Distributed cognition in joint music composition: exploring the role of language and artefacts in multi-session creative collaborative work

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Abstract

My thesis takes steps towards understanding the role technology can play in supporting multi-session creative collaborative work. This is achieved by exploring the relationship between the outcomes of a session of work and the resources available within the environment where work takes place. My domain of study is Joint Music Composition, which is a form of collaborative work that requires participants to generate, share, develop and remember information about a musical composition across a number of sessions. Although musical instrument and recording technology have advanced, there appears to be little understanding of how technology can be used to support collaboration in Joint Music Composition. To investigate this, I used the Distributed Cognition framework (Hutchins, 1995a), which has traditionally been employed to study work activities within socio-technological settings, to better understand how to support collaboration and coordination within my domain of study.

The findings of my thesis are based on studies conducted in real life settings (i.e., field) and in environments that I helped to organise (i.e., laboratory). Research from the field describes how groups naturally organise their session, their physical setting, and their communication. It also helps to highlight a number of issues relating to the cognitive burden associated with compositions when they are in development. The first laboratory study illustrates the distributed nature of problem solving in Joint Music Composition by giving examples of different ways knowledge is shared within the group and across sessions. The second laboratory study describes how a shared work space appears to change the way knowledge is represented and distributed within two different rehearsal set-ups. Overall, the main insights that are applicable to informing design relate to the way practitioners of Joint Music Composition manage the distributed nature of problem solving using transient representations across multiple sessions of work.

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Chapter One: Introduction

1.0 Introduction

The development of Information Technology tools to support creative work has been an emerging research area in Human Computer Interaction for a number of years (Abrams et al., 2002). However, the majority of Human Computer Interaction research on this topic is geared towards single users. Whilst the field of Computer Supported Cooperative Work focuses on supporting collaboration amongst a number of people, research in this domain has rarely tried to understand how groups manage the development and sharing of ideas across multiple session of work. My thesis contributes to the gap in knowledge by helping to outline the means through which Joint Music Composition, which is an instance of multi-session creative collaborative work, manages the distribution of knowledge across several sessions. The findings in my research illustrate that musicians do not solely remember and learn compositions by themselves, but instead distribute the cognitive burden of working with transient information across other musicians and artefacts available to them in the context of work. Through these findings I identify a number of challenges faced in Joint Music Composition, which are used as a basis to form high level design considerations for Information Technology tools.

My findings are based on data analysed from field-work and two laboratory studies. The framework used in the analysis stems from cognitive science, which considers people and artefacts as part of a single information processing system. One of the key concepts outlined in this thesis is the notion that the product of Joint Music Composition is the knowledge that is created and maintained between musicians and the artefacts that they have access to. This consideration is important to design because it suggests resources available within the context of work shape what people create and reproduce over time.

1.1 Research context and motivations

One of my original motivations was to study how design can support people involved in creative collaborative work in domains that do not currently employ Information Technology. Part of this motivation was to learn how to study work situations where resources in a physical setting may not always be set up in a predetermined way. The availability of resources can have an impact on people's ability to coordinate action. Human behaviour in the context of an activity can be described to be partly improvised and partly predetermined. Often the improvisational elements of work may be the hardest to account for because they may be based on unpredictable use of

resources. However, outside of the improvisational elements of creative collaborative work, there are structures which support the way groups of people coordinate their activities to develop and share ideas across time.

As my research progressed I became more interested in creative collaborative work that spans several sessions. Joint Music Composition is an example of this type of work. In this domain, musicians gather in a rehearsal room to collaborate together to create a musical composition using artefacts such as musical instruments. Compositions are rarely created in a single session. Consequently, musicians often have to wait until the next time the group meets before they can continue to work on a composition. In some cases, members of the group may continue to develop composition ideas outside of the sessions on their own. These ideas are often relayed back to the rest of the group in subsequent rehearsals. What I have outlined is a simple view of multi-session creative collaborative work. However, the context of Joint Music Composition is slightly more complicated. Often groups work on several different compositions in a rehearsal session. This means ideas about several compositions have to be maintained across time.

What is interesting about Joint Music Composition is the lack of recorded information that is used within sessions of work. The majority of what is said and done is not recorded. Therefore, the musicians must remember elements of the composition in order to continue working across multiple sessions. Another feature of work that makes the activity more complicated is the lack of prescribed rules and regulations that can help guide the process of work. This can be contrasted with a more typical workplace: in Joint Music Composition the musicians are not employees working for an organisation and are unlikely to have job descriptions set out in a contract, a staff handbook, or training in how to work in rehearsal rooms. There is a degree of uniqueness to the work context of each group. This makes Joint Music Composition complicated to study.

Structures such as rules, guidelines and cultural conventions are important to help understand human behaviour, even in the most complex contexts. These structures can act as a resource that support people's understanding of what they need to do. Other resources, such as physical artefacts used in the context of work, also help to shape behaviour. In addition, the physical environment where work takes place can have considerable impacts how people coordinate their activities. To elaborate on this point, I will give an example of how two different forms of

creative collaborative work, football[1] and Joint Music Composition can be viewed from a similar research perspective to explain how human behaviour can be examined in context where activities take place.

Football is a team sport with numerous rules, regulations and guidelines. In football, rules and regulations impact the way the game is played. The most fundamental and simplest rule regards the scoring system. Players know that putting the ball between two goal posts constitutes a *goal*. The team with the most goals at the end of the game is the winner. This, however, is inadequate to describe a player's behaviour on the field. The markings on the field represent constraints on the boundaries the ball has to be kept within. This has an impact on decision making and is a consequence of the physical setting where football is played. Another key area is the ongoing monitoring of other players' performance and the movement of the ball; this impacts how people position themselves on the field. A team is likely to communicate instructions to each other in order to support organisation. Players will be asked to run back and defend or pass the ball at a certain point in time in order to support coordinated action. In addition, an organised football team is likely to have a game plan which outlines how to successfully organise a division of labour, giving each player a role to perform. It is inefficient to ask every player to run up and down the field after the ball; players will run out of energy and will not make use of the wide spaces left open on the field. This simple illustration highlights that there are many dimensions that account for human behaviour, including the division of labour, communication, rules and regulations, plans, and constraints created in the physical setting. These concerns provide avenues to investigate what design can do to support an activity. It is not just about designing how to support an individual player to be more creative, but potentially more about how to create better coordination in team performance in order to support individual creative performance. This can be relevant to other creative collaborative domains such as Joint Music Composition.

As in football, musicians involved in Joint Music Composition rely on a collective group performance in order to successfully achieve a collective goal. In addition, there is a distinct division of labour because it is not feasible or even possible for one member to play all instruments at the same time. Therefore, better coordination in team performance is also desirable in Joint Music Composition. However, Joint Music Composition is different from football for a number of reasons, which actually makes it potentially more difficult to study. Unlike football, there are no guidelines to define the equivalent of a goal or what constitutes a win. There are mainly cultural practices that have evolved over generations that define what a

[1] Also known as soccer.

composition should sound like when it is deemed to be completed. Even this description does not totally account for what is created as a consequence of Joint Music Composition. The physical setting where Joint Music Composition takes place, like a rehearsal room, is not marked out like a football pitch. The rehearsal room layout is partly constrained by the existing placement of artefacts, and partly shaped by the musicians themselves within each session. The group is responsible for organising the session timetable (i.e., what they work on within a session and for how long). It is also the group that determines how communication is arranged and what artefacts are used within a session. However, there are many conventions that help shape the behaviour of musicians taking part in Joint Music Composition. For example, the division of labour in a rehearsal room is partly determined by the convention of how musical instruments are normally employed for a particular genre of music. In Western Contemporary music it is convention that drums create rhythmic sounds at regular intervals whilst the keyboard creates melodies. Therefore, when musicians walk into a rehearsal session, they have a common notion about the role that each person is likely to play. These conventions may have been learnt from existing popular compositions or the way popular music bands compose.

Within both my descriptions of Joint Music Composition and football, the implementation of how work is conducted is missing. In particular, there is no insight into exactly how people come to know what they know during the process of work. I have described some of the structures that explain human behaviour in a certain context. The most important concept within the research perspective that I have described is the notion that human behaviour is best explained in the context of the interactions among a number of human actors in a given activity, whilst taking on board the impact of the external environment and cultural influences of the domain. This is the research perspective of Distributed Cognition (Hutchins, 1995a), a framework that helps to analyse work from a cognitive, social and organisational perspective, taking into account the role of structures and resources within the environment where work takes place. One of the most important concepts put forward in Distributed Cognition is the notion that the properties of cognition produced in collaborative work are considerably different to those of an individual mind because of the way social structures and physical environments are exploited. Such a perspective is an expansion of the traditional cognitive science unit of analysis which solely focuses on studying cognition at the level of an individual's mind.

The main theoretical motivation of my work is to narrow the gap in knowledge that exists about the process of Joint Music Composition, using Distributed Cognition as the framework to guide the analysis. The application of Distributed Cognition to the study of Joint Music Composition has not been attempted before. Indeed, the characteristics of Joint Music Composition cannot be described to be typical to the characteristics of work domains traditional Distributed

Cognition research has studied. Distributed Cognition has often been applied to “well structured systems, in which all of the problem-solving resources are initially known to the ‘functional system’” (Perry, 1999). In addition, traditional Distributed Cognition research has often been used to describe work settings that already contain an array of existing technologies that are embedded to how work is conducted. An example of this is the cockpit of an aircraft (Hutchins, 1995b). A cockpit system is highly regulated in order to minimise the risk of potentially fatal errors occurring. The people who work in the cockpit (e.g., pilots and co-pilots) are well trained and experienced. The actions performed by the cockpit system - which involves the pilots, their knowledge, their communication, their actions, and the artefacts that they use - are greatly influenced by institutional codes of conduct (e.g., regulations set out by air traffic controllers and institutes that train and employ the pilots). The cockpit itself is a complex technological setting, which has been specifically designed for different people to work with different instruments. The pilots already know where they have to sit even before they walk in to a cockpit. Therefore, many aspects of the physical layout is predetermined and in a fixed position (e.g. the seating arrangement of the pilot and co-pilot, instruments such as speedbugs etc.). Whilst Hutchins’ work brings to light the fact that there is more to the work of pilots than following a procedure, the work setting is nonetheless set out in a fairly structured manner.

Joint Music Composition has certain characteristics of work that differ considerably from a cockpit system. One obvious distinction is that the outcomes of Joint Music Composition may be shaped and distributed across many sessions both inside and outside of the environment where the work takes place (i.e., the rehearsal room). Therefore, there needs to be an understanding about the way knowledge is shared and maintained across multiple sessions of work. Such considerations are not necessary in studying a cockpit system because the outcomes of work are shaped in one setting (a cockpit) and one session of work (a single flight). Another distinction lies with the organisation of the physical environment and the resources used. In contrast to a cockpit system, the physical layout in Joint Music Composition, including the placement and use of artefacts, is largely managed and arranged by the practitioners of work. These can be said to be less predetermined, and consequently more unpredictable to study. Nevertheless, the Distributed Cognition framework offers the opportunity to consider the study of Joint Music Composition from a number of perspectives, which can be used to understand how collaboration and coordination can be supported in this domain.

1.2 Summary of issues and questions

Previous studies that have applied the framework of Distributed Cognition have often looked at settings where representing information in recorded form was part of problem solving activities. Whether the representations were maps on paper (Hutchins, 1995a), air traffic information on radar screens (Halverson, 1994b), or emergency dispatch information on computer monitors (Furniss & Blandford, 2006), the analysis of work involved looking at recorded representations. My study of Joint Music Composition looks at how the distribution of knowledge is achieved both with and without the support of artefacts that are designed to help represent recorded information. Understanding this can help inform the design of possible new forms of support in the process of Joint Music Composition. Therefore, the key questions that are outlined in this thesis mainly deal with the way knowledge is distributed and shared within Joint Music Composition. This includes investigating the following core areas:

What are the main outputs of a session of work?

Joint Music Composition is different to domains that produce relatively fixed or predetermined end products as a consequence of a session of work. For exmaple, systems such as an emergency medical dispatch team that Furniss and Blandford (2006) studied produce relatively fixed outcomes in a successful operation (i.e., an ambulance is dispatched to an appropriate address). In Joint Music Composition, the final state of the composition is unknown and more prone to be shaped by the process. Questions are raised about what each session of work contributes to the development of the composition. For example, what are musicians achieving in each session?

How is knowledge distributed within rehearsal sessions?

The simplest view of how knowledge is shared can be based on how different musicians come to know what they have to play on their instruments. How does this occur? For example, how do musicians come to know where to place their hands on their musical instruments within each rehearsal session?

How is knowledge reconstructed about compositions in different sessions of work?

Since Joint Music Composition involves working over multiple sessions, how do musicians reconstruct knowledge about where to place their hands on their instruments in different sessions? What resources are used in this process?

What types of challenges do musicians face in Joint Music Composition in working with transient representations?

Playing musical instruments and communicating verbally and gesturally all produce representations that are transient in nature. What challenges, if any, does this pose musicians involved in Joint Music Composition?

What design considerations can be made based on my findings of this research?

Overall, the practical implications of the thesis lie in how my findings can be used to form the basis of design considerations for creating a system that supports Joint Music Composition. However, my findings by themselves may not provide design insights, and therefore considerations must be made about how design can be informed. Also, questions are raised about whether the unique nature of Joint Music Composition studies can be used to inform design.

What are the theoretical implications of applying Distributed Cognition to the study of Joint Music Composition?

The Distributed Cognition framework has never been applied to studies of Joint Music Composition. Is this a practical framework to use? Will the types of findings that the Distributed Cognition framework traditionally produces help to answer the research questions set out in this thesis?

1.3 Studies, approach and findings

My research involves observations of groups involved in Joint Music Composition both in a rehearsal studio setting (i.e., the field) and in settings that I helped to organise (i.e., the laboratory). The field-work conducted in a London rehearsal studio helps to illustrate how groups naturally organise their session, their physical setting, and their communication. It also helps create an understanding of the overall outputs of the sessions. Two sets of laboratory based studies were used to further my understanding of the way knowledge was shared within and between rehearsal sessions. The first laboratory study illustrates how the distributed nature of problem solving in rehearsal sessions requires the outputs of local activities to be disseminated across the group in order for progress to be made in music composition. It also illustrates how the reconstruction of knowledge about a composition occurs at different times using different resources. The second laboratory study is made up of two different sets of observations based on two different settings, which include a tool that enables inscriptions to be made in a shared work space. My findings illustrate a number of different ways in which

knowledge is represented within the rehearsal sessions and across time. High level design considerations emerge from my study findings, which aim to provide a rationale about *what* to support in Joint Music Composition. Overall, the main insights gained in my studies relate to the way Joint Music Composition, as an exemplar of multi-session creative collaborