting"

0:15:08 "Ohoh, that's a long sound (after resizing a stroke)"

0:15:47 "Can I copy and paste? Oh yes. What can I do on the group?"

0:16:00 "If you go to the inspector, you can listen to each sound of the group independently"

He used copy and paste to repeat the shape he drew last. Figure B.15 shows the accumulation of the shapes that result from the copy/pasting.

The composer went on to use the filter effect.

0:18:00 "What I would really like to do is to stretch the sound. That would be really useful at this point, but that's fine that I can't. Hmm. All right. Let's just try that (save a sound with the filter the effect). I'll tell you what I'd really want to be able to do. I don't necessarily want to stretch the sound, I want to stretch the

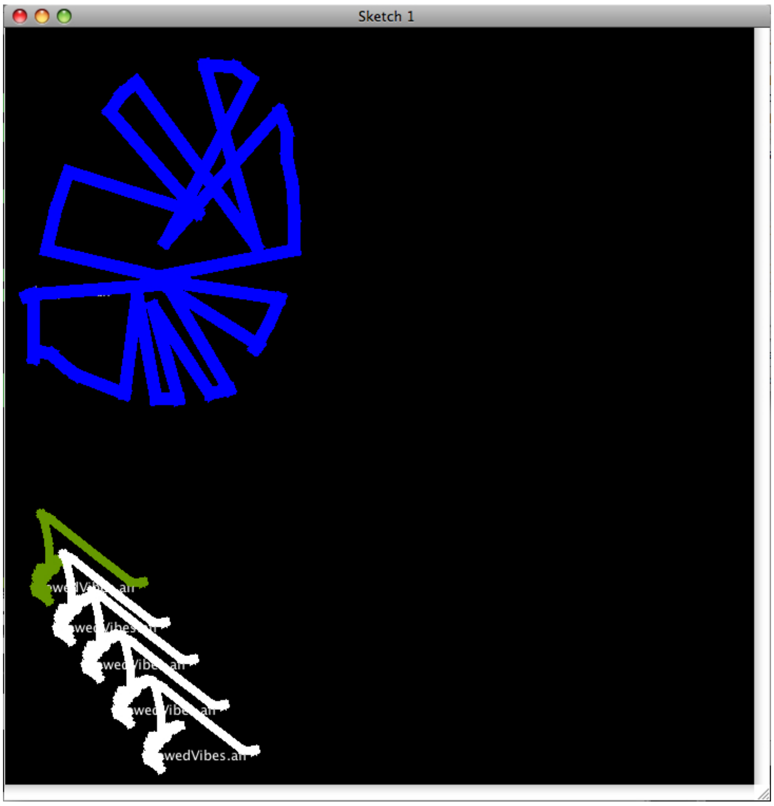

Figure B.15: Exploratory sketch 3

effect, I'd like to be able to save the effect for a short or a long period of time. Would that be a problem? I want this control information to last ten times the length, do you se what I mean?"

0:19:00 "Hmm, yes, so if you loop the sound..."

0:19:15 "So you want the sound to be the same, but, say if I... because it's quite annoying having to, see, well if you wanted a modulation, a very quick modulation for example, it would be very difficult to draw a line that'd be doing this for ages and ages and ages.. If you could just do a bit and loop it and apply that to the whole sound. Certainly, a lot of the kind of stuff I write tends to be quick modulation."

0:19:58 "Ok. so you'd define, somehow the modulation on a defined period of time and apply it to the whole stroke"

0:20:20 "Exactly, that would be really cool"

0:20:55 "All right. So.. Oh, loop sound..."

0:21:18 "That functions make the sound repeat if the stroke is longer than the length of the sound"

0:21:25 “I see. I was just wondering about... I’m trying, as a user, not to think. I’m just trying to.. do things the way I like to do them. I don’t want to think logically about what I do. Because the thing about the composition process, for me, it has to be a mixture of totally intuitive and logic as well. So I’d think about something and then stop thinking about it deliberately.”

The composer graphically edited a stroke and then tried several transformations

0:23:39 “So if I rotate the stroke, it rotates the pan. That’s fantastic.”

0:23:57 The composer tris several transformations on the same stroke and finally keeps one (see figure B.16). He reorganises the strokes onto the sketch and play the whole sound.

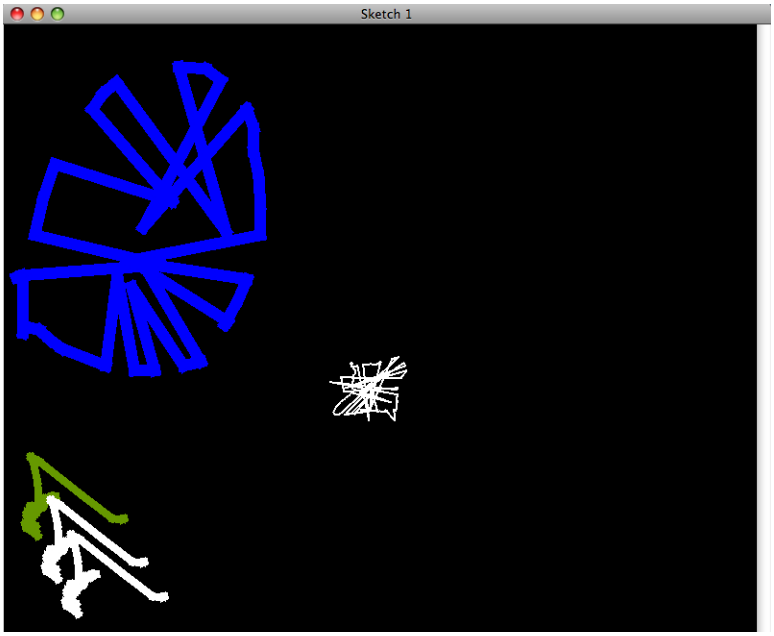

Figure B.16: Exploratory sketch 4

0:24:40 He used the filter on the sound and recorded the result

0:25:45 “I’m actually quite enjoying this”

At this stage, the composer draws an undulated stroke and chooses a sound for it. He applies an effect and then rotate the stroke. Listens to the effect again and rotate the stroke. He then rescales the stroke. He tries several transformations but cannot find what he looks for and goes back to the stroke to modify it. He starts to change the points in the stroke when a bug occurred with the inspector. The result is shown in figure B.17.

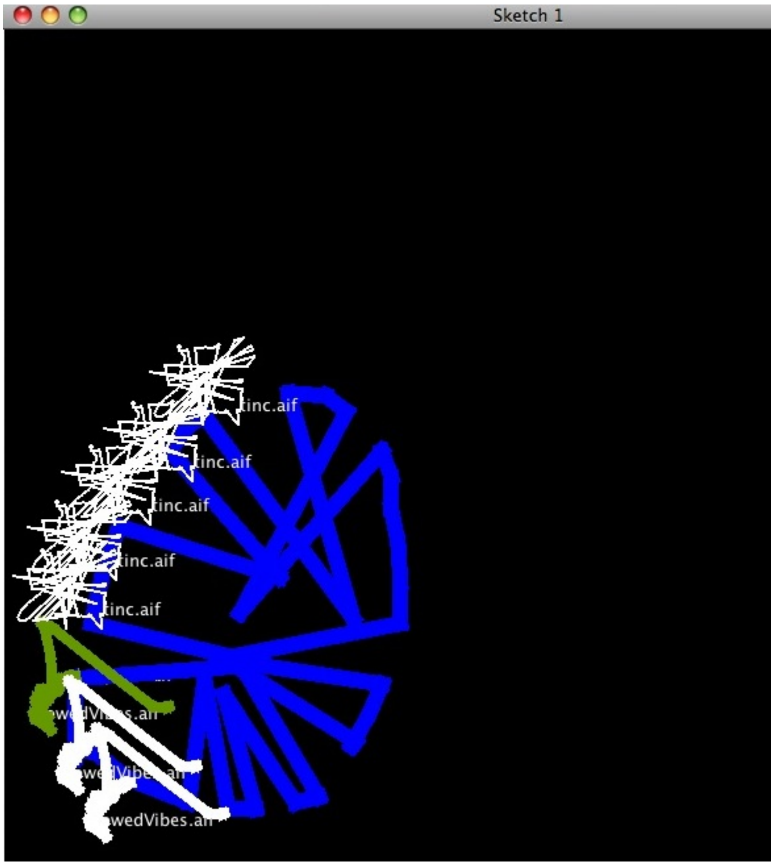

Figure B.17: Exploratory sketch 5

0:30:29 “Ok, I’m going to save this and restart”

0:31:24: The composer draws a stroke similar to the one that he drew before and chose a sound for it

0:32:04 He starts applying transformations. He saves it. He then rescaled the stroke and copy and paste it several times. He then listened to the result.

0:33:42 “I’m nearly finished. One more gesture”

0:34:00 The composer draws another stroke across the board. He chooses a sound and affect it to the stroke. He tries an effect and ask:

0:35:05 “So, logically, if I rotate that, the transformation is going to change, right?”

0:35:07 “Yes”

The composer tries the effect and is satisfied. He saves the sound. He then move the stroke closer to the group of strokes.

0:35:42 “Ok that’s it”

He then saves the sketch and listens to the whole composition. The result suggest him new modifications. He applies transformations to the last sound.

0:36:31 “That’s nice. I wouldn’t know how to do these crazy things. They represent what they are. That’s interesting, because the transformation’s done and I can redraw it and then retransform it. So it’s like a mark of what I did to the sound. That’s really interesting, I can see that ’s working for me. So logically I can do this...”

0:37:10 the composer rotates the last stroke and applies a transformation. He then saves it. This took a long time.

0:39:21 The program crashed, out of memory. The program was restarted

0:40:25 The composer listens to the sketch as it was when it was saved.

0:41:30 “Could you get to display a pen when you’re drawing? Because I don’t really know when I’m drawing or selecting a stroke”

0:42:00 “Yes, that’s a good point”

0:42:18 “All right, I feel comfortable that I would use this, as a way of getting started with a composition. To generate early materials.”

0:43:00 The composer draws another stroke and affects a sound to it (see figure B.18).

B.3.1 Interview

0:43:44 “Ok, what I’d like to be able to do, is to do some sort of time stretching.”

0:44:04 “Yes, but how would you see the mapping between time and its representation?”

0:44:14 “Well, there’s a deviation from the actual, current time. So if you had a central line the same way you do with the pitch shifting and you were deviating in time, either way, shrinking or expanding. So you would end with a multiplicative factor to do time stretching. And it’d be nice to know how long does a sound last. But you don’t have to do any of this, it’s fine as it is! It’s quite flexible. And it’s an interesting way to abstract away from the sound itself. What is interesting for me, when you’re making a composition and you’re using Pro Tools or Logic,

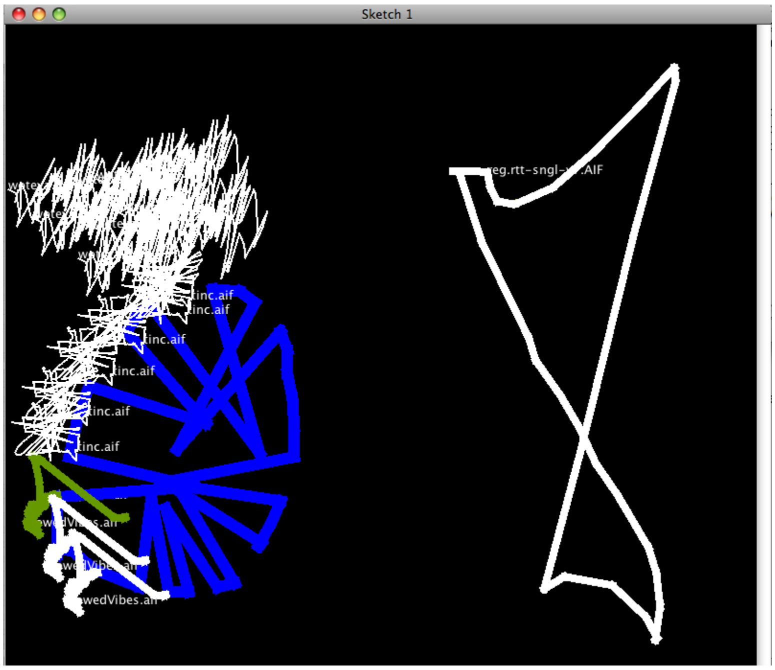

Figure B.18: Final sketch

you spend an awful lot of time looking at the waveform and not listening to the sound. A friend of mine turns the monitor off when he composes. Looking at the waveform is not actually very compositionally interesting. Having an abstract representation, it's really exciting. And it does mean that you engage with an abstract process as opposed to engage with a technical process. So from that point of view it's a lot of fun because you feel like you're exploring in a mess, in a limitless, you know what I mean"

0:47:39 "You mentioned that you would use this program to generate early material. Would you use that to explore a composition before you develop it?"

0:48:00 "Yes sure, absolutely. In the same way that I would use something like Audiosculpt. Not for the same reason though. When I use Audiosculpt, I use it because... it's a way of generating sound materials. What's really interesting about your program is that you can actually get sections of music as well, so that's one step beyond that. I'm not comparing it to Audiosculpt, because it's not the same thing, but what I like about this is that I can mess about and make a sound and then import that somewhere else and then use it. I would certainly use this for the same sort of reasons. It's got the kind of open ended creative approach, which means that you can just think irrationally. Which you really have to do when you compose. Anything that gets you away from the.. especially in the early stages, anything where you can just try ideas out. The fact that I can take sections that I developed in this preliminary area and put them together in a different way and reorder them. As chunks of essentially abstract graphic notation of a transformation that I've done. Because I'm thinking of it in terms of the transformation, as opposed as in terms of a representation of the sound. I'm thinking: I did something and I could remember doing that and I know what it is. This works as some sort of a refined marker for the process I'm engaging with, which is easier for me to remember. It feels quite intuitive, just in terms of elements, you know? It's like a record of your practice in composition, of your exploration. And you remember just that, so you know what it's for and you know how to think about the representation. And so, that layer of abstraction, what's being stripped away, are all other things to do with doing the process, which are technical. You don't have to remember what it was you did, you know that this shape make this kind of sound. That's quite a powerful idea."

0:53:21 "What do you think about the mappings? The idea that you associate a sound to a stroke and use the coordinates to control the effect. What do you think should be enhanced?"

0:54:10 "There's on way I think that it could be improved. It would be good to have a more real time feedback. That would be quite satisfying. The more real time, the more intuitive the process can be, the better it is, in terms of getting to that irrational space that you occupy particularly at the beginning of a composition. The more you can strip away and facilitate play, the better it is for that kind of activity."

0:56:00 "What kind of transformation would you like to have?"

0:56:15 "Having a time stretch would be good, and a good synthesizer. Also chaining transformations together."

B.4 RH

0:00:00-0:09:12 In the first part of the study the composer explored the possibilities of transformation

0:09:12 “So, if I decide that this is the kind of things that I want, I can actually save that drawing for that sound specifically, can I actually write another sound on top of that, I mean it’s a compositional tool so I can actually start layering different sounds?”

0:09:42 “Yes”

0:09:45 “What tells me about the duration of, hem, of length of the sounds or anything, is there any graph that you can have, I mean, if I place an other object here (he points at a location on screen on the left of the stroke that he had drawn) does it mean that it would play that first before that one?”

0:10:02 “Yes”

0:10:05 “Ok. So this is almost like a time frame.”

0:10:10 “It is. Exactly.”

0:10:52 “And is there a set length at this time, of what you can actually draw on here, like 2 minutes or 1 minute or something?”

0:11:12 “Yes, the overall length of this sketch is about 40 seconds. The time is 50 ms per pixel. The cursor here, if you press the play button it would move across the whole sketch and trigger the sounds”

0:11:35 “Allright”

0:12:00 We explained the selection of objects and dragging. The composer then went on to play the sketch.The options for playback were then explained (loop sound / play once / resize the stroke)

0:13:19 “Ok, so for example if I want to keep this sound, what do I do to go to the next sound?”

0:13:26 “You just click on the pen button and carry on drawing on the sketch”

0:13:30 “Oh ok and then you just associate them with whichever audio file that you want”

0:13:36 “Yes”

0:13:40 “And you can, I mean I take it, I could just drag another drawing, I can draw something right across the surface of this one and it’s not gonna affect anything?”

0:13:53 “Yes, you can do that, it wouldn’t affect anything”

0:14:00 “So, at this moment in time, is this only a free tool, or is there like a, can you synthesise it with pre drawn shapes, like a ellipse or anything like that, is it purely a free hand tool?”

0:14:16 “Yes, it is just a free hand tool”

0:14:20 “Ok, so it’s not lik the Acousmographe where you can actually associate sounds with sort of actual patterns or such or anything?”

0:14:32 “No, there’s no pattern”

0:14:38 “I would imagine, this would be a lot better with a graphic tablet, cos I mean there’s no dexterity with the mouse really, is there? Is there any way, I mean is there any button combination you can draw just a perfect straight line or anything?”

0:14:56 “No”

0:15:20 “That would be very handy. If you can have a button, you know like a configuration where you would just hold down ’control’ and drag so that would be a perfectly straight line, that would be good. Vertically or horizontally I would say. It immediately strokes to mind that that would be a much easier concept to work with.”

0:15:45 “Undo?”

0:15:48 “There’s no undo”

0:15:51 “There’s no undo? Oulalalala. So you can’t erase?”

0:15:58 “You can erase, you just have to select a stroke and use the delete button”

0:16:03 “Ok”

0:16:05 “You can copy and paste things. You can open a new sketch, if you want to elaborate on them and then import your movement in the main one”

0:16:13 “Can I combine any of these? So if say, I just draw a line if I want to add something to it can I actually combine them?

0:16:24 “No, it’s something that has been reported in the past studies too”

0:16:34 “Yes, that would be quite important to me too if you want to fine tune a shape, not so much with the editing of the strokes or the resizing or anything but to actually sort of emphasize certain elements of it, that would be very, you know, to be able to copy and paste onto the original design anyway so if you want you can make change. That would be very desirable for me, I think”

0:17:10 “And can you, I take it, can you time stretch with things?”

0:17:15 “Hm, no”

0:17:30 “Ok” The composer went on to draw a new stroke and allocate a sound to it (see figure B.19). When exploring the samples he asked

0:17:44 “And is there a preview function for any of this?”

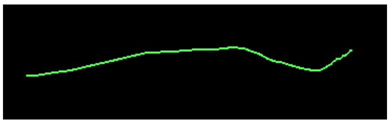

Figure B.19: Drawing of a stroke

0:17:50 “No, not in the explorer”

0:17:53 “So if I just preview it there (in the inspector) that’s gonna be from that sound, from that graphic?”

0:17:58 “Yes, but it doesn’t affect the sound”

0:18:00 “Ok” The composer went on to listen to the sound using the preview button in the inspector. He then edited the points in the stroke and listened to the transformation using the filter (see figure B.20).

0:19:45 “At this moment in time there is technically just four parameters with which we’re actually using manipulations of the original sounds?”

0:20:00 “Yes”. The composer listened to the outcome for different settings for the filter and finally deleted the stroke.

0:20:45 “Also, something else, which I take would be tricky to use, is to assign, if I wanted to make a cluster of very short percussive sounds, I would have to draw each one and assign the same sound to each.”

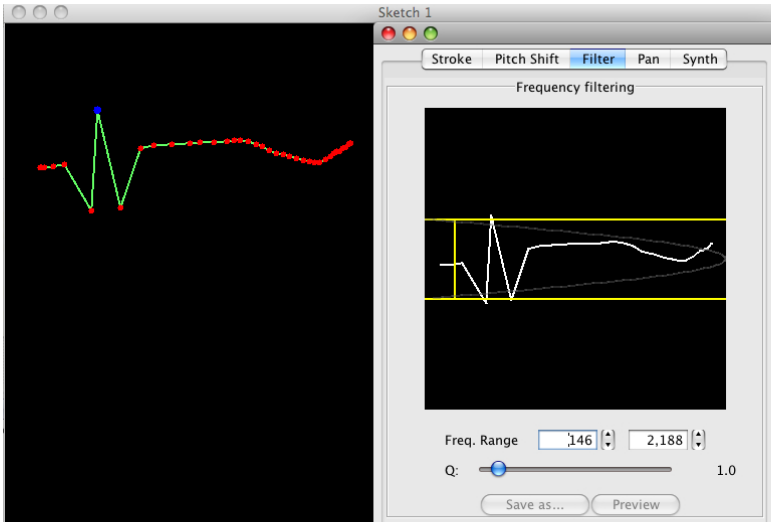

Figure B.20: Manipulation using the filter effect

0:21:00 “No you can select all the stroke and assign the same sound to all of them”

0:21:35 “Oh ok. So (he draw several shapes) I would have to select them all and... (he select all the sounds and go to the inspector to load a sound)” He then listened to the whole sketch twice.

0:23:04 “Ok. So regarding the actual length of the illustration here, it just triggers the sample. It can’t alter the length of the sample with the length of the actual illustration. That would be very important I think. To be able to adjust the length of the sounds or the playback, and obviously with using a cluster of very short attacks there, hearing it, it’s kind of, you’d have to try and, as well as temper the sound to the actual illustration of how long you wanted the sample to play back. It’s also interrupting, so to me, it would be that if you wanted something as complex as this as you can hear it’s kind of like the sound is jittering and being sort of interrupted in a way, which would obviously make you want to refrain from trying to do anything too complex with one individual sound by itself because obviously right now it seems to be struggling with sort of operating that kind of complexity, even though it’s hem...”

0:24:50 “Well, it used to work better...”

0:25:02 “Yes, it seems that the smoothness is not there. The reproduction of.. it’s jittering too much” The composer went on to play the sketch again, and the outcome was jittering, as the Music Sketcher wasn’t able to play back all the samples properly.

0:25:22 "Yes it is struggling, maybe because the sample is very long (30 sec)"

0:25:02 "And I definitely think that, you know, because now it's just playing back the whole sample in itself it would be much more easier to be able to adjust the length of the sample to the actual length of the, hm script."

0:25:35 Reading the inspector when several strokes are selected: "Select one stroke at a time to apply an effect. Ok, so also again can you apply one effect to all of the sound or does this have to be individual?"

0:25:50 "Individual"

0:25:53 "Right so I wouldn't be able to group, filter these sounds , it would have to be... Ok"

0:26:02 "Yes"

0:26:06 "That would be very handy, to be able to actually group, hem, a selection, to apply each effect. Otherwise it would be very time consuming."

0:26:17 "If they all contain the same sound, you could edit one of them and then reassign the transformed sound to all the strokes"

0:26:32 "That's true. But it's kind of, I think when you try to do something, I mean I would see this much more as a compositional tool rather than a improvisational tool. I think it would be, I don't think you would get much done in an improvisational context"

0:27:08 "No, absolutely, but this is a compositional tool, so that's ok"

0:27:32 Confusion with the pen and selection. The composer tried to select a stroke but the system was in drawing mode. The composer tried out a transformation on one sound. Given that the stroke was very flat and short, the transformation was not smooth. The composer went on and recorded the result.

0:28:38 "So one thing that is a bit annoying is that you need to wait for the whole sound to be recorded before you do any more interaction"

0:29:11 "Oh ok"

0:29:31 "Is there a notification when this is finished"

0:29:36 "Hm, not really but when it's finished you can interact again"

0:29:42 "Ok" The composer then carried on applying transformations, but this time Max/MSP crashed so the effect couldn't be applied. Max/MSP was then relaunched

0:31:09 "At this stage, it is not as complex as, for example, than GRM Tools. Certainly, a much more sort of, kind of multi operational effect application would be interesting in the sense that you could have a pitch and a delay combined. I think, the thing for me is that, right now, what immediately strikes me now is that I wouldn't, what I would find frustrating is that I couldn't have any sort of real time sense of what is going on in the sense of the reproduction of the sound on what I'm doing, so, I think I would find it frustrating to, even though it's a compositional tool and I understand that, I would find it frustrating to, it almost strikes me that it would take me too long to actually do something in its current form that I would want to hear quicker results from various aspects of it and certainly with the application of the effects, and also that the, not being able to control the sample in itself, in the sense of being able to, you know, apply the actual length of the sample in itself, that would be graphically represented with the actual illustration. You know, you decide, obviously if you wanted a short attack or a longer note or something rather, that would be very interesting to me to graphically represent in time how much of the sample you actually use. But also to be able to have a much more, quicker interaction with the actual effects themselves, I think, in the sense of being able to create a little bit more complex, hem, effects. As it strikes me right now, I would personally, I think would use this much more as a singular sound source for individual sounds rather than a compositional tool to make a composition on the board itself. I would use it as an application to actually use a treatment of a very individual sound in itself, record that and then actually use that recording of that sound in an other application, iLogic Pro or something like that really to actually create the compositional sense and the use of sounds. I think, as it stands right now that's what I'd find myself using more, more than actually using this representation as a compositional script or context. Hem. I mean the way I often work anyway is very much in the early stages of doing anything like this is very much based on an individual sound and the way that I would manipulate that individual sound with a process. You know, in my music, my processing is not so defined by the dynamics of the process in itself, it's more about the actual recorded sound, and all the processing is always very subtle, just enough to enhance the movement of the sound or the tonation of the sound, the timbre of the sound. I mean I would never personally use pitch shifting in the sense of actually having the sound go from one pitch or another in that very sort of linear fashion of just tuning it down. I mean it's interesting but at the same time it's not really part of my style of composition. I think I would again use the pitch shifting very subtly but I would only use it in the sense of actually pitch shifting the entire sample itself rather than taking from one semi tone to another, I would actually just use the whole sample and pitch that and then make a combination of those pitches, of the way that the sample would shift in the very dynamic sense."

0:38:10 "Could you try to compose something, even though it's not ideal?"

0:38:20 "Sure, sure, these are just my initial thoughts that strike me immediately of how or why I would come to interact with something a bit more in the sense of how or why I approach my own work in itself, so these are just initial thought. Right now, just finding my feet with the processing. Let's try and see what we can do. So, hm, how would I, unless I've actually drawn something rather, is there ways of accessing the individual sounds themselves to preview before you do manipulations? "

0:39:40 "You can browse the samples in the finder, there"

0:39:45 "Sure, but I think maybe what would be good is to have a browsing menu in itself where you could list, kind of what they have on radio where you can just have the samples in a very accessible point without having to sort of jump through menus all the time. So maybe another window where you basically have an access of the sounds that you could preview in the individual sense. And also maybe even a drag and drop function of that sound, you just grab the sound and put it straight in the sound file itself."

0:40:30 "You can do drag and drop from the Finder to a stroke"

0:40:40 "Ok" The composer went on to listen to sounds using the Finder. When he found one that he wanted to use he asked:

0:41:10 "So I can't just grab this now and drag it anywhere?"

0:41:16 "You would need to draw a stroke first and drag the file onto it" He then drew a straight line and dragged the sound onto it. He edited the points and listened to the filter transformation.

0:43:20 "So, hem, these edit points, I can't actually shorten this line drawing, I can't just say, ok I really want to keep this part of it I don't want to keep that part. I can't just edit those?"

0:43:34 "Like a crop, no there's no crop function. But you can zoom the whole thing out"

0:44:10 "It's just trying to harmonise, control the actual illustration with the actual length of the sample itself. You don't want to sit there just keep drawing too many different lines or too much of everything with the sample, that would last only for a certain amount of time." He then erased the stroke and started to draw a new one, after having changed the thickness of the pen. He listened to the transformations, which once again were very subtle, as the line was almost straight.

0:46:20 "I think if there was a way to multi process these individual sounds without having to keep going and save individual sounds and then do an other process on top of that, that'd be a bit more interesting I suspect. That I could actually pitch shift it, have a function where I could keep the pitch shifting and then go to the filter and combine the two instead of having to maybe save the thing, pitch shift that, save it, and after open that to actually doing any filtering...."

0:46:36 "You wouldn't have to open it though, the new sound is automatically loaded in the stroke"

0:46:40 "Yes but you'd have to rename it, because you'd want to keep the original sound itself" The composer chose another sound and operated some transformations. Again, the sound result was not smooth, due to the little variations in the strokes. He erased all the strokes and started to draw new strokes to which he assigned the same sound (see figure B.21).

0:52:00 He went on to listen to the sketch and then operated a copy and paste on the strokes that he drew. He then listened to the result and reported:

0:51:20 "I definitely think that something a timeline or a grid function would be an

Figure B.21: Exploration of the time axis

useful adaption for someone like me. Of just, sort of having an awareness of exactly what time is being used in that respect." He operated more copy and paste, resulting in figure B.22. He listened to the result, which last 40 seconds

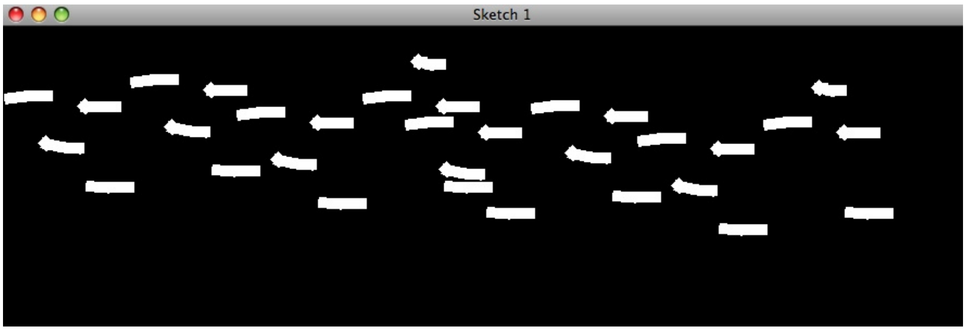

Figure B.22: Exploration of copy and paste and accumulation of strokes/samples

0:55:40 The composer went on to delete strokes and copy and paste them at different places, but he did not seem to particularly be attracted any more by the transformations. "What would be nice, is if you could superimpose the drawing function on the top of it (the stroke) so you'd have this arrangement, so to speak, in the very loose sense of the word, so you could actually draw a function of panning or something that would go right across. Because if you wanted to have something, although this is not particularly complicated, I would have to actually assign, if I wanted to, I mean what I should have done now is to just draw one stroke as a left stroke, saved it, one stroke as a right stroke, save that, and then map this out, so I would have... But if I wanted to actually have each individual stroke panning in different areas of the stereo image, possibly a function that you could superimpose the effect across the whole cluster of these strokes would be interesting, because then you could, however rudimentary, if you could sort of, actually draw the direction that you want the sound to move in the sound field, in the stereo field. And obviously, a multi channel function would be very interesting"

0:58:20 "What would that do?"

0:58:25 "In the sense of that you could say, I want that sound in channel 1, that sound in channel 2, you know if you had like a surround sound function or something rather, if you wanted to allocate each individual sound to an outptut would be really interesting. So you could, if I was sitting in the studio now with an 8-channel system, to be able to allocate each individual sound to certain part of the room would be very interesting"

0:59:12 The sketch B.22 was saved at this moment. The composer went on to draw a new stroke. When trying to chose a sound for it, he reported:

1:01:46 "Definitely, a menu, a drag and drop menu would be very useful". He went on to try the filter effect on the sound that was selected. He deleted the stroke and drew a new stroke, very flat. When he tried to interact with it, he forgot that there was no sound associated to it. He had to find again the sound that was allocated to the stroke which was deleted. When he listened to the result of the filter, he reported:

1:03:20 "It's very radical isn't it? I think, maybe, it needs to be a bit more sensitive in the sense that I wouldn't assume that that would be so radical in the filter sweep, in such of a sort of a small movement, which is possibly why I think it would be good for the function to be able to draw a straight line with the key command to draw a perfectly horizontal line or a vertical line."

1:05:45 He then erased the last stroke and attempted to draw a straight line. He allocated the same sound than previously to it. and tried the filter again. He then listened to the whole sketch. He copied and pasted several times the new line that he drew. He aligned the strokes and listened to the whole sketch (see figure B.23).

1:06:20 When he listened to the whole sketch, the new sounds would end at a moment

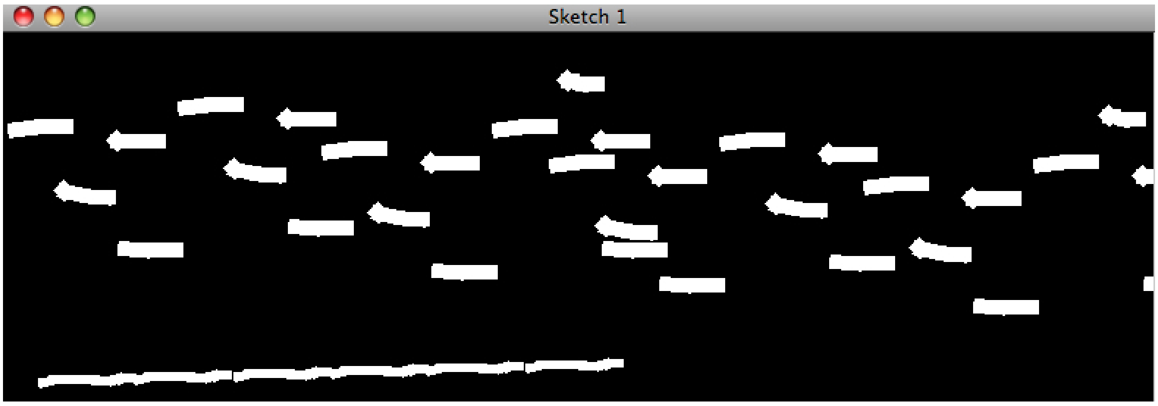

Figure B.23: Exploration of the time line. Issues of representation of time

that he didn't expect: "This is definitely something that would help, the correlation of the length of the lines to the application of the length of the samples."

1:07:10 "If you click on 'resize the stroke', that would resize the stroke to the actual length of the sound"

1:07:20 "Oh ok, I must have missed that function. That's a good function for sure. (trying it). But it would still actually play the whole sample?"

1:07:40 "Yes"

1:09:10 The composer went on to relocate the strokes where he wanted them to start and the result seemed closer to what he expected. He listened to the sketch again and moved the new series of strokes closer one to another. He then applied the filter effect to the sound and saved it. He then erased the new series of stroke but kept one. He chose another sample that he allocate to a new stroke, placed at the beginning of the sketch. He listened to the whole sketch. He then started to accumulate the new sound on the sketch.

1:12:31 "It doesn't want to move that one" The composer struggled to select a stroke, as two of them were superimposed.

1:13:02 "Maybe if you try to select the stroke at the boundaries?"

1:13:27 "Oh yes, that works" He then selected the first strokes he drew on the top of the sketch and moved them slightly on the right, in order to play them after the new samples that he added (see figure 7.32).

1:18:15 This last image was not altered by further interaction. However the composer tried a few transformations for the sounds.

B.4.1 Interview

1:20:25 "Another thing which would be very nice is to be able to change the dynamic range of every sound as well so you could have a softer strike or a harder strike. For if you were using any of the, even if you were just using an individual sound, to be able to create within each sound file the actual volume of it, even if you're using the same sound, so you could create a much more natural dynamic. Cos I take it right now there's nothing you can do with the volume. I think that would be a very good function, to have a utility to create the volume."

1:23:50 "I think what I would be looking for if I were to use this software is a much more interactive, real time interactive sense of that. I know it's a compositional tool but at the same time to be able to control these parameters a little bit more individually but also that you could mix the parameters themselves, so basically if you drew the sounds and you had a pitch shift on one part of the sound and a filter on the other part, you could actually draw within the sound itself of what you wanted it to do, kind of like what I was saying about sort of maybe being able to draw like a graph to actually feed the sound into the pans or the channels or the multi channel aspects. So in the same way you would have a much more hands-on approach of movement within the sound itself on the very, much more dimensional sense of using each individual parameter."

1:24:22 "EQ would be good. Rather than a filter, just a parametric EQ would be interesting. Reverb would be interesting."

1:24:35 "Personally, I would never use the synthesis, but that's a personal aesthetic that I have."

1:25:30 "Definitely, a menu containing the samples. It would be more intuitive to me to have a very quick access to the sounds. Literally having a list of samples in you palette, so to speak, and then you could literally listen to each one individually without going back to other menus. "

1:27:10 "I think if there was a way of correlating the length of the stroke with the amount of playback in the sample itself would be very interesting. And what would be even more interesting than that, is if you could actually have a parameter within that you could actually say, I want the sample to start from half way through or something. So if you wanted to you could take the attack away and create a little drone or something from that. To be able to manipulate the individual sample itself within this program would be much more interesting. It does only have to be at a very rudimentary level, I don't think it would need to have anything to do with editing, but just having a playback function that you can fine tune from the start and the end of the sample, like you have with rudimentary samplers where you can decide which part of the sample you use."

1:29:30 "I guess in a way, you would need to have a function here (in the inspector). To do that you would need to have a representation of the sound itself, I'm not sure. Fine tune the actual individual sample itself to correlate much more with the stroke of how you wanted it to sound would be very interesting. I think that you would have a flexibility there that would be much more appealing. In the sense to just being able to key the stroke to a certain length and it only plays back a certain length of that sample, but to actually even fine tune that further and play within the sample itself would be very interesting. You would have a flexibility there that would be quite nice to work with, cos you would then go into the sound a lot more, of your actual palette of sounds, you would be more willing to go into the sound itself and see the possibilities within this representation of it. Because then you would find a way of multi layering the same sample in a much more intuitive manner of having the same sample, in the same way that you could do with the parameters of Max/MSP, it resamples itself. A granular tool would be very nice."

1:31:44 "I'm finding it a bit hard, in this situation, to actually sort of explore within a sound what I would want from it really and I'm not quite used to using these kind of sounds anyway. I think it would be more of a case of that, for me to explore with this to be on my own and work on it for a couple of days even, to really come up with something that I would even vaguely be satisfied with. But that's more of a sense of me rather than anything else, because I'm totally unfamiliar with kind of sounds I've been given here. Because the way I work always, is to create the sounds first and then make the arrangements. It's very much in a reverse way of working to the way this works. I would be much used to having the sounds I created and would know very intimately and then look to going into a much more compositional sense."

1:34:27 "With the effects themselves, I think we could have a slightly more elaborate array of effects. And to be able to control the actual sound itself within the strokes would be very interesting to me. I definitely think that a certain element of MIDI interaction would be good. Everybody wants to get a physical interaction between the sounds and, readily have an exploratory surface to manipulate that sound. I think you would have to have that blend to get people to want to explore within that in composing."

1:35:34 "The concept of it is very interesting. I like the concept of it. I like the idea of being able to draw and get a result, a bit like HighC, where you could actually draw the pitch on the screen"

1:38:40 "Being able to combine an effect without having to keep saving it is definitely a function that I think would be appreciated. In the sense of that I could say, right, well, I want to pitch this, if you don't have a pitch representation on the screen to be able to pitch it and then filter it and be able to shift backwards and forwards between the two without to keep saving it so I think you would find yourself working in a much quicker way, if you did something that was too extreme, you could just actually go straight back and say, oh the pitch was too much I'm just gonna lift that off a little bit, without having to keep saving the sound and when you've got that combination of manipulation you go and saving it. It's a shame that you can't play this back with the pitch and the filter all at the same time. I think to be able to model the sound a lot more would be interesting, you know to model the actual manipulation and the movement of the sound within these stroke parameters would be very interesting."

1:41:30 "Personally I would want more of real time interaction, which would help with the actual compositional sense in itself. I don't think it needs like a pictorial representation like in MetaSynth because it has already been done. With Metasynth, you always have a kind of trial and error thing. You know you can't, you just have to keep trying until you find something that you like."

1:42:50 “I think that a graphical sense of time would be very important on there, to really have a time scale involved. Because then it wouldn’t be so random, if you wanted to have a much more tighter sense of the clusters of sound. A grid or a time scale would be very important, so if you copy and paste, you could actually fine tune it.”

1:43:40 “To be honest with you, for me to really feel comfortable with this, I’d need a couple of days and work with the sounds more intimately, because that’s the way I work.”

1:47:51 “This, I guess, as a prototype or anything, has a big potential, for sure. But I think who this is addressing is a bit of a grey area. I am not sure how seriously it would be taken by a genuine composer in the sense of, it’s very much used to it, notational sense, compositional sense. I think the dynamic of it would appeal much more to the... I can’t think of the right word, someone who was curious in manipulating sounds and would quite happily have a very sort of more simplistic way of wanting to create more individual sounds. I would use this much more as an individual sound manipulation rather than in the compositional sense, compositional in the sense of structuring sounds, but I’m not so sure whether I would really use it to multi layer different sounds without a lot more flexibility in the sense of being able to control the mix of it, with volume and stuff like that. I think you would have to have a lot more kind of mixing desk capabilities to really look at it as a multi track element to it. To have the thing seen as a whole would be very interesting to me.”

1:49:02 “I think on a pure level to me, it would have to have more control over the sound itself. I would like to have more control over the playback and the volume. Everything that has to do with the playback should be represented in a separate window or something”

1:50:07 “I appreciate that for you, it’s not the best pre compositional tool, as you get started with the sounds themselves. Here, I am taking sides in the sense that this is meant to fill the gap between your idea and the realisation of it.”

1:50:32 “Sure, yes, in that respect then definitely the way I would use it is as a way of modeling a sound”

1:51:16 “It makes sense for your practice”

1:51:22 “I’d like to show you a last thing, is that you can export all this in Audacity to refine your sketch”

1:55:23 “Oh that’s good. That’s really interesting. And then you’re free to move the sounds. I didn’t realise that. I see your point now. Being able to sketch, in the improvisational sense and then... That’s very interesting, have an idea and then... Ok. That’s really interesting. So it’s almost like a sketch pad. That makes it much more interesting, I mean to be able to do something like that and then fine tune it afterwards. I mean, as a tool for that alone, in trying to create that as an idea works much better now. Because obviously you got your individual sounds here and then you can work on them. So I mean, yes, possibly with going back to the original functions of it you don’t need sophisticated effects. Because you can act upon the sounds much more in this (Audacity).”

1:57:08 “As a sketchbook idea, to sketch away of doing sounds, it’s perfect. I would use that a lot. I’ve gone against everything I said before but I didn’t realise this had a much more a post editorial function to it. I was looking at as an individual tool.”

2:00:39 “Definitely I think, what is very important with the graphical sense of it would be to pitch things on screen. A grid also, to represent time. Playback also would be very interesting. And actually, forget about the interface part of it. As a tool to sketch, it takes away an element of this (DAW). When I’m at this stage of combining samples and making an arrangement so to speak, I look at it very much in the sense of I’m composing there and then in a very literal manner of like, that goes there, that goes there etc. But to have an idea of being able to demo or to sketch sounds, and to be able to do it graphically which you wouldn’t be able to do here is definitely interesting , it kind of puts a freer, a more improvisational context in composing, because you would be more free to explore. I wish I’d known!”

B.5 PS

0:00:20 “Ok, so the idea is that you use this program to draw, it is intended to facilitate starting off a composition”

0:00:25 “So, as a sketch pad for a work that you would then develop?”

0:00:30 “That’s right. It works with sounds. You have the ability to import a sound onto a stroke. You can draw by just clicking and dragging, like so...”

0:00:44 “And then you can attach a sound to that? Do you have to attach the sound after you made the stroke or can the sound...happen while you make the stroke?”

0:01:00 “It’s after. You have two ways of doing that. Either by importing a directory or a file into that browser. For this experiment I have some orchestral sounds, if you want to use your own samples, you can also use those”

0:01:19 “No, it’s interesting to work with your sounds, cos I don’t know what they are”

I demonstrated how to attach a sound to a stroke

0:02:05 “So you just literally drag and drop onto that. So what is that affecting how it sounds? How do I now trigger that... event?”

0:02:20 “You can play the whole sketch by pressing play, like so”

0:02:28 “Ok right.”

0:02:43 “So, now there’s probably something that you’d notice, the representation of time and how things unfold... The sound is not yet affected by the things you’ve drawn.”

0:02:53 “Right, so at the moment it’s just the duration that occupies this (pointing at the stroke)”

0:03:00 “Roughly, yes, but by default you’re free to represent things the way you want them to look. As opposed to impose a straightforward mapping between the representation and the transformation. If you want to know how long a sound last, you can do so by clicking on this: it reveals the length of the sound attached to it, in terms of space / time relationship. The distance in both directions is mapped to time”

0:03:53 “ So, that’s distance there, is...”

0:03:58 “The whole distance is calculated along the whole path. It’s the overall distance which is mapped to time”

0:04:08 "Right, what's the calibration though? Where is a zero point? And is it calibrated in seconds or frames?"

0:04:13 "It's in seconds, here's the zero"

0:04:20 "It's in seconds ok. So that sound commences at roughly 6 seconds and finishes at 12?"

0"04:28 "It's probably going to finish later, cos it has some variations in the vertical axis and we consider every move in every direction So if you draw a spiral for example, you could have a very long sound contained in a rather short distance, horizontally"

0:04:56 "Oh I see, right, ok. So this curve here, what is that equal, is that a fluctuation in duration or a fluctuation in volume or pitch?"

0:05:09 "Well, for now, it's doing nothing, just the way you choose to represent it at that moment. But you can use that fluctuations to control some transformations"

0:05:22 "Right, so if I want that stroke to equal pitch, how would I do that?"

0:05:28 "You can select the stroke and then in the inspector there, you have a pitch tab, and there you have two yellow lines"

0:05:39 "Oh, they're your extreme, I see. So this is the top pitch and that is the lowest pitch. Then this movement should now move between those two points"

0:05:48 "That's right"

0:05:57 "How do I know what this 'seventeen' equals in pitch"

0:06:02 "That's semitones"

0:06:04 "Oh right So that's actually 34 semi tones difference between the two. So that would now be audible?"

0:06:15 "Well, you can preview it"

0:06:20 "All right (press 'preview'). Ok, so it increments, as opposed to smoothly... So the semitones are actually steps?"

0:06:40 "Well, usually it's smoother, but that's because the stroke is quite flat"

0:06:49 "If I narrow the range of that... that's interesting, if I narrow those down, it means it would ignore all the information falling outside of those two bars, yes?"

0:07:20 "Actually, the bars are misleading in this regard. They just show the top and lowest pitches that the top point and lowest point in the stroke would correspond to”

0:07:55 “So maybe, what I’ve done by narrowing the range, it’s still applying to the entire drawing even though those two lines are showing.. right, ok”

0:08:05 “Yes, actually it does the same thing as before but now its between a smaller range”

0:08:17 “ So if I hugely reduce the possible range, here...”

0:08:24 “If you take the same value for both lines, that would just do a simple shift. If your range is of one semitone, it would oscillate within that range”

0:08:35 “Ok, yes, that makes sense”

0:08:41 “So now it’s much more subtle and smooth in the transition”

0:08:48 “Sure. So now, if I now wanted to apply variations to this, how would I do it? How would it apply to that drawing?”

0:08:56 “If you go back to the ‘stroke’ tab, you have a volume envelope”

0:09:05 “Ok, so I can draw on that?”

0:09:10 “Yes, you can drag points up or down to control the volume envelope”

0:09:20 “Oh right (doing it). And then I can drag that window onto there?”

0:09:45 “No, it applies automatically. It’s visible on the stroke here”

0:09:50 “Oh right, I see, you got this, interesting it’s almost like a brush stroke. And to play that I just, I go back to there and then (presses the space bar and listens to the effect of the volume control). Oh that works pretty well”

0:10:30 “There’s one thing, with the pitch shift, it needs to be saved to apply to the stroke”

0:10:45 “All right, so I need to go back to there and hit... ‘save as’, yes?”

0:11:05 “Yes”

0:11:10 “Ok so you have to give it the name you want to represent what it does?”

0:11:28 “Yes, it just have to finish with an aif or wav extension. It now will process the whole thing...”

0:11:43 “So, ok. That’s very interesting. If I now, if I want to make a new stroke and... I want to apply this new volume envelope, I guess it’s applied now?”

0:11:55 “yes”

0:12:06 He plays the sketch to hear how the pitch applied.

0:12:20 (referring to the volume) “I’m assuming that down there is zero, right?”

0:12:26 “Yes”

0:12:28 (inaudible) PS modifies the envelope

0:12:39 “You can remove points by pressing ‘alt’ when clicking on a point” PS carries on editing the envelope and remove some points.

0:13:05 “Can I change the duration of this? Can I stretch this event?”

0:13:10 “You can’t do time stretch”

0:13:18 “So if I want to make that event take much longer to happen, I can’t do that?”

0:13:24 “Not by time stretching, but you can loop the sound”

0:13:28 “Right, no it’s just that I like the shape of that event, but I want that event to take thirty seconds instead of five seconds”

0:13:35 “No, that’s not possible”

0:13:45 “That would be very useful above everything else, because if you want to design something like this that takes place over an extremely long period of time, it’s much more economical to design it in microcosm here and then go ’whiiit’, so then you know, there’s an incredibly slow ramp rather than draw a twenty second fade. That’s certainly something, for me, that’s something I would want to use all the time. Taking an element, where you meticulously design something in a short period of time and then you really stretch the duration, not stretch the sample or anything, but take the duration of the event to be much longer. ”

0:14:33 “But then that would change the sound sample”

0:14:38 “Well, yes, but it would, wouldn’t it, in the sense of if the sample didn’t have incredibly sophisticated looping in it, you would hear, yes, that’s true. I mean I’m used to write in MIDI then the time is kind of entirely flexible. Ok, let’s say I now want to go a new stroke, I don’t need to save the volume envelope do I?”

0:15:16 “No, it’s attached to that stroke automatically”

0:15:20 “If I... the position, vertically, if I want something to happen simultaneously, does that matter whether it’s above or below that, does that have any meaning?”

0:15:30 “No”

0:15:35 “So if I just... (he draws a stroke) At the moment, all that has is duration as information attached to it. What pitch would it start at if I don’t do anything else?

If I attribute that same sound to that drawing, if I go into this (the browser)..."
PS listens to sounds in the browser.

0:15:50 "It wouldn't affect the pitch unless you choose to do so in the inspector"

0:16:50 "I'll just drag that onto there... And then go to... Do you know what would be very useful, when you are drawing this (the envelope), it would be nice to have some calibration that was relevant to that (the stroke) appearing here (the envelope) so you knew... Ok you know that's zero, but you don't quite know how much louder than zero that is. So within the reference... Actually what would be really useful would be an indication somewhere here (the envelope) of the maximum volume of the other sounds. That would be quite useful. So if the other sounds were different colours you'd just a red notch there, an orange notch there and a blue notch there, so you could see where this was going relative to the sounds that are already there and their volume already, because then you'd have, I mean you're gonna find out eventually, but usually as you progress into a piece and you're making a decision about the position of a new sound, the volume of the other sounds would be useful to know, because normally of course when you're doing that at a mixing desk you can see that very quickly with the maximum levels of the tracks. What I'm wondering is how loud is this gonna be compared to the things that are already there"

0:19:00 "Well you can listen to the sound to get an idea"

0:19:05 "Yes, what I'm thinking is speedy feedback that removes none musical processes from what you're doing. The fewer number of times you need to go and think about numbers the better. Because all you want to think about is sound. This is why I hate digital mixing, because you're always having to open new windows and look at all of these things instead of with a desk, you glance at it and in a second your brain goes 'I can see what the volumes are, what's being sent to somewhere, whether there's EQ on that channel or not' and so it's an instant snapshot and you're not derailing the creative process by having to go 'open window number five, going to the send window, going to the EQ window' because by then, for me, the process is starting to break down. Especially if you work quickly, it makes working difficult."

PS plays the sketch

0:21:03 “Ok, so now I want to go back to the one that I’ve just clicked”

0:21:11 “Well, I think you’re still in drawing mode so you’d need to select the mouse here”

0:21:24 “Ok I go back to the pitch shift. You can’t have a smaller range than a semitone? That would be very useful, because in this particular instance, for me now, I really want that pitch shift but I don’t want anywhere near as much as a whole semitone. Like I want a quarter tone maybe of drift and a semitone is too much. It would be really nice to have, maybe, I would divide again by half or even by quarters, cos actually, the amount of drift that you would have, if I was instructing performers to play this part, I would instruct them to play tiny, microtonal sort of amounts”

0:22:23 “But in this case the variation applies between the lowest and top point, so the variation within this range are really tiny”

0:22:33 “Cos obviously, if you increment less than a semitone you can create all kinds of very complex overtone system that behave very very differently than if it’s a whole semitone. So that would be really useful. I mean I’m only thinking of things that I would immediately... or what would be nice to use, what would be good”

0:23:03 “There’s something that I need to show you. If you go back to the stroke tab, you have this button ‘edit the stroke’ and if you press it, you can edit the stroke”

0:23:25 “Oh ok, so you can change the stroke after the fact, interesting”

0:23:32 “So, a way of doing what you wanted to do is to drag a point very low”

0:23:40 “Yeah, reduce the amount of... Now the only problem with that is I can’t really se what Im doing cos it’s so small”

0:23:45 “You can extend it if you wish, using the magnifier. You can either use the magnifier individually for a stroke in the inspector, or globally in that bar”

0:23:57 “Perfect. ” The composer started editing the points. “I suppose that it could become quite quick when you get use to it”

0:25:12 “One thing though, you’d need to save the sound each time you want the transformation to apply”

0:25:20 “Ok. Can I replace the sound then?”

0:25:51 “Yes”

A problem occurred while saving the new sound in the same file.

0:27:48 “If you drag a sound onto the sketch but outside of a stroke, it would import the sound as a flat stroke”

0:27:55 “Oh ok, can I undo that then? ok”

PS imported new sounds onto the sketch

0:29:45 “So how come that this sound goes much further than the graph?”

0:29:54 “It’s because one of these sounds is very long, so you’d need to reveal the length of the sound to see how long it lasts”

0:30:10 “That’s fine, cos I like it being that long and I think it’s always good to embrace things that happen. Can I add more strokes now?”

0:30:49 “Yes, sure”

0:31:06 “How can I get new sounds?”

0:31:18 “You can import a new directory of sounds, here under the folder ‘samples’. ”

PS went on exploring the library of sounds

0:32:42 “I like this sound, but it’s quite long. Is there a way to shorten it?”

0:32:55 “There’s a way around it. You can edit its envelope”

0:33:09 “Ok, so to make it shorter, I need to guess... That’s another thing that would be useful, to get a time calibration here cos I know that this represents the whole sound but I don’t really remember how long the sound is. Ok, I’ll just play that now. That gives me an idea.” The composer went on editing the length of the sound using the envelope. He added several sounds onto the sketch.

0:41:08 The composer imported a new directory of samples

0:42:05 “It doesn’t really matter where I put the sounds in the sketch does it?”

0:42:12 “It matters when you play the whole sketch back, but otherwise it doesn’t”

The composer listened to the whole sketch

0:42:51 “That’s interesting because there’s a lot of different ways you could do this. You could just start scribbling and loading sounds on them, and then listen and adjust them or do each file separately. Yes, it’s has different consequences for each different method.”

PS listened to the whole sketch, which lasted 45 seconds. We started to save the sketches automatically from that point.

0:44:28 “How far this would go before break up? (referring to the pitch shift)”

0:44:38 “It wouldn’t break up but the sound would contain artifacts”

0:44:58 “That’s interesting, it’s as far as it would go. I’m going to save that. ”

0:45:43 “We now have to wait for this long sound to be processed”

0:45:55 “That’s ok. We can amuse ourselves by watching it. If the system is too quick then you don’t have time to think about your decisions. You don’t have some ‘thinking time’. That’s the problem with too much computer based stuff, once it reached a certain speed of operation, you don’t think, you don’t have a moment of silence to think about your decisions. It’s good to have this, just to give your ears a rest.”

0:47:40 “(referring to the pitch shift) It’s interesting that it incrementally move to the one semitones so it broken the semitones into four steps, which actually would be nice. That’s a strange error, but it’s a nice error that I would use cos it works pretty well I think.”

0:48:02 “I think that if there was a larger variation between the extreme points that would work better”

0:48:07 “I think that’s probably true, but... yeah, I’ll save that”

0:48:43 “So presumably, would you imagine that if you were using this process, you would then move to another tool to do more elaborate editing, or should this be a complete thing?”

0:49:00 “That’s yet to be determined. But the primary idea was to allow observing the early stages of composition”

0:49:14 “Ok, so that’s fundamentally more for sketching than for... final editing”

0:49:18 “In the first experiments I’ve done, I developed a way for this program to communicate with Audacity to further refine their composition, but it was rarely used, for some reason.”

0:49:38 “Maybe it had to do with the fact that composers don’t use Audacity”

0:49:45 “Yes, maybe it would be more sensible to do it with Logic, cos everyone uses it”

At this stage the piece was played and it closed the subject.

0:50:53 "When the cursor reaches the right end of the sketch, it goes back to the beginning and carries on playing, so some samples can be played again while other samples can still be playing"

0:51:01 "Yes, of course. So you have to start from the beginning."

0:51:32 "Dum dum, How could I know where that sound comes from? Because I can't see the length... It would be very useful to see like a ghost on here (by the stroke) of the sample's actual length, as opposed to the length of the stroke that you've drawn. Because you draw the stroke, but in fact if this sample, because I haven't ended the sound in the volume envelope, actually continues to thirty second, it would be nice to be able to see that it will because you could then say 'oh I got all this extra material'. This is one of the problem I find all the time working in Logic, is unless you go into the sound wave viewer you can't see how long things are. So if you extend something past the end of the sample, you don't know that you've extended it past the sample, until the sample just stop. So if you had like a... a filler, where you could draw up to here and then it stops, you could say 'ok so I need to put a loop in here' or something. It would be really useful to see the capacity of the sound file as opposed to what you think you've drawn."

0:52:24: "You can do that by doing a right click and choose 'reveal the length of the stroke' and then..."

0:52:53 "Oh ok, so then you would see... So for example now, when we're there, how could we figure which of the things we're looking at actually makes the sound we're hearing?"

0:53:14 "You could listen to the sounds independently to check which one it is I guess"

0:53:23 "But I'm thinking of a quick way. Because to do that now, would actually take several minutes, because you'd have to turn them off systematically and..."

0:53:32 "Actually no, you can select a sound and listen to that one specifically"

0:53:46 "Which sample, which stroke am I listening to?"

0:53:55 "That's the one which is selected here. Do you want to reveal the length of it?"

0:54:02 "Yes, that would be really... Ok, that's definitely that one. So in fact you can do exactly what I wanted to do. SoI can now drag that stroke and... Ok, so volume envelope, I need to chop that... Ok that's what I needed to do, so that's good. Is there a shortcut for revealing the length of the sample?"

0:55:05 "No, the quickest way you can get there for now is by using right click"

A few edit on the strokes occurred.

0:59:18 "Would you imagine that at the end of this, the sketch then becomes a score, or you're not interested in that?"

0:59:30 "I am interested in that, absolutely, although it's not the primary goal. But it is important to see how composer would end up thinking of their sketches as a score, or as a record of the process"

0:59:49 "Yes, because it's what is. That's legitimate I guess. I suppose that it depends on, if having a score of the process is important to you, because it wouldn't necessarily be a score that could be used by anyone else, because it's so specific to this process"

1:00:02 "But it represents something for you"

1:00:10 "Yes, totally, but in the sense of... I mean a score has two functions. It has a functional role, like a document for you or its function might be to communicate to someone else. So this is useful for the first one, but less for the second one."

The sketch was played then, and its loudness prevented continuing that discussion.

1:00:42 "That's interesting, the looping thing is interesting cos if you set something up properly you could really have it play in real time and you can constantly delete and include and extend things, randomly. I really like the idea."

The composer went on drawing a few more strokes. He added sounds to them. He used the filter effect on one sound. He applied subtle transformations to the envelopes of the sounds

1:07:50 "I'm gonna have to stop soon, cos I have a conference call in fifteen minutes. But what's very good about this is that it allows me to do things that I would do anyway, it doesn't force me to do things that I wouldn't do. If I were trying to do something with any number of different methods, it would work like this. Which is good, cos you know, my principal problem with software writing is that they force you to write in the way they want you to write, so this seems a very easy way to do what I do anyway, so that's pretty good. I mean, this is a much more comfortable way for me to work than Logic is. I mean it's a great tool, but it doesn't suit the way I think at all. Now, when we move over the stroke, are we still over the stroke that we selected before?"

1:09:44 "Yes"

PS went on editing the volume envelope and then listened to the whole sketch. A distortion was noticed which came from the accumulation of the sounds.

1:11:04 "Another thing that could be useful is a global volume envelope, so if you go to one of these sounds rather than having to adjust every single point down you could then just capture the whole level of the entire event, literally like a master. That'd be very useful, because that first accordion sound is too loud. Cos you don't want to turn all the recording down, but go there and if you want to attenuate that sound a little bit then you would need also to edit all the points."

1:13:02 "It's very usable. I think once you got used to it you could build up a sketch very quickly. The only thing for me, if I could make one change only, it would be to change the length of an event, so you could actually sketch in microcosm something that you actually want to last an hour and half. Because a lot of the work I do is very long durationally and it isn't practical to do that in the real time, you know, if you're making a 5 hour piece to have to go over it in 5 hours every time you review it, you've got to go for 5 hours of it, and that's very time consuming. So if you can actually say 'ok this is the configuration of events in relative position to one another, now stretch the duration for forty minutes or whatever'. Of course you'd have to check the samples to make sure that they work but, it's more the proximity rather than duration of the events, the distance between the events that is important. And if you know it has integrity over five minutes, you'd know it would hold that integrity over a longer period. But it's quite hard to set that in real time, cos you lose your sense of duration structure. It's very hard to concentrate on large structure."

1:14:56 "There's a couple of options that we didn't go through, like copy and paste or grouping"

1:15:01 "When you say 'group things" you could grab those sounds and edit them together, could you apply pitch or filter transformation to them as a group?"

1:15:15 "No but you could export the sounds as a single sound and then import it back and apply a transformation to it"

1:15:23 "So if I apply filter information to that sound, I could copy that filter information to another sound?"

1:15:38 "Yes, if you copy that stroke, the filter information is preserved so you could use that on another sound"

1:16:15 "Cool. Well it seems to be a very powerful tool. And then you do, as you said, you do have, even if it's only for your own reference, you do have this graphical representation after the fact. And it would probably be nice to use the tablet. Although when you start drawing, how'd that reflects the sound, I'm not so sure, if you'd draw a spiral for example assigning meaning to the spiral in a way that would make it sound good would almost be more becoming about making the spiral sound good and not about the sound, the music. So that's almost like this graphic score would become the end artifact, really."

1:17:18 "How do you usually relate to visual interfaces?"

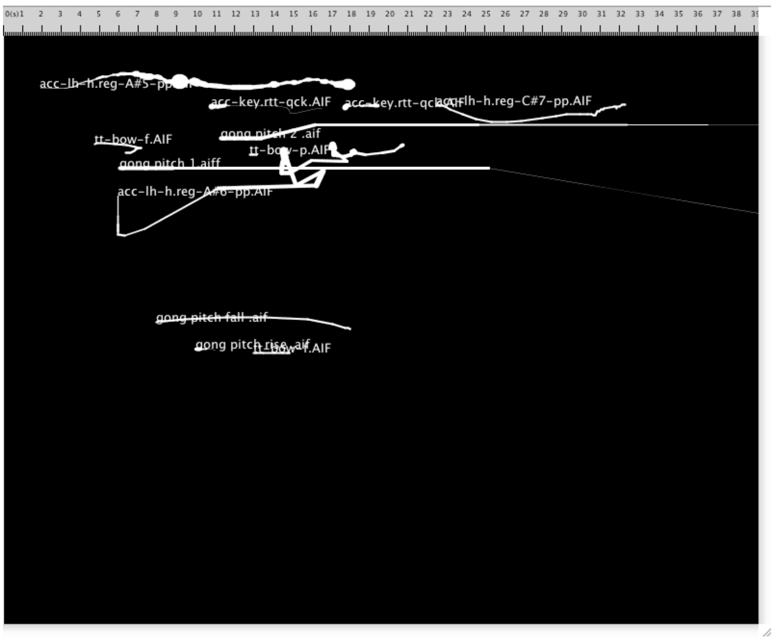

Figure B.24: PS, final sketch

1:17:25 "I try not to use them. I usually don't use them at all. For years and years I've just used the Roland MT 500 micro composer, which I'm good enough to use it without looking at it, it's just a little keyboard, it has no display. I'm slightly phobic about looking at displays because I think that too many composers start to make the music about the display and they're not listening any more. You know the thing about anticipating, because you can see a sound coming, I don't think you hear it the same way you would hear it if you didn't see it coming already. I think it's a big problem, you need to hear the sound purely in the context of sound. A lot of people, I go to their studios, they're mixing with the computer here and I think 'you're not even listening to the stereo field properly, your head is in the wrong angle, just put a towel or something over the screen and just listen. So I usually use another person to edit who would be sitting between me and the screen, because I think it compromises my hearing. So in a perfect world I would always have someone driving the computer, that'd be my ideal option. But if I had to use it, I would certainly prefer to have this kind of interface than say Logic's interface or Pro Tools' interface"

1:18:42 "For what reason do you think?"

1:18:49 "Because it's less numerical. The problem for me is, the part of my brain that deals with numbers is not the same that deals with sound. And as soon as I have to think, oh, you know, '-24.3' the whole process is interrupted permanently, or if I have to open up three more windows and figure out which of these channels I'm looking at. If I do it on the mixing desk, it's fine, because for me a mixing desk is just a patent where I don't see the numbers but as soon as I look at a computer screen, I think it compromises the part of my brain that thinks about sound. And I can feel the whole process just go 'splash'. So I try to avoid it as much as possible."

1:19:47 "Do you think that it would be the case in all contexts? For example, if you work to pictures, do you still have the same relationship to the screen?"

1:19:56 "No, no no. Absolutely not. With pictures, it's absolutely, intimately related to the screen but because that's what it's for. And also it's a completely different thing because the link for me between a picture and the sound is an absolute perfect link. It's the numbers that I can't deal with. All the work I do, because I'm also a visual artist, the process for me between making a photograph and making a piece of music is exactly the same, there's no difference. It's numbers and diagrammatic things that don't work for me at all. Pictures are absolutely fine. You know I scored films for ten years, I'm completely, detachedly, (inaudible) the way I write with images. It's just numerical information, the way screens are laid out. You know, I've never seen an interface that I felt comfortable with, so you know, I nearly always have another person between me and the computer. It's just a much better way of working. It's also quicker because the other person is just concentrating on numbers and I'm just concentrating on the sound, and if they're really good, it's a very very streamed line, intuitive process. It runs under its own logic instead of having to be constantly derailed by the logic of someone who wrote the program. But I only ever made one graphic score before I did the the work and then I followed the graphic pretty closely for the work, but generally I don't work that way."

1:21:55 "How did you relate to your graphic? Did you have like temporal relationship or...?"

1:22:01 "Well it's a diagrammatic score which is based on an event over time which was an eclipse, it was basically to make a piece for a solar eclipse, so the diagrammatic score actually mimics the process of the eclipse completely. I'm not sure I can find it, quickly. Yes, that's it. This mimics the process of occlusion and reveal That's basically the time axis and I followed it pretty precisely. The piece was actually built pretty well around this 'score' "

1:23:10 "So is that meant to be interpreted by a musician?"

1:23:25 "No. It could be, but it was just a diagram for the assembly of the piece, for me"

1:23:31 "So it was a kind of intermediate representation for you to build the piece. Did that help you to build it?"

1:23:40 "Yes completely, it was the first time I've ever built a piece following a diagram that was made beforehand so I worked out how I thought the piece should work over time and the transitions of timbres and instruments, and we did follow it pretty closely."

1:23:54 "I wonder how it unfolded, because this seem quite open to various interpretations"

1:24:09 "It is of course, but because I was imagining the piece as I drew this, the piece sounded in my head exactly as this looks, so it wasn't ever made for anyone to read. But I'm sure if you just gave this to a group of players, the same number of players that we have elements in here, it would be interesting to see how they interpreted it. And if you sort of say, 'the duration of this is 32 minutes. there's zero, here's 32, off you go'. The vertical axis is density, I guess. But that's sort of explained in various parts in there. It's the first time I've ever done it and I've never done it seems. "

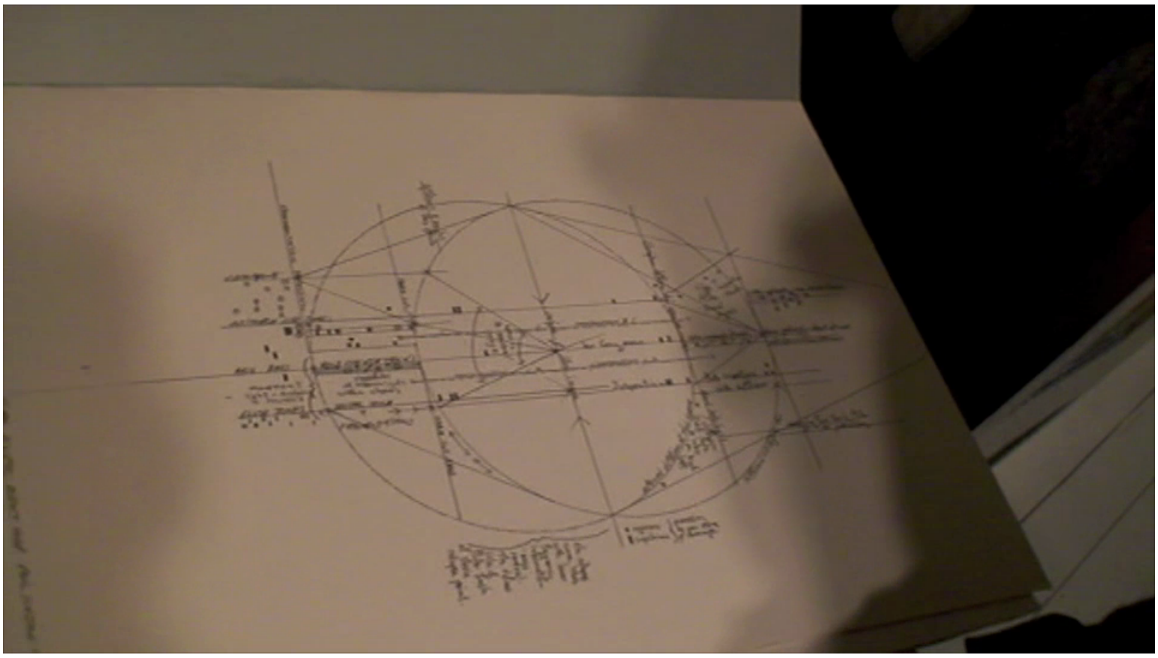

Figure B.25: Sketch of *Solar Eclipse* by PS

1:24:52 "But you felt that there was a need for that composition?"

1:25:02 "Well, only because this composition was extremely, specifically designed to reference a particular event, which had its own specific chronology and I thought that it would be interesting. And also the people who commissioned this would be very interested if there was a score and I thought 'what I don't want to do is make a fake score after the event, so I'll make one first' and in fact it really helped with the thought process when it came to make it. But, my pieces are usually not that specific in terms of their utility, so I haven't needed to do that since."

1:25:45 "So, you wouldn't sketch, really"

1:25:51 “No, I don’t. The pieces are never planned before I make them usually. I just sit down and the piece comes because of I find a sound and it tells me which sound goes comes with it and how long it should go, unless I’m making a score for something. I recently made a score for this exhibition, I don’t know if you saw this, it was installed at the White Cube and I made a score for the film. And so the film was five three-minute pieces, each one of which needed to correspond with five different models of how the universe was formed. And the models are quite specific in shapes, so we talked a lot about that and tried to mimic the sort of geometry that the pieces were made. And then the film was cut to the music, so I didn’t have to follow the film structure. So that’s really luxurious, because when you see the film it’s extremely precise, the correspondence between the film and the music.”

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