

Investigating the Usability of Software Systems for
Music Production and Distribution

A thesis submitted for the degree of Doctor of
Philosophy

by

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Abstract

The work here aims to evaluate the usability of software applications and define their quality for stakeholders in the music industry. Initial work focuses on standardised tools and procedures and sets benchmarks for performance times and completion rates across software packages, before aiming to make some suggestions about how improvements could be made in the design of said interfaces. Further work goes on to explore industry tools in the context of the real world, live performance tools, categorising them according to purpose and evaluating their success. Finally, a series of workshops and discussion groups aim to identify problems and solutions, suggesting a novel way of evaluating music information systems from a usability perspective. The work here explores usability issues in terms of efficiency, effectiveness and user satisfaction, showing that systems can fail in all three categories. While typical software tools such as Cubase are found to be somewhat usable, the changing requirements of users mean that software systems are no longer effective in performing day to day tasks required of them. There is further exploration into how software tools are used incorrectly or inefficiently, where learning curves are too steep to overcome and where systems inevitably fail. The thesis culminates in a suggested set of heuristics which can be used to evaluate current systems and used as a guideline in developing human-centred systems within the context of music performance and production. The work highlights the strengths of existing systems in terms of enabling creativity and providing an efficient platform for content creation, while making suggestions about future directions of such systems including a discussion in social web integration and pervasive interfaces.

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Chapter 1. Introduction

The following chapter describes the structure of the thesis and general expectations of the work herein.

1.1 Structure of thesis

The thesis discusses an investigation focused around the theme of usability and user experience within music centred systems. We begin with a discussion into the successes and failures of existing systems. The discussion that follows is focused around technology and music, aiming to bridge the two fields in a meaningful discussion about how technology and music can and do co-exist.

The work here takes a mixed method approach in trying to understand multiple user perspectives and user scenarios. Each method (study) is designed to encapsulate a particular user base and understand usability from their perspective, with a corresponding literature review to introduce the work and an evaluation to culminate. Each study concludes with some general remarks and a commentary about the relevance and significance of the work. The thesis culminates in a discussion about the findings from the final series of workshops and focus groups a, 'traffic light system,' designed to provide general usability heuristics about the design of such systems. Finally, conclusions are made about the significance and relevance of the work, some suggestions about future developments in the field and some commentary about the generalisation of the results in a broader context.

Chapters two and three discuss relevant literature and approaches in the context of the work being conducted. The work here aims to bring together multiple fields (sociology, interaction design, design sciences, computer science and ergonomics) in order to better understand the applied context of usability of software systems in the creation of digital audio. While there are large bodies of knowledge in music composition(Laske 1990; Jordà 2005), music theory (Ilom 2008; Leman 2007), human-centred design (Abrás et al. 2004; Hurtienne & Blessing 2007; Hurtienne

2009) and usability (Lindgaard & Dudek 2003; John & Marks 1997; J Nielsen 1992; Shneiderman 2000), there is little research that crosses these boundaries and explores the very nature of human-centred software for musicians and musical producers.

1.2 Investigative chapters

Chapter four discusses industry tools, digital audio workstations (DAWs) and general effectiveness and efficiency of such systems, before further discussing aspects of user satisfaction and how well user requirements are met in the context of DAWs. The work here is both inductive and deductive. Tasks are generated based on observations of users and documentation that exists in the environment, to model tasks that are typical of this working environment. Users are then observed and timed, before taking part in a series of sketching exercises. The sketching exercises are designed to map off current usage scenarios against user requirements and to identify any mismatch between such requirements and existing functionality.

Chapter five takes a more involved approach in evaluating the success of music systems in a human-centred context. The work here moves away from traditional studio based environments and DAWs, where the focus shifts on 'typical' use cases to more complex scenarios that occur in real world working environments. The work here is entirely deductive and the researcher has very little input in regards to the process in order to better observe usage of these tools and evaluate their success in a rich contextual environment.

Chapter six then combines the work from the first two chapters, examining user requirements and existing systems. The aim here is to generate new theories and ideas about how people interact with music systems, their wants and needs and whether or not such requirements are met. The discussions/workshops are aimed at facilitating creativity and discussing requirements in a broader context than simple use cases and scenarios. Chapter three presents a novel contribution in

the form of a framework – a set of heuristics that can be used in the design and evaluating of systems where humans, computers and music are involved. There is also a discussion here about future direction of the research. The final chapter aims to draw conclusions from the work, discuss future directions of research and make some general statements about the findings, with reference to the significance of the work and interpretations about the design and direction of future music systems.

The following section highlights the main components of the research, including the direction of research and associated aims and objectives. The work that follows then goes on to discuss the approach of the study, findings and a review of the significance of the work, including future directions.

1.3 Aims

To investigate how information systems are used to produce and perform music from a user centred perspective

To evaluate requirements of musicians against current systems

To provide a framework by which future systems can be developed

1.4 Objectives

To analyse usage of digital audio workstations in an industrial, work based setting

To explore how systems are used in a real world context and ascertain how successful such systems are at meeting general user requirements

To make a series of recommendations regarding usable implications of software based music systems

1.5 Research Direction

The top down approach here, first focuses on a very small subset of the community involved in creating and consuming audio media designed for entertainment. Each study builds on the last by switching the focus (context) and appreciating the usability of the tools which fit that particular context. The following diagram describes the typical audience of each of the studies, with a wider audience being considered as the context and goals become less defined and barriers to entry are reduced (top-to-bottom.) The thesis increases context across studies, where the findings become more refined and detailed as the work progresses. Figure 1 represents a view of this structure. As the context changes through chapters 4, 5 and 6 more complex scenarios emerge and rich context is evidenced in the latter parts of the thesis.

Study one (chapter 4) focuses on traditional tools and working patterns, through the discussion and examination of typical tasks. The first study closely relates to the three major usability factors of effectiveness, efficiency and a component of user satisfaction. These are discussed at greater length in the first study in terms of their importance and why they have been chosen as the major usability factors in examination.

Study two (chapter 5) examines usability of such tools from the field, trying to understand how well these tools work in context and whether or not there is a disconnect between the system and the user. The work here is largely qualitative and relies on the interpretations of the researcher to put findings into context and make a judgement in regards to the appropriateness of information and relevant significance of events and discussions. Study two adds context and

provides a contrast to the lab based setting of the initial study, taking a field oriented approach in research.

A final series of workshops and focus groups (chapter 6) enable the generation of recommendations about designing usable systems for musicians. This section is essentially the contribution section of the thesis, wherein the discussion focuses on findings from all three studies, with additional reference to the literature, in order to substantiate a novel contribution.

Figure 1 describes the flow of the thesis and how the investigative chapters converge on associated aims increasing deliverables over time and context across studies.

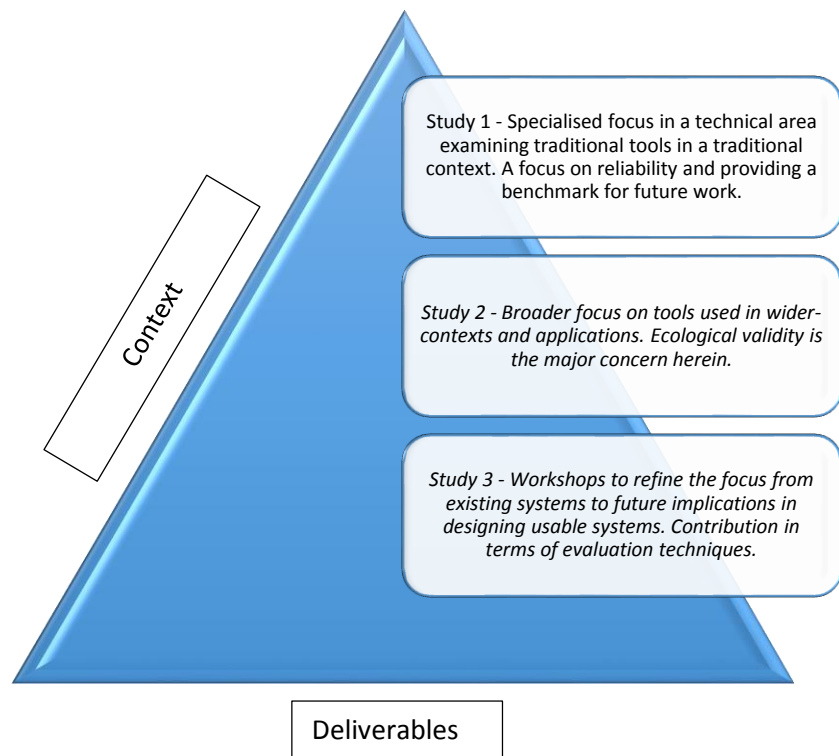


Figure 1 - Description of the direction and flow of the thesis

1.6 Summary

This chapter has explored the aims, objectives and direction of research. There is also a discussion here regarding the relevance of the work, general importance and a view to possible directions for further exploration. The chapter that follows explores relevant literature in the field and adds to the discussion of usability, user experience, user centred design, participatory design as a tool for developing robust systems and music-centred systems as a whole.

Chapter 2. Literature Review

The following chapter provides a background to the work here, describing and defining usability research and framing it in a musical context.

2.1 Usability

Usability is described as a three pronged process (Gould & Lewis 1985.) A human-centred design process, iterative design (continual) and empirical testing are described as principles of good usability practice. These techniques are utilised to produce a 'useful' and 'easy to use' computer system. Since the paper by Gould & Lewis was published in Communications of the ACM, much research has been conducted into the construction of usable systems. Nielsen later described a similar iterative process of design and development, with the same end goal of producing a usable system (Nielsen 1992.) Nielsen also produced a set of guidelines, design heuristics to apply in good design and to be used to evaluate the usability of systems, based on a number of given principles or rules (Nielsen & Molich 1990; J Nielsen 1992.) These definitions of usability engineering and user-centred design still provide a basis for contemporary research guidelines and play a large role in defining usability from a broad perspective (Seago et al. 2004; Lindgaard & Chattratchart 2007.) While many of the usability guidelines have remained the same, systems have changed. Technological advancements (Mack 2011) mean that systems are becoming faster and more powerful, providing new opportunities. Developments in the mobile market (Korhonen et al. 2010; Satyanarayanan 2011) for instance present new challenges in the form of smaller, more compact devices to design for (April 2006.) Systems are also becoming more diverse, functional and complex (Reddy et al. 2010a) presenting new challenges for developing usable systems that aim to manage that complexity (Albers & Still 2010; Redish 2007.)

While usability has improved drastically due to initiatives such as those by the World Wide Web Consortium and recent advances in technology (Dubey & Rana 2010), (Hopper 1994) the music development field has seen little change in usability of systems (Lee 2006). The problem space is not clearly defined, due to the fuzzy nature of roles within the industry and an inability to encapsulate creativity as an asset – a functional aspect of systems (Coughlan & Johnson 2006a). Various attempts have been made to bridge the gap between business and creativity and support such processes (Benedikt Schmidt Todor Stoitsev 2010),(Kerstin Klockner Kirstin Kohler & Niebuhr 2010), However, these are very limited in terms of application and focus and do not necessarily transcend well to music based systems or creative systems in general. There are no widely accepted standards in content management for creative environments. Where you compare education for instance, tools like Blackboard are widely used. Darcs, Git and various other iterations also exist around the development of software iterations and cycles. There are good examples of production suites, such as the Adobe Systems Creative package, but formalised or industry accepted standards in music production do not currently exist. This poses a number of issues in regards to production, collaboration and communication within these types of environments. The lack of a standardised system means that content can become distributed and that users have to impose their own systems or improvise with existing systems. Recent innovations have recognised the value of systems which enable creativity and provide a usable interface in doing so. The MIDI based TENORI-ON (Nishibori & Iwai 2005) for example, provides great utility in a simple but effective hardware implementation (Sasamoto et al. 2010a). The system requires no musical skill and enables novice users to pick up the system and begin using it to create music. The visual interface integrates both hardware and software, expressing each note in a linear fashion on a chronological grid. The focus here is on simplicity, splitting the interface between controls and effects and providing external support on the extremities of the device. This way the interface focus is on the creation and composition, with the frame acting as a control hub. The user effectively moves outward to increase control and configurability. Providing this type of utility in a single interface has great value in terms of usability, however it limits creativity in terms of what can be done within a finite space or domain.

In the examples mentioned previously, there is an effort to enable creativity or to enable usability, though these tend to be mutually exclusive and lack a two-pronged focus. Ultimately, a cohesive approach is necessary in both managing the complexity that creativity creates and reducing barriers to entry for users. The challenges in designing and developing usable systems is explored herein.

Modern research suggest that usability is far broader than previously defined (Hornbæk 2006.) The research here suggests that the measures of usability are context dependent and not easily defined in broad terms. Usability research takes many forms and approaches, both quantitative and qualitative (Cecez-Kecmanovic 2007; Cecez-Kecmanovic 2010.) While guidelines are present in applying usability engineering techniques, the process can be difficult for novices and experts alike (Howarth et al. 2009.) Supporting tools have enabled some headway to be made in this direction, using techniques such as sketching (Hennessey et al. 1998; Kieffer et al. 2010; James & Brad 2001; Kodagoda 2009) to bridge the gap between the user and system developer. These techniques make the design and developing of systems quicker and easier and enable both functional and non-functional representations of interfaces to be produced. This opens up lines of communication and applies some context to discussions, which often results in better interface designs.

Definitions of usability extend beyond effectiveness, efficiency and user satisfaction. Learnability (Elliott et al. 2002; Jeng 2005; Grossman et al. 2009)(Elliott et al. 2002) and memorability (Stobert 2010) are key factors in assessing the usability of software. However, the definition here is still not clear in terms of application. In practice, these factors can be difficult to implement (Molich et al. 2007; Howarth et al. 2009.) It is also important to recognise the value of good design in building usable applications (Hurtienne & Blessing 2007; April 2006.) Aesthetics also play a huge role in defining both actual and perceived usability (Lee & Richard J Koubek 2010.) Aesthetics relate back to the factor of user satisfaction, but are much more difficult to define and measure in the context of usability (Lindgaard & Dudek 2003; Tuch et al. 2012.)

2.2 Music Systems

The music industry presents a unique set of challenges in designing a system that is functionally useful and also usable. The importance of music cannot be understated here (Negrotti 2010), with some theories suggesting that it is older than language (Wallin et al. 2001; Ball 2011.) When we consider the complexity of modern instruments and the effort that goes into their design and development (Jordà 2004; Sachs 2012) then we can say that digital systems are equally, if not more complex (Jordà 2004; Jordà 2005; Farrett 1996; Fels 2004.) This complexity has to be managed in a way that promotes good design principles but also enables creativity and functionality to co-exist in a usable space (Rohrmeier & Koelsch 2012; Redish 2007.) Having defined usability in a larger, more generalisable sense, we now must examine usability in the context of music systems and determine the value of such.

Firstly, we must identify issues of music production and consider if the systems are appropriate for purpose. As a process, there is a dynamic set of interactions in place that enable music production to take place (Scott 1999.) Though these processes exist, as the previous literature has discussed, it is important to maintain a degree of creative freedom. Therefore it becomes difficult to define a process of music creation beyond an individual. The process here does not necessarily generalise well and what works for one individual may not be considered suitable for another. Secondly, there is a trending shift from traditional studio environments to home studio based recording and production (Leyshon 2009; Hughes & Lang 2003.) This extends the problem space in that instead of considering the user as a functional professional, performing a job on a day to day basis, the definition broadens. Now we must consider the roles of professionals and amateur-professionals as one in our investigation and find a suitable approach which encompasses both of these groups. Additionally, we must consider factors in building usable interfaces for this context in enabling creativity and innovation to happen (Riley et al. 2009; Gall & Breeze 2008.) There is also a suggestion that there may

be a disconnect between interfaces for musical activities and interfaces for musicians (Miletto et al. 2006; Miletto et al. 2007.) Again, this research explores the fact that goals of producers and the user experience are somewhat disparate, though both have to be considered important factors when suggesting design guidelines for building these systems. The literature identifies common features amongst users but also highlights the different goals and agendas, creating a disparity that challenges any formal definitions that may arise as the result of research in this area. The work here refers to expert interfaces and the problems of building an interface which expects a user to have an understanding of how the instrument works. This creates problems where an instrument based tool isolates non-musicians. This could also become problematic in a reserve scenario, wherein a system is designed to be all inclusive and fails to encapsulate useful metaphors and imagery that can ease the transition for musicians. The work here supports presentation of multiple interfaces, but this in itself could cause a problem when interactivity becomes an issue. Migrating between application interfaces for instance, is likely to cause similar issues to arise and make single screen collaboration difficult.

It is important to consider how soft systems are used and how they compare to digital systems. Collaborative music making is communal by nature (Benford et al. n.d.) A process as simple as managing music in groups for instance takes into consideration a number of factors (Cunningham et al. 2003; Cunningham et al. 2009; April 2007.) Digital music systems are also expressive by nature (Hook et al. 2011; Oliveira & Cardoso 2010; Mohamed & Fels n.d..) This means that systems have to be communally acceptant, interactive and manageable and also allow freedom of expression in creativity. This presents a risk in that many of these factors are interrelated and in some cases may prove to be interdependent. Additionally, music is inherently difficult to tag, store and retrieve (Kaminskas & Ricci 2012.) Therefore not only is the very nature of interactivity a problem, but the content management aspects too. We also must consider the technical issues that arise from collaborative system. One major concern in the design of software and hardware is latency. While attempts have been made to handle latency in limited contexts or scenarios (Stelkens 2003) the technology does not necessarily scale well. This is in part due to the nature of music creation, that it is not always goal oriented

(Arrasvuori & Holm 2007a) and that levels of experience, competency and musical training differ vastly (Laske 1990; I Cross 2001.)

2.4 User Experience

While usability and music research provides a good starting point in discussing areas of interest, user experience would perhaps be a more appropriate way to define the research herein. Traditional research in usability lends itself well to task based evaluation (Jeng 2005; Dubey & Rana 2010.) User experience research extends traditional definitions of goals and scenarios to more complex interactions. (Beauregard 2007.) User experience focuses on a holistic approach that is better suited to the nature of research conducted herein. The focus here is on the user being at the centre of design and development of research activities (Wu et al. 2004; Davies 2008; Arrasvuori et al. 2010.) In the particular context of music systems we also have to consider elements of creativity (Shneiderman 2000; Laske 1990) as an essential process in relation to the technology in use. This is perhaps an area that has been explored in more general terms (Crow 2006) however, without considering the context of digital audio workstations and musicians in performance and production.

User experience research aims to encapsulate a broader number of factors, relating to sociological and psychological elements as well as the interactions between technology and people. Much of the work here is grounded in anthropology (Suchman 1987; Woolgar & Suchman 1989.) The value of this research in modern terms enables exploration of ideas and processes such as situated practice (Adelson 2003) to emerge as new processes of research. The value of this research can be seen in a shift from academic value to that of both academic and corporate value (Suchman 2007.) It is clear that there is an inherent value in user experience as a mode of exploration over traditional usability research (Zimmermann n.d.; Riche et al. 2010.) This mode of research has also yielded positive results in other areas of music and systems research (Cunningham n.d.; Arhippainen & Hickey 2011; Leman 2007; Ahmed et al. 2012; Benford et al. n.d.)

Driving the goals, requirements and findings around the user is an approach known as participatory design. This process enables the joint exploration of ideas by both researcher and participants in dictating the direction, focus and outcomes of the research (Pekkola et al. 2006; Wu et al. 2004; April 2006.) The value in this approach is that it enables the exploration of complex or ill-defined problems beyond the scope of existing statistic models. Here, the exploration of contextually rich situations enables the discovery of complex and socially driven issues that extend beyond traditional metrics. By enabling participation, there are opportunities present to explore issues which are inaccessible using other methods (Lindsay et al. 2012; Wu et al. 2004.) Many of the approaches explored herein provide this opportunity and present findings rich in context and explanatory power. Sketching (James & Brad 2001; Ma et al. 2009,) ethnographies (Millen 2000; Ahmed et al. 2012) and workshops (Maiden, Manning, et al. 2004; Shneiderman et al. 2010; Schlosser et al. 2008) all provide opportunities for participatory design to take place. In the work mentioned, themes such as creativity, innovation and problem solving are integral to many of the processes. This fostering of user-adapted contexts and complex knowledge representation has enabled research to occur which may be more difficult or even implausible outside of traditional research methods and metrics. The exploration of ideas and concepts in this way also enables the exploration of otherwise difficult to measure factors such as flow and engagement (VittersÃ, 2000; Jordà 2005.)

2.3 Challenges

When we take all of these factors into consideration, even before examining usability in this context, we can begin to appreciate the magnitude of the problem space. There are many factors, requirements and complex social interactions in place, all embedded within this system. Having previously considered the complexity of these systems, we can now begin to look at applications and attempts to solve certain issues.

The creative domain is an ever changing one, with constant growth in both revenue and stature. The entertainment industry is built upon the foundations of creativity and innovation but the end result is often a tangible product or service which the end user can consume. In contemporary society, there is a fundamental need for business and creative practice to work cohesively together in order to meet the needs of a user and build a successful system (Maiden, Manning, et al. 2004; Schlosser et al. 2008).

The music industry is a thriving one, as can be seen by recent sales figures.

‘Digital music revenues to record companies grew by 8 per cent globally in 2011 to an estimated US \$5.2 billion. This compares to growth of 5 per cent in 2010 and represents the first time the year-on-year growth rate has increased since IFPI started measuring digital revenues in 2004.’

IFPI DIGITAL MUSIC REPORT 2012

Attempts to digitise music with associated metadata attached have been made, with varying degrees of success. Ontologies have been developed (Rahman & Siddiqi 2012) which focus on an annotation technique designed to be interoperable. While the idea is good in principle, it requires widescale uptake in order to be

truly useful. Other efforts to tag music in a meaningful way have been made. While IDv3 meta tags are part of the file itself, they only provide information about the track. Efforts have been made to combine existing standards (in this case extensible markup language) with metainformation about a track or series of tracks (Haus & Ludovico 2005.) If we consider the pervasiveness of XML and its variants (RecipeXML, RSS) and their popularity in various domains then we can see that this approach holds some weight. Many applications already embed XML as a presentation layer (Valbom & Marcos 2005; April 2007; Bainbridge et al. 2005) suggesting that if this approach were to be used to tag information then it would be both human readable and interoperable with other applications and tools. This is not to say that XML solves all of the problems present here. We have yet to consider elements of interaction, embodiment and overall user experience. There are also cultural factors that relate to such systems (Lidy et al. 2010; Cornelis et al. 2010) and how they are used, which cannot be encapsulated through markup alone.

Another approach taken to sort and categorise music information relies on data mining and sorting techniques that are automated (Schedl et al. 2011.) While this approach provides results of some value, it also has inherent weaknesses. Firstly, the cost of computing in terms of managing and processing this data is quite high and requires a fairly technical complex and robust system. Secondly, the system is not entirely accurate and there is a suggestion that the addition of natural language processing could be used to improve results. The system also fails to account for various situational aspects mentioned previously such as time dependency (Stelkens 2003; Benford et al. n.d.) In summation, while automation does produce some value, the cost of developing such a system far outweighs the benefits of such a system. This may be the reason why such systems do not currently exist in digital audio workstations and production environments and that the natural sorting methods of the user are perhaps a more effective or efficient solution.

While much has been said about music and creativity (Laske 1990) the area of musical creativity in modern contexts is largely unexplored (Crow 2006.) Research

here tends to focus on either a particular aspect of interaction (Oppenheim 1996; Gall & Breeze 2008) a particular user focus (Ilom 2008) or a medium for interactivity (McPherson & Kim 2013; Leman 2007; Sasamoto et al. 2010a; Arrasvuori & Holm 2007a.) While these factors are certainly important, they fail to take into account the factors mentioned earlier in terms of interdependencies, social structures and soft-composition alternatives. We are already aware of the importance of enabling creativity in a software setting (Shneiderman 2000) but part of that creativity in this context relies on the ability to interact and engage with a large audience.

Musicians have previously discussed the importance of social media and social factors in their working patterns and behaviours (Arhippainen & Hickey 2011.) If metaphors are designed to provide a cognitive map from the real world to a system (Alty & Rigas 2005; Hurtienne 2009) then it is curious to discover no such mapping exists from instruments to digital systems. As has been discussed, the creation, performance and composition of music is complex. The interactions between participants and between the participants and the system are equally complex, with different expectations and experiences present. The challenge then is designing for multiple users with multiple objectives. There is also an ever present challenge here in maintaining the relationship between the tool and the user through solid design and development principles (Jordà 2004; Hao & Jaafar 2009.) The issue that arises amongst all of these techniques is that there is not a widespread adoption of a single method and without acceptance in this format then the multitude of methods that exist simply add unnecessary complications to a process designed to make things simpler.

Some efforts have been made to encapsulate the social and cultural factors in exploring the usability problems of music systems. In an area where context is vital (Kaminskas & Ricci 2012) there are many factors to consider. The perspectives of DJs' work can be seen (Ahmed et al. 2012) to explore social, cultural and commercial problems and investigates how these issues are solved in a real world context. Here, the system takes into account the complex set of interactions, planning and general attitudes to technology in this context. The research here describes a four

stage process, shedding light on a previously unexplored area and highlighting how systems could be better designed to accommodate this type of user. The work looks at how DJs store, retrieve, accumulate and hide their libraries. Rather than aiming to define a set of guidelines, the approach focuses on exploring the motivations and reasoning behind decision making and the issues that can be uncovered through contextually rich investigation in this setting. Of the body of research herein, this work is perhaps the most comprehensive in exploring real world day to day problems over suggested guidelines which may not apply in a broader social or organisation context. Here we learn that creativity can sit within boundaries (physical collections) but also be extended through software. The challenge herein is that as the context shifts, the approaches, aims and motivations also shift. Where we explore the context of the DJ, the use of 'crates' for instance is exclusive to this particular context and would not generalise to a wider audience of musical people.

Driving the goals, requirements and findings around the user is an approach known as participatory design. This process enables the joint exploration of ideas by both researcher and participants in dictating the direction, focus and outcomes of the research (Pekkola et al. 2006; Wu et al. 2004; April 2006.) The value of this approach to research can be seen in the literature referenced. Here, the exploration of contextually rich situations enables the discovery of complex and socially driven issues that extend beyond traditional metrics. By enabling participation, there are opportunities present to explore issues which are inaccessible using other methods (Lindsay et al. 2012; Wu et al. 2004.) Many of the approaches explored herein provide this opportunity and present findings rich in context and explanatory power. Sketching (James & Brad 2001; Ma et al. 2009,) ethnographies (Millen 2000; Ahmed et al. 2012) and workshops (Maiden, Manning, et al. 2004; Shneiderman et al. 2010; Schlosser et al. 2008) all provide opportunities for participatory design to take place. In the work mentioned, themes such as creativity, innovation and problem solving are integral to many of the processes. This fostering of user-adapted contexts and complex knowledge representation has enabled research to occur which may be more difficult or even implausible outside of traditional research methods and metrics. The exploration of ideas and concepts in

this way also enables the exploration of otherwise difficult to measure factors such as flow and engagement (Vitters, 2000; Jordà 2005.)

2.5 Summary

This chapter discusses existing literature in the context of music systems and usability research. While efforts are being made to produce more usable solutions for musicians and non-musicians alike, problems still exist in both the design and development of current music systems. This problem space is also relatively unexplored in terms of how problems exist and the cause and effect of such problems. The following chapter discusses research methods that could be used to explore these issues further and potentially solve issues that occur, or at least better understand their cause and effect relationship.

Chapter 3. Research Methods

The following chapter discusses research methods and appropriateness in different stages of the work. There is a discussion as to how the research methods are applied and their inherent strengths and weaknesses.

The work here utilises multiple methods of research. The motivation behind using multiple methods is to ensure that the results are both valid and reliable. This is achievable in this way because reliable and valid methods can be combined. As each research method has strengths or weaknesses, the combination of methods enables representing strong examples of both validity and reliability. The concerns of validity in a lab based study for instance are examined in a real world environment to better manage the risk of making generalisations from limited information.

The methods used herein are largely qualitative, using grounded theory as an overarching method to generate theories and eventually propose themes and categories relating to such theories. This is a design decision by the researcher. As the field of literature discussing usability in music systems is relatively scarce (Fels 2004; Stowell et al. 2009), the qualitative approach enables the discussion and representation of ideas in a contextual way. Usability issues have not previously been clearly defined and so a qualitative method enables the representation of these issues in context, highlighting how these issues occur and why systems are or are not usable. While previous studies explore systems in this domain, the context is something that is missing in the discussion and forming the discussion around user experience may be more appropriate for this reason. Context here can be used to highlight requirements of the user and usability factors as a whole. Previous work has explored interesting areas such as the context of DJs and collaborative sharing (Ahmed et al. 2012; April 2007,) though the context and usage scenarios here are limited in that they do not explore the complex systems of interactions that take place in the creation of music. The interactions, dependencies and social factors are all relevant in this context and lack exploration from either

quantitative or qualitative approaches. With that said, qualitative approaches may be more useful in providing a descriptive analysis of events and may be more useful for this particular research topic. This is not to say that standardised usability questionnaires, mathematical models and testing do not provide results of value, but that these areas need to be explored and examined in a contextual way for this particular area of research to answer questions about usability and user requirements.

3.1 Methodological Considerations

Grounded theory is used as a supporting method throughout the thesis in order to analyse and substantiate findings from a contextually rich setting. This thesis however does not employ traditional grounded theory. The aim here is to use grounded theory as a means by which to help define and explore areas that are somewhat subjective. Grounded theory enables the representation of themes and categories, coding ideas in a structured way and permitting theories to emerge naturally. In the first instance, grounded theory is used to enable a theory to emerge from the data (Pace 2004; Elliott et al. 2002) and due to the lack of previous work within this domain, provides a useful starting point. As the work becomes more complete, categories are refined and the final contribution in the form of a framework is a product of loose grounded theory. The likeness to grounded theory emerges from the process by which theory generated using such a method is suggested rather than proven (Razavi & Iverson 2006.) For this reason, grounded theory has been used as the basis of the work here (categories, coding) but has not been employed as a strict process, where for instance codes are formed and reformed. While codes emerge to generate theories, in this case in the form of figures, they are not re-formed in the traditional sense of grounded theory. The process here suggests a theory but does not aim to re-code or re-define theories. For example, codes are not defined through strict processes and continual refinement. Rather, the work aims to borrow elements of multiple methods in order to best facilitate the exploration of problems in context. Where a more appropriate theory about the data emerges then there is an opportunity to pursue that course of action. The richness of data and context here does not

necessarily lend itself well to any coding structure, though where possible an attempt has been made to visualise findings in a coherent way ie diagrams, tables and such. The work here could perhaps be considered a hybrid of grounded theory and user experience research. While human-centred design might be an appropriate way to define the research, elements of grounded theory do provide a useful starting point (such as inter-related categories) and where appropriate, a means by which to describe the data through informal codes and categories. However, rather than using strict coding criteria, themes emerge through user-focused activities and the categories and development of themes are driven around user activities to better facilitate the freedom to explore ideas. Here, rather than employ the researcher as a means to refine and validate categories, the emphasis is on the participants to explore their ideas further and offer a less formal definition of what is happening in situ.

The utilisation of workshops and ethnographies to drive context and refine findings using a problem-solution based approach help to combat the issue of the researcher defining their own problem set. There is a real risk in the interpretation of the research missing the points and driving it around use cases and user discussions reduces the risk of an agenda or pre-disposed notion defining findings. Grounded theory is also useful here in drawing from fields that are not music related, but usability focused, as they also provide a model for constant comparative. Previous usability and human-computer interaction research, as well as research into music systems outside this domain are of use. In this case, so are theories of interaction and use cases beyond the scope of production and performance. Where usability is a somewhat subjective field, largely defined through different metrics and perspectives, grounded theory lends itself well to defining and describing such phenomena (Brown & Cairns 2004; Cross 1999.) Grounded theory is also useful in the specific field of usability and human-centred aspects, as it can be used to generate general concepts about usability from a user centred perspective (Namkung et al. 2007.) Guidelines have been followed in regards to using grounded theory in the research of information systems (Urquhart et al. 2009.) The application of such is described in the following section.

The previous chapter discusses the relevance of user-centred research in this context, including the merits of such methods. These methods are inherently mixed, as to best encapsulate the views and experience of a broad user base. For this reason, it is therefore difficult to frame the thesis around any particular method or approach. Grounded theory is used here as a best fit for the majority of the work, though focus groups, sketching, traditional usability metrics and workshops also contribute to the findings here and explore some of the codes and categories in detail. As discussed, grounded theory provides a useful starting point for the research but is by no means an exclusive approach in investigating the issues that emerge from the systems explored.

3.1.1 Open Coding

Open coding takes place at the beginning of the work, before any testing or observations occur. In the first instance, open coding is used to describe the typical tasks that are required from a digital audio workstation. A review of software systems in use (installed on systems) and associated documentation enables categories of tools to be formed. Defining processes in textbooks and in notebooks helps to form the basis of typical tasks performed. From there, tasks that can be performed with one or two clicks are described in terms of 'productivity tasks.' These are then refined using any documentation available, in this case both hard and soft copies of documentation pertaining to the software. Strict coding categories are not employed here. Limitations in terms of access of such systems are also an issue. It is important that the researcher does not disrupt the working environment of the participants here. For this reason, codes are initially defined and then refined using informal discussions with the users. Processes described as 'essential,' 'important,' or similarly described with significance are coded as key tasks in the first instance. In total, six software packages and six core tasks are defined using this method. Heuristic evaluation tools (Seago et al. 2004; Nielsen & Landauer 1993) are used as the constant comparative here, in grounding each task or functionality into a particular bracket. Initial codes begin with effectiveness, efficiency and user satisfaction upon which the results of the tasks and observations can be

used to extend these definitions further. Open coding again takes place at the beginning of the ethnographic exploration and series of workshops to add further raw data to the pool by which categories can be formed. Semi-directed focus groups are also used as a follow up technique (Kitzinger 1995; Morgan 1996). Focus groups help to frame findings in context and act as an opportunity to follow up on questions or issues that occur during the investigation (Downey 2007.) Focus groups provide a useful basis for refining and redescribing categories, groups or roles. The basis of the workshops which follow are around the concept of directed focus groups.

3.1.2 Category Development

Categories are formed in each of the three main bodies of work, with the final framework the contribution of all three in combination. The refinement stage happens based off observation, in particular where the ethnography is concerned. Here, categories of work naturally emerge and are described by the user. At this stage, distinct processes can be seen and as user roles become more defined, categories become more contextually focused (relevant, ecologically valid.) There is a risk here of focusing on a single use case and failing to recognise the generalisability of themes and categories accordingly. The arbitrary nature of categories has been discussed previously, though the aim is to try to categorise elements in terms of a particular area, such as defining elements of production and performance in terms of a distinct set of processes. The participant driven focus of the research enables these processes to be tested and explored in more detail using alternative methods and approaches such as sketching and ethnographies.

3.1.3 Sampling

Theoretical sampling is one of the core aspects of grounded theory (Fernández n.d.). Theoretical sampling enables the enhancement of theories and analysis through defining participants according to a particular theory or notion (Urquhart et al. 2009; Brown & Cairns 2004). Samples are purposive (Peters & Eachus 1995;

Podgurski et al. 1999) in relation to a particular approach or notion. In this case, theoretical sampling is used throughout the body of work. Firstly, theoretical sampling is applied in the context of producers working with digital audio workstations to ascertain whether effectiveness and efficiency are relevant usability factors in such systems. The ethnography uses a sample of working professionals in order to describe theories of social interaction and to describe working patterns outside the studio. This tests a separate theory and provides a comparison against more traditional use cases, testing real world systems in a real world context. The final theoretical sample draws from participants from multiple walks of life and different areas (both functional and non-functional) of music production. This extension of users and use cases enables the representation of multiple scenarios and interactions in order to produce a theory which is more generally applicable. The addition of multiple perspectives also enhances the data that theories and categories can be formed from and provides a useful basis for analysis of existing theories by testing them against a different user base entirely.

3.1.4 Themes

The categories generated in both the investigation of digital audio workstations and ethnographic exploration provide a solid foundation for the work here. The workshops are then used to form further categories which are again compared against the heuristics to produce an eventual theoretical framework. Where themes emerge from tasks based around the digital audio workstations and working patterns explored in the ethnography, the workshops provide an ideal platform for refining such theories. The workshops enable participation from a wide user base and therefore the themes are examined in a way which is generalisable, transcending particular working patterns or cultural barriers and aiming to encapsulate a wide a user base as possible. The workshops generate themes in an explorative and combinatorial way and refine themes in a novel way through transformative approaches to creativity. At this stage the work can be directed in a meaningful way due to the existence of a large data set and the previous generation of theories. The framework provides a saturated version of the categories

and themes. This refined analysis of themes provides a foundation for design of systems and a platform in which all systems within this domain can be evaluated.

Ultimately, the work here rarely follows grounded theory as far as axial coding in that the findings are far too complex and interspersed to define using such an approach. While the final contribution could be seen as a product of grounded theory, it is largely defined by discussions and workshops. As the work aims to focus on human-system interactions, many of the sociological areas explored herein are taken at face value. It would be presumptuous for the researcher to suggest a definition in this context and this is best left to researchers capable of commenting on these areas. As the focus is on user experience, it may be inherently difficult to define such axioms of code as the experience is difficult to define (Arrasvuori & Holm 2007b; Bainbridge 2003; Petridis 2004.) At this stage in the process, participatory design, user experience or user-centred design may be better definitions of the research conducted.

3.1.5 Structure

The thesis begins with some quantitative benchmarks to identify whether there are differences in task performance times amongst groups of similar users. The work then goes on to discuss observations made of the 'typical usage scenarios' before asking the participants to take part in some sketching exercises. The purpose of this is to highlight any requirements that the users have that are missing from the design of said systems and allow users to define and describe some design guidelines. These representations in visual form are important here. The placement, sizing and visual relationships between objects on a page all tell an interesting story about features and functionality requirements from the user's own perspective. The thesis then goes on to explore a broader set of requirements. Firstly, the ethnographic work describes the successes and failures of systems in a real world context. Chapter five discusses the findings of this exploration and aims to frame the work in some kind of relevant context. Finally, chapter six explores the use of workshops in defining and refining guidelines about what it

means to design good software interfaces for musicians. The workshops are designed as a way to promote creative thinking amongst stakeholders, encouraging them to think about the implications of software usage in the past, now and even future implications of software design.

3.2 Sketching

Sketching is a low fidelity prototyping technique used to highlight usability problems and solutions in the early stages of design and development (Kodagoda 2009; Craft & Cairns 2009; Buxton et al. 2006.) This approach to participatory design enables the representation of objects and items and generation of ideas to happen through participants, rather than through the researcher's interpretation. Sketching also provides a platform for creativity and innovation in the design and development of such systems. Buxton explores the area of complex design requirements through his sketching work. The research mentioned previously also highlights the value of sketching in new research areas, such as those of new media and exploratory design. The work here focuses on using sketching as a technique to compare and contrast existing systems against user requirements and attempts to fill in the gaps where appropriate. Sketching proves a useful tool in early user interface designs in this way (Mueller et al. 2003.) Sketching provides value in comparing lab based work such as task time analysis against incomplete design solutions, with a view to suggesting how such designs can be improved. It is also important to recognise the value of sketching in creative discovery tasks (Hennessey et al. 1998) as a platform for both elicitation and generation of new requirements that may be missed when using other techniques. Sketching is also a useful way of understanding collaborative aspects of systems (Craft & Cairns 2009) and describing key interactive components of a system (Obrenovic & Martens 2011.) While creativity has already been discussed in the context of music producers, sketching also provides a creative outlet for users where they can provide a visual outlay, describing components in terms of importance through elements such as sizing and positioning in the context of a larger interface. The real value in sketching though, lies in its ability to produce more usable interfaces

when utilised in a human-centred design based approach to development (James & Brad 2001.)

3.3 Task Time Analysis

Task time analysis enables the representation of typical tasks in a numerical, measurable format (Sousa & Furtado 2005.) Tasks can be measured in terms of either how long they take to complete or whether or not tasks can be completed at all (Jameson 2005.) Task time analysis is used here to compare multiple digital audio workstations, using tasks suggested by users, to determine whether there are usability differences across software packages. Further analysis of performance is covered in more creative tasks (Coughlan & Johnson 2006b.) By using a mixture of strict and fuzzy tasks, both creative and typical tasks can be measured. The aim here is to assess goals against a metric to determine whether systems are effective and efficient (Nielsen & Molich 1990; Seago et al. 2004.) By gradually removing criteria from the tasks, users are provided with a starting point and then able to work in a way which enables them to be creative and innovative in solving problems that they themselves dictate. The concept behind this methodology is to emulate the way that a producer works in a typical environment, with some strict goals, some fuzzy goals but largely in an autonomous and free manner (Jordà 2004; Oliveira & Cardoso 2010.)

3.4 Ethnography

Ethnographic research is a qualitative research method focused on the complex set of social interactions and cultural context in a given environment (Grudin & Grinter 1994; Wolcott 2003; Malmi 2011; Jackson 2012.) Ethnography is used to explore social constructs, rich real world contextual environments and originated in anthropology and sociology research. Ethnographies are famed for their power to explain issues in a rich, detailed context and examine perspectives in an ecologically valid way.

Ethnographic methods have been criticised for being directed by researcher focus and lacking in methodological control, particularly where reliability is concerned (Cecez-Kecmanovic 2007; Cecez-Kecmanovic 2010.) Ethnographic research is also criticised for being time consuming and inherently difficult to conduct (Millen 2000,) where time critical alternatives are suggested. These issues are not limited to ethnographic approaches, though they may be more apparent here than in alternative methods and need to be considered. The motivations for using this method follows.

It is important to recognise that multiple methods provide balance in researching a complex topic such as that of HCI in regards to music systems (John & Marks 1997; Huart et al. 2004; Cecez-Kecmanovic 2010.) The use of ethnography is designed to validate existing theories and findings as well as to generate new theories, themes, categories and codes accordingly. While ethnography is used to test tools in context and to examine real world usage scenarios, grounded theory still remains an underpinning method used and each theory or category formed here can be validated through other approaches and methods. Task time analysis for instance provides a useful comparison in looking at usability from both a lab and field perspective. The real value in an ethnographic method here enables the explanation of phenomena in a wider context (Wolcott 2003.) Ethnography provides value in terms of its exploratory and explanatory power, highlighting contextual issues with real world examples to support theories and notions (Ahmed et al. 2012.) In terms of music making, the process has already been defined as a socially broad, situational and interdependent (Benford et al. n.d.; Jordà 2005) therefore it needs to be explored as such. An ethnography provides an ecologically valid alternative to previous work and the generation of new themes, a large dataset for open coding and a better understanding of requirements in relation to the user (Perez & Valderas 2009; Newell et al. 2006.)

Usability issues for information systems in socially complex environments are examined elsewhere using qualitative methods (Cunningham et al. 2009; Rohrmeier

& Koelsch 2012.). Here the aim is to explore problems and solutions in relation to the complexity, rather than trying to limit the focus. Research into online communities (Preece 2001; Lazar & Preece 2002; Preece & Maloney-Krichmar 2003) for instance, produces results of value. Dynamic approaches which help to elicit requirements and usability issues also exist, for example by using theatrical contexts to tease out usability problems (Newell et al. 2006.) These approaches are useful at teasing out complex issues and help to enable participation through active approaches.

Ethnographic approaches are also applied to music information systems research (Cunningham et al. 2003; Ahmed et al. 2012; Crabtree et al. 2006.) In these studies, the explanatory power of ethnography leads to interesting findings which could not have been explored as thoroughly using alternative methods. The considerations here go beyond traditional research methods in examining a particular hypothesis or theory and utilises multiple sources of information in generating research findings. The use of ethnographies enables the representation of complex social interactions. This type of study acts as a cultural snapshot, wherein a view of the people and their interactions with one another and their environment can be closely observed and documented. When we consider the difficulty in measuring user experience (Lindgaard & Chattratchart 2007; Følstad et al. 2012; Albers & Still 2010) and the difficulties in explaining and exploring these issues using alternative methods (Nielsen 1994) ethnographies provide a useful platform for research in understanding context, reasoning and motivations.

3.5 Workshops

Creative workshops enable the formation of new ideas, theories and processes (Schlosser et al. 2008.) Through creative workshops, a discovery about a complex domain can occur, through a three pronged process (Maiden, Manning, et al. 2004.) Explorative, combinatorial and transformative types of creativity can occur through this process (Maiden, Gizikis, et al. 2004), highlighting problems and solu-

tions that are generalisable and transcend the use of a single system or workspace. Workshops also provide a useful format in eliciting user requirements, understanding and appreciating multiple contexts of use and exploring broad contexts (Perez & Valderas 2009.) The use of workshops here focuses on taking knowledge from previous literature and exploration and framing it in a broader context. In our context, we aim to explore design guidelines and solutions for producing usable music systems, essentially reverse engineering previous examples of usage (Schlosser et al. 2008; Maiden, Manning, et al. 2004.) Where these workshops use the music composition process as a comparative process, we aim to use the findings of the workshops to compare against our findings of how music systems are used. Ultimately the aim is to generate new concepts, define new roles and describe the experience of positive interactions between musicians and computer systems, where goals and requirements can be accessed in a more effective, efficient and pleasing manner.

3.6 Positivist and Interpretivist Approaches

Most research utilises either positivist or interpretivist approaches (Cecez-Kecmanovic 2007; Cecez-Kecmanovic 2010.) The first method focuses on the scientific and analytical, relying on statistics, experiments and hard data in order to test theories and draw conclusions (Vuust et al. 2009; Zheleva & Guiver 2010; Grossman et al. 2009.) This approach is very useful where a problem is concrete or a hypothesis is easily defined (Følstad et al. 2012.) In the context of this thesis, positivist approaches are not particularly useful, though quantitative approaches to provide an interesting benchmark in identifying differences between and within user groups for the task time analysis. If the problem space were better defined then it may be appropriate to use such methods in the form of comparison. Here, the complex nature of the work means that this approach would be inappropriate for any context beyond identifying differences between the groups already defined. While some task time analysis and general lab based studies provide a useful starting point to benchmark and identify that issues do exist, it is difficult to define the role of a musician and often the role is ever changing. In this context, a more robust, descriptive model is necessary. There is a need here to

explore qualitative issues, understanding reality in relation to lots of different dynamically changing elements. Cultural context, meanings and actions are all relevant in understanding the usability of systems in this context and so an interpretivist approach is more useful here.

3.7 Summary

This section has highlighted some of the research methods used throughout the thesis. The value of techniques has been discussed in general terms, where the chapters that follow discuss the usage of these techniques and justifications for using such techniques in more detail. The discussion here identifies gaps in knowledge. These gaps relate to areas of user experience within this particular domain and relate closely to usability and user experience elements, with a focus on creativity and innovation. The challenge is to provide an interface which is both usable and enjoyable that enables creativity to take place, while still supporting the user in general, identifiable music production processes.

The following chapter explores usability in the context of digital music production, using software based audio workstations as the tool for exploration and analysis.

Chapter 4. Digital Audio Workstations for Music Production

This chapter focuses on exploring digital audio workstations in the context of usability. There is also a discussion regarding successes and failures in relation to creativity. The sketching exercises that follow discuss the relationship between performance of current systems and the needs and wants of users of these systems. The initial work produces benchmarks to identify usability issues between software packages. The more in depth descriptive discussion then follows.

4.1 Introduction

The following section discusses DAWs from a usability perspective. The aim here is to evaluate and discuss typical usage scenarios and how successful they are across multiple applications. The work here also aims to tease out issues relating to different tools, with the focus of understanding how and why certain tools can be considered more usable according to previously defined criteria.

The perceived and actual value of music is widespread. Producers, composers and consumers all have a role to play in the distribution of such content. As computing power and complexity have increased, musicians no longer need to rely on a team of technically minded specialists in order to facilitate the development of their music (Leyshon 2009). Software such as Cubase, FruityLoops and Sonar exist in the commercial space to provide a platform for home studios and for musicians to get more involved in the technical phase of recording and producing their own music using their own tools (Cross 2001). The process of creating music is 'fuzzy,' a series ill-defined processes to go from inception to a finished product (Benford et al. n.d.). Lack of standardisation here means that mixed methods and approaches can be used in different ways to achieve similar goals. In this industry, unlike industries such as manufacturing, the supporting processes are variable

and susceptible to change and the production methods and models vary from place to place. Standards here are more de facto than de jure. The music industry also exists as a dynamic entity in itself. The very nature of creative industries cause them to be dynamic, but this may also cause issues in solving problems and in communicating both needs and wants successfully (Scott 1999; Whitaker 2003; Reiss 2011). Audio production environments do not benefit from business communication platforms such as supply chain management, nor do they benefit from being built in a way which enables participation and collaboration (Stelkens 2003). Though functionality and features have grown, the underlying structures supporting interaction and reducing barriers to entry in terms of usability have not been considered. To the contrary, the complexity has imposed a layer of confusion and difficulty in using the software and imposed as many challenges as it has presented opportunities (Hughes & Lang 2003).

There are two unique sets of challenges in evaluating music based systems. Firstly, the music industry in terms of interaction models and tools, is quite expansive (Sachs 2012). Stringed, percussive, wind, electronic, electric and keyboard based instruments only scratch the surface of instruments types available, with each category of instrument hosting a wide range of variable tools. Guitars for example, have various iterations in the forms of electric, acoustic, electro-acoustic, resonator, baritones, basses, all built with different specifications, sounds and equipment. Usability research has also grown vastly since the move from back office systems to the modern era of pervasive and intelligent systems (John & Marks 1997; Mendoza & Novick 2005). Usability itself is a mix of elements of psychology, sociology, design, development and business (Abrams et al. 2004). Combining the two areas of designing systems for musicians and usability engineering into a single area of interdisciplinary research is likely to yield valuable insight, examining creativity and supporting a body of knowledge into how usability can be improved in this setting - beginning with contemporary technical systems. The work should hopefully provide a deeper understanding about where usability problems in complex or complicated environments occur. It is important first to make the distinction between the terms complexity and complicated. Norman distinguishes clearly between the two concepts of complexity and complication and advocates complexity without unnecessary functionality (Norman 2010). It is

important to recognise here that inherent complexity should not hinder the user in performing tasks (Sousa & Furtado 2005; Coughlan & Johnson 2006b) and that complexity is something that can be managed. Norman uses the example of a pilot's system as being inherently complex but not complicated.

It is important to understand how usability and creativity can co-exist in the complex dynamic environment of a digital audio workstation, the typical working environment of a digital producer. The work here approaches the problem first by categorising groups, then by determining traditional performance metrics before finally examining creativity and innovation within this type of environment.

4.2 Aims

The first aim is to understand how usability and creativity can co-exist in the complex dynamic environment of a digital audio workstation. Further aims are to evaluate how well industry tools perform typical (static) tasks such as cutting and pasting versus more complex (dynamic) tasks where goals are less easily defined. The final aim is to evaluate how successful digital audio workstations are at enabling meeting user needs.

4.3 Pilot Study

The pilot study provides useful insight into how well the tasks designed will work in understanding usability issues. It also highlights any flaws in the experimental design and possible complications or issues that may arise that have not previously been considered. The aims of the pilot study are to ensure that the problem space and experimental design are suitable. The pilot study here is also relevant in defining different user groups and identifying differences that need to be taken into account when exploring the issue of user experience in this context. The pilot therefore acts as a benchmark to define a starting point where users are all at similar levels. Design guidelines must first be grounded in the knowledge that they fit the specific user group they apply to. It is important here to distinguish

between types of users and evaluate whether or not such tasks can provide interesting insight into such user groups, in a valid and reliable way. Cubase is used as the testing environment as all users suggest they utilise at least one version of the application as part of their work. This was defined during the recruitment stage. By using the same workstation results can be tested between groups to determine if there are any differences, before further exploring said differences in more detail. Tasks are generated based on documentation in the users workspaces, where these tasks were described as 'typical,' 'important,' or mentioned as 'basic,' or 'everyday' tasks. Each of the tasks are confirmed to be important in a preliminary discussion group formed when participants are initially recruited.

4.3.1 Design

The following section details the design of the investigation reported in this paper.

4.3.1.1 Participants

Three groups of participants are investigated with three distinct levels of capabilities: novices, regular computer users and advanced users who are intimately familiar with the systems being tested. Each group consists of six users. Participants are recruited wherein they fall into the criteria of a given capability group and are equal in terms of age, gender and physical properties. Groups one (novice) and two (intermediate) have been selected using a stratified sampling technique (Podgurski et al. 1999.) The final group are recruited from studio environments (theoretical sampling,) where their experience differs greatly from the first two groups. Users begin by specifying a capability, before this is tested further using generic tasks such as asking them to send an e-mail, search the web and navigate to a song. This is to ensure that users are familiar with basic functionality such as clicking buttons, drag and drop and keyboard interaction. The cost benefit analysis performed by Nielsen (Nielsen 1993) categorises five users as being sufficient

for a usability test, however six users lends itself well to the number of applications that have been described as 'widely used' by the expert group. Modern research questions whether or not the probability of major usability issues being discovered with five users is large enough, depending on the context and tasks performed (Turner et al. 2006). The argument for using a smaller user group and testing thoroughly, rather than testing large user groups in a generalised way is one which is advocated strongly (Lindgaard & Dudek 2003; Lindgaard & Chattratichart 2007) in the literature and one which resonates. As this is an iterative testing method, Nielsen's suggestion of five users through multiple iterations works well in highlighting usability issues. Participants are openly recruited into the first two groups based on their own perceptions of capability. Users in groups a or b, either state that they are novice users or intermediate users. Group c consists of studio engineers who specialise in the use of digital audio workstations and relies on purposive sampling.

4.3.1.2 Procedure

The initial screen presented to the user is the main interface, with a single desktop icon present, Cubase. Discussion with users highlights Cubase as the most familiar, therefore it has been chosen as the software package to use for the pilot study. Each user is then asked to perform the same series of tasks, designed around typical tasks that users perform. Such tasks are highlighted heavily in discussions with users and in the supporting documentation for the software packages. The testing methodology involves presenting the user with a printed sheet of these tasks. The users are timed by an observer with a stopwatch. Where the user is unable to complete a task, the table entry for that corresponding task is marked as incomplete and no time is recorded. As the tasks test consecutive and cumulative completion rates and times in a sequential process, non-completion of a single task ultimately results in the end of the observation, as users cannot complete subsequent tasks. This methodology models real world environments, as a song is not considered 'complete' until all the relevant tasks have been performed on it (Hook et al. 2011; Sawyer 2011). This definition of completeness is also described by participants in the discussion groups leading up to the pilot study. They

describe their experiences as cumulative and part of a process. Participants decided that a single edit on a track would not be sufficiently reflective of the type of work typically performed by a studio engineer, even in a very basic setting. Tasks are not randomised, as the experiment design aims to encapsulate cumulative usability issues, as well as isolated ones, in an ordinal way. This better reflects the nature of the tasks. Each user had up to three minutes to complete a task, with the option to stop before that if they felt that they could not complete the task assigned.

Table 1 describes a list of the tasks given.

1. Launch the program Cubase.exe
2. Import the 3 tracks specified
3. Play the tracks
4. Move track 2 to 00:16
5. Remove Track 3
6. Cut the first 4 seconds from track 1

TABLE 1 - INSTRUCTIONS FOR USERS

4.3.1.3 Data Collection

Data collection at this stage is focused around task times, though grounded theory enables the collection of other forms of data as and when they arise. Task completion rates and times are considered to be the main data of the pilot study, though it is also important to recognise the value of overt observations, discussion groups conducted and informal discussions with users. Task times provide a standardised, objective measure of data, with supporting data collection providing more subjective or qualitative results.

4.3.1.4 Initial coding criteria

The first stage of the pilot study involves examining suitable ways to assess usability, including the type of participant involved in the study and the nature of the study itself. After three 5 minute, non-directed discussion groups based around the theme of usability in music composition and collaboration systems.

Table 2 describes some of the issues that arose from the discussions.

1.	Clear and obvious instructions, logos and content. In this instance, typical users mention being able to understand the nature of the task and find a logical way to achieve the task. Users describe buttons as key to finding information and understanding functionality.
2.	An intuitive interface. Here, participants talk about not having to spend a great deal of time learning patterns and trends in the system. The consensus of the third and final discussion at this stage focuses on an interface that should be 'obvious,' 'clear' and 'concise.'
3.	A system which is quick. Participants here mention speed and goals. Anecdotal instances of systems which they consider poor in terms of usability are also of concern. Existing systems are described as being slow, either at completing a particular task or at loading up the necessary materials to work on a track.
4.	A system which enables the user to do what they need to do, when they need to do it. Here the discussion focuses around a system being simple but having an underlying structure which enables the user to "dig deep" and achieve complex or complicated tasks in a manageable and speedy way.
5.	Reliability is also mentioned. Participants here discuss using a range of tools to complete a task and how well these tools integrated with one another, as well as the supporting hardware (input) and software (drivers.) The need to have a consistent and understandable layout amongst different tools emerged as a key concern for users, with them speaking about difficulty. "Having to learn lots of different software and ways of doing things is unreasonable. Time is paramount when a project has a three week deadline, from inception to post-production and the finished, polished version."
6.	Software or hardware which supports existing processes. Here the discussion centred around the idea of having a series of ill-defined but formative processes, where the software needs to be robust enough to cope with changes in the way that people work, the things that they choose to do and ultimately in the production of a track.

TABLE 2 - INITIAL CODING CRITERIA FOR SUCCESSFUL USER INTERFACES

4.3.1.5 Testing Methodology

The following section describes the methodology used to investigate digital audio workstation usage.

Participants are openly recruited using a self-selection approach, wherein they are asked to define their level of competency with computer systems before being given a number of basic tasks to assess whether their results show a low or medium level of competency. The final group have an additional selection criteria in that they must be familiar with digital audio workstations. These participants perform the basic tasks more quickly and completely than the two other groups defined and therefore are categorised as advanced users in the final group. The set of tasks performed herein have been generated using a lossegrounded theory approach. They are defined uniformly in initial discussions with musicians as 'typical tasks' and are heavily featured in the documentation and support material in the work environment. Tasks are completed in a North London studio, using a laptop where the software is pre-installed. Users are presented with a single icon, 'Cubase.' Upon loading the software they are presented with the default Cubase interface. The software is emulated in a Virtual Machine so that the content can be reset after each task in order to reduce issues relating to memory, caching and performance of the system. All instructions are provided on a sheet of A4 paper to minimise interaction with the research and ensure standardisation in testing.

4.3.1.6 Materials

Data is collected using paper and pen to record task times, completion rates and observations. A stopwatch is also used during observations to accurately record task times. Sketches are drawn using a pencil and a piece of paper, though the sketches presented herein have been converted to digital forms for readability purposes. Observations are made using a pen and a notepad as users complete the series of tasks in order.

4.3.2 Results

The results of the study are split into six tables. Tables 3,4 and 5 relate to task completion times. Tables 6, 7 and 8 relate to whether or not users completed the task assigned. The first (table 3) and fourth (table 6) tables details the completion times and rates respectively of users from Group A, the users with the lowest level of exposure to computer systems who performed the initial task set in over 45 seconds. The second (table 4) and fifth (table 7) tables show the task completion times and completion rates of Group B, who spent approximately 45 seconds completing the grouping task. The third (table 5) and sixth (table 8) table show the results of users who have regular exposure and experience with the system being tested. All tasks were completed by all users in under 45 seconds.

4.3.2.1 Efficiency

The following three tables show the task completion times in seconds of each user, grouped according to ability. The x here signifies an incomplete time and task times are presented in seconds.

Table 3 presents inexperienced users and their associated task times and completion rates

User	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
A	24.2	45.2	5.4	62.5	74.1	x
B	22	x	x	x	x	x
C	18.7	42.2	9.7	x	x	x
D	7.5	53.8	5.7	x	x	x
E	11	27.2	6.3	33	12.4	49.5
F	14.44	15.6	6.34	19.25	x	x

TABLE 3: GROUP A - INEXPERIENCED USERS TASK TIMES IN SECONDS, WHERE 'X' IS INCOMPLETE.

Table 4 shows intermediate users with some level of technological experience and their associated times and completion rates. Here we see that two out of the six users were able to complete all six tasks, with generally better performance times as a whole. However, there are still fairly significant gaps here, with the range of task times between 31 seconds and 2.1 seconds and a varied completion rate across the results.

User	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
A	7.0	14.3	18.4	12.9	x	x
B	5.0	9.4	22.2	15.2	x	x
C	6.0	10.3	16.3	17.9	19.3	7.8
D	9.0	8.7	2.1	3.1	x	x
E	11.0	2.9	8.9	32.0	31.0	x
F	10.0	11.2	3.0	12.1	25.0	15.1

TABLE 4 - GROUP B - INTERMEDIATE USERS TASK TIMES IN SECONDS, WHERE 'X' IS INCOMPLETE.

Table 5 shows a full set of completed tasks, with some variations in task times. The range of results here is much smaller (1.7 being the quickest and 17.27 the slowest.) This suggests that in this context the systems are somewhat effective (all tasks completed) but vary in terms of efficiency.

User	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
A	5.12	8.2	7.09	7.11	14.87	15.79
B	3.33	6.89	10.38	12.65	13.88	15.4
C	1.09	5.56	6.79	31.91	29.85	8.02
D	4.19	12.48	8	8.8	5.61	8.25
E	3.93	9.22	14.06	16.63	17.27	7.89
F	4.86	7.86	1.7	6.16	3.06	8.12

TABLE 5 - GROUP C - EXPERIENCED TECHNICAL USERS TASK TIMES IN SECONDS.

4.3.2.2 Effectiveness

The following three tables show the completion of tasks by each user, grouped according to ability. Tasks are considered either completed or incomplete, shown by ticks or crosses respectively.

Table 6 shows completion rates without task times. The variation here shows both extremes, of a user being able to complete all tasks and a user only able to complete a single task. The response here is that this user group could not be sufficiently assessed in terms of performance where such a huge distribution in capability already exists.

User	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
A	✓	✓	✓	✓	✓	x
B	✓	x	x	x	x	x
C	✓	✓	✓	x	x	x
D	✓	✓	✓	x	x	x
E	✓	✓	✓	✓	✓	✓
F	✓	✓	✓	✓	x	x

TABLE 6 - GROUP A - INEXPERIENCED USERS TASK COMPLETION RATES.

Table 7 presents a similar issue in task completion rates for intermediate users. Variation in completion rates is fairly broad. Users A, B, D and E were unable to complete all six tasks, where only user E in this group was able to complete the fifth task. Two users, C and F, managed to complete all the tasks.

User	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
A	✓	✓	✓	✓	x	x
B	✓	✓	✓	✓	x	x
C	✓	✓	✓	✓	✓	✓
D	✓	✓	✓	✓	x	x
E	✓	✓	✓	✓	✓	x
F	✓	✓	✓	✓	✓	✓

TABLE 7 - GROUP B - INTERMEDIATE USERS TASK COMPLETION RATES.

Table 8 describes completion rates of expert users. The table identifies a fairly obvious trend, in that all users were able to complete all tasks. This provides an opportunity for further investigation in that we no longer have to identify two variables (effectiveness and efficiency) and can focus on testing efficiency as a single variable in future cases. Whereas previous cases identified issues such as required learning and memory functions, here the users all show similar levels of competency in terms of completing tasks.

Task	1	2	3	4	5	6
A	✓	✓	✓	✓	✓	✓
B	✓	✓	✓	✓	✓	✓
C	✓	✓	✓	✓	✓	✓
D	✓	✓	✓	✓	✓	✓
E	✓	✓	✓	✓	✓	✓
F	✓	✓	✓	✓	✓	✓

TABLE 8 - GROUP C - EXPERIENCED TECHNICAL USERS TASK COMPLETION RATES.

4.3.3 Summary

Based on the results here and the informal discussion with the technical users when trying to form theories, it is clear that a gap exists in terms of competency and technical capability. Testing usability amongst users who are unable to complete basic tasks is likely to yield very little in terms of results. It would be presumptuous to try and measure efficiency when users are unable to complete a task. Through testing technically capable users in an environment in which they are both comfortable and familiar with, usability goals such as efficiency, satisfaction, aesthetics and productivity can be more accurately considered. The pilot study has provided insight which supports this theory in refining the scope and criteria for measurement in the work to follow. The huge gap in task time completion and overall completion rates of users, depends largely on technical capability. Testing usability therefore can only be performed by measuring like for like, testing similar users against one another. In this case, we can only measure learnability and memorability with users who are unable to complete all of the tasks. To test usability in terms of other aspects, technical users must be considered.

The pilot study identified a noticeable difference between the three groups of users and also suggested variable performance times between 'technical' users. At this stage, only one software application had been tested, so more work needs to take place before a conclusion could be formed. The work here is purely aimed at producing a uniform study design. We can see from the data that the tasks are reasonably appropriate, in that all 'technical' users were able to complete the tasks within a reasonable length of time and that such tasks and the use of DAWs to as a platform for performing these tasks, are fit for purpose. These tasks are designed to measure effectiveness (completion) and efficiency (task times) but do not necessarily reflect further elements of user experience such as user satisfaction, enabling creativity or reduction of cognitive workload. This does however highlight the need for further work to be considered as a process for describing user experience.

4.4 Main Study

The following section details measurements of the user experience using desktop based music software in the pilot study. The section is organised into creative and none creative parts. To test usability using production methods, a formative approach is necessary. First, users must be tested using a range of commercially available systems, extending on from the work in the pilot study to look at differences between software tools. Secondly, highlighting usability issues in relation to creative goals (requirements) and techniques (approaches.)

The purpose here is to obtain a holistic view of user experience, by combining different perspectives and tasks in a way which models how existing systems are used. The variety of methods used to capture information and form knowledge also help to minimise observer bias and validate findings. The user describing a problem or cause for concern in a directed discussion group and during the course of an overt, observation are two very distinct scenarios that are more likely to produce valid results than a single methodology. While the observer has a very active role in the directed discussion groups and when asking questions informally, the uniform, standardised tasks aim to minimise observation bias and ensure reliability of results, as well as aiming to improve validity by verifying tasks against discussions.

4.4.1 Participants

The following section describes the participants chosen for the study.

4.4.1.1 Sample

The users chosen for the main study are users from group C in the pilot study – expert users. To maintain consistency and ensure validity, changing the number of users between a pilot study and the main body of work seems redundant. The

pilot suggested that sample size of six users works well and it enables closer interactions with the users, including discussion groups and informal interviews. For this reason, the same six users in group c are used uniformly throughout the course of the work. Gender, age and specialisms are not defined here as they are not being compared or indeed investigated. The only criteria defined for this sample is that the user is a professional music producer.

4.4.1.2 Expertise

The users are technical people who work as producers. Two of the users are regular DJs. Both of these users host large, 600+ people, events in and around the Greater London area. Two users work in studio environments, composing, mixing and distributing audio content. The final two users are professional musicians who have home studio environments and work with other musicians using technology, as well as working in digital production studios. Working with technically capable users ensures that the user experience issues are real world issues and not simply 'learning' or 'finding' tasks. As the tools being tested are somewhat technical in nature, it is reasonable to expect that a learning gap would exist. Isolating this variable is important for the validity of the study. Testing usability of technical software amongst users with no technical experience is likely to result in a learning curve which will be more reflective of exposure and familiarity than usability. Learnability in itself could prove to be a confounding variable in the measurement of usability. Mendoza et al. (Mendoza & Novick 2005) describe learnability as usability, however this view fails to take in to account the impositions that learning have on usability, in particular relating to user choices, memory and consistency. The purpose here is to only work with users who have a fundamental grasp of the systems in use, to truly test usability in an objective and fair way. The final sketching exercises enables the representation of missing requirements and suggestions in aesthetics in design which may have been overlooked in the previous study. Sketching is useful in highlighting usability problems from the perspective of requirements in the early stages of design and development (Kodagoda 2009; Craft & Cairns 2009; Buxton et al. 2006.)

4.4.2 Procedure

The procedure for the main study is divided into three sections. The first deals with timed tasks and observing behaviour from a simple instruction. The second section deals with creative tasks, where goals are fuzzy, focusing on pure observation. Finally, sketches are used to elicit requirements from users about the types of features and functionality that they would find useful in a system.

4.4.2.1 Metrics – efficiency and effectiveness

Six users are asked to perform a series of six tasks to completion, each on an individual and independent basis. The participants have been recruited due to their predisposition and experience in studio and recording environments. The user is briefed, explaining to them that their usage of the software is being tested. The user is then informed that they will be asked to complete a series of tasks and that each task will be timed using a stopwatch (Ritchie & Roast 2001.)

In each set of tests, the user is asked to complete the set of tasks in the same order, where the tasks are numbered one to six, modelling a real world production environment. Each user is presented with a Windows 7 Professional desktop environment, with a series of six icons present plus three pre-recorded tracks. Each icon corresponds to a particular software tool used for testing or element used within the test. The users are assigned the same set of tasks to perform in each software application. Time in between tasks, used reading or where the user is not interacting with the computer, is not counted towards task time or overall time.

An equal probability of selection sampling method (Peters & Eachus 1995) has been chosen, where any individual user could possibly be testing any given environment.

The only interaction between the observer and the participant is the presentation of a sheet of paper with a series of tasks. The order could not be varied as the study has been designed to reflect a typical process, from start to finish, with distinct steps or 'stages' therein. This process is designed to model a real world scenario of building a track from start to finish, containing the simple processes involved therein. In earlier discussions, these tasks are formed as key tasks in production environments and the issue of order effects in relation to usability are relevant, therefore the order should not be changed.

Table 9 shows the tasks assigned to users.

1.	Launch the program 'ProgramName.exe'
2.	Import tracks '1.mp3,' '2.mp3' and '3.mp3'
3.	Play the tracks
4.	Move track '2.mp3' to 00:16
5.	Remove 'track3.mp3'
6.	Cut the first 4 seconds from 'track1.mp3'

TABLE 9 - USER TASKS PERFORMED IN TEST.

Table 10 describes the Digital Audio Workstations (DAWs) used for testing.

1.	FruityLoops Studio 8
2.	Sonar 8
3.	Cubase SX3
4.	Sony Acid Pro
5.	Pro Tools 9
6.	Ableton Live 8

TABLE 10 - DIGITAL AUDIO WORKSTATION PACKAGES USED IN TESTING.

4.4.2.2 Open Ended Task

Users are then asked to complete the task, 'to an acceptable level of quality.' The observation is conducted while the users perform the task specified. The observation is overt, with a single observer present at all times, however participants have not been informed as to what is being observed during this stage of the process. The observation is semi-directed, as a series of coded categories have been formed. However, due to the nature of the study, it is also possible for new coding criteria to emerge from the observation or previous criteria to be refined. Observations are recorded using pen and paper. Through the course of the observation, written notes are taken, describing the usage of the system relating to the features defined. The results of the observation are taken in note form as memos and the key issues are mentioned in the results section.

4.4.2.3 Sketching to evaluate requirements

The final stages of the study involve users creating a sketch or series of sketches of interfaces they would consider to be usable. These sketches enable the representation of ideas and functionality not present in current systems. The sketches provide a contrast to the task time analysis and observations in helping to understand what might be missing from these systems and whether or not they are usable in terms of user requirements. This is particularly useful in understanding the user satisfaction element of the usability spectrum, in judging how different sketches are from the original interfaces (digital audio workstations.) While it is important to take into account that the user here is not a designer or design specialist, eliciting their requirements through sketching is beneficial in helping to highlight their expectations in a contextual way. Focus groups, use cases, storyboarding and other techniques can be used to elicit requirements, though sketching requires no formal structures and provides more information than these techniques. It also reduces the chance that a single individual will contribute more and that shy individuals will contribute less, as

everyone has to create a sketch of an interface and users can choose to work in groups or alone. These choices are not possible using other techniques, so the sketches provide a way in which each user can voice an opinion.

4.4.3 Results

The results of the investigation are split into sections. The first focuses on the concurrent task time analysis, with a discussion of the creativity task following. All tasks are observed and discussed.

4.4.3.1 Task time results

The following section details the results of the performance tasks across the six products tested. Times are measured in seconds. Mean and standard deviation are presented here also. The six tasks are defined previously in table 9.

Table 11 shows the results of task times from a popular loop based DAW – Fruity Loops Studio. Here we see some of the fairly simple tasks taking a while to complete. This can be seen particularly from the results of users 1 and 2 in test 2. A simple task like this in importing three tracks identifies a serious issue in terms of efficiency. The observations from this task identify an issue in navigating the menu and finding the appropriate context (option.) User 2 attempted to use a shortcut, however the control (accelerator) mappings for Fruity Loops were different from the package that the user was familiar with. The mean values here are also the highest of all DAWs, suggesting that efficiency is a real problem.

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Mean	SD
User 1	3.9	11.77	3.24	8.26	7.43	12.91	7.92	3.95
User 2	1.55	12.36	2.09	8.61	9.81	9.59	7.34	4.45
User 3	2.78	8.1	1.15	5.83	4.98	7.96	5.13	2.78
User 4	3.67	7.81	0.97	4.87	4.39	6.15	4.64	2.32
User 5	3.59	5.02	2.58	9.33	9.63	9.19	6.56	3.20
User 6	2.35	6.06	2.77	12.88	9.77	11.86	7.62	4.56
Mean	2.97	8.52	2.13	8.30	7.67	9.61		
SD	0.91	2.98	0.91	2.83	2.49	2.48		

TABLE 11 - FRUITY LOOPS STUDIO TASK TIMES IN SECONDS.

Table 12 shows task time results for Sonar, a DAW published by Cakewalk. Although many of the users were unfamiliar with the current version of this software (version 8) the task times show good performance results overall. Test 5 in particular shows little variation in performance, even though it is one of the more complex tasks to be completed. If we look at the standard deviation results for test 1 we also see a very low deviation of 0.42 seconds. The highest deviation we see amongst tasks or indeed users is less than 4 seconds across all tasks. This suggests that people were able to adapt to the new version and complete tasks irrespective of any subtle software version variations.

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Mean	SD
User 1	2.69	4.64	3.05	6.4	4.19	5.15	4.35	1.37
User 2	2.47	7.74	0.9	7.43	6.32	8.43	5.55	3.11
User 3	3.38	7.51	1.33	2.37	8.41	10.68	5.61	3.77
User 4	2.17	7.93	2.71	7.97	8.46	7.85	6.18	2.91
User 5	2.45	5.11	2.28	6.02	6.34	8.93	5.19	2.53
User 6	2.35	6.74	3.46	7.14	9.14	13.21	7.01	3.93
Mean	2.59	6.61	2.29	6.22	7.14	9.04		
SD	0.42	1.41	1.00	2.01	1.86	2.72		

TABLE 12 - SONAR 8 TASK TIMES IN SECONDS.

Table 13 shows performance results for Cubase. This software package was identified as the one used most by all users and each user reported a high level of experience in using one or more versions of Cubase. Here we see little variation in the first 4 tests. Tests 5 and 6, the more complex tasks however showed a much broader variation. Test 6 for instance had completion times of 4.62 for user 1 and 10.14 for user 5, a fairly substantial difference in the context of a single task. The standard deviation here across users is fairly uniform. This is likely a reflection of the increasing difficulty as they progress through the tasks. The highest deviation in tests is present in test 5, with a value of 2.86. The mean value here however is still fairly low (5.11) when compared to packages such as Fruity Loops and Sonar. This suggests that the tool is fairly efficient in this context.

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Mean	SD
User 1	3.44	5.76	3.53	11.27	9.22	4.62	6.31	3.23
User 2	3.76	8.29	1.71	7.04	4.35	8.03	5.53	2.66
User 3	3.82	7.14	1.45	10.8	7.65	10.52	6.90	3.69
User 4	1.18	9.02	3.32	9.33	2.2	8.72	5.63	3.79
User 5	4.25	8.21	2.4	10.01	5.04	10.14	6.68	3.23
User 6	1.11	7.43	1.91	9	2.19	9.09	5.12	3.77
Mean	2.93	7.64	2.39	9.58	5.11	8.52		
SD	1.40	1.14	0.86	1.51	2.86	2.12		

TABLE 23 - CUBASE SX3 TASK TIMES IN SECONDS.

Table 14 shows the task times for Sony Acid Pro. The deviation across tasks here is relatively high, suggesting that the complexity of the task is reflected in time to complete. Task times are fairly long when compared to Cubase for instance. Test 1 presents task times ranging from 1.13 to 4.21, a fairly large range considering that this is the simplest and quickest task of the 6. The higher values of 3.99, 4.21 and 3.14 here identify an issue with efficiency in performing simpler tasks as opposed to the more complex ones presented in test 5 and 6, where this type of variation might be expected.

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Mean	SD
User 1	1.13	7.53	2.05	10.68	1.82	8.64	5.31	4.13
User 2	1.79	9.01	4.01	7.96	2.86	7.69	5.55	3.04
User 3	4.21	10.06	3.37	10.11	8.68	9.13	7.59	3.01
User 4	1.68	8.73	2.03	6.42	3.10	6.08	4.67	2.83
User 5	3.14	12.91	4.00	7.43	5.31	11.06	7.31	3.94
User 6	3.99	6.00	1.18	7.94	4.35	10.78	5.71	3.35
Mean	2.66	9.04	2.77	8.42	4.35	8.90		
SD	1.30	2.35	1.18	1.64	2.44	1.88		

TABLE 14 - SONY ACID PRO TASK TIMES IN SECONDS.

Table 15 presents the results of Pro Tools. This DAW is widely accepted as an industry standard and users report this tool as being the most complete and functional of the DAWs tested. Here we see some of the quickest task completion times, particularly for the more complex tasks. Three users were able to complete the final task in under seven seconds. Test 4 however presents some unusually long task times (user 2, 4 and 5.) This issue was attributed to these users being familiar with hardware interfaces when working with Pro Tools and struggling to remember the shortcuts for these features. These results therefore cannot be expressed as a failure of the system. Arguably these longer task times reflect a more usable system – ie one that integrates well with hardware applications where the user chooses to use physical equipment they are familiar with to interact with the system. The integration of these physical interfaces cannot be considered under the remit of this thesis as the range of tools is too broad, though it is important to consider this as a factor when presenting the data.

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Mean	SD
User 1	3.99	6.48	1.06	4.82	9.98	6.89	5.54	3.01
User 2	2.75	6.79	2.86	12.81	1.67	5.71	5.43	4.11
User 3	1.18	6.01	1.88	5.71	3.96	8.15	4.48	2.65
User 4	2.35	6.12	1.49	13.55	6.35	13.26	7.19	5.20
User 5	2.05	12.7	1.83	14.02	9.13	6.96	7.78	5.17
User 6	4.33	4.52	4.35	6.21	5.13	9.74	5.71	2.10
Mean	2.78	7.10	2.25	9.52	6.04	8.45		
SD	1.20	2.85	1.19	4.36	3.14	2.72		

TABLE 15 - PRO TOOLS 9 TASK TIMES IN SECONDS.

Table 16 shows the results of task times for Ableton Live 8. This DAW was identified as the most fun and enjoyable to use in completing the tasks and shows relatively good performance across all six tasks. There were however issues here with particular users who did not use the application on a daily basis. While each user performed one or more of the tasks quite quickly (User 2 – test 5, user 1 – test 3) there were some longer completion times for particular tasks (user 3 – test 4, user 6 – test 6.) This suggests that certain functions work well in certain usage scenarios but not in others. Ableton is the most visual of all the DAWs and the presentation layer provides both opportunities for success and failure. Interactivity focuses less here on menus and more on metaphors drawn from physical studio environments. This may mean that the software package cannot be reflected well in task time analysis and is something that is addressed in the observation results that follow. Like many of the packages here, accelerator (shortcut) commands are not uniform and this caused a degree of confusion in some of the tasks.

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Mean	SD
User 1	3.03	10.52	1.23	11.96	10.01	8.63	7.56	4.38
User 2	1.13	11.68	2.01	6.38	2.52	10.49	5.70	4.56
User 3	2.89	7.78	1.31	14.17	6.4	8.27	6.80	4.54
User 4	1.23	10.92	2.52	13.14	10.25	5.63	7.28	4.87
User 5	3.73	4.67	1.47	9.38	4.84	7.83	5.32	2.86
User 6	3.58	7.87	2.87	13.96	10.47	10.8	8.26	4.36
Mean	2.60	8.91	1.90	11.50	7.42	8.61		
SD	1.14	2.63	0.68	3.06	3.34	1.89		

TABLE 16 - ABLETON LIVE 8 TASK TIMES IN SECONDS.

4.4.3.2 Task Times Discussion

The data here provides an interesting benchmark for future research. The pilot study identified a significant difference between completion rates and task times between groups. While the data here cannot be explored inferentially due to the limited sample space, we can begin to describe relationships and patterns in the data that may be of interest.

Firstly, unlike the pilot study we have a fairly limited range of results in performance times. In many of the software packages tested we can equally identify a fairly limited range. It is difficult to identify patterns or make assertions when using such a small data set and it is important to recognise that powerful statistics require a broader base in which to draw conclusions from. In the context of the data present however, Ableton shows some interesting variation across tasks. While the first and third task show fairly uniform results, there is an obvious distribution of results amongst the other tasks.

We can begin to describe the data in terms of performance. While there does appear to be some uniform distribution here, we see outliers. The Ableton results for instance, show fairly large variation in performance times. Users two and five for instance, show much quicker performance times in task five. This suggests that even amongst the expert users, particular tasks within particular software applications can be performed more efficiently and that, in spite of obvious patterns some users are better at particular tasks than others.

In terms of the tasks performed, we can begin to identify outliers in the data. While tasks one and three show relatively low times to completion, tasks two and five show interesting splits. At least one user in each instance performs tasks in an unusually short amount of time (4.67 seconds and 2.52 seconds.) When we compare these task times against those typical in the data set at ~8 and ~10 seconds, the results look even more unusual. While it is difficult to draw conclusions from these task performance times, due to the outliers and lack of consistent trends,

we can at least say that there are some interesting and unusual variations in the data. This then provides justification for further explorative work to be performed which can aid in teasing out how and why these issues occur.

Figure 2 shows all task results across all users. Here we see that variation exists across tasks and there appears to be no pattern in the data. This then provides a platform for further discussion as to how and why these issues have arisen.

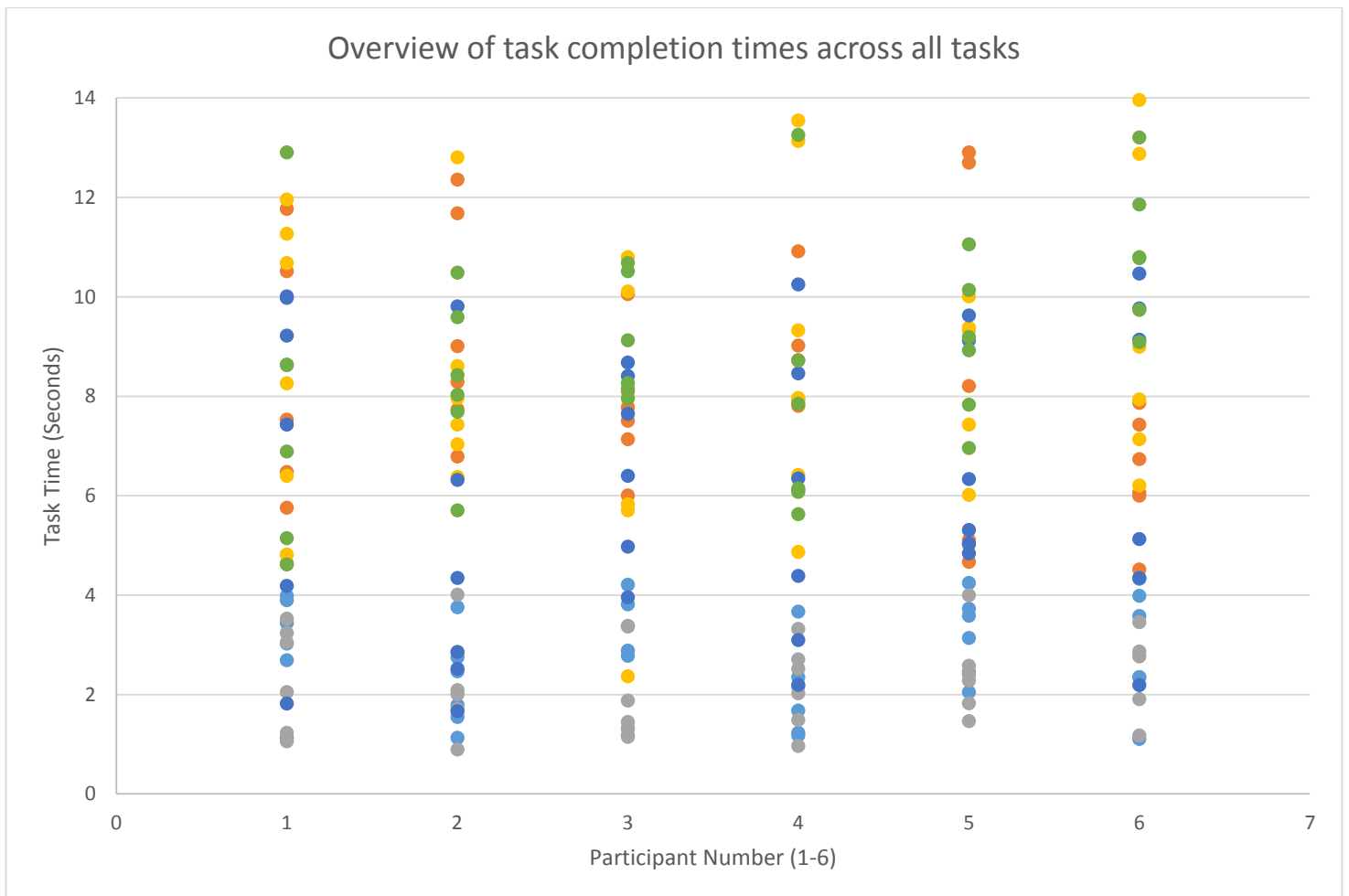


FIGURE 2 – VISUALISATION OF ALL TASK TIME RESULTS FROM ALL SIX PARTICIPANTS.

Here, it is clear to see that there is a great deal of distribution in the data. This disparity exists independently of either software package or task, as can be identified by outliers in each case. There is no clear mapping between tasks and performance times or indeed between users. This shows that each task performed is unique, not only in the context of the task but also in the context of the software application in which the task is being performed. Ultimately, this suggests that the approach is limited. While this data provides a useful benchmark to identify there are issues about uniformity in task times, the causes and reasoning behind such issues is less clear. Further research is required to tease out the complex issues presented herein.

4.4.3.3 Observation Results

Following on from the six tasks across six software applications, users are then observed in a creative scenario, where they are asked to “finalise the track.” The results do not examine the finished track, as these are often different genres of music, with varying time patterns, scales and instrument usage. It would be difficult to remove the factor of bias towards a particular type of music by an observer, therefore only the behavioural aspects, speed, efficiency and ease at which users worked are considered to be measurable.

What is actually expected of the user is that they will begin to form their own ideas and concepts and change their approach from following a strict set of instructions to performing self-directed tasks. This encourages users to be creative and allows them to do what they feel is necessary to take the track from its current state to a state by which each user perceives it to be complete. In order to do such, users must innovate and define their own levels of acceptable quality within the given timeframe. This section deals with affective and non-numerical data, focusing on the user experience, information architecture and user satisfaction. The following outcomes are observed.

Fruity Loops proves to be the software used with least variance in performance times (ie the lowest range between longest and shortest times to complete.) Each of the users relies heavily on pre-defined samples and content, rather than working with the tracks provided. Only one of the six users cuts or processes the track, where five of the users all choose to add and edit samples provided within the software package. Users remain in the 'main workspace' interface, failing to use any of the extended functionality or tools provided. In terms of creativity, this poses two major issues. Firstly, that the user prefers to 'create' content based on materials provided. This could be a reflection on the quality of the samples provided and suggests that the user either has more options or a better choice of options by using the samples. The choice of some users to process tracks rather than rely on samples in other instances likely discounts this possibility. As this is not seen in a uniform way across different software packages, the user may have found it easier to work with tracks cut into specific lengths where the samples could better 'fit' the current state of the track. The choices of users here, differing from choices in other software packages, suggests that issues do exist.

When working with Sonar, users tend to use a much greater variety of tools and effects. Sonar does not provide the same volume of pre-defined samples as alternatives such as Fruity Loops, however a mix of different samples is made available to the user to work with. Two users chose to use plugins to create their own drum samples. The number of tracks created also exceeds that of other software solutions, with Sonar users showing a greater degree of variance (some short, some very long) in track length than other software packages.

The results of the, 'finalising the track,' task for Cubase are as follows. Users are much more ambitious and creative, with a range of advanced features used alongside the traditional basic features provided in the main interface. Two users use VST plugins to extend the sound of existing tracks, while all six users add some kind of pre or post effect within their tracks. Effects range from simple phaser effects to layering the same track, transposing in different keys and modes, to create a *"bigger and more concert like sound."* One user even customises their drum sounds, changing the length of beats, resonance and other high

level options hidden several sub-menus away from the main interface. This type of affordance could have been made obvious to the user by the navigational structure or could have been learned in previous usage. What is clear here is that users are more willing to negotiate the structural aspects of the system in order to achieve a particular goal.

Sony Acid Pro also enabled the users a great deal of opportunity to customise their tracks and work in a creative and formative way. Some of the one click effects improve efficiency for the user and enabled them to do fairly advanced things easily, such as applying the, 'invert track phase,' effect. This means that users have more time to work on selected parts or sections of tracks, creating a multitude of fade in, fade out and transitional parts to provide a more, "*structured and better sounding,*" piece.

The usage of Avid Pro Tools in the, 'finalise a track' task show a huge variation in results. Four of the users mention difficulties in finding certain functionality that they are familiar with in a hardware based interface. Not providing input or hardware devices seems to limit their ability. This relates closely to their experience and exposure to the system, in that they are unable to perform tasks using the tools provided and rely on an intermediary where possible. One explanation for this is that the experimental design is flawed – users do not only work with software, but a series of tools and technologies. On further examination however, the functionality provided by the hardware could be found in the software, albeit in areas that the user might not necessarily find easily. The fact that two users are able to produce tracks which are generally perceived as some of the best in the group suggest that the advanced functionality is powerful but also well hidden and learnability is poor within this particular interface. Users have not identified similar issues in other software packages and there is no evidence to suggest that they use hardware to gain any particular advantage or additional functionality. The two users with tracks perceived to be "well created" by the rest of the group most likely have more exposure to the software interface and so are able to remember where certain features could be found. The hardware proving a limiting factor is certainly a concern, but is likely beyond the scope of the work here.

What can be said is that the clarity of functionality is not provided here by the software alone and this is an issue for concern.

Ableton users seem to have positive experiences. Though most of the users admit having limited previous exposure to the system, they seem able to find what they are looking for and even express an emotional reaction to the system. Users describe the interface as, “nice,” “pleasant’ and one user commented that they are “enjoying getting to play with,” the software. Users also comment on the skins and colours used in the interface, describing it as, “bright” and “visually, quite nice.” Aesthetics are one of the more modern usability features, where work has recently highlighted the importance and effect of aesthetics on perceived user experience and efficiency (Lee & Richard J Koubek 2010). It would be presumptuous to say that no other software package focuses on aesthetics without considering Garageband and other packages, however based on the distributions tested, Ableton was the only one with visual factors that users commented on.

2.4.3.4 Sketching Results

The sketches are converted into a readable format using Balsamiq Mockups and presented here.

In the first group, users attempted to design a commercial solution, discussing ways to monetise a tool in this context. This group did not produce a sketch, instead discussing mobility and marketability.

Figure 3 and 4, sketches from group two, show a design focusing on giving the user a visual overview of the content. Here the design has two views. The first view gives descriptions about tracks based on the time (presented as sticky notes) so that multiple users can interact. This provides a platform for non-musicians to describe the content and 'talk' to the musicians. Upon clicking, the user then presents a 'contextual' interface, showing notes and chords that describe the track musically. This way, each user regardless of instrument can get a 'feel' for the music, without having to listen to each track. It is designed as a universal way in which notation can be described and observed quickly and easily. Users also suggested that a similar interface could be used to describe tempo, modes scales and such, with chunks representing time here instead of notation or both elements in a clear way.

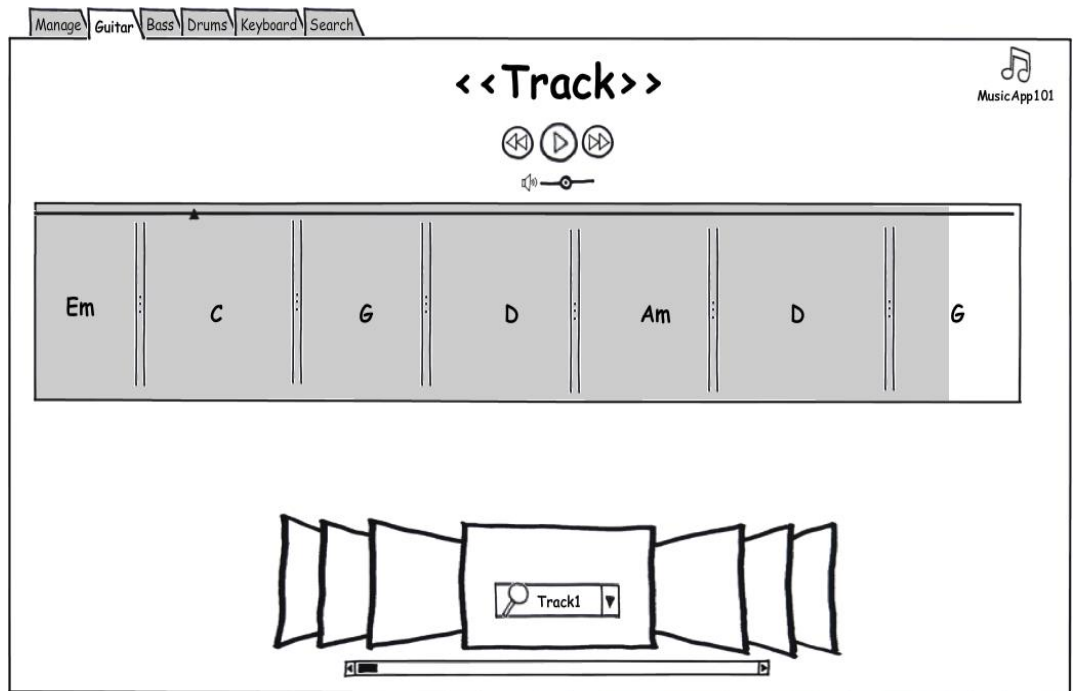


FIGURE 3 - SKETCH OF A GENERAL INTERFACE FOR MUSICIANS

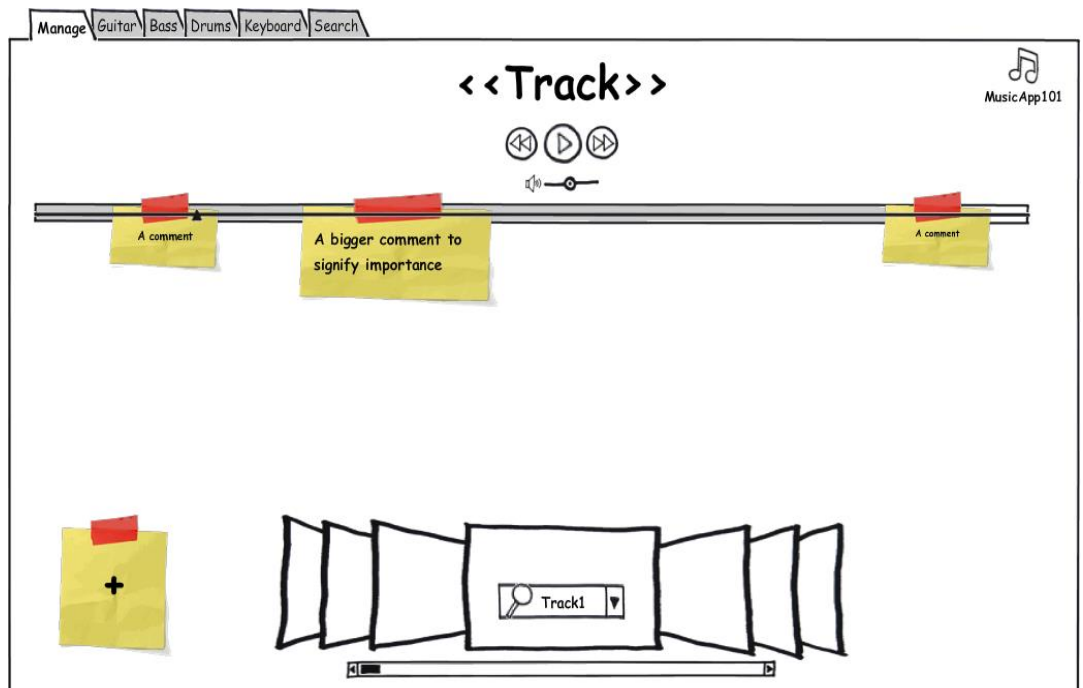


FIGURE 4 – TIMELINE BASED NOTATION AND SWIPE NAVIGATION

Figure five, a sketch from group three, shows a different approach to design, choosing to focus on 'views' of the system. The first view, shown here, shows an instrument by instrument interface, with the track the main point of focus based on the instrument selected. This contextual approach to design was uniformly accepted by the group.

The second view in figure 5 shows an interface for searching for tracks, showing multiple search criteria working together to find a series of tracks that meet the given criteria in the search boxes or metatags. The final design view shows a user working on a track from the perspective of a guitarist. Interestingly, neither participant reported being able to play the guitar in the discussion groups which followed. The notes are present and the track also shows the progress of the track in terms of both playing (bar at the top) and completion in terms of composition (darker area.) Although technically two separate pages, this group describe this design as a single workspace interface. It actually shows two browser windows open with the editing facilities built into the browser in a native way. The view on the left shows the tracks from the perspective of the instrument, as a general overview, with the option to share by clicking the F (Facebook) icon. The view on the right shows a menu to manage the track, with search options, a novel tag cloud for searching by clicking popular links and the current track in the bottom of the window. The current track has icons around it, allowing users to record, play, edit, retrieve or set track information and lock the track to make it uneditable. This view is the most complex of the designs, but still fairly limited in terms of the products that the users actually tested.

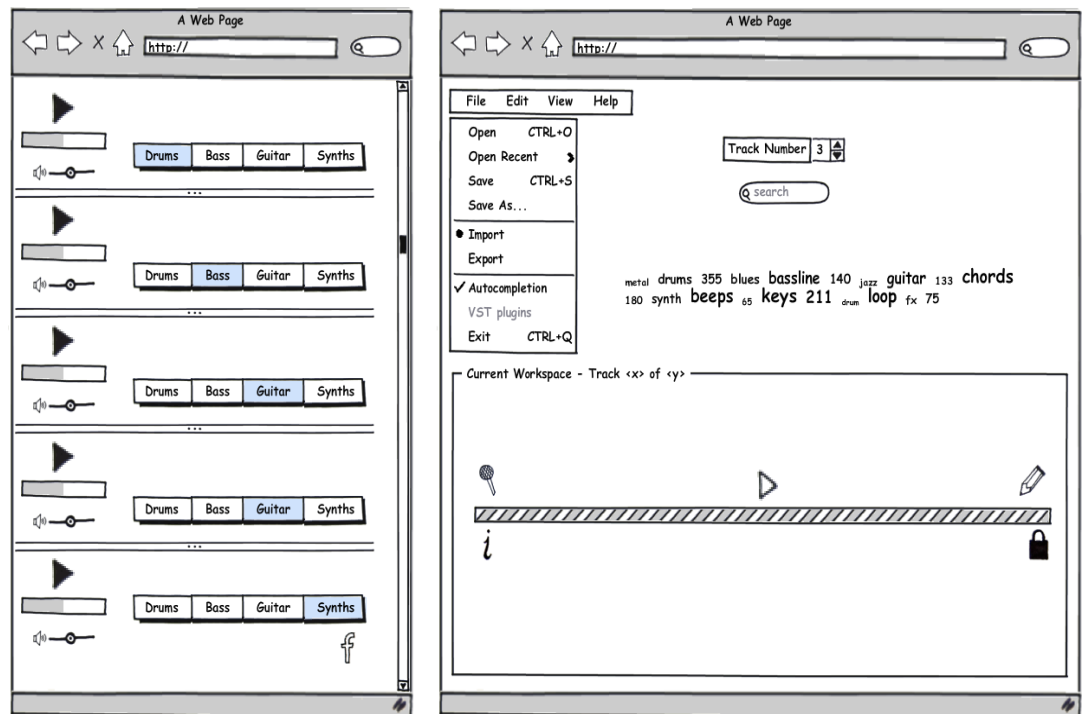


FIGURE 5 - AN INTERFACE SHOWING TRACK-BY-TRACK AND FUZZY SEARCH

Figures 6, 7 and 8 presented by the fourth group show several iterations of their design, focusing around tracks at the centre of the design, navigational links on the right and menu options at the top. The second iteration added a percentage complete feature, to notify other people involved in creating the track how far along the process was. The group also added 'to do' notes, suggesting improvements and changes that needed to be made to the track, or reminders for later work. Their final design iteration focuses on a user-centred approach. The username can be seen at the top of the design and the user can also tick or untick checkboxes for parts of the track that they wish to pursue or defer responsibility for.

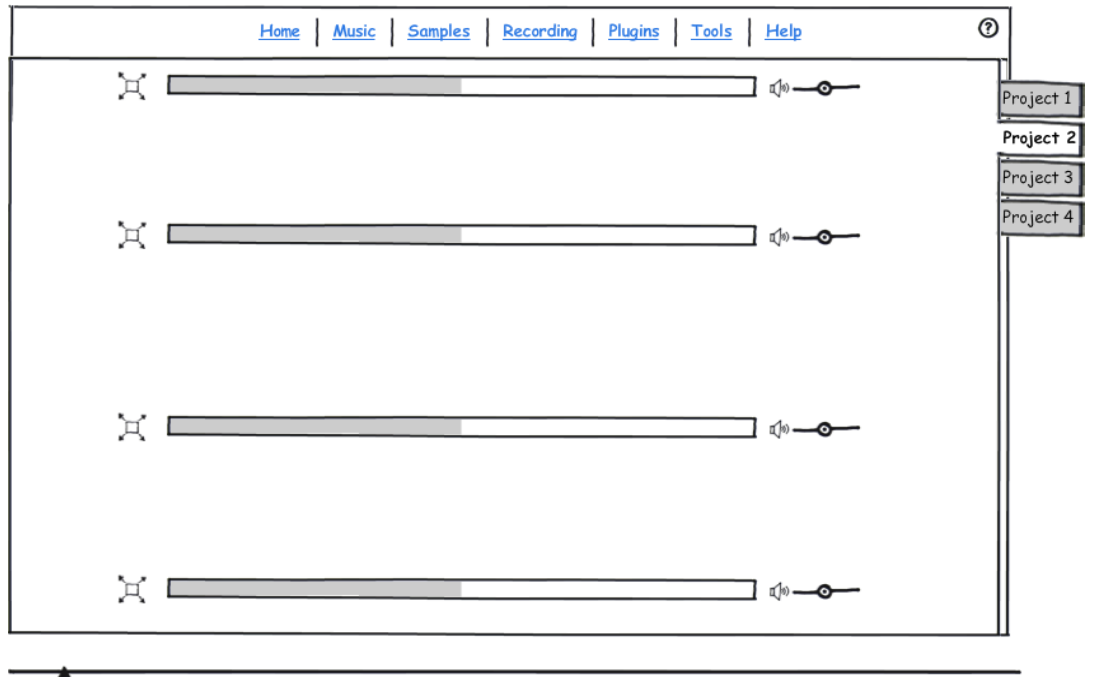


FIGURE 6 – CATEGORIES FOR NAVIGATION AND SONG STRUCTURES

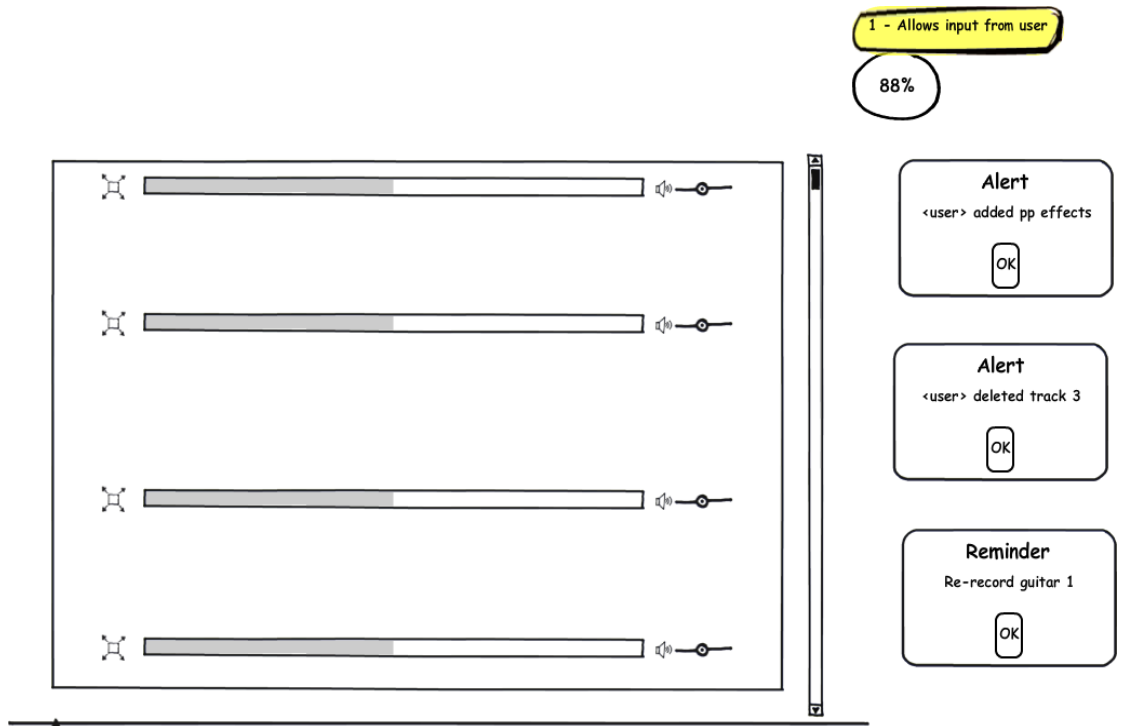


FIGURE 7 – ATTACHED OWNERSHIP AND PROGRESS TRACKING – WITH EVENTS TO DO.

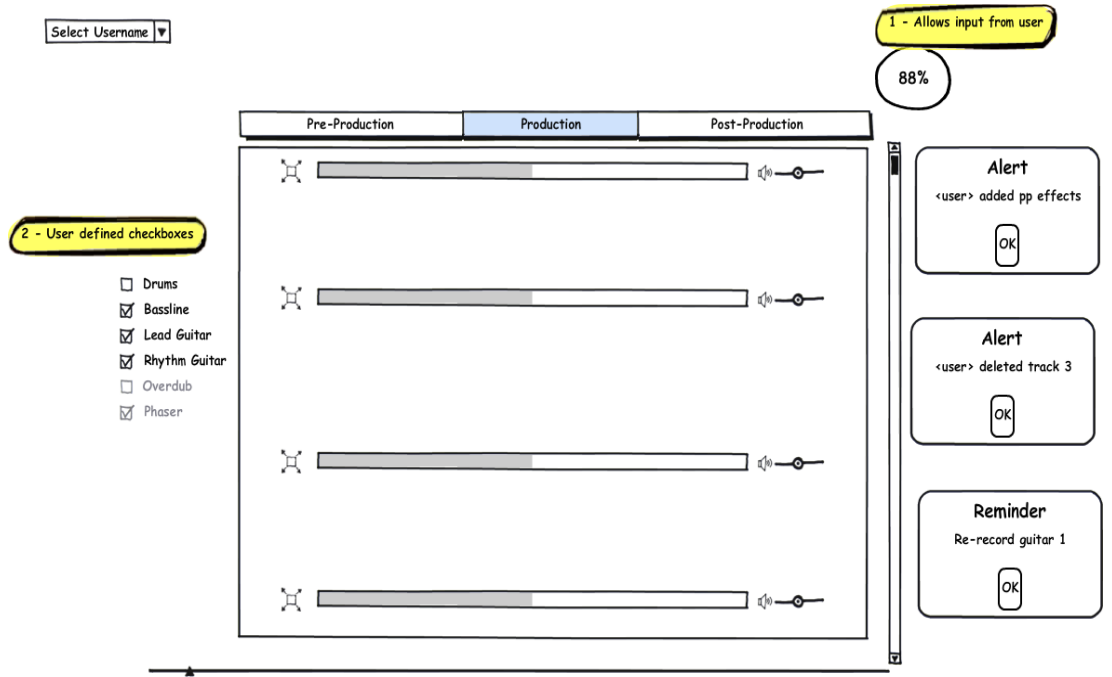


FIGURE 8 – CHECKBOXES AND USER SELECT OPTIONS ADDED.

4.5 Evaluation

Through the first set of pre-defined goals, there is very little variance in performance times. The related criteria of efficiency and effectiveness therefore could not be sufficiently measured through such a stringent and structured set of tasks or goals. While task time analysis (Ritchie & Roast 2001) provides insight into how efficiently a process can take place, they fail to measure the other aspects of usability (Nielsen 1994; Ilom 2008; Lindgaard & Dudek 2003). Nielsen himself however states that, 'usability is a general concept that cannot be measured.' He goes on to mention that the parameters themselves however, can be measured. In the same way that Nielsen splits measurements into objective and subjective measures, the methods imposed here aim to achieve a split between what users do, what users say and what users say about what they do. It provides a good foundation for further work and enables the researcher to form two general conclusions. Firstly, there is a difference between performance of users even when testing amongst experts (Følstad et al. 2010.) Secondly, music systems are not usable when considered in the complex domain of ever changing technology and user requirements (Seago et al. 2004; Jordà 2005; Kaminskis & Ricci 2012; Inskip et al. 2008.)

The process of defining usability in this context is one which relies heavily on grounded discussion with participants and validation through observation. Only the people using the system can describe its intricacies in terms of how requirements and functionality match. Even then, users cannot be simply asked about how 'usable' the software is, as the definition of usability is broader than defining how easy it is complete a task, especially when innovation and creativity are core processes (Lindgaard & Dudek 2003). By describing typical tasks and then being asked to complete the tasks described, participants create a set of goals that are truly grounded in their own experiences. If the researcher were to impose goals on them or expect them to use the system in a certain way, it would be unlikely to match their own experiences and expectations. It would not measure usability,

rather it would measure learnability. Equal probability sampling is also a potential concern here, (Peters & Eachus 1995), as users are likely to have more experience with some software packages than others. However, having users only testing software that they are familiar with limits what can actually be measured. Therefore a robust set of goals, grounded in discussion, with a mix of strict and unstructured tasks lends itself best to measuring usability in this environment. The unstructured tasks are aimed at testing the usability of a dynamic environment, as opposed to the static tasks that are typically performed. Participants identified creativity as a key process between production and completion of a track and this method proved the least problematic in identifying creativity.

The observational data provided great insight into areas of user satisfaction and preferences, which are inherently difficult, if not impossible to measure using task time analysis (Lee & Richard J. Koubek 2010; Tuch et al. 2012; Følstad et al. 2012). An interesting observation made is that the users perform more uniformly in the main study than in the pilot study, with less variation in results. When comparing the set of tasks in this study to the pilot study, it is clear that the points of frustration, at least in the first task, are no longer a major issue. In two usage scenarios, pilot and study one respectively, the user task times improved to a more uniform distribution. Average times varied between 33 and 41 seconds. While 8 seconds might seem a negligible length of time, an 8 second increase is greater than a 24 percent increase in the time it takes to perform that particular task. Over a forty hour week, that's potentially over nine hours extra work. This type of statistic does not necessarily generalise as such, however it does shed light on an interesting issue of efficiency in task times and suggests that in some instances there is variation in efficiency (therefore usability) of the software being tested. It is also important to recognise that the user no longer experiences observable signs of stress in the second set of tasks. In the pilot study, two users appear to experience stress, which would account for the sudden increase in task times that can be observed in the initial data set. While this is a somewhat subjective explanation, the posture of users in the second set of tasks supports this theory. When performing the tasks this time around the user appears to be much more relaxed. No users lean forward or move closer to the screen and there are no obvious

physical signs of stress, such as sweating and heavy breathing. Each of these observations exist in the pilot study, though there is not a relevant comparison to make at this stage in the process. The points of frustration, or lack thereof, could shed light on the issues of learnability and memorability and are the most logical explanation for the issues at this stage. Further exploration is needed to highlight the context of both where and why usability problems are occurring – especially considering how fundamental the tasks performed are in a working day scenario.

Based on performance times alone it is clear that users as a whole improved from the pilot study to the first study, where tasks did not differ. Time and resources show very little variation from the pilot study. However, when the users are asked to complete the tracks, they become much more careful in their approach. The users no longer show signs of haste and one user navigates as far as four sub menus deep in order to find the resources that they needed. While this might initially suggest that creative tasks have a higher degree of usability, there is an equally valid argument that performance times in comparison, are much slower. Usability is measured as more than a set of metrics and time based tasks, as discussed previously and creative tasks exhibit a set of problems which become more difficult to measure than those presented in simple task based scenarios (Shneiderman 2000; Coughlan & Johnson 2006b). As tasks become less strict, the user is then able to express a certain level of freedom. With limitations on boundaries and constraints, the user has the choice to either explore the system in a complex set of interactions or to perform more simplistic repetitive tasks in order to achieve a result. Discussions with users highlight aesthetics as a major factor in how willing they are to explore the unfamiliar components of the system and try to be creative. Ultimately, creativity hinges on a willingness to explore, through lack of fear and a certain sense of curiosity in exploration of the system.

The results of the sketching exercise highlight the mismatch between current systems and necessary features. Many of the features suggested in the designs are unavailable in all six commercial software packages, including the many social features suggested and the contextual richness that was expressed within. Sketching has been used to highlight such mismatches elsewhere (James & Brad 2001; Ma

et al. 2009; Buxton et al. 2006) and are also used as an effective way of understanding requirements from an early stage. Were the researcher to design an interface based off the sketches alone then it would likely appear very different to existing implementations. While these sketches may not necessarily generalise to a larger audience, they do highlight that there are contexts where current systems are not appropriate and that by using a human-centred approach to design, requirements of users can become more apparent. The thesis explores more involved methods, such as ethnographies, in later work and refers back to the problems highlighted through the sketches in relation to current systems.

It is also important to verify that user experience is being measured holistically, rather than addressing isolated issues relating to learning, memory, effectiveness or efficiency. Herein, learning is difficult to measure in this context as many of the users have variable experience that is too difficult to control for. It could also be suggested that usability decreases as boundaries and barriers are lowered, which is difficult to isolate in any setting without first addressing cultural and contextual issues that a richer, more exploratory research method may highlight (Ahmed et al. 2012; Hammersley 1989; Albers & Still 2010). At this stage, this point is unclear and leaves room for further work and discussion. A similar discussion can be had about the legitimacy of the results in terms of perceived usability versus practical usability, a distinction which can prove difficult to make. This topic is addressed in existing literature (Lee & Richard J Koubek 2010). While these issues may have been addressed elsewhere, within this given context it is difficult to isolate perception as a variable. Whether perceived usability is a factor of user satisfaction or related to other disciplines, such as user experience, is a discussion that extends beyond the scope of this particular project and could be addressed in further work. The task times and proceeding discussions with users suggest that core functionality should be made more immediately obvious, that design could be more pleasant and that an overall uniform structure may reduce the variation in efficiency across platforms. The appearance of digital audio workstations differs extensively, with users performing well in each of these packages in at least one instance. This makes it difficult to generalise about a best case scenario in terms of appearance and supports the argument for having different interfaces for different purposes (Kaminskas & Ricci 2012; Vuust et al. 2009; Hurtienne & Blessing

2007). The tools all seem to be effective in the given scenarios, as can be seen by a 100% completion rate. Therefore, it would not be unreasonable to suggest that existing implementations are somewhat usable from the perspective of being able to complete typical tasks, but require refinement in order to better facilitate the wide range of user requirements observed.

4.6 Summary

In summary, the findings here show differences between usability of each digital audio workstation. Through observation and sketching, it is also possible to identify a mismatch between user requirements and the types of functionality provided by these systems. There seems to be problems between aspects of social media, content management and control, key aspects highlighted in the sketching exercises. In a modern, digital age the ability to utilise network technology is available, though largely provided by external tools and software. The same is true of content management in that structure of individual songs are controlled using the digital audio workstation, but the management of content is user dependent. This is an oversight that has been highlighted as a core requirement by users in follow up discussions and can be considered a failing in both effectiveness (doing a particular task well) and user satisfaction (not meeting user requirements.) It could also reduce efficiency in terms of users having to connect multiple tools together, either through middleware or manually. While each of the systems were able to complete all tasks in a timely manner, the difference in times is a concern. As the tools provide similar functionality in these tasks, the delay in completing tasks can only be attributed to usability issues. The confusion often arises in areas where systems provide the same functionality in different ways, for instance where shortcut keys are not universal or where a visually similar button has a different meaning or functionality. Standardisation has been suggested as a solution to this problem but relies on multiple vendors communicating and agreeing on design goals, which may be impractical due to the commercial nature of these businesses.

The results here show that user experience is a key concern within this field and can impact performance greatly. The way that humans interact with music systems has been tested across a number of platforms. Criticism of existing software seems to be overshadowed by the annual release cycle of each updated software package. While interfaces change from generation to generation, the major usability concerns do not seem to have been addressed. Perhaps this is due to accessibility issues or relates more closely to the insular and technical culture that these systems currently adhere to. While barriers to entry are high, it may be that learning occurs through multiple generations of a product, rather than by simply using the current release cycle. The research shows that there are usability issues amongst real world users. The lessons that can be learned here transcend far beyond the systems they encapsulate. Much of the functionality remains unused, suggesting that many of the features provided have far less value to a musician than the features that could be incorporated. This is particularly evident in discussion with musicians and there seems to be a gap between user requirements and system design. There is much room for development here and this work provides some very brief insight into potential challenges for the future.

The purpose of the first study was to examine software tools for musicians in a traditional environment. The writing and recording process has long been conducted in a studio based environment. Abbey Road, Gold Star, Rockfield and the Rolling Stones' portable studio are all examples of well-known recording environments that have been used by popular artists dating back to The Beatles. This study focuses on the usability of the software tools used in the studio. By trying to understand the requirements of a broad user base and model scenarios which reflect the work of industry counterparts, some interesting discoveries were made about the variety of tools used. The study tested a series of scenarios, using both traditional usability metric measurements and more novel, fitting scenarios that encourage creativity and innovation. The study was completed with a sketching exercise in order to propose 'better' solutions to the problem. The sketches attempted to simplify the environment in providing basic functionality, as a means

to support the tools that exist. The participants agreed that there was a necessarily layer of complexity in the tools and an inherent learning and memory gap that would be difficult to remove.

The first study used a holistic approach to research, in forming questions and understanding the research problem. Much of the preliminary work focused on discussing the requirements of a typical user and the relationship between entities involved in the creation and publication of music. The discussion highlighted major stages including inception of a track, pre-production, production, post-production, dissemination and live performance aspects. Rather than describing the weight of each process against supporting processes, participants described each step in the process as imperative to the overall model. The participants recognised that without a digital track, the company would have little if any revenue streams, however the issue of live performance and merchandise providing the largest revenue streams also arose during the course of the discussions. Participants could not describe the order of performance and production and often talked about them interchangeable, though as a group largely defined them as disparate processes.

Figure 9 presents the results of a discussion that followed the study. The discussion group described a broad area of focus for a musician, with major themes continually occurring. The following, non-directed diagram, describes the process and relationship between components. Elements that are side-by-side have a direct relationship with two other components that they are connected to.

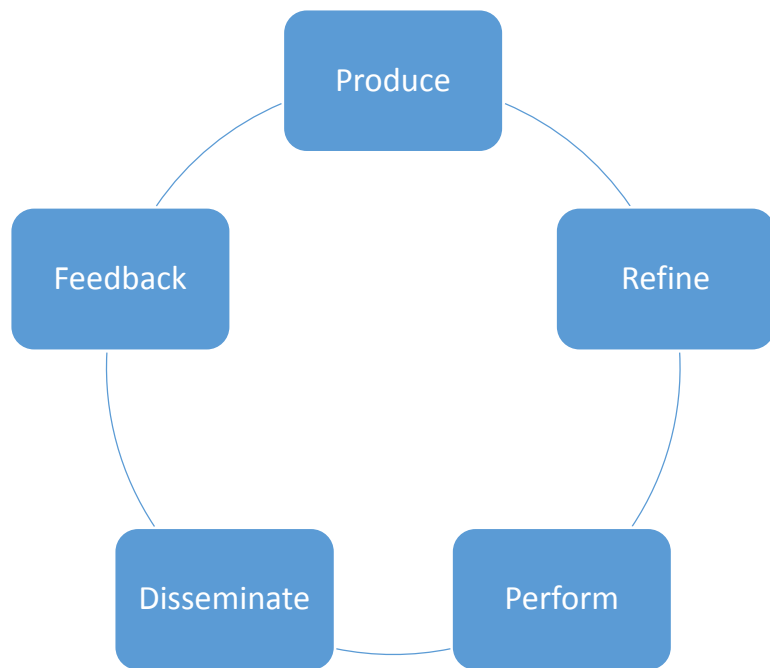


FIGURE 9 - DESCRIPTION OF THE CYCLIC PROCESS OF A MUSICIAN

There are however, some gaps in the first study. Firstly, the live element of music production and performance is not considered. These tools are imperative in the work of musicians and live performance can often make up the largest revenue stream for the artists, when considering merchandise sold at gigs and CD/download sales. To ignore these tools of the trade would be ignoring the musical process and the work could not be considered 'complete,' without a thorough, directed and contextual analysis into the range of tools that exist. These tools are more 'fuzzy' in nature, as such they provided a non-directed approach to musical creativity. Here, an 'end goal,' as was clear in the first study, is not easily defined. Music is no longer created in the same environments as twenty or thirty years ago and the process has both become more portable and more complex.

The section that follows explores a work-based environment in further detail, taking the research on the road and exploring how musicians use digital software in their day to day lives. The definition of software here extends beyond traditional

software systems for music production and explores how software is used to plan, communicate, collaborate, compose and evaluate performance elements. This method compliments the previous work in that both traditional studio environments are tested alongside the dynamic working environment of today's musicians. The mixed method approach provides balance and multiple perspectives in understanding the complexity of usability for music based systems.

Chapter 5. Ethnographic Exploration of Music Systems in Context

In the last chapter the key findings that emerged were that usability of commercial software applications differs depending on the task and context of the user. The theme of creativity was also explored, with some systems performing well in creative tasks where others did not. The final exercise in the study explored requirements against existing functionality and determined that many of the modern functionalities required, such as social integration and collaborative workflows, were not available in any of the systems tested.

The following chapter aims to explore this problem further by looking at the usage of these and other systems for musicians in real working environments. The effort here is to explore the 'how' and 'why' of usability in this context and produce a set of results that is descriptive and ecologically valid - to compare against the less descriptive results already explored. Here, the discovery of real world context and usage scenarios provides a contrast to the work in the study in order to understand usability from two conditions – the ideal scenario in a studio with time and equipment versus the on the road perspective, where time and resources are limited and performance elements are time critical.

5.1 Introduction

The music industry relies on technology from production, right through to dissemination as can be seen through the popularity of services like iTunes and usage of production studios. In terms of production and performance systems, a variety of attempts have been made to produce a usable system. The problem of creativity, innovation, usability and generating successful requirements can often dictate poor user-centred design and an end product or service which does not meet user needs. Multimedia systems such as composition and collaboration environments

are inherently difficult to design. In many instances, the kind of problems that occur can be attributed to evaluation and testing methodologies in order to verify that the tools are fit for purpose. A user-centred, formative approach to evaluation would prove increasingly capable of identifying and reducing usability issues in such an environment (Huart, Kolski, & Sagar, 2004.) Huart et al address this issue in their work. While the evaluation methodologies used to assess usability vary greatly, there seem to be problems in evaluating particular aspects of systems and how they relate to the variable requirements of users in an ever changing technological environment (Hewett 2005)(Benford et al. n.d.)

Other attempts have been made to build a usable solution through utilising modern technology. One approach which may hold weight is one which suggests using processing tools which are powerful, but also transcend well to user schemas. Many of the successful efforts tend to be in contextualised situations, where the user has a specific process or goal within the system. The eJay project (Gall & Breeze 2008) made some headway into understanding the usability factors, rather than simply proposing an overly complex and multi-layered structure that adds complexity and little else. The work here focuses on a specific environment (educational, collaborative) and the management process, without focusing extensively on the technology. The results here are somewhat promising. In terms of understanding context (Laske 1990) some interesting discoveries have been made about creativity in musical compositions. The work here suggests a three pronged approach, similar to modern requirements engineering, in understanding the process involved. The three pronged approach is as follows. Firstly, an event is generated by making changes to a hypothesis element. Expectations are then generated by posting changes. Finally, a goal is generated by posting desired changes.

There are a number of different approaches to enabling creativity in multimedia environments (Crow 2006)(Riley et al. 2009)(Ahmed, Benford, & Crabtree, 2012.) The evidence presented thus far suggests that creativity is an imperative process

and for a system to be considered usable, even by broad definition, it must at least be effective and efficient, as described by in early usability research (Nielsen, 1994.) A collaborative effort by different media, technology and infrastructure providers in Norway summarises the literature on the value and relationships of creativity (Karahasanović et al., 2009.) The paper provides a succinct and valuable overview of creativity and requirements engineering, their interdependencies and the challenges in providing technological solutions for creative or innovative people.

DMix (Oppenheim 1996), a musical interface, proposes some solutions in bridging the gap between requirements and usability. The difficulty in understanding creativity is highlighted as a key concept by Oppenheim. The value of context is highlighted here as a key aspect in building systems which can be considered successful and usable. Oppenheim ultimately describes a user-centred approach, stating that flexibility and interoperability as the major components of a successful system. This concept can be observed in modern systems, where connectivity between hard midi applications and soft applications such as VST plugins enables users with different level of technical skill to communicate. The research by Oppenheim goes on to suggest a presentation layer which provides such functionality.

The following section describes the purposes and objectives of the research, including any considerations that need to be taken into consideration when evaluating the success of the research and making and generalisations about the results. This research focuses on the usability of live performance software from the perspective of the user. Here, the definition of a musician has to be broadened to user in order to take into account the fact that not all live performance artists are encapsulated in the traditional definition of a musician. Users, may rely heavily on sampled music in order to create new media. This is not composition in a traditional sense, though it is an original composition of existing material into something new, therefore it can still be considered a creative process.

The work here is based around generating a hypothesis and then further exploring it through real world scenarios. As such, the first study provides a solid foundation by which initial hypotheses and questions can be formed. While these questions and assertions are likely to change as more in depth observation occurs, they form a good starting point by which the researcher can categorise problems and solutions, with refinement a possibility once enough data has been collected to modify the theory.

- *How is music created in a live environment? Are these tools more or less usable than traditional alternatives and why are they used?*
- *How can software tools be used to better plan and organise a live performance? Do these tools enable a complex process to be broken down or made easier and if so, how?*
- *In what ways are software tools used to add to performance and how do performers gain from a seemingly additional layer of complexity? Surely playing would be simpler than playing and using additional tools?*
- *What additional functionality does the software provide, if any? Also, are there degrees of usability within these tools and does that correlate with a more positive performance?*
- *How are supporting software packages used to streamline the process from song inception to performing in front of a live audience?*

5.1.1 Aims

The aim of the second study is therefore to examine these two groups of people and understand user experience factors relating to the tools that they use to support their performance (or indeed perform with.) This works follows on logically from the initial study by providing a comparison – from studio based environments to real world usage scenarios. The aim here is to provide two sets of results, with a focus on reliability in the first instance and validity in the second. The ethnographic approach breaks the focus down into a set of requirements, an evaluation of the tools in relation to their context and finally a generalisation about

the current state of tools for musicians in a live setting. Here the focus is on ecological validity, producing results that may not generalise well, but highlight the issues in some detail, with description about problems and solutions.

5.1.2 Objectives

The main aim here is to understand the factors and features relating to the usability of live music production and performance systems. The objectives are:

- To describe how technology improves user-centred processes from traditional pen and paper or instrument based systems.
- To investigate how technologies could be used to further improve usability of systems to ensure that they provide additional benefits to live performers.
- To understand the relationship between requirements of a user and discuss how various implementations of software based music systems match said requirements within a given context or situation.

5.2 Pilot Study

The pilot study enables the examination of methods to ensure validity, reliability and to reduce any confounding variables (Riley et al. 2009; Følstad et al. 2012). This study focuses on ethnographic approaches with a view to highlighting context and understanding the intricate details of usability problems, examining qualitative data as it occurs in a natural environment (Ahmed et al. 2012; Cunningham et al. 2003; Hammersley 1989.) Ethnographies are much more difficult to control in terms of isolating environmental factors, removing confounding variables and controlling the nature of the experiment (Benford et al. n.d.; Inskip et al. 2008; Cunningham et al. 2009.) An experiment in a lab based setting, where the temperature, environment and equipment can all be controlled is likely to produce results which are more reliable however the validity comes into question with this type of method. The dynamic nature of such experimentation results in a series of

events occurring which are difficult to predict at best, though the researcher has taken every effort to reduce the effect that they might have on the research, it is impossible to remove this effect entirely. The ethnographic approach has been chosen primarily for ecological validity (Benford et al. n.d.). In spite of the outside effects, the research examines musicians in their workplace, performing tasks which are not a simulation but have real world effects and consequences.

For the purpose of this research, the pilot study needs to be thorough in considering a multitude of possible outcomes and confounding variables that are likely to affect the results (Kaminskas & Ricci 2012). For this reason, the pilot study takes place in three different venues, with different musicians in each venue and different criteria to measure in each environment to determine the best course of action going forward. As the ethnographic method is largely about forming a contextual, domain specific set of measuring criteria and due to the lack of existing knowledge with in the field of music-technology ethnographics, this approach can be used to find a ‘best fit’ for the method used.

5.2.1 Pilot 1

The venue chosen for this study is an acoustic open mic night in Elephant and Castle, London. Here, musicians perform for thirty minutes in a genre of music of their choosing. This study involves two participants, with differing technical requirements. The first performer professes to use no technology to aid their performance, while the second relies heavily on technical tools.

Table 17 describes the participants of the first pilot study.

	Musician 1	Musician 2
Pilot 1	Non-Tech	Tech

TABLE 17 - PILOT 1 PARTICIPANTS

It is important to recruit participants before the performance event, in order to get informed consent, explain the nature of the study and examine their technical habits in planning and preparing for a performance. While the initial scope of the study focused around performance elements only, participants explained the usage of technology before and after the performance as key to its success, therefore these areas cannot be ignored.

5.2.1.1 Results

The first musician described technology as a “nuisance” and “another way to make things more complicated than they have to be.” Upon probing, it was later discovered that the participant did use technology in other aspects of life. The participant owned an iPhone, a laptop and several other technologies. In spite of this, the participant exhibited a real reluctance to use technology to aid their performance. Even tuning aids were dismissed. The performer described their rehearsal as, “polished and prepared,” explaining that they would play through their set list several times a day in order to get the performance right. Without the use of technology, the performer completed their set with no obvious causes for concern. The performer used only a Westwood acoustic guitar into a digital input and a Shure SM57 microphone. The sound engineer used a hardware based interface which fed directly into the amplification system at the venue. The engineer also used a laptop to keep track of performers and record performances. The audience watched and listened attentively and applauded after each song. While it is difficult to gauge the success of a performance on an audience’s reaction, it would be unreasonable to suggest that the performance ended badly. One member of the audience described the performance as, “lovely and warm,” elaborating by saying it made her feel, “like being on holiday in the Caribbean.”

The second (technical) musician described their performance as, “using software to make my life easier.” The rehearsals of the performer involved using a number of technologies to assist. These included various applications to generate backing

tracks to play along to and a metronome application to help with timing and rhythm. The musician struggled to name the tools that they used, but mentioned FruityLoops, Sibelius and Metronome for OSX. The performer did not mix their own tracks however, choosing to leave the process to a studio that they relied on and trusted. Their reasoning is described as follows.

“it takes too long to use all of that stuff. I’m out four or five days a week playing. When I do want to record something, I’ll spend a couple of hours in the studio, then be back out playing later. Going to classes or spending money I don’t have trying to learn something I don’t need has no value for me.” – Technical user

The second musician, the technical user, performed with the assistance of various technologies. Many of the technologies used were iPhone based apps, including a portable metronome and guitar tuner. They used an electric guitar, into an effects pedal which changed the sound to make it sound like an acoustic guitar. They also used an SM57 microphone for vocals. They also used a sound level monitor to measure the decibel level of ambient sound and ensure a consistency in their performance. While this is largely controlled by the sound engineer, the performer explained that they can affect the levels by, “moving closer or further away from the mic” and “strumming harder.” When prompted, the participant explained that, “sometimes adrenaline takes over and you think you’re playing at the same speed or volume. Quite often, you’re not.”

While the second musician didn’t receive as positive a response as the first, the audience did applaud each song and seemed to enjoy the music in much the same way. One audience member described the performance as, “good, probably not the sort of stuff I’d listen to at home, but that’s what these nights are for. We get to hear four or five completely different styles of music and that’s nice.”

5.2.2 Pilot 2

The second pilot study took place in a small pub in Clerkenwell, London. While the study was designed with three participants in mind, one of the participants had to cancel their performance due to illness. This meant that the second pilot study matched the sample size of the first and was able to provide a contrast against the discussions and observation of the first study. The audience here was much more intimate and involved. For this reason, the researcher did not have the opportunity to speak with them personally, though groups could be addressed in this setting.

5.2.2.1 Results

The setting here was somewhat different to the first. A sound engineer was not provided, nor was there a PA system. Musicians were expected to bring all of the equipment that they need to perform for 20-30 minutes, with 10 minutes for setting up and packing up. The first participant reported as, “semi-technical,” while the second reported as, “technical, or very technical.”

Table 18 describes the participants of the second pilot study.

	Musician 1	Musician 2
Pilot 2	Semi-Tech	Tech

TABLE 18 - PILOT 2 PARTICIPANTS

The first performer relied largely on supporting tools, rather than tools for performance. These tools enabled the performer to track progress, make notes and keep track of the information that they needed the most. In essence, the system chosen could be described as a semi technical management/knowledge information system. The three main tools the musician relied on where as follows:

- An electro-acoustic guitar with built in active pickups that could act as a digital tuner. The pickups are a standalone device, designed to measure pitch of a note and describe the tuning of the instrument, as well as boost the signal of the instrument before it passes on to another output device. This enables tuning without having a separate tuning device and is physically attached to the instrument. It runs from a battery and literally ‘picks up’ the noise of the guitar. It is similar to a pickup used in an electric guitar, however with a hollow body to capture the resonating sound.
- A physical, portable recording device. The device is a generic, non-brand, portable recording device designed for taking notes of speech or sound. The performer used this tool for both note taking and recording elements of performance, including clips of vocals, guitar riffs and drum riffs tapped out on the guitar. The performer described their use of this tool as, “a way to store ideas, things that are on my mind, a way to get it out and keep it safe. My recorder enables me to come up with song ideas and keep notes of sounds that I like. I use it like a journal for music”
- The musician also owned a laptop with Sibelius for recording, “more concrete riffs, ideas that have become songs, or parts of songs.” Though they went on to state, “I don’t really like relying on technology too much. I can’t really afford to lose money or work when it [the technology] lets me down or goes wrong. As much as I love what I do, it’s hard work making a living out of it.”

The performance ended with a round of applause. Upon consulting with members of the audience, the general consensus was that the performance was, “good,” and one group mentioned that they’d like to, “buy his album, if he has one.” The audience seemed more engaged than at the previous venue, though this may be due to the timing of the event, local factors or for entirely different reasons.

The second musician relied heavily on technology, beyond supporting their performance. It could be said that the technology is a part of their performance and

enables the performance to take place, in the same way that an instrument, microphone or dancer may be integral to the performance. The tools are split into three sections, based on the chronology of where they were used.

Table 19 describes where the tools were used, before, during or after the performance in question.

Before	Performance	After
Guitar Pro	BackTrack	Cubase 6
BackTrack	BOSS ME-50	Pro Tools
MIDI Pickup		SoundCloud

TABLE 19 - TOOLS USED DURING, BEFORE AND AFTER PERFORMANCES

The tools are described as follows:

- Guitar pro is a specialised tool for guitarists, which also includes other instruments. Guitar pro enables the composition of tracks, as well as playing along with the tracks. The software enables the customisation of each track, composition using external tools or the keyboard and mouse and a range of other effects, utilities and export mechanisms.

- BackTrack is a physical device created by Line6 for musicians. It enables the recording of tracks, exporting, importing and provides a portable platform for musicians who travel. Line 6 describe the device as, ‘a creative safety net.’ Guitar, vocals or any 1/8 or ¼ jack input can be used with the device.
- Cubase and Pro Tools are examples of Digital Audio Workstations, examined in the first study. These are used to produce music, including stages of pre-production and post-production.
- SoundCloud is a web based platform for musicians to upload tracks and communicate with their fan base. It is a primarily free service, with some premium features for musicians who wish to communicate to a wider audience. It is similar to services provided by MySpace and several other musical web-based apps that are currently available. It provides a unique feature in that users can comment ‘in time’ with the track, where comments are not placed in a forum structure but on a timeline of the song.

The second musician to play, described their process of music as one which was “evolving all of the time.” Here, Guitar Pro was used for ideas, which could then be passed on to other musicians or fed into software which would create a more ‘realistic’ sound. The musician described a typical usage scenario as follows.

“I’ll get an idea or something and sketch it out on GP [Guitar Pro.] Once I’m happy with how it sounds, I’ll go down to one of the rehearsal studios in Denmark Street and get hold of a drummer who can emulate the sound. If it sounds good together with what I’m playing, then I’ll throw it into Pro Tools, add some effects and customise the sound how I like it, then stick it on my BackTrack and take it with me. That way, I don’t need drummers, bassists, or anything else. I have my BackTrack and it does the job that they do without all the fuss.” – Technical user

They also explained that they use a MIDI pickup device on their guitar, so that sounds can be input directly into the software by clicking a button and then playing. While this didn't work well when asked to do it, the musician put this down to, "software error," and a later demonstration of the device showed that it worked well with the software in question. The significance of this is that the software failed to work as expected and provided no reasonable solution to the user. Not only was a solution not provided, but the problem could not be clarified beyond it simply not working. This failure of the software forced the user to look for solutions in finding a way to solve an unknown problem. The support pages provided little help beyond reconnecting the devices and ensuring that everything was plugged in and switched on, as well as being configured in the settings screen. The user having to go to these lengths to solve a problem like this would seem unreasonable and suggest at first, that the software solution is not usable. However, the user choosing to persist with the device suggests that there is some value in using it, perhaps as the user mentioned in time saved or because a similar solution would be equally cumbersome.

The musician described the use of technology in the following way.

"It makes my life simpler. I don't need to drag a drummer, kit, bags and other instruments around with me. My MacBook is like my band and the parts I need for my performance that night, go straight on to my BackTrack. Pro Tools and BackTrack are all I need to do what I need to do." – Technical user

The user was then prompted about their reasons for choosing technology over a traditional touring band or alternative method.

"Time is the main thing. I probably spend half my week travelling. I've got all I need in my bag, when I need it. I dunno... I mean, sometimes it would be easy to get a travel guitar or something. I

just like that I can re-create the sound and feel of a song on stage.
After all, I am a performer.” – Technical user

When prompted about the usage of a travel guitar for their performance, the participant commented as follows.

“To be honest, I kind of look down on ‘simple’ performances. I don’t wanna pay to see that unless you’re Adele or something. No, even then, no.” – Technical user

Finally, the user was asked to comment on the emerging theme of usability and reliability of the tools as opposed to traditional methods.

“Stuff goes wrong all the time. I’ve used Pro Tools since college [5 years] and I don’t use half the stuff on there, unless I’m trying to be fancy with it.” – Technical user

5.2.3 Discussion

An ethnographic approach is one which is designed to be deductive however, there are instances where being inductive can also benefit the research. As with either approaches, there are concerns. The underlying issue is that of reliability. There is difficulty in repeating such research in a controlled, consistent and dependable environment. The only feasible way to approach such research is by examining musicians within an environment in which they are comfortable. It would

be unreasonable to expect the results of a controlled experiment to yield valid results. The setting is unnatural and the musician is being removed from an environment in which they are familiar and comfortable. For this reason, the musicians are more likely to behave in a way which they believed they should.

While many of the musicians relied on technology, it seems as though these technologies are also met with a certain cynicism and fear amongst a few. The musicians who chose not to use the technology at the core of their performance, addressed the issues as related to trust, reliability and difficulty in learning or gathering the tools required. While it is expected that a digital divide would exist, as in any technical field, themes emerged which have not been previously addressed. The literature and previous research fails to discuss the issues of trust, difficulty of gathering tools and ultimately of the reliability of the tools. Whether this reluctance to rely on technology stems from a fear of the technology failing, a learning gap or a cause for genuine concern in the design of systems is, at least at this stage, unclear.

It is clear from the observation and discussion around the theme of technology in assisting musicians that users did not feel that the technology was at all usable if it could not be relied upon (trusted.) The users who did choose to use technology as a supporting tool, did so because of trust and a belief in the tools being reliable. What is clear is that a tool cannot be considered 'usable,' even in the basic sense of effectiveness, if it cannot do the job it was meant to do successfully. The pilot study however, is not conclusive and this theme requires further investigation in a larger, more applied setting in the main study itself. The discussion amongst musicians lacks any kind of consistency, in that each user has a different set of requirements and pre-conceived notions about the use of technology. However, it does highlight major usability issues and this is the aim. The approach chosen seemed to work reasonably well. The only issues are those inherent, between validity and reliability. For these reasons, the approach chosen is a satisfactory one and the experimental design will remain the same for the main study.

Flaws in the experimental design relate to data gathering techniques. Initial pen and paper information gathering methods proved troublesome. This method of collecting information does not lend itself well to an environment where observations and discussions happen quickly, over a short space of time. A combination of video data, pictures, audio and pen and paper techniques enabled the researcher to collect data that was meaningful in an efficient way. It is imperative that the methods and approaches to the research are validated before continuing, due to the novel nature of what is being examined. Enough was derived from the research that the methods and approaches can be considered successful and the main body of the research can be pursued.

The approach shows real promise in generating rich, contextual data. The sample size proves manageable in that data can be collected in a timely manner and there is sufficient time for questions and discussions. Pen and paper data collection proves to be troublesome, especially as events happen quite quickly. Photographs with annotations prove to be the most successful method of data collection as they can be recorded and expanded on when time is a less critical factor and events are not happening as frequently. Audio notes also prove to be useful in explanatory and discursive issues, for instance where a link between cause and effect can be identified or a scenario occurs which requires a more involved description about supporting processes and multiple events occurring simultaneously.

Issues arising at this stage include poor time management, ineffective interaction with the system and a lack of structure in the interface to match that of the performance. While no errors have been observed, a lack of fluidity and a struggle to interact with the interface using one hand proves to be equally problematic. As the performances are informal and semi-structured, many of these issues may not transcend to other scenarios or identify real world problems and so further, more involved work is required to better understand the cause of usability issues.

5.3 Main Study

The following section describes the approach and findings of the main study.

5.3.1 Design

The design of the investigation is set out as follows. A sample size of 12 participants, over a 12 week period, from 6 different venues are observed, questioned and asked to discuss their use of technology in relation to live performance. Participants are recruited using purposive sampling to reduce effects of learning and memory as users have prior experience of using similar systems. Four males and two females are recruited, all based in London. The pilot study encompasses two sets (two separate venues) of three participants, with the major study containing six participants. Each participant is expected to contribute to at least three discussions and perform at least once, for ~30 minutes, with ~15 minutes spent setting up and clearing up on completion of their performance.

The general design is to capture as much data as possible and then sort the data into meaningful categories. It is important that the data is analysed in great detail, however it is difficult to determine the correct course of action before a large repository of data has been captured. While theoretical and conceptual models can be generated at this stage, it is impossible to determine how closely they will match what is observed and discussed during the course of the ethnography. Any kind of discussion is likely to be speculative at best. As such, the data collected may be difficult to verify in terms of validity and wider context, however the richness of the data should provide value and the discussion, albeit subjective, is likely to provide value in understanding a very specific context or setting where the data is formed.

The study takes place in multiple venues, over a twelve week period. Participants are interviewed to discuss their usage of technological tools, with a chance for the

researcher to ask questions relating to their choices. Participants are then asked questions relating to their usage of non-technical tools and if appropriate, questioned about why they choose a non-technical tool over a technical one or vice versa. There is also an opportunity to ask further questions as themes and concepts become more apparent throughout the course of the investigation. Participants are then observed for 45 minutes, including their sound check and performance. The observation involves taking notes relating to their usage of technology, including any problems or limitations they encounter. Questions are then asked to the participant about their performance and usage of technology.

5.3.1.1 Participants

The following table describes the participants.

Description	Years of experience	Age	Gender
Live performer	29	52	Male
Mastering engineer	11	33	Female
Musician/producer	4	27	Male
Musician	7	18	Male
Songwriter	3	22	Female
Live sound engineer	9	37	Male

TABLE 20 – PARTICIPANTS SELF-REPORTED DESCRIPTIONS

5.3.2 Method

The research method models an ethnographic approach to music. The aim here is to highlight contextually relevant value in the way that Nottingham University's mixed reality lab did when investigating DJs (Ahmed, Benford, & Crabtree, 2012.) At some point within the evening of investigation, the researcher will also perform, in order to become more involved in the process and provide a relative comparison of technology usage in live music performance. Data is collected through various mediums including paper, video recording, audio recording, e-mail communication and telephone conversations.

Hammersley's process of analysis (Hammersley 1989) is the model of analytical induction chosen for this research. The process focuses on reformulating a hypothesis presented on page 88 until there is adequate fit between consistency of occurrence and explanation of said occurrence. Where relevant exceptional cases are highlighted.

The process takes place as follows. Initial discussion for the basis of the work, asking about tools used. Discussions also focus on the reasoning behind the use of tools, typical usage patterns, reliance on tools and range of technology used (environment.) Performance should follow, with observation into the use of tools, matching the initial discussion results and comparing and contrasting, with an opportunity to 'fill in the gap' where necessary and prompt further questions or investigation. Post-performance discussion should then follow. This should be split into two parts, with the first part being compulsory. After the performance, participants should be asked about positive and negative aspects of their performance and how technology did/could have/should have enabled certain aspects of performance. As necessary, performers can be contacted upon completion of the first part of the study (provided consent has been sought) and asked further questions relating to the findings of the study. Finally, the study should culminate in a group discussion to try and elicit any further information or fill any gaps that exist in knowledge where a problem has been described but a solution has not been found. If any major tools are found to be used by more than half of the participants, a sketching exercise might help to refine the design of the tool(s) and understand where the problems in the tool(s) lie.

Initial areas of interest are formed first, based upon discussion groups in the first study, described as follows in table 21.

Live Composition Tools	Emergent Themes
Supporting tools (visual for writing, non-visual for sharing.)	Supporting technology (midi interfaces, on-screen timers, crowdsourcing.)
Production tools (keyboards, synths, monitoring software.)	Performance tools (feedback, level indicators such as noise (dB), visual and special effects and controls.)
Collaborative tools (bands only.)	Collaborative or communicative technology (Twitter, Facebook, sampling, live streaming such as Twitch)

TABLE 21 - CATEGORIES OF TOOLS IDENTIFIED FROM SKETCHES AND DISCUSSIONS IN THE PREVIOUS STUDY

Hammersley's process of analysis (Hammersley 1989) is the model of analytical induction chosen for this research. The general steps involved in the process are as follows.

1	<i>An initial definition of the phenomenon to be explained is formulated. In this case, the pilot study should generate some general ideas, explanations and at least a single, simple case.</i>
2	<i>Some cases of this phenomenon are investigated, documenting potential explanatory features.</i>
3	<i>A hypothetical explanation is framed on the basis of analysis of the data, defined to identify common factors across the cases.</i>
4	<i>Further cases are investigated to test the hypothesis.</i>
5	<i>If the hypothesis does not fit the facts from these new cases, either the hypothesis is reformulated or the phenomenon to be explained is refined to exclude negative cases.</i>
6	<i>The continual process is reformulated until the hypothesis is confirmed with consistency.</i>

TABLE 22 - ETHNOGRAPHIC PROCESS DEFINED BY HAMMERSLEY

In this case, the process can be described in a more specific and detailed way. Each participant should follow an ordered path of discussion and observation as follows.

Initial discussion, general, asking about tools used. Should cover the reasoning behind the use of tools, typical usage patterns, reliance on tools and range of technology used (environment.) Performance should follow, with observation into the use of tools, matching the initial discussion results and comparing and contrasting, with an opportunity to 'fill in the gap' where necessary and prompt further questions or investigation. Post-performance discussion should then follow. This should be split into two parts, with the first part being compulsory. After performance, participants should be asked about positive and negative aspects of their performance and how technology did/could have/should have enabled certain aspects of performance. As necessary, performers can be contacted upon completion of the first part of the study (provided consent has been sought) and asked further questions relating to the findings of the study. Finally, the study should culminate in a group discussion to try and elicit any further information or fill any gaps that exist in knowledge where a problem has been described but a solution has not been found. If any major tools are found to be used by more than half of the participants, a sketching exercise might help to refine the design of the tool(s) and understand where the problems in the tool(s) lie.

The themes that have already emerged representing live music is split in to two distinct tables. The themes generated here are based upon discussion groups and sketching exercises in the first study regarding how tools are used and are described in two categories. The first category concerns live composition tools, while the second focuses on the live performance element of tools.

The following table describes points of interest in relation to the set of initial observations. These are not exhaustive and are subject to change (as is seen) however they provide the basis for categorisation and investigation in the first sense.

Live Composition Tools	Theme
Supporting tools (visual for writing, non-visual for sharing.)	Supporting technology (midi interfaces, onscreen timers, crowdsourcing.)
Production tools (keyboards, synths, monitoring software.)	Performance tools (feedback, level indicators, visual and special effects and controls.)
Collaborative tools (bands only.)	Collaborative or communicative technology (Twitter, Facebook, sampling.)

TABLE 23 - CATEGORIES OF TOOLS USED

5.3.3 Results

The results of the investigation are split into sections relating to the key aspects discovered. There is some crossover here and the content may or may not be suitable for each section. To avoid repetition, discoveries are mentioned in the section where they have to most relevance or grounding, in particular where problems originate. For example, where a musician has issues with processing in the software, though the eventual output is a hardware based interface, the software is the source of the issue and will be addressed as such.

5.3.3.1 Environment and equipment

The study takes place across a number of different environments in order to best model the working practices of musicians. The investigation takes place amongst six different areas of London as follows.

Formal practice and rehearsal sessions are usually held at a specialised rehearsal venue in Central London. Recording and dress rehearsals usually take place here, as the venue has sufficient equipment to model that of a live venue.

Performances at The Elephant and Castle, London and Camden, London, are the main focal points of the study. These venues host the dress rehearsal and main performance, at the core of the investigation.

Impromptu busking sessions, as a means of promotion, in and around the Camden Lock area also take place. These sessions are generally about promoting the musicians who are set to perform at the venue and tend to take place on the day of the event, in the hours leading up to their performance. All of these impromptu sessions take place after 11am and before the live performances at 7pm on the same day.

Early stage practice sessions are held at a private location. Through the course of this study, private practice sessions are not just held at a tailored location. Two of the performer's homes are used for private practice, on an ad-hoc basis and attendance is through invitation only. An 'open' venue, a local park, is also used for less formal practice sessions and discussions relating to non-performance elements. Here, things such as venue hire, promotion and structured goals are discussed, relating to the aims and expectations of the performance and performers.

Each of the users perform a setlist of tracks at the event. While some users chose not to involve the usage of software, others used several software packages at each stage of production and performance. This variation in usage patterns again provides a contradiction for the researcher to contend with in explaining reasons for choosing (or not choosing) to use a particular software package. The variation in tools used and the ways in which they are used is also relevant to the findings and this will be discussed here.

First and foremost, it is important to recognise that software is non-essential to the processes of rehearsal, production or performance. Many musicians choose not to rely on any software and instead rely on hardware based solutions or deferring processes to those specialised in the usage of these tools. It is not imperative, or in some cases even necessary, for a musician to familiarise themselves with the software packages available. While some would argue that the software provides an additional layer of support, others cite reasons of wanting to "control the sound" of their recordings. This can be even further compounded in the usage of language to describe the level of control required. One user described their controlling nature of the production process as follows.

"I'm a Nazi when it comes to my music. I don't trust anyone else to do it right. I have a certain sound in mind that I want to recreate and if I don't get that sound in the recording I'm not happy. I'm not saying the studio don't know what they're doing, I'd just rather do it myself and not risk a bad mix [recording.]" – Live performer

The user is prompted at this stage in order to ascertain how the production process works in this scenario and described the following situation.

"It can take weeks, months to get an idea, or it can just come. Sometimes I'm sat on the train and get this really great idea for a jazz scale or something that sounds really funky. I don't really know when the creativity happens... probably when I least expect it. The recording process is strict though. I might come up with an idea really quick, but I'll spend ages practicing it until it is right, sounding like it should. When everything is written and I'm happy with it, I'll hire out a rehearsal space and get whoever I need in. I do all the recording with my laptop [Macbook Pro.] Most of the time, I'll do all

the instruments myself. You just can't rely on drummers [laugh.]" –
Mastering Engineer

The user was further questioned in relation to the usage of the software and asked about how the software enables them to work independently, while maintaining the quality and synchronisation required of a band or series of session musicians.

"I know my own timing. It's weird, like a clock inside me. I'll sit and tap my foot or something. I try not to use metronomes. I can usually synch it up fine. The software lets me listen to what I've done already and play along with it. Sometimes it goes out of synch, but if I do the drums first I usually have a good start to work on. I suppose it would be easier having some help as I wouldn't have to re-record the track ten times. I just don't trust other people and if I have to keep teaching different people to play my tunes on different instruments it just becomes a bit of a pain. If I get really frustrated, the samples are there as a safety net." – Musician/Producer

Initial discussions with the users yielded little, if any, results. There wasn't a refusal to discuss their music, however they seemed very insular in their approach. The performers sat around in a circle in discussion and acknowledged the researcher's questions with single word responses, in some cases ignoring the researcher's comments altogether. The only time in which they began to openly discuss their experiences and music was when the researcher began to participate in practice sessions. From here, the users were relatively open in their discussions and seemed to view the researcher as a fellow musician, rather than an outsider. The reasoning for this could not be discovered through the course of the experimentation, though it was an observation made in several cases. Musicians often ignored photographers and fans. Perhaps this is used a method to improve concentration and reduce cognitive load, but any assertion made here is likely to be

flawed and lacks any scientific approach in which a theory can be tested. Ultimately, the willingness to interact with others is not within the confines of this research and so this point will be dismissed from hereon in.

Rehearsal sessions typical happened ad-hoc and on a variable basis. As the musicians devote most of their time to the pursuit of musical endeavours it is difficult for the researcher to remain engaged in this environment on a continual or even consistent basis. On the other hand, by breaking down the interactions into a few hours every few days, the musician usually has something fresh or important to share. This gap between interactions also aids the musician in giving them time to refine and reform ideas. Unfortunately, any issues with the software are discussed at the musician's discretion and any moments where the musician has had issues or problems may or may not be shared.

The total number of interactions with all of the musicians, on a group and individual basis, exceeded twenty. While some of the interactions happened briefly, over an hour or two hour period, some of the shorter interactions were some of the most informative. Musicians seemed to participate in discussions more actively under time constraints, such as in rented rehearsal spaces or during timed rehearsals. As time passed, usage patterns shifted. Where some participants relied heavily on technology in the initial stages, they then shifted to a less technology based approach. This was evident during the course of a series of open mic nights, where performers relied (mostly) on acoustic instruments and some very basic amplification and mixing equipment. In this case, the sound engineer remains responsible for the amplification and mixing, while the musician focuses on their performance, through instruments, singing, or both. Very little timing equipment is used in the situation, with the sound engineer using a watch to gauge the length of the performance. While the sound engineer described the length of a performance as, "about 20-30 minutes," performances ranged from 4 minutes to 46 minutes in length. In some instances, this even involved multiple musicians on stage at a given time, playing and singing songs that had not been rehearsed in full beforehand. This largely manifested itself as a mix of the two or three tracks performed by each musician, to create an entirely new and eclectic mix of original

content. The musicians seem to enjoy this process the most, with smiling, laughing and hand gestures suggesting that the performance element is an enjoyable experience for those involved.

In spite of the time critical atmosphere, each of the open mic nights tend to take an unstructured and variable approach, enabling creativity, innovation and collaboration in an atmosphere where these things would seem to be unlikely. The researcher approached this situation after interacting with musicians. The elements of strict rehearsal, structured setlists and rigour in practice were not utilised within the course of the performances, though one could argue that the strict rehearsal method enabled the collaboration and live improvisation in that each musician had an intricate and thorough appreciation for the music which they performed. It is clear at this stage that a culture of hard work and discipline is present within musical communities and that collaboration can occur almost spontaneously, even without invitation or approval for such. What is not clear is whether or not this type of interaction is seen as an invasion of performance. The musicians each failed to comment when this question was proposed to them, however reasoning for this is not clear. Perhaps the musicians were uncomfortable in addressing the issue or did not want to criticise those around them. The smiling and seemingly happy nature of musicians in this environment though, seems to suggest that the experience is largely a positive one. There is certainly room here for further investigation into performance space and collaborative invitation, though probably not in the scope of this work.

The rehearsals are very much a formative workspace, where ideas meet creativity and innovation in a very informal manner. Here, musicians tend to behave according to their internal goals and perspectives. At each session, at least one participant specified a goal in which they aimed to achieve something by the end of the session or end of the day. These goals varied in scope and complexity, with the most common goal being to learn how to play a track all the way through, using their preferred instrument. Goals extended to such things as, "nailing this riff," and "getting the right sound." While these goals are not necessarily more difficult to achieve than others, the inherent difficulty is in the use of language to specify

end tasks. Requirements here no longer fall into the category of tangible. Requirements are also not necessarily achievable, timescaled or even realistic within this problem space. Unlike goals specified previously, these tasks are no longer strictly 'goal oriented.' Though the user has a conceptual goal in mind, these goals cannot be clearly specified and would be better described as either scenarios or stories, depending on context.

Story-oriented requirements engineering techniques best model this type of system in that they provide little, if any, constraints to the user. Dependencies (both people and system based,) resources and goals themselves are fuzzy and difficult to define without specifying their given context and associated players. A good example here presents itself when the user specifies their aim to, "make good music." This poses more questions than it provides answers. What constitutes as, "good?" How can a user possibly know when they have completed this process if they are not familiar with where the end-goal is set? Is this type of process a requirement or a continually developing exercise? Users did provide some clarity in providing a unified answer for their description of who the music is targeted at. Here, the live audience were specified as the key component here. The musician's hard work, dedication and seemingly fuzzy goals become more formalised and more easily specified at this stage. Users hoped that their music, "makes people feel good," and "appeals to the audience." Here, one participant added that they have, "good and bad nights," in terms of performance. Here, the researcher prompted the participant by asking them what happens when they perform badly.

"It doesn't look good on me. My music is about making people good, so if people don't feel good, how can I feel good? I'd rather make bad music that people enjoy than perform classic songs terribly. People say music is complicated but it's not, it's easy. The people listening should enjoy it and if they don't then it's pointless. There's always someone who doesn't like it because they're 'indie' or whatever, but I'd like to think most people enjoy it. Nobody has

ever said anything bad, at least not to my face. No, that would break me." – Musician/Producer

Here, we find that not only does the musician have a fuzzy set of goals in mind, but they aim to achieve something which they then admit is difficult at best. Understanding goals and requirements here is key to measuring the successes and failures of existing systems and understanding both where and how they can be improved.

5.3.3.2 Software Tools

Through the course of investigation, many software tools were used. At the beginning of the investigation, musicians are expected to provide a list of software which they consider to be imperative. This does not necessarily transcend to the software they use, but provides some insight into which software is considered important and which software proves to be important through usage patterns. When describing and using these tools, however, the musicians show a great deal of variance in terms of how and why they are using the tools. Though each tool is used at least once by at least one of the participants in their own production cycle, the purpose for these tools becomes much more vague when discussing usage scenarios and patterns. Several of the tools mentioned herein are used throughout the performance process, for example. This crossover of tools is something which has not been anticipated and could perhaps shed some light on how broad tools can match somewhat fuzzy requirements.

Many of these tools have been examined fairly extensively in previous work and the key here is to identify issues relating to the software that have not been mentioned in previous research. In understanding how successful the tools can be, it is first important to understand their purpose and to understand the requirements of the user within this context. It is possible to identify each of the applications being used, however, understanding the reasons why one tool might be

used is less clear. Surely a production system must hold a set of functions or values which are key in creating a sound. The researcher here is able to identify, both from their own experience and from observation, that many of the functionalities of the software tools are not unique in their appearance. The researcher posed the following question.

“Why are there so many different applications for creating music, when they mostly do the same thing?” - Researcher

An informal discussion followed, which shed some light on the issue.

“I suppose they do. It’s much more about experience than them being different though, isn’t it? I’ve used a few and they mostly do the same thing, mostly. It’s just sometimes easier to work with something recognisable, knowing where stuff is and how to place it.” - Musician

Much of the discussion that follows discusses key technical issues of the software and identifies functionality that participants find to be unique, before eventually coming to the realisation that the application feature’s ‘uniqueness’ usually dissipates with the release of a new cycle of applications. Two key pieces of information can be identified from this discussion. Firstly, the functionality of these applications, even those familiar to participants, is somewhat fuzzy. It proves difficult to identify whether an application can perform a task beyond the user’s personal experience and identifying where or how to perform a task is something that users struggle with. Whether this is a learning or memory issue is unclear, though the discussion focuses around experience and considering that these users are all somewhat experienced in using these systems, memory would certainly seem to be the key issue. Secondly, the issue of familiarity is key in choice of applications. Though participants tend to argue about their reasons for choosing a

software tool, the discussion often culminates in the same conclusive remarks relating to familiarity. This can be seen through the following comments.

“Ultimately, it’s about getting the job done. Cubase does that. Everything is where it should be.” – Musician/Producer

“I wouldn’t say Pro Tools is better, just I like it. I imagine someone else learning to use it would struggle. Even I sometimes find it hard to use. I usually find what I need though. I know where to find things, not always where they are, but I know where to look.” – Mastering Engineer

“Pro Tools is horrible, it’s hideous. It’s terribly designed and probably wouldn’t even exist if it wasn’t for studios hopelessly clinging on to the old way of doing things. There are so many better alternatives, but nobody wants to learn any different. Producers are lazy and that’s the only reason it even exists anymore.” – Mastering Engineer

While some of the comments are fairly extreme and do not necessarily transcend to a general consensus of musicians, or even the group in question, the points raised are valid ones. The issue of learning and memory has previously been tested both through an array of tasks and sketching exercises, though memory can be examined much more thoroughly through day to day usage scenarios that reflect those of the real world. The pressures, constraints and concerns of the real world soon began to highlight some serious issues in the software being used. One participant in particular showed signs of frustration, swearing and lots of noise making. While this may purely be a ploy for attention, it seems unlikely that a participant would aim to bring focus onto their failing to use a system. The environment is very much a competitive one and it would seem unusual for a participant to try and draw attention to any of their flaws. Hours are often spent where

participants aim to come up with “better riffs” than one another and this competitiveness could be one of the key reasons for participants behaving so diligently. At this stage, the questions asked were very short. The researcher does not aim to ask leading questions, but to gauge the successes and failures of the software. Short, vague questions give the participant an opportunity to express their own viewpoints at the time in which they are experiencing an issue. The researcher asks a very simple and open ended question.

“How’s it going?” - Researcher

Comments were as follows.

“I’m struggling. I’m trying to sync[synchronise] my tracks in Reaper but it’s misbehaving. It’s great for customisation, but not so good for problem solving. I’ve reached the track limit trying to connect everything together with my other mixers and I’m confused about where everything is going. I don’t know if the synch issues are latency or a problem with one of the tracks. I should’ve probably used Pro Tools, but it’s hard and over rated and I don’t have time to learn one crappy way over another.” – Musician/Producer

The tone here was one of familiarity and trust. At this stage, the researcher felt comfortable in asking further questions about the nature of the tools, without overstepping marks or creating any bias through questioning. Further prompts were made as follows.

“So where do you go from here?” - Researcher

Again, a vague and fairly open ended question. The participant has already identified an issue and the key here is finding out both the perceived problem and proposed solution. The participant responded as follows.

“I... I don’t know. I think I’ll spend a while trying to clean up some of the transitions and then if that doesn’t work, go back to an earlier mix. I hope I have an earlier mix.” – Musician/Producer

Here, the user became visibly quite upset and the researcher took the initiative to give them some space, wishing the participant, “good luck,” before moving focus elsewhere. The participant later returned to the researcher and described the issue in more detail.

“You remember that mix earlier? I had no idea where half of it was going and that was fine while it was working. In the end I scrapped it and went back to an older version. Picked out some of the timing issues in the drum track too. Sounds great now, come take a listen.”
– Musician/Producer

The inability to perform or automate backups as in a version control system is something that would be expected of the software. The participant described the process of settings backup and restoration, but did not identify a viable backup method beyond being proactive and relying on naming conventions and a file system structure to create backups of tracks. The issue itself however is one of visibility and clarity provided by the system. The user knew where the core audio recording and midi versions of the tracks were and could access this, however the software fed into other applications and as the feed began moving between applications and tools, it became less and less clear where the processing on the track was taking place. Until this point, it can be considered a non-issue. When latency issues present themselves in delays and the track becoming inconsistent, the user experiences a seemingly unsolvable problem.

The previous discussion and findings led the researcher to further ask questions relating to managing content.

“Where do you store your music?” - Researcher

One of the participants answered this question as follows.

“Personally, I have stuff all over the place. A load of websites, plus band pages and three or four different computers that I’ve used in the last year. It’s all a mess. I used to use a USB but I can’t remember to do backups every five minutes. If I went ‘round picking up all my old tracks I could probably make a CD out of it all. Maybe I’ll do that...” - Musician

Another participant made the following remarks.

“I try to use DropBox. It’s a better way than before. But I don’t always have Internet. It’s really difficult on the train or waiting for buses. I don’t use more than one computer but it would be nice to access it and show friends, family and other people when I don’t have it with me. If it crashed, well, then I’d be lost. I should back it up but I don’t.” – Mastering Engineer

While companies such as Adobe are providing tools like the Creative Cloud to enable distributed working patterns of real people, the current crop of software for musicians fails to provide the same features. When such a system was proposed to the participants, they each suggested that this would be a feasible solution to

their problem, however when asked about why they thought such a system did not already exist, they failed to respond. While SoundCloud and similar tools provide a vaguely similar functionality, they require a great deal of user input and this seemed to be the issue for many users. In fact, one user in particular commented that the process is, “too long as it is and doesn’t need to be any longer.” Even large scale desktop systems, through providers such as Apple, are providing both hardware and cloud based backup systems. Where time and music are huge sources of revenue, it seems counterintuitive that these are not the major concerns of software providers.

5.3.3.3 Communicative and Collaborative Tools

A variety of software tools used through the course of the investigation cannot be categorised as performance or production tools, at least not in the strictest sense. Though the pilot study highlighted pre-production, production and post-production tools and some performance related tools, communication is not something that has previously been considered. Interestingly, many of the core processes that a musician goes through do not relate to either production or performance of music.

Firstly, musicians need to communicate with one another. The types of interactions observed range from sharing and collaborating on tracks to organising events and sharing contact details. Interactions take place on both an informal and informal basis and some of the interactions and processes taking place are described in the following table.

Purpose	Tool
Organising events	Facebook, Eventbrite (tickets)
Discussing events	FB Chat, Skype, MSN Messenger, Google Talk
Informal chat	See above
Video discussions	Skype, MSN Messenger
Communicating with fans	Soundcloud, Youtube, Facebook, personal webpages, E-mail
Distributing Audio	Soundcloud, iTunes
Distributing Video	YouTube, personal webpages
Sending out information to fans	E-mail groups, Newsletters (PDF), Facebook posts

TABLE 24 – CATEGORIES OF TOOLS AND USAGE

N.B. Some users mentioned Myspace, however during the course of the investigation, none of the participants actually used Myspace. For this reason, it has not been included in this section.

The first observation made is that the specialised software for musicians (Abelton, Cubase, ProTools) are not used for communication or collaboration. Upon further investigation as to why this was the case, the researcher came to the realisation that these software packages, designed for musicians, do not enable them to communicate beyond the constraints of the system. While it would be unreasonable to expect a tool for musicians to enable social networking as something akin to Facebook, the basic functionality should be there. This led the researcher to ask further questions about the types of communication that can take place within the constraints of such a system. At this stage, the researcher took the initiative to try to find methods by which musicians could at least communicate information about the state of a track. Again, the search turned up little information beyond some improvised ways of working. One musician identified some novel

ways of tracking progress in Cubase by naming the tracks accordingly. The tracks used naming conventions as follows.

'<song_Instrument_Effects>'

Where song is the name of the song that the individual track belongs to. <Instrument> is the first letter of the instrument recorded (G for guitar, B for bass, D for drums.) <Effects> describe any processing already on the track, for instance <Wah>, <Distortion>, <Echo> and <Phaser>.

These naming conventions, while ingenious in nature, are not easily understood by other musicians. The researcher and other participants could not identify the reasons why tracks were named this way. There are a number of possible ways that tracks could be described, as in tools such as guitar pro, instruments are described, while Garageband shows icons of the instrument in use. The inherent problem here is that a track may not be 'instrument based' or the instrument that the track could be played on might not be obvious when working on early versions of the track. Ultimately, this type of discussion is frivolous. The point here is that the tool does not provide clarity amongst collaborating musicians or the facilities to communicate outside of the constraints of the system. One of the ways musicians overcame this issue of clarity is by using a web based track management system known as SoundCloud. Here, the website allows a user to upload tracks and write notes on the tracks that they own or tracks of other people. There is also a personal messaging service, however this ability to provide feedback in the context of track time proves to be very useful amongst musicians. This type of communication happened frequently, between those participating in the study as well as to outside individuals such as fans and band members who did not take part in the study. SoundCloud provides a form of content management system in that it allows communication, while the tools used to create the tracks are specialised in their own purpose. One musician described this process as,

“having the best of both worlds.” Further discussion highlighted the reasoning behind stating such a comment.

“Which two worlds do you describe?” - Researcher

The participant answered this question in the following way.

“Well, I have Cubase. It works well when I'm messing with my track, trying to find the right balance and key. It's my own private workspace that can't be seen by outside eyes. When I'm ready and happy with the track, I can share it using a different forum. I have a personal space and a public one. It would be nice if I could pass information between the two, but it works well enough for me.” - Musician

Throughout the study, Facebook proved to be the major point of communication. Each musician has a Facebook page which they openly shared with fans and musicians alike. Each of the musicians also used Facebook on multiple occasions, with most usage happening shortly before and shortly after a live performance. Participants were asked about why they chose to use Facebook and the kind of facilities and benefits it provided for them. They responded in the following way.

“Everybody uses it don't they? Everybody knows what Facebook is and everybody knows how to like pages.” - Musician

Further comments were made by another musician.

“Most people have it on their phones or iPods or whatever so they can connect instantly. I don't have to worry about giving out any personal details and they can go on Facebook and like my page, see what I'm doing, where I am and connect with me. I'd prefer a bit more control, but it's not like I can change Facebook. It's good enough for what it is” – Musician/Producer

When observing software based communication tools, the researcher noticed a series of sticky notes being used. These notes had images drawn on by hand and the participant who was making these notes was asked about what they represent.

“It's a way to show progress of a part of a track. We're working on a track together and he needs to know how far along I am. If I draw a picture of a guitar on one of these notes and write '1' then he knows the first guitar is done. He will do the same when he's finished with the drums and the lyrics. It's just better this way so we don't have to disturb the other person mid-work. Obviously you have to concentrate and it's a silent way for us to communicate without any fuss.” - Musician

The software in use has no facility to express the completeness of a track or to allow multiple musicians to communicate progress. This novel concept enables the communication of status while allowing the participants to focus on the task at hand and know when the right time to come together is. While tools such as Garageband represent tracks in an iconic way, progress in this software state is unclear and the way that musicians tended to use the sticky note software tool was largely to formulate their own ideas and opinions. Often, notes were as brief as a single word, such as 'finish' and '7ths.' While this might have meaning to the person writing the note, it is certainly not intended to communicate such concepts or ideas to others.

5.3.3.4 Activities and Sequence

The initial theory of activities and sequences proposed a three phase process, involving pre-production, production and post-production. The stages involved were then examined and refined into relationships focusing around a central performance (production.) While the three-phased approach encapsulates many of the processes that a musician goes through, it fails to identify a task or goal based approach and can therefore only be used as a general tool to categorise data collected. Ultimately, a more robust relationship model needs to exist to fit key goals and major aims of musicians within any given context.

The following groups of tasks have been generated based on the ethnographic data, with four distinct stages described; all focused around the major theme or goal of performance.

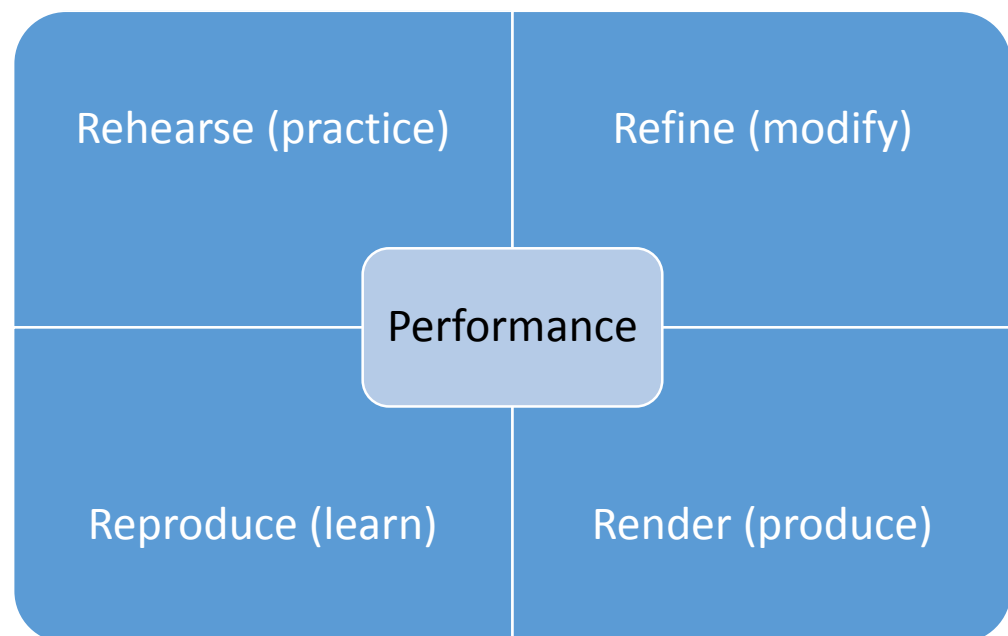


FIGURE 10 - INTERCONNECTING COMPONENTS OF LIVE PERFORMANCE AND THEIR RELATIONSHIPS

It is important to recognise here that any independent or non-formalised process, for instance rehearsal at home, is not strictly considered rehearsal. In the same way that a cognitive model of a song cannot be considered a refining process, as no action is taking place. Each of these stages has some kind of activity attached to it to enable the achievement of a goal and should be treated as such. It is also important to recognise that this model does not aim to encapsulate 'fuzzy' goals, ie goals that can be categorised as either scenario-oriented or story-oriented. The space between the processes is also relevant in understanding where there is crossover. Rendering and refinement are adjacent as one process (refinement) enables another (rendering.) For this same reason, rehearsal and rendering have been kept apart, with only refinement, reproduction and performance linking the two distinct stages. The stages on the right are processes which rely on existing knowledge or state, while the stages on the left can happen at any stage in the course of a musician's work. These goals have been identified and categorised through the following observational and discursive approaches.

Table 25 describes the four stages of music production observed, including situations and places where they take place.

<p>Rehearsal</p>	<p>Happens in a particular space where instruments and equipment are available. This is either at a studio or at an event where a performance is or will be taking place. This stage has been observed and discussed in arranging times and spaces to rehearse. Software such as metronomes or click tracks and guitar pro are often used herein.</p>
<p>Refinement</p>	<p>Working within the constraints of either a software or paper based tool to make changes to a song. This process sits alongside rehearsal as changes that need to be made are recognised in rehearsal and made in refinement. This process usually culminates in a rendering of a “final version,” though this is not always the case. Many track productions were not complete in the time that the study ended.</p>

<p>Reproduction</p>	<p>Reproduction is the process of recreating an original sound or song, or covering an existing song. Reproduction involves creating a sound which matches the musician’s expectation or minimum rate of recognition. While difficult to quantify, it is ultimately a criterion which varies from person to person. The musician usually identifies a song as being successfully reproducible when it is added to their list of tracks that they play (“setlist.”)</p>
<p>Rendering</p>	<p>Rendering involves processing the track, either recording it or using a software package to create a finished version of the song. The song is considered ‘rendered’ as and when it has been exported into an audio format such as MP3 or OGG.</p>

TABLE 25 - FOUR STAGES OF MUSIC PRODUCTION OBSERVED

5.3.3.5 Knowledge and Decision Making

Much of the knowledge to make decisions and choices exists within the musician's own mind. Eliciting this knowledge is integral in understanding how software systems could better cater to a user's needs. In the first instance, it is important to recognise whether a need for software exists within such a context.

Meetings were often held on a non-formal basis, with impromptu jamming sessions and general discussions being formed around a rehearsal set. Much of the information and knowledge that was required to make decisions, if non critical, would be discussed leading up to an event. Many of the more formalised knowledge and decision based information is encapsulated within a set of systems. Again, Facebook and texting prove to be a very effective and efficient means to communicate important information across musicians, promoters, events managers and the general public (potential audiences.)

One of the major issues identified with the method chosen is that information has to be passed and processed by multiple individuals before that information can then either be transformed into knowledge or to aid in decision making. This also caused some information replication, in that many people had the knowledge to help to make a decision, however that knowledge remained tacit and unspecified beyond a single context. An example of this problem arose when trying to promote an event. Rather than use a centralised system leading up to the event, detailing who would be arriving, or even using a ticketing system and recording sales, no such system was set in place. Instead, questions were often asked about how many people were turning up, with a great deal of confusion caused.

The end result of a lack of knowledge sharing highlighted some of the positive and negative aspects of formalised process and content control systems. The advantage of having a system here is that the progress, sales of tickets and each musician's responsibility to sell their 'allocation' of tickets can be tracked. The advantage of not having a system here however, enabled the musicians to make a

quick decision on the day of the event to go out and promote it through busking and sell tickets this way. In spite of the effort made, however, the event did not sell out. As this didn't present itself as an issue in the first set of events leading up to the study, there was no reason for the team to believe that this type of incident would occur. However, a lack of information is considered the cause of concern here. Had the musicians for example not been familiar with the environment or area (as was true with the pilot study) then a lack of knowledge would result in an inability to make a quick decision regarding busking. Knowledge is a key factor in the success of these events. Though it might not be considered integral for musicians to share knowledge about their compositions and practicing styles for example, it's imperative that they are able to work together on the day of a performance. It is also imperative that users recognise their accountability within the constraints of a system, whether people or software based. Even beyond the musicians, everybody within the system has a set of goals and should be able to ascertain accountability. In this study, there is little evidence to suggest this exists and for these reasons, responsibility is often deferred. Musicians being forced to busk as a means to improve marketing is a clear oversight from the marketing manager and one which could have been addressed had a system of responsibility been introduced.

The communication and collaboration sections of the study detail further issues relating to a lack of formalised structures. This section has detailed how the lack of communication can inhibit successful decision making and essential knowledge sharing. It is unclear at this stage whether or not a software system would be able to accommodate the needs of the user, though this provides a course for further investigation.

The knowledge, both of how to play and how to use the systems, is key here. A user relies on competency in order to produce tracks and to perform tracks in a live environment. While this knowledge is not necessary to share, it is important for musicians to open lines of communication to ensure that collaboration and performance can happen in a problem-free environment. The issues of time management, communicating concerns, sharing ideas and appreciating the magnitude

of problems within this context are important. The tools that currently exist fail to consider these concerns successfully. Though there were not too many major issues with the performances, in part due to the experience of the people involved, these issues could have proved detrimental to the success of the project and the musicians' reputations. It is also important to recognise here that the event is one of a relatively small scale and while the issues may not necessarily transcend to environments that are broader in scope, it could very well be the case that these issues are further compounded. In this case, everyone had a key role and responsibility, from photographer to marketing manager. Had this have been a distributed environment where lines of communication cannot remain closed and distribution is greater, then the issues become an even bigger threat.

5.3.4 Evaluation

The results of the study are promising. Both typical usage scenarios and patterns (trends) in behaviours were examined in order to develop a holistic perspective of the usability of software tools for musicians. Identifying problems in usability (Å 2006)(Lindgaard & Dudek 2003) and perceived usability (Tuch et al. 2012) proves challenging, especially in a complex environment such as the one here. The results show that the usability problems in these software tools are not in functional areas. Often, the usability issues proved to be the system failing to encapsulate the requirements of the user.

The reasons for the failings of a system to encapsulate requirements are likely to be varied. Through participatory requirements elicitation (Perez & Valderas 2009) and by better understanding how requirements map to functionality (Alexander 2011) it would be possible to eliminate some of these issues. Here, the focus is on building functionality into a system without imposing barriers to entry when migrating from other software packages or upgrading from previous versions. Ultimately these tools are designed as a means to an end, ie a production tool and developing multimedia interfaces for this purpose is often challenging (Gall & Breeze 2008)(Miletto et al. 2006). Whether or not these tools should provide the

facilities, functionality and tools to better plan and manage working patterns is debatable. What is clear here is that musicians both identify a need for clarity and seek out alternative tools to meet their needs. As such, this functionality can be considered a requirement at a fairly fundamental level. When we further consider the context of this situation, in that these people are earning a living and depend on live performance to do so, it is critical that they are able to plan and organise their performance in a manageable way.

Communicative and collaborative tools are not the only areas with usability issues. The sheer complexity of the tools proves problematic, in that users could not understand the flow (Lee 2009) in the same way that they might with a physical guitar and pedal system for instance. Users are in some cases, forced to revert to previous versions of songs that are days or even weeks old, losing a large volume of work.

The reasons identified for a loss of flow and continuity could be due to a lack of clarity in presentation and the hidden nature of VSTs and plugins. Tools relating to mixing, processing effects and such are well hidden, within multiple sub menus, several layers deep. While this seems logical in that screen space is limited, when we consider the hardware counterpart this is not the case. Take a guitarist in performance for example. At bare minimum they will have a guitar, tuner, PA, amplifier and a series of cables. When we add multiple daisy-chained effects pedals, a microphone, multiple stands, plectrums and the variety of configurations, the complexity of these tools models that of software counterparts.

The musician is able to recognise many of the features that they may not be able to recognise in the software counterpart though. Flow presents itself in order, from the instrument, through multiple effects and then more outputs. This complexity is well managed, mapping off to a cognitive model which the user is able to understand. Changes in the structure do not affect the flow of information. If an issue is identified here, the user is able to manage that through investigating components through systematic removal. First, by testing the outputs by using a

direct input and then, if necessary, identifying where the problem exists in processing. It is also important to recognise that any of these components can usually be disabled with the click of a button or by kicking the pedal. It is not to say that these hardware counterparts are not with issues. The sheer volume of cabling required is a nuisance in itself and the software can benefit by removing the medium altogether. What is clear here is that a strategy has been employed to better understand flow of information, presence of status (red lights, green lights) and that each of the elements in the system are both tangible and accessible.

Time and portability are also key concerns, which the software does not necessarily accommodate for. While tools like Guitar Pro provide an intermediary tool between the early stages of music composition and eventual production stages, there are further processes involved where software either does not exist or is not easily accessible. Time-essential tools need to exist to enable the user to perform quick actions, such as record a snippet. The load time of Garageband for example, far exceeds that of what the user considers reasonable and this is before any interactions have taken place. Musicians used very few mobile tools and this is also of concern. As people and software become more pervasive, the tools provided to people should model their behaviours and working patterns in order to better accommodate both wants and needs.

Much of the literature supports the findings here, in suggesting that the work of musicians is unstructured and diverse. The Mixed Reality Lab at Nottingham University embarked on a similar research venture, looking to evaluate how traditional music making can be supported (Ahmed et al., 2012.) Other researchers recognise that the social and collaborative issues are the major ones that need to be supported (Benford et al. n.d.) Here, as in the work done by the Mixed Reality Lab at Nottingham, musicians were able to perform and involve the crowd with little, if any, assistance from technology. The findings here in relation to the aims suggest that there is a need to extend the social and collaborative facilities to a point where the technology can either enable these interactions to take place, or support these interactions through a centralised management interface. The tools

used are simply too disparate and different to be considered effective. Simple issues like using different 'standard' versions of MIDI present with complications when moving between interfaces and this problem has been identified in a variety of systems and contexts.

Explaining social and collaborative needs of users within this environment is a much more varied and broad discussion. In regards to the aims here, many of the social and collaborative requirements of the system are where it fails in terms of usability. Technically, the systems can provide all kinds of functionality. Beyond the technology is where things become problematic. Previous work (Cunningham et al. 2009) aims to address this issue in an investigation of selection and presentation of music in a social atmosphere. While they choose a party as their main area of focus, the environment is not entirely dissimilar to that of a pub or club venue where a professional musician might play, thus the discussion is certainly relevant within this context. Social music and the idea of applications and software helping to enable this type of activity are at the centre of the discussion here. In spite of the non-structured atmosphere in which the study is conducted, many of the key activities here also model those within a working environment of a musician. Sampling, communication and collaborative decision making are key processes. The study also addresses issues that have not been envisaged through the course of this research, including access control and permissions, event specific information relating to contributions and time management facilitation. Here, even in a soft environment, the social aspects become quite broad and difficult to manage without some kind of centralised repository or interface to control the structure of the evening. It is important to recognise that the study here is only conducted for a maximum of four hours and the investigation is somewhat limited in terms of scope. It does however show the value of ethnographic approaches within novel areas of research, in helping to uncover issues that do not present in a lab setting such as how content is retrieved (Cunningham, Nichols, & Zealand, 2009.)

Previous research in collaboration and communication within a music retrieval environment focuses on the information access and storage aspects of music. This

research also uses an ethnographic method to generate a comprehensive understanding of the environment in which the study takes place (Cunningham et al. 2003)(Cunningham et al., 2009.) The method and findings here are clearly valuable in understanding the usability problems, but also where requirements fail to match the system aiming to encapsulate such requirements. Here, the suggestion is that the requirements are not generated based on real world usage scenarios. The findings of this study show that in real world environments, musicians struggle to organise, collaborate and communicate effectively. While these might not be immediately perceived as 'usability issues,' effectiveness and efficiency relating to their job task are facets of usability and certainly relevant in the context of this discussion. While the software seems to work reasonably well when complexity is limited and when communication is facilitated by specialist tools (e-mail, telephone, conversations) the usability of the software could be improved by adding an additional interface for management, storage, retrieval, communication and collaboration. As these are high level tools that have not been considered essential to the process of songwriting, software vendors have failed to encompass them within their technology. This provides a platform for future research and software development that extends beyond the scope of this paper.

5.3.5 Conclusion

The findings of the study enable further, more detailed work within this area. Many of the findings are distinct and personal, though various themes emerge around the discussions, quotes and observations discussed herein. Firstly, problems have been identified relating to the usability of software tools, where visible status needs to be present and the inherent complexity needs to be managed, in order to avoid the software becoming complicated and confusing. Secondly, the software fails to meet some of the basic requirements of the users, where communication and collaboration are key.

Tables 23 and 27, highlight a workflow defined across distinct stages and the tools that are used therein. The work here describes problems relating to each of these

stages, including tools that are either repurposed and worked well or are not available to fit a particular task and therefore workarounds exist. We can take the example of social media usage here (SoundCloud, Facebook) for managing content. Here, users are choosing an external tool to work with their content rather than rely on the DAW. The social media phenomenon is something which needs to be encapsulated within this type of system, rather than continuing with a traditional, archaic model. Ultimately, software needs to be designed with an experience in mind (Arhipainen & Hickey 2011), rather than a specific set of tangible goals. How to approach this type of problem is, as yet, unsolved. However, the problem has been identified and discussed at some length, with a view to performing action research through iterative prototyping and user testing in future applications.

Beyond this, there is some discussion around supporting tools and making tools fit purpose. The refinement process and collaboration process for instance, are very disparate in nature. A variety of tools are used here with no clear consensus in which tool fits this dynamic purpose. Ultimately, the lack of flexibility and flow within tools offers the greatest challenge. Users are expected to learn and interact with a number of distinct software applications, hardware applications and processes in order to achieve their goals. Each tool is used for a specific purpose and even the massively complex digital audio workstations lack the flexibility to move between elements of production, collaboration, communication and supporting processes.

Chapter 6. Formative Requirements Engineering through Collaborative Workshops

The findings of the previous study point to some serious issues in terms of usability. Many of the issues here have been solved through workarounds and in some cases, the issues prove so problematic that a user has to begin again. At this stage there is no way of evaluating how critical usability issues are in the context of such systems. The initial study highlights problems in traditional studio based environments, including differences between usability of software packages in both creative and non-creative tasks. The work here follows on from the more tangible tasks and aims to highlight a larger, broader set of usability goals that transcends to multiple users and use cases. Here, the aim is to stretch previous definitions of functional usability and determine whether or not they generalise well across a larger user group.

The following chapter aims to explore critical user experience issues through a series of workshops aimed at generating ideas about creativity and understanding this unique problem space in context. The final aim here is to generate a set of heuristics which apply both in terms of designing future systems for the user (human-centred) and evaluating the novel types of systems that are likely to appear as technological innovation continues to propel the field forward. The previous work provides a basis by which recommendations can be generated and tested in a dynamic format.

6.1 Introduction

The importance of music, in any society cannot be understated. Music is a necessary component of modern life (Ball, 2011; Negrotti, 2010.) It can be used for communication, as an approach to eliciting emotions, as a measurement of time or for entertainment purposes. Music in some instances is older than language

(Negrotti, 2010)(Wallin, Merker, & Brown, 2001.) Therefore it is important to recognise the value of tools that aid in the creation and composition of music(I. Cross 2001). Modern technology has provided a new platform by which music can be created and consumed but has also opened up opportunities for collaboration and communication within the song writing and sound engineering processes. Strategies and approaches using technology can make the composition element more accurate and more efficient. However it is important to recognise that technology is a medium, a channel by which composition happens. By enabling efficiency and effectiveness in production, there is a risk that the user is forced down a particular path and that the inherent creativity that comes with playing an instrument is lost (Jordà, 2005.) The technology itself presents unique challenges which need to be overcome. The work here aims to identify problems and potential solutions in enabling creativity in music systems without reducing usability.

One way in which creativity can be encouraged is through the creation of constraints (*Readings in Music and Artificial Intelligence*, 2013.) While this may seem counterintuitive, constraints create a simulation of a real world environment. Instruments are constrained by key and tonality. Mixing equipment is constrained by the number of available inputs and so forth. No system is all encompassing, though functionality is increasing through iterations. KOMLETE 9, a package of digital instruments and effects - for instance, contains 33 products and over 120GB of sounds. This is double the number provided by KOMLETE 6, a package released only a few years earlier. The trend here is that capacity and functionality is ever increasing. However, even these systems are constrained in terms of the functionality they provide. These constraints then, need to be considered in the design of any music system. To embrace constraints as a means of encouraging both flow and creativity could have some value. It is important here to first recognise the value of flow within a system that is constrained. There is an inherent trade off here between the flow of information and presence within a system versus goal orientation which does not have flow, but an end requirement. This can be seen in comparison of systems. ERP systems for example, provide very little opportunity for creativity but a fairly refined flow. They are constrained in a goal

oriented way to encourage flow and increase efficiency and effectiveness, ensuring that tasks are completed in a particular way. However, creativity and innovation suffer in such an environment (Legare, 2002.)

The importance of flow in modern music systems cannot be understated. Flow provides a platform for engagement and enables the user to become more engaged in the process, by which they can be more productive (VittersÄ, 2000.) With that said, there is a trade-off here between the complexity of applications and engagement of the user against the usability factors of learning and memory. There is also a discussion on going in terms of flexibility, about how much should be provided within a given system. Nielsen and Gentner discuss alternatives to the traditional GUI and how rich representation of objects can produce value (Nielsen & Gentner, 1996.) This challenge however still remains an issue in contemporary systems, particularly where creativity and innovation are goals and usage scenarios are not clearly defined. There lie challenges in removing the presentation of visual tools and integrating the instruments and tools with the user in a cohesive manner in any type of system. When we consider the nature of music systems, in that there is a two step learning phase, we can begin to recognise the magnitude of the problem. The ultimate goal here is for technology to 'disappear' when used, as the digital instrument then becomes a vessel for expression over an entity or object (Leman, 2007.) Such a goal may be considered unreasonable in the development of a small scale system, though converging towards this goal is certainly necessary in order to better facilitate the production of music. There are interesting challenges present here. Firstly, addressing issues of functionality against the concept of engagement and flow becomes problematic in this setting. Forcing the user down a path may improve efficiency and overall structure of the system but may also disrupt flow and engagement. Approaches in similar systems can be used to model a strategy in which subtlety and performance are key. A study into piano techniques and expressive gestural interaction highlights some methods that could be transferable (McPherson & Kim, 2013.) Here, the findings show that expression is important to musicians and providing subtle platforms for such can enable creativity and produce better end results.

Metaphors drawn from the real world can also be useful in helping to facilitate ease of use within this context. Image schema theory research (Hurtienne 2009; Hurtienne & Blessing 2007) discusses the theory of metaphors in user interface design to ease use in a similar context. The focus here is on reducing cognitive load and enabling users to draw from previous experience. Metaphors can be drawn from the real world or the technical one. The goal here is to make systems intuitive, by drawing from image schema theory, fields of design and psychology. However, ease of use is not the only goal here. In fact, music often lacks a particular goal. Ease of use may not be clearly defined and the effectiveness and efficiency are often difficult to determine in an ill-defined context such as a music system. It is also important to recognise the need for facilitating creativity within this context, which could again conflict with the focus of goal oriented systems. It is also important to recognise that music as a process is not always goal oriented and that groove (jamming) and enjoyment are often key aspects in both composition and creativity (Holland, Wilkie, Mulholland, & Seago, 2013.)

The composition element is possible without the use of a digital system (Jordà 2004) though there are challenges in presenting an interface which enables creativity. Early work in the support of innovation (Shneiderman 2000) sets the basis of what would later become more refined work in musical aspects of enabling creativity, with a focus on more intimate aspects of the system (Fels, 2004.) The initial work suggests models of creativity in a structured and clear approach. Modern work has enhanced these models, taking a more general approach of attaching the domain specific context after formalising context, requirements and testing feasibility (Shneiderman et al. 2010)(Hewett, 2005.) While these approaches make some headway into understanding how context and creativity can be mixed and matched, the domain of music systems is one which still requires further exploration. The work here aims to draw from both fields of creativity and music systems and combine approaches to better understand creativity, innovation and music systems in a usable context.

6.1.1 Previous work

Previous work in this area has investigated and explored how music is created, including highlighting some of the major tools used and typical usage scenarios. Field studies have highlighted the contextually rich detail about usage of such tools (I. Cross 2001)(Cross, 2001b.) This work explores both the importance of music and the relevance of music in varying settings. The ethnomusicology approach enables the discovery of rich, contextual data by which the researcher can explore music as a 'human activity.' The findings of these studies show that music is a social activity and that such activities are not reducible or easy to relate to. Music does not happen in a controlled environment but is created in a semi structured way, with some rules and formal structures, but for the most part freedom of expression. There is no formal structure, a correct or incorrect way of writing music and usage and behaviour differs from person to person. The emphasis here is on the musician to use the tools in a distinct and personal way and this cannot be formalised in any particular method or approach that generalises well. If we consider that culture, learning and levels of musical experience are all very real differences, then designing for these factors can become infinite and cyclic. The social factors explored by Cross are just some of the issues that may present when designing usable systems for the creation and composition of music. There is some discussion as to whether or not ease of use is a valid criteria argument for musicians. The history of musical development and non-intuitive nature of notion present as problems which existed before the computer interface and as such, cannot be addressed as computing problems (Beckwith, 1992.) While this is both an interesting and challenging problem, it will not be addressed in the scope of this work.

The first study investigates the usability of music systems, in particular DAWs, in the context of the studio. Engineers work on static, linear tasks and gradually move towards more creative tasks. The sketching exercises are then used to identify issues with current systems and to ascertain where improvements could be made. While the sketching provides some insight in regards to functionality that is missing, it is important to recognise that users are not designers and therefore

cannot be expected to design fully functional systems that take into account factors like aesthetics and ergonomics. Within this context, eliciting a robust, comprehensive set of requirements is challenging.

In the second study, we explored how systems are used in a work based setting. The ethnographic approach enabled the exploration of rich, contextual data about how and why tools are used and for what particular purpose. Often was the case that tools were, 'made to fit,' regardless of their intended use or particular purpose. Participants described the difficulty in finding and learning how to use new tools as a major issue here and were happy to compromise by using existing tools in a way in which they were not initially inten

ded. Many of the issues explored focused around the area of usefulness in usability. Patching together multiple tools to perform a particular task was seen to be the norm here. Through understanding requirements beyond functionality and looking at general themes and concepts (such as communication, organisation) these tools could be redesigned and made more appropriate for purpose. In some cases, this may mean developing new tools for a requirement which has yet to be met. Tools for communicating with stakeholders proved to be one of the bigger issues here. While the ethnography provided useful insight in problems that exist, it was not particularly useful in understanding how such systems could be redesigned. Though it was identified that a series of interdependencies did exist and that tools were, 'made to fit,' a more appropriate method needs to be used to elicit the requirements of use. Here, a holistic approach is necessary in understanding multiple perspectives of usability in order to build a universally usable solution.

The workshops have been designed to encourage participants to think in a creative way. By bringing together participants from multiple disciplines and with varied levels of experience, contributions can be made using domain specific knowledge that transcends traditional theory on music systems. The work here can build on the sketching exercises in the first study and problem identification in the second to propose solutions to both sets of problems.

6.2 Aims

The aims of the final study are to identify some of the major challenges in designing and evaluating user interfaces and user experiences in music systems. To explore the concept of creativity in music systems with relation to usability and identify usable approaches to enabling creativity. To evaluate components of the interface and identify how existing functional tools enable users to meet their requirements. The aims of the study should manifest as a set of recommendations or 'guidelines' based on designing usable interfaces for music production.

6.3 Objectives

To use creativity workshops as a means to generating a robust set of heuristics for music based information systems.

To explore the concept of creativity through active roleplays, scenarios and storyboarding.

To identify areas of usability improvement in existing systems and propose a set of design guidelines for future systems.

6.4 Methodology

The following section details the methods used to encourage the generation of creative ideas and assess how existing tools could be made more usable. A workshop format has been chosen as it allows stakeholders with varying backgrounds to communicate thoughts and ideas in a formative way. The format models previous workshops (Maiden, Manning, et al. 2004)(Maiden, Gizikis, et al. 2004) where analogies relating to the music industry have been used. Here, the process is reversed and analogies are drawn from other areas in regard to composition. If we

consider Maiden's work, the motivations behind accessing a wide user base are to promote the creation of new ideas and to bring multiple perspectives in, with a view to improving innovation through a wide array of experience and skills.

The process is conducted in a creative environment, a rehearsal studio, where instruments, digital audio workstations and SoundCloud are open and available to be used. The process is somewhat similar to cultural probes in a creative space, though sessions are split into twenty minutes of activities and then ten minutes of reflection across three days. Here, each day corresponds to a single workshop, with three days, or workshops, conducted as part of the study. The findings of the workshops are presented later in terms of three areas of creativity, exploratory (day one storyboards,) combinatorial (day two focus groups, sketching,) and finally transformative (day three, reflective discussions.)

Recruitment of participants models that of previous workshops. They are recruited from multiple fields and walks of life to bring together different disciplines and try to encourage problem solving from different approaches (Schlosser et al. 2008; Maiden, Manning, et al. 2004.) Digital designers, print designers, teachers, students, musicians and professional boxers all take part in the exercises. The workshops each have twenty participants from multiple disciplines and fields. Each workshop contains 24 participants. Six of the participants are producers, six are involved in the music industry and the remaining twelve are from alternative areas.

Focus groups are also used to follow up on the workshop findings. Each focus group comprises of ten participants, all from different areas of the music industry. Producers, promoters, live artists and management all take part in the focus groups.

6.4.1 Storyboarding

Storyboarding exercises enable the representation of time, dependencies and objects in a finite space (Maiden, Manning, et al. 2004.) They can be created from

multiple perspectives and identify flow, navigation, structure and interactional components. They can also be able to identify how people interact using a system and recognise that usability is not purely functionality based. Storyboards are then evaluated through active 'roleplays.' The roleplays follow the direction of the storyboards and allow users to switch roles and imagine how scenarios would play out. The roleplays are defined and explored by the users to identify problematic areas, such as where a conflict of interest or interdependency happens. The roleplays are then translated back on to paper in a refined storyboard format. This enables a fit with previous findings and helps to identify user contexts. Though some specific understanding of context exists in multiple settings, this could be expanded upon through clearly defined roles and understanding the interactions that take place between roles.

Storyboarding happens as a group activity. Participants storyboard the 'flow' of a system, the typical processes in composing a track. Each storyboard is created using a sheet of A4 paper and pens in a group of ten. Groups are formed by participants as it enables people to work with the individuals and a group size they feel most comfortable with. Users are asked to sketch the process in as many different ways as possible, before bringing the storyboards back for discussion later. Participants work within a rehearsal space amongst various instruments and with access to digital audio workstations. Participants are also provided with sheets of paper, sticky notes, pens, pencils, whiteboards and markers. Planning the storyboards happens on a series of A4 sheets of paper, using a throwaway method to allow quick and easy idea generation (Snyder 2004.) The sessions are split into three, twenty minute sessions with ten minutes between to reflect on the activities. The storyboards are then reflected on in a semi-directed discussion group that follows.

6.4.2 Focus group and creative triggers

The second workshop focuses on mapping off ideas and expectations against current systems, to identify flaws within the design of current systems. Focus groups are composed of musicians and non-musicians, creative and non-creative people,

self-directed in the same way as the storyboarding exercises and a natural continuation of such. Participants again return to a creative workspace wherein, after having time for reflection, are asked to discuss their ideas about good design patterns and how music systems should behave. The discussions enable the generation of new ideas and thought processes and extend beyond traditional systems to make suggestions about how and why system design could change. The purpose here is to give users a sense of ownership of the system that they are designing to encourage participation. The opportunity to present ideas to the group also acts as a means of reinforcing design strategies, as users have to have a clear conceptual idea of their own design before they can then express it to the group. This solidification of concepts acts as a creative trigger in offering a new way to solve problems, particularly where questions or critical comments are made about a design.

A total of 24 people, in groups of 6 enable different ideas and dynamics to form. The focus groups are directed by the active roleplay exercises, initially generated by the storyboarding. The storyboards are 'played out' in real time in order to elicit the complex requirements and interdependencies that exist within these types of systems. Users are presented with SoundCloud and asked to discuss their findings in relation to the web based music sharing and commenting tool. Here, iterative evaluations take place using SoundCloud as a creative trigger (Schlosser, Jones, & Maiden, 2008.) There should be a clear definition of requirements in relation to roles ie what usability means to individuals. It should also be feasible at this stage to find functional requirements and explore ideas as a group to identify task driven requirements.

6.4.3 Designing a solution

The workshop focuses around designing a solution based off the storyboarding and focus group activities and aims to generate a transformation of existing models into new methods and contributions. The aim here is to propose solutions to existing usability problems, highlighted in previous work. While the novelty here is similar to that of the combinatorial process it extends beyond a familiar space, in this case SoundCloud, to generate new workspaces and approaches to solving

problems. Here, the system is no longer the focus but the process. People are the centrepiece for such a system and the process revolves around their relationships with both the technology and each other, describing the sociotechnical relationship therein. Here, the users no longer have the storyboards and creative triggers, but are instead expected to think beyond what they have produced and discussed and describe problems in a way which generalises. While the previous exercises provide context, here the context is fuzzy, as is the workspace. Each workshop lasts for approximately twenty minutes, with a five minute cooling off period for reflection and refreshments.

Participants work with a given problem set and then reverse engineer from a series of use cases to validate their own models ie, *does this design solve the problems of users x, y and z?* Participants are presented with problems that have been previously addressed, asked to 'describe the problem' and then asked about potential solutions to the problem. At this stage, problems are grouped according to similarities. Categories are refined, codes are described and participants discuss a solution in terms of each unique problem space. Here the problems are not limited to real world issues and participants are encouraged to come up with new or interesting problems which have not been previously mentioned.

The designs produced follow a hybrid model of theoretical and discussed designs, where users are no longer constrained by tangible paper based prototypes, but instead allowed to think and create freely. The workshops and supporting focus groups aim to identify the major challenges and suggest feasible solutions for overcoming such challenges - through the design of a more usable system. Ultimately, the solutions must be clear and generalisable, transcending particular software packages and focusing on a holistic system (or set of systems.) A move away from the system and towards the user encapsulates a human-centred approach to design, in order to better facilitate the production of usable systems and useful evaluation of current systems.

6.5 Results

The findings from the series of workshops are as follows.

6.5.1 Storyboarding (exploratory)

The storyboarding exercises identified three major roles in the composition and collaboration process. These roles were defined as the performer, the producer and the agent.

Roles are clearly defined to guide the process:

- 'The performer' – musically inclined
- 'The producer' – Technical, technological
- 'The agent' – Advocate end product or service (customer focused)

The following table (table 26) defines and describes these roles in more detail.

<p>Performer</p>	<p>The performer is defined as a musical individual, where they may or may not have technological knowledge about the systems they are using. The performer is described as someone who has an intimate understanding of the music they write and perform, whether it be through music theory or through rigorous performance. The performer has particular goals in either live performance (playing,) composition or to communicate with other members of the overall system. Other members that they may wish to communicate with include performers, producers or agents. In some instances, the performer and producer can be the same individual or group and are not mutually exclusive. The performer here is also essentially the product, consumer facing and responsible for the direction of the music.</p>
<p>Producer</p>	<p>The producer is defined as someone who works with technology, in some instances exclusively from performance elements. Musical knowledge is not imperative for this role, but the producer must have a thorough working knowledge of how digital audio workstations can be used. Here the focus is on taking input from performers and agents and working on a compromised version of a solution that matches the requirements of both users. Live producers and sound engineers are also included in this definition. Producers are often operationally efficient in the context of a system (or systems) that they are using, enabling them to create material quickly and with relative ease.</p>

Agent	The agent is described as any user which does not directly contribute to the production or performance element of music, but has a supporting role in the process. Here, the agent may be defined as a representative from a recording label, the management of a band or an external stakeholder such as a financier. The agent relies on technology for more general usage scenarios such as communication, time management, planning and project scheduling. The majority of information handling is done through processing information that comes as an output of the system. Their contribution to the system is often in the form of progress, tracking and general direction.
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TABLE 26 - ROLES AND HOW THESE USER TYPES INTERACT WITH THE SYSTEM

Interactions are described as taking place across different timescales, with the major point of focus on entities and their relationships and dependencies therein. While typical examples describe a simple chronology of performer->producer->agent, the structure can differ vastly. This is particularly true where multiple entities of each role exist, for instance multiple agents working with multiple producers.

Figure 11 describes a rough outline of an interface for interacting with music.

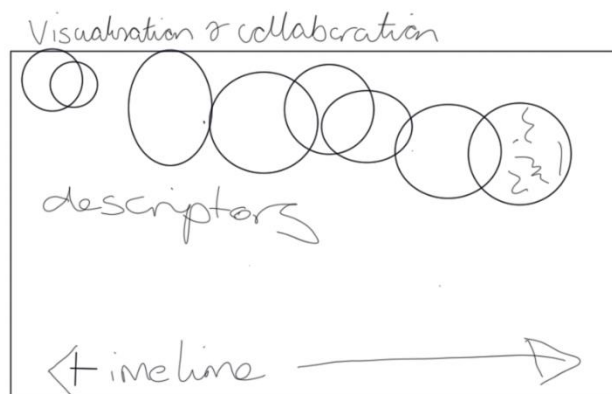


FIGURE 11 - AN EXAMPLE OF A SKETCH BROADLY DEFINING THE MAIN FEATURES OF AN APPLICATION

6.5.2 Focus groups and creative triggers (Combinatorial)

The workshop format here focuses on using the predefined roles, generated in the storyboarding exercises, to work through active roleplays in real time. Participants actively utilise SoundCloud as a creative trigger, to communicate thought processes and ideas, define status updates, progress and to manage memory and resource allocation. Participants focus on what the software does well currently and consider what could be done to improve the process in future iterations.

SoundCloud provides a useful platform here as it has limited features and functionality, instead focusing on the visual space and a commentary along a timeline. Many of the central features are hidden under additional layers (menus) and the tool itself provides shortcuts within the context of a track. This allows users to work within the constraints of a 'track' or a 'playlist' and think about the context of that particular piece of music over a large library of sounds and opportunities. By limiting choice the idea is to enhance creative ideation and encourage thinking about new or interesting ways that various things could be achieved.

Table 27 highlights key points in discussion of existing features in applications and problems that occur as a result of using these applications.

Current Feature	Future Implications
<p>Personal inbox and playlist feature make it easy to deal with multiple tracks and multiple people. The website makes this easy to manage and maintain.</p>	<p>Could become difficult when working with large volumes of content. Not everything presented on the screen is relevant or useful.</p>
<p>Integration with Facebook and Myspace or sending via e-mail all options. Relative ease in uploading tracks, downloading tracks and performing basic tasks. Some crashes and errors.</p>	<p>Integration could be tighter (seamless.) Amazon's one-click-to-buy feature identified as a valuable resource in time critical situations.</p>
<p>Visually the interface is pleasing. Comments are presented on screen at the time in which the comment was made, relative to each track. This makes it easy to point to particular parts of a composition and adds context to the comments. Interface becomes cluttered as networks grow. Focus on finding new content over reviewing existing material.</p>	<p>Further richness of information and visualisation. Working on the track in the browser and making live changes would allow even tighter links between agents and producers and could open up channels for live performance. YouTube provides something similar, but without the features of SoundCloud.</p>

Current Feature	Future Implications
Internal messaging and external embedding of tracks allows information to be passed outside of the confines of the website. Sharing on Facebook or personal websites and having a customised player enables agents to define a 'look and feel' that they feel best reflects the sound.	Lack of control or tracking cause problems in visualising how and why tracks are shared. Customisation options are currently limited but there are opportunities here for stakeholders to define and further refine the user experience when listening to music. A full featured website provides this control but can be expensive and time consuming to develop. Current content management systems provide a suitable compromise, but unlike educational systems lack a de facto music CMS.

TABLE 27 - EXISTING FEATURES AND FUTURE IMPLICATIONS OF SUCH SYSTEMS

The approach here used sticky notes as an extension of the system. These sticky notes were attached to the screen to create a new system or series of systems. Users effectively created a blended space, utilising existing systems and adding features through the use of pen and paper and integrating them by physically attaching them to the screen. Many of the features presented here enabled further control (changing the tempo of a track, transposition of notes, allocating ownership or tracking progress.) Many one click functions were added, including tools such as 'sort by user' and 'sort by genre.' Users described these features as being able to work seamlessly together in order to maximise effectiveness and reduce confusion.

6.5.3 Exploring the unknown (Transformative)

The workshop format here enables the representation of new ideas or concepts in a novel way. Participants are no longer constrained by the system. Here, participants explore a ‘flow’ based system and define this by the usage scenario rather than the system.

The final series of workshops highlighted information about the process of production (table 28) and the distinct scenarios and processes contained therein.

	Pre-Production	Production	Post-Production
Owner	Performer	Producer	Producer
Sub-owner	Agent	Performer	Performer defines, Agent releases
Tasks	Define rules	Digitisation	Processing
	Define tempo	Track-by-track	Effects
	Allocate people	Key matching	Levelling (volume)
	Manage time	Refining tempo	Signal processing (flow)
	Choose instruments	Layering	Preparation for release
	Define melody		Distribution (fuzzy)

TABLE 28 - DESCRIBING THE RELATIONSHIPS BETWEEN USER TYPES AND TASKS PERFORMED

Participants here describe the pre-production phase as a balancing process, finding the right fit and testing how well content works cohesively. Production is described as the least creative process, in that there are expectations and digital/music theories that can be used to automate the process. Much of the production process can be defined in metrics, where creativity and innovation are at their lowest. Post production is also described as a creative process, where a user imparts a personal touch on a song. Here, participants describe the process as a merging of a series of tracks into a single track, thus changing the definition of the

work in progress. The final stages are described as a signature process, where a producer can mimic their signature sound and apply it. The processes here are interchangeable, with each step imperative to the process but order changing as a matter of personal preference.

The workshop also highlights the process of music production here as both distinct and personal. While some producers share certain 'general processes,' their working patterns, behaviours and expectations of what the system can and should be able to do differs broadly. Beyond production the process then becomes individual, with each producer adding their own 'touch' to a song. Many of the users here are happy to hand off control to the system provided that it is a system that they trust, ie one that they work with on a regular basis. Where less familiar tools are suggested then users take more ownership of their production process and choose a more distributed set of tools to achieve a task rather than the all in one (albeit unfamiliar) package available. Intuitively this seems less efficient, however it reduces learning and memory as users do not have to learn a new set of rules in a system. Each distinct stage is defined by producers, though links between each vary on a user by user basis.

Figure 12 describes the process of 'formal production' ie the steps involved in creating a professional 'mixdown.' Here the process is defined as circular or cyclic (iterative) where start and end points are unclear, however they focus around a central element of a mixdown. The closeness of objects in the diagram also relates to how close they are together in a process. For instance compression happens around the same timeframe or in the same given space as both equalisation and filtering. While these elements have unique characteristics they also share many features and this diagram aims to describe the relationships between the components and describe the overall nature of production over identifying a specific process.



FIGURE 12 - THE MIXDOWN PROCESS

Each user also defines their own constraints in terms of each process. Levels are set dependent on a pre-defined notion of how each instrument or sound is important in the overall context of the recording and this can differ from one producer to the next. Instruments do have pre-defined frequencies, whereas elements such as compression and equalisation focus on the holistic sound. Each of these steps is imperative to the mixdown process, though order changes vastly from user to user and how they are applied. In some instances, this process is defined as a cyclic one, where others take a more systematic approach. At this stage the process can be generalised in that users utilise one or more of these processes in their work, while some utilise most or all of the processes in their production. Any further exploration of this area would no longer be generalisable and would have to focus on a particular use case or users.

At this stage, there are now two tools available to begin investigating usability in context. The mixdown process is described as integral steps in the development

of a track and the workshops have enabled definitions of roles and inherent problems therein. The problems identified thus far have been focused on a particular tool or piece of technology, however previous work has already identified that multiple tools are used in production. Often times these tools are described as not fit for purpose but used as they are familiar or comfortable. The usage of multiple tools to perform a task has also been described as problematic in that there are learning and memory gaps when moving between systems or adapting to an entirely new system. We must then explore these problems further to determine why these problems exist, how detrimental they are to the process and approaches to solving such issues. The following section highlights the results of a series of focus groups aiming to define problems in terms of existing frameworks and examples and to explore strategies that may help to overcome such problems.

6.5.3.1 Focus Groups (iterative)

Focus groups support workshops by enabling the discussion of ideas and concepts in a less formal manner, no longer constrained by focusing on a single system, but describing working patterns and typical working environments. Focus groups enable the representation of ideas in the form of categories, which can then be related to existing structures, in this case heuristics. From here, generalisations can be formed about the design and development of usable systems in this context, with an opportunity to evaluate such designs in a structured way. Three focus groups form to discuss ideas about existing systems, potential applications and future directions of music systems. The three groups match those in the workshops, focusing on exploring, combining and transforming. The aim here is generate a unique set of recommendations in designing and evaluating systems for musicians. This is explored through problem identification and citation of examples, before looking at the severity of problems and identifying potential solutions.

6.5.3.2 Group 1

The first group describe the following categories of general usability problems, with examples where appropriate. Participants agree that such problems are inherent of all music systems and are not related to a particular software package or tool. These problems are described as 'common,' occurring on a regular or semi-regular basis. They are not focused on a singular system but a group of systems and such behaviours are observed in multiple instances of system design.

Table 29 describes examples of issues that were identified in the use of existing systems as a platform for discussing future implications.

issue	example
features	too much control, too many things on each page
flow	illogical order, no flow, no visibility of status
disconnect	metaphors poorly used, unclear symbols, doesn't match instrument
controls	accelerators not uniform, behaviour of controls varies in different contexts

TABLE 29 - PROBLEMS CATEGORIES WITH RELEVANT EXAMPLES DISCOVERED

6.5.3.3 Group 2

The focus of the second workshop is on describing additional issues and contextualising them according to severity. Participants choose a traffic light system to categorise issues with a corresponding number between one (low) and three (high) to rate severity. Issues coded as green are considered a nuisance but do not cause the system to slow down or stop working. Amber coloured issues are described as issues which cause a system to slow down but not stop. This loss of efficiency can exist in both the system (in issues such as slow processing, many clicks to access a simple feature) or in cognition where users become confused and flow is lost. Red

issues are described as severe in that they either result in a large drop in efficiency or cause the system to come to a halt. These issues often cause users to revert to previous iterations or earlier versions of composition in order to solve issues that are unsolvable in current state. Additional suggestions were made about issues that occur and were added to the table accordingly. The traffic light system which follows enables a quick representation of usability issues in terms of severity (green not severe, amber causing inefficiency and finally red as issues which cannot be easily overcome.) This system also enables a quick evaluation to happen in that issues can be coded according to severity and then rated on a dynamic scale. As the number of elements in the table becomes larger and considering the purpose of the tables, it is important to be able to quickly and easily recognise problems in terms of severity. As the numbers require skim reading, a colour coding approach has also been applied to enable faster searching amongst elements in the table.

Table 30 highlights the major issues discussed in the workshop.

Control (2)
Functionality or lack thereof (3)
Order (1)
Flow (2)
Visibility (3)
Metaphors (2)
Symbols (2)
Digital Instruments (1)
Accelerators (3)

TABLE 30 - ISSUES COLOUR CODED IN TERMS OF SEVERITY ON A TRAFFIC LIGHT SYSTEM – NUMBERS RELATE TO COLOURS AND REPRESENT SEVERITY OF ISSUES, WHERE A 3 (RED) IS AN ISSUE WHICH CANNOT BE OVERCOME

Users are unable to code such problems in terms of regularity, but instead choose to focus on severity and the opportunity to fix problems, by either making a change to the existing system or reverting to a different system of choice. The coding is agreed upon by all participants and explored through examples. Each example is described in terms of severity and then coded as a category. Where crossover exists users are asked to define the category which best fits the context and then code it accordingly.

6.5.3.4 Group 3

The final focus group aims to further refine these categories by relating them to appropriate heuristics and coding them, with the support of the researcher in describing each heuristic. The format here comes full circle, in bringing the groups back together to evaluate categories in a context driven way. Each of the smaller groups come together for a directed discussion about the categories and their related heuristic. Previous categories are taken, applied to a heuristic (Nielsen & Molich 1990) and discussed in context, with relevant examples. The examples help to evaluate the issues by providing a real world problem and the difficulty of solving the problem (if at all solvable) defines the severity rating. This process of validation ensures that the coded issues are contextually relevant and therefore valid. Each issue is categorised in a group format, with participants discussing and agreeing on a final rating based on the examples discussed. The severity rating (1-3) is unanimously agreed upon by the group in each case, where in some cases multiple examples of issues are used to finally agree on a severity rating. These heuristics relate to the most common problems explored in music systems and each is listed alongside a 'traditional' set of usability heuristics.

Table 31 highlights the issues and how they relate to already established heuristics. In heuristic evaluations these categories are given equal weight, however in the context of these music systems the domain is more applied. Efficiency and effectiveness are the key goals, where learning and memory issues are not, as experts invest time in learning. The weight of these factors is described herein as a particular context, where if the context shifted to a task where operational efficiency was also key (trading stocks and shares for instance) then the thresholds may be even higher. It is expected that a degree of learning will be required in using any complex system, such as flying or performing an operation on a patient. Equally, you could argue that effectiveness and efficiency here, in a similarly focused environment, may prove to be the biggest factor.

Issue	Heuristic
Control (2)	Learnability
Functionality or lack thereof (3)	Efficiency
Order (1)	Learnability
Flow (2)	Memory
Visibility (3)	Efficiency
Metaphors (2)	Memory
Symbols (2)	Memory
Digital Instruments (1)	Effectiveness
Accelerators (3)	Efficiency

TABLE 31 - ISSUES WITH SEVERITY RATING AND THEIR RELATED HEURISTIC

Results show that efficiency is the major issue. Effectiveness and learnability are issues which prove cumbersome, but can often be overcome by choosing alternative approaches to interacting with the system. In some cases, such as those for digital instruments, the tool is avoided entirely and a format such as MIDI or tabular notation preferred. This knowledge can then be applied by going back to the first table of problems, coding issues by severity (colour) and presenting potential solutions to such problems.

Table 32 describes these relationships as follows.

Example	Factor 1	Factor 2	Factor 3	Solution
Too much control, too many things on each page	Efficiency	Learnability	Visibility	Simplification
Illogical order, no flow, poor visibility	Visibility	Memory		Clearer expression
Metaphors poorly used, unclear symbols, doesn't match instrument	Learnability	Memory	Visibility	Standardisation
Accelerators differ across packages, same controls perform different functions depending on context	Learnability			Standardisation

TABLE 32 - PROBLEMS AND SOLUTIONS RATED FOR SEVERITY IN TERMS OF THEIR USABILITY

HEURISTIC FACTOR

Problems in learnability are the easiest to solve but also the least critical. Through simplification and standardisation, most of the problems identified here can be overcome. The more complex problems present as difficulties in learning, memory and through poor expression. Examples here include issues such as buttons not corresponding to the heading directly above, tools not appearing in logical areas (workspace or menus) and difficulty in accessing regularly used tools (multiple clicks, hidden several submenus deep.) The difference in behaviour of identical tools (buttons, sliders) also presents as a visibility issue that detrimentally affects performance.

6.6 Discussion

The workshops provide interesting insight in two different contexts of digital music production. In the first instance they highlight major issues in solid integration and cross platform support. Musicians are no longer confined to a single room and single system. The environment they work in is both diverse and rich in contextual information, with unlimited customisation and personalisation options. When we consider this context in a digital system however, the constraints are far greater. One of the reasons for this may be the difficulty in accessing data stored in different forms in different entities. Music XML provides a solution to this problem of segmentation (Haus & Ludovico 2005) though as of yet fails to be supported by many digital audio workstations and web based equivalents. Many of the steps in the process could be automated entirely. The systems here rely on the knowledge entity (digital producer) rather than aiming to encapsulate such information within the system. The importance of knowledge sharing has been explored in a general context (Kuhlen 2003) as has the importance of knowledge in music systems (Beckwith 1992) and collaborative contexts (Schrire, 2006.) Tools such as SoundCloud aim to improve collaboration and visualisation of ideas and attempts at collaboration. Digital audio workstations however, fail to address this audience entirely. It could be argued that the focus of DAWs is on the production element and that they are different tools entirely. With that said, a failure to encapsulate the requirements of a user in a context-driven way leaves a gap between what the DAWs provide and what supporting tools provide. This further emphasises the need for both content management and knowledge sharing, preferably in an integrated way. Through representation of knowledge (and therefore automating large chunks of the process) the producer could then spend more time on the other aspects of the project.

Convergence towards a more efficient solution is not the only issue present here. Visualisation of status, presentation of information and context are ever present issues in music production. The inherent complexities of such systems (Reddy et al. 2010b; Jordà 2005; Albers & Still 2010) suggests that there is an even greater need for deference of cognitive load and easier recognition of elements in the

system than more traditional systems, where complexity is less present. Visualisation of information becomes even more problematic when appreciating the different types of users and contexts that exist. Many of the solutions presented here are from a contextual perspective and would not necessarily be usable solutions in all contexts. If we consider similarly creative tools, we can begin to appreciate the need for contextual interfaces. Many of Adobe's packages, such as Photoshop and Dreamweaver, provide 'contextual views.' These contextual views enable the representation of different interfaces depending on a predefined context. As we already have three roles defined here, software solutions could provide three different interfaces focused around the views. The 'agent view' for instance, could provide information about ownership, progress tracking and general sharing capabilities, without presenting the unnecessary elements of composition such as equalisation, compression and panning.

The final issue presented in the workshops is one of collaboration. While SoundCloud provides a fairly robust collaborative interface, digital audio workstations do not. Users overcame this problem by adding sticky notes to 'increase functionality.' Buttons such as 'share with Facebook,' 'E-mail,' 'Update status,' and 'track progress,' enable moving between current interfaces and suggested ones. This represents a need for additional functionality in a contextually driven way, in this case focused on the work in progress composition. Sharing is fairly important in the context of music (April 2007) and this is an area which has yet to be explored by digital audio workstations. Other complex systems such as software development environments provide content and knowledge management systems to overcome many of the problems we have explored here. This approach could potentially translate here and improve the usability and learnability of digital music environments.

The focus groups highlight some of the critical success factors in designing usable systems for music production. The examples provided generalise across multiple systems and contexts and highlight a need for standardisation, solid integration and more user control. Many of the problems highlighted relate to memory or learning and could be overcome by simplifying the interface in terms of context.

Often, users would simply choose to use an alternative tool rather than deal with complications of adapting to an unfamiliar tool. This is the case even where the process is much more time consuming and therefore less efficient in the tool of their choice. Where tools such as Photoshop provide multiple 'workspaces,' as in different interfaces depending on context, tools for music production do not. In terms of working patterns, by allowing users control of their own interface they can work in a more efficient and effective manner. The physical world is not defined by such criteria. If we take the example of the guitarist, using multiple pre processing and post processing tools (digital effects pedals, noise cancelling, amplifiers, PA and such.) The space in which a musician works is defined by their working patterns and they are free to express themselves in a manner of ways. The issue of flow in this context has already been discussed at some length, though the use of hardware based tools over software is still prevalent. Allowing users control in a similar context could potentially reduce a fear of using the technology, reduce barriers to learning and create a more usable system as a result.

The issue of complexity and learning exists even before any software is used. Instruments themselves are complex technology, though digital systems provide an additional layer of complexity and learning hurdles (Jordà, 2005.) The suggestion here is that more usable solutions could be built first by better encapsulating the requirements of the user. Allowing the user control over their system would enable better awareness and would allow users to remove some of the unused features of the system to drill down to a more contextually relevant version of the software. Tighter integration is also likely to provide more usable solutions, for instance by using a universal language of communication between software packages (Haus & Ludovico 2005) rather than relying on the currently distributed architecture.

6.7 Evaluation

The following chapter investigates the successes and failures of the work as a whole. Through critical analysis of the tools, techniques and findings of the studies, it is possible to frame the work in context and discuss elements of generalisability and relevance, as well as to highlight future prospects for the work herein.

The study highlights the issues in both digital audio workstations and supporting technology, including social media sharing and collaboration. The need for content management and knowledge encapsulation is ever present. Users present unique solutions to the problem of collaboration in a distributed environment. The suggestion is that current solutions could be improved through the use of ownership, tracking progress and knowledge sharing. There is also an inherent need for personalisation, customisation and freedom that does not currently exist in modern systems. This is an ever present challenge in integrating such functionality in current systems without further complicating an already inherently complex tool.

The results here highlight the key changes that need to be made in order to build more usable systems. Many of the solutions proposed here for the improvement in quality of the software interfaces involves subtle changes. By simplifying unnecessarily complex areas, the software can then be used in a more effective manner. While users define alternatives as a realistic solution, a reasonable effort at standardisation and simplification could overcome the distributed nature of such systems and create a platform by which users could improve flow across both single and multiple systems without having to acclimatise. Some of the more complex issues present in memory and visibility, manifesting in efficiency issues. A loss of efficiency in such a system is detrimental because it then breaks flow and creates a disconnect between the user and the creative process. Ultimately, the lack of control reduces opportunity for users to tackle these usability issues and the emphasis is on the software designers to make steps in the right direction.

Many tools provide the ability to integrate raw sound data such as MP3s and MIDI information, though the many different formats that exist only add to the problem. A universal solution would enable better control over sounds and better integration between software tools designed to edit and manipulate sound. This is a problem that is unlikely to be solved easily due to the various legislative restrictions and proprietary nature of music formats. MusicXML may provide a language to communicate ideas, progress and information about tracks. This would enable a multi-faceted information system to focus on metadata in the first instance and processing of sounds in the second. This would also enable distributed systems to encapsulate different types of users, rather than assuming that every user should be competent with every type of system. The necessity for an agent to familiarise themselves with equalisation and processing for instance may seem like a waste of time, where their time might be better spent focusing on the tasks that they wish to perform. The added benefits here are three fold in that effectiveness, efficiency and learnability can all be improved.

The traffic light system suggested herein provides two novel and useful purposes. Firstly, it offers a novel taxonomy of usability issues from the perspective of a musician or music producer. Through identification of such problems the system also presents a set of tools that can be used to evaluate other systems, proposing suggested guidelines and categorising problems according to severity and relevance. The system here could transcend the desktop boundary and be used in pervasive workspaces to further improve the usability of such systems. Though the list of issues here is not exhaustive and only highlights common usability issues, it could be further expanded upon to identify issues not only in the music domain but in other creative domains, such as media production, live performance and areas where creativity and innovation are considered imperative. This framework may also provide a new way to think about designing systems

A system with better control (Sasamoto, Villegas, & Cohen, 2010,) knowledge management (Kuhlen, 2003,) visualisation (Lee 2009) and flow (VittersÃ,

2000)(Lee 2009)(Jordà 2005) would solve many of the inherent usability problems here. The suggestions by the participants here are not beyond the scope of technology, though they do require an understanding of working patterns of users and also taking control from the system and putting it into the hands of the user. The general consensus here is that systems are designed to be functional under any context, but for such functionality to be useful the user needs to adjust to using the new system and learn and adapt to a new set of rules or constraints. There is a severe lack of control in such systems, unlike hardware based environments. If we consider the failure of MySpace and relative success of Facebook, systems that allowed control and restrict control, we may begin to appreciate why system designers are cautious in handing off control to users. The user is not a designer, nor are they cognitive psychologists. Control here is a double edged sword in that it allows users freedom of expression but too much control could cause further usability issues. Requirements are ever changing, as is context, meaning that these problems are difficult to solve without causing further complications. Digital interfaces are as prone to clutter as any physical workspace, in that they use the same set of distinct processes and working patterns. We have found that current solutions are fairly robust and reasonably fit for purpose, though we have made some suggestions here in how to improve solutions in the future. There is certainly room for future work here in exploring the value of each of these solutions. The growth in technology and development of such systems means that functionality of these tools continues to increase rapidly. Though it is important to recognise that these tools are not the centrepiece of such a system and should not be described as such. A stronger focus on the user and user-centred design processes would enable the development of tools where functionality is driven by the user and working patterns are improved. The suggestion here is that software developers need to focus less on building complex functionality and more on designing usable solutions for technical and non-technical musicians alike.

Chapter 7. Conclusions

The following section discusses findings, contributions, limitations and future work.

7.1 Contribution to area

The work here is seminal in two respects. Firstly, this area of interdisciplinary research explores a relatively narrow area of music systems in the context of user experience. While music and HCI are fairly well established fields in their own rights, the literature focused on HCI in music based systems is both disparate and lacking. The work here aims to bridge the gap between the two and make suggestions about the design and evaluation of said systems. Secondly, the work provides a discussion in a grounded and contextually rich way, through the use of ethnographies and workshops, with validity and relevance at the core of understanding a broad user base of 'musical people' all working within this domain. While qualitative studies provide a good basis for discussion and comparison, they may fail to encapsulate the complex needs of creativity and innovation in both a technical and technological space. Here the work aims to bridge that gap. The research here focuses on practical aspects of usability for music systems, highlighting flaws in existing systems. The work then goes on to discuss general guidelines that can aid in the development of such systems and suggests possible improvements that can be made in terms of matching user requirements with software experiences. The mixed methods approach also helps in triangulation of research, exploring themes of both validity and reliability, with a view to balancing findings and discussing the relevance and value of each. As the research is grounded in real world working environments, the results are also likely to be more ecologically valid than a small scale laboratory study.

7.2 Findings

Firstly, we explore the usability issues that occur in traditional production environments and examine how well they match requirements of users. The work explores some interesting problems, such as the failure to encapsulate contemporary technology such as social media integration and content management. Music happens through collaborative and compositive stages (Negrotti 2010; Ball 2011) and the failure to encapsulate the true nature of music composition within digital systems can be considered a failing of the system itself. In terms of usability, soft systems provide such functionality through location (Cunningham et al. 2009; Cunningham et al. 2003.) The process of composition however is not limited to a series of social interactions and a set of limited tasks, as discussed earlier in the thesis. The literature here fails to explore the real world context of systems, that music is a social process. The process here is one that is both dynamic and ever changing. One of the major failings of the systems, highlighted in the sketching exercises, pertains to the storage and content management aspects of digital audio workstations. When we consider that successful music storage and retrieval relies on visualisation and clear interactions within a system in a way which encourages flow (Fu et al. 2011; Lidy et al. 2010; Lee 2009) we can see problems. Firstly, the lack of clear storage and retrieval is likely to cause inefficiencies in the system, thus wasting valuable time. We saw with the sketches in chapter 3 how systems do not necessarily match requirements of users in terms of managing and finding content. In regards to the flow of the system, we can also discuss a lack of flow in this context as damaging and potential harmful to the creative process (Pace 2004; Vitters, 2000; Riley et al. 2009; Hook et al. 2011.) As we saw in chapter 4, the loss of flow causes a user to restart a composition based on the failings of the system and being unable to trace their steps back to where the mistake happened. The literature here also fails to explore the area of flow in a distributed working pattern, ie happening in social and dynamically shifting contexts and environments. The work here aims to bridge that gap by exploring the rich social contexts and problems that occur therein. The other interesting set of findings relates to performance times, in that none of the software packages did uniformly better than other in terms of completing typical tasks. Each software package has inherent strengths and weaknesses in relation to usability. If we compare

this to software in music theory (Ilom 2008) for example, we see similar issues arise. We can also discuss user preferences and opinions about software packages as a subset of usability. Aesthetics played a fairly large role in defining user satisfaction here. Aesthetics in relation to user experience and music systems is fairly well mentioned elsewhere (Lee & Richard J Koubek 2010; Tuch et al. 2012; Fels 2004) and the value of such is important in achieving satisfaction from the user. It is also important to recognise here that interacting with any media technology is not purely functional and can be better defined as an experience (Arrasvuori & Holm 2007; Valbom & Marcos 2005; Brown & Cairns 2004.) While these systems might be functionality successful, albeit with a degree of necessary complexity (Riche et al. 2010; Albers & Still 2010; Redish 2007; Rohrmeier & Koelsch 2012) they lack usability in terms of social functionality and clearly structure content management.

Secondly, we explore the real world environment of music performance and production. Here, the aim is to examine how tools are used in the field. The value of field studies are as follows. Firstly, ethnographies highlight social and cultural issues (Wolcott 2003; Malmi 2011; Jackson 2012.)

The ethnographic work raises a number of interesting points and highlights some interesting contextual situations where the problems occur. The contribution here is in the form of rich descriptions and associated categories and themes. Table 24 for instance describes tools and how they are used in this context, while table 25 offers a description of music production as a process. We then see examples of quotes relating to problems in both of these areas, the tools used and the holistic process of production. The results here highlighted both strengths and weaknesses of these systems. While many of the tools prove very usable, visibility of status and unnecessary complexity proved to be the major usability failures here, where users became lost in the flow of the system. These factors are key usability concerns for any system (Arndt & Katz 2010; Lee 2009; Collins & Taillon 2012.) In this time critical environment, users often chose the wrong tool for a particular task, but made it fit to avoid learning to use another tool or investing in alternatives. If we consider a synthesiser as a relatively small example of the type

of tool used herein and highlight just some of the usability issues (Seago et al. 2004) we can see how this might become problematic as systems grow in both functionality and complexity. The learning curve here is steep in that users have to develop a knowledge of computer systems (Hurtienne & Blessing 2007), music theory (Vuust et al. 2009; Purwins et al. 2008) and appropriate interactions with the software (Riley et al. 2009; Arrasvuori & Holm 2007; Leman 2007.) Unlike the instrument counterparts, there are more factors to consider than modes, scales, tonality, tempo and such.

The limitations of a physical workspace and tangible elements of the system proved costly here. Where a typical guitarist would have an idea about how their system flows and be able to modify and test this flow accordingly, users routinely get 'lost' in the software systems. These systems also prove difficult in terms of managing content, particularly where users wish to take several steps backwards. These issues have also been addressed in earlier work, arising in both lab based tests and field work. The importance of flow extends beyond these systems (Pace 2004; Jordà 2005) and proves to be a core aspect of usability in context. The systems in usage here also fail to encapsulate the needs of musicians beyond just production and performance. The complex set of interactions that takes place between stakeholders in the music industry relies on a connection of existing tools, rather than a tool that fills this specified purpose. This problem is typically solved through the use of multiple tools to serve one purpose, where examples include using soundcloud, e-mail, DAWs and a mobile phone to pass on simple pieces of information such as progress and expectations. This also proves problematic from the single user perspective, creating data redundancy and a lack of clarity in terms of progression.

Ultimately a lack of cohesion and structure, with simple visual queues proves costly (Duarte et al. n.d.; Lee 2009; Hurtienne 2009; Sousa & Furtado 2005.) The systems are usable in terms of simplistic tasks, however it is clear that the creative process of interaction is anything but simple. Systems need to enable users to

manage cognitive flow through means other than a series of input boxes and hidden windows and enable connectivity with external services in order to cater to a broader set of user requirements.

The final study focuses on a set of design heuristics - guidelines for developing systems for musicians. The heuristics are loosely based on previous guidelines (Nielsen 1994.) These heuristics however are rated in terms of severity in the context of music production. The contribution here extends beyond 'heuristics' and opens up the definition of 'musical people' to anyone who works within this context. This provides breadth and generalisability in terms of designing these systems for multiple users but also offers enough context to be useful in informing the designs of such systems without overextending and being too general. The problems highlighted in the first two studies, coupled with the findings in a series of creative workshops enables the structural development of a 'traffic light system.' This system provides design guidelines and also a quick and easy way to evaluate current and future technology, by looking at requirements outside of physical systems and looking to future possible designs and solutions. It is important to recognise that this system is not yet all encompassing. One could argue that this could be the case for any set of heuristics, as each criterion holds different weight in regards to the type of system. A health critical system would depend heavily on effectiveness and largely on efficiency whereas an educational game or entertainment system may have a stronger emphasis on user satisfaction or learnability. The workshops highlight issues from a non-functional perspective, looking at issues that generalise and transcend all systems. This means that the use case is no longer limited to the 'expert system' (user) but extends to external dependencies who wish to interact with the system, looking at opportunistic users. Through participatory design, users can define usability in their context (Pekkola et al. 2006.) This also provides value in understanding and developing theories about user requirements (Perez & Valderas 2009; Maiden, Manning, et al. 2004; Newell et al. 2006.) As definitions become more clear, the effectiveness of systems can be improved (Schlosser et al. 2008.) Ultimately, the focus is on designing and building better systems than currently exist. The aim then is to open up access to systems and provide a usable offering for experts and beginners alike (Riley et al. 2009; Jordà 2005.)

7.3 Limitations

The work here is not all encompassing. While interesting and unique issues are addressed, the results do not necessarily transcend to a larger audience and further exploration of these tools is needed. While the aim is to explore social and cultural issues in context, the wider cultural issues have not yet been explored. There is no examination into how external entities interact with these systems and due to time constraints, no room for further exploration and prototype development. The work here is limited to contextual examples of problems, with a discussion as to how to solve these problems and is yet to explore connotations of solving the problems suggested. It is possible that solving many of the usability problems addressed here may indeed present new and interesting challenges and so the work needs to be appreciated in context rather than cast like a fishing net across all systems in existence. In the same way that heuristic approaches to scanning for malicious software help antivirus software companies detect viruses earlier, these tools could be used as a means to solving usability problems in music systems before they become a problem.

7.4 Future Work

The framework produced here is useful in both designing and evaluating usable systems for musicians, however further exploration is needed to help to redefine and refine this framework. The framework does not for instance, explore novel interaction techniques such as gestural systems and touch based interactions. As systems continue to change and develop they present new challenges in providing usable interactions and the framework here has been designed to adapt to these challenges. The work here could be used as a basis for further exploration into signal processing environments or explored through longitudinal studies that aim to stress test the constraints defined herein. Future work would likely be based around the generation of prototype software to solve some of the problems mentioned here, such as content management, storage, retrieval and visualisation of system status.

7.5 Summary

The thesis focuses on lab based tools, the usage of tools in the fields and culminates in a discussion about general performance aspects of these systems. The work here takes a mixed method approach, generating themes, concepts and categories throughout with an aim to continually refine these categories. The final contribution is a product of multiple themes and categories in a cohesive structure, namely a set of heuristics for designing usable systems for musicians.

The work explores three distinct processes to highlight user experience issues in the context of music production. Firstly, we look at how well these tools match the circumstances and needs of users through task times, observations and sketches. Secondly, we highlight contextually rich issues about flow, engagement and discuss the limitations of tools on the market. Finally, the workshops bring together the previous two discussions and open up to a broader user base of ‘musical people’ in defining and describing design guidelines for these types of systems. User experience problems have been explored from multiple perspectives. The work here utilises multiple tools and techniques to examine music systems in and out of context. The work produces original contributions in terms of social understanding (ethnography and associated discussions) and an eventual framework for discussion – a set of heuristics for design and evaluation of digital audio software.

There is certainly room for further exploration here, namely testing such theories and concepts in novel systems, through novel interaction techniques and determining their applicability in this context. While the theories discussed here generalise well amongst typical systems such as digital audio workstations, as discussed in the results section, there is still room for further examination. Firstly, in the context of novel types of interaction, such as gestural and embodied systems. Secondly, in examining the link between hardware and software and bridging the gap between both.

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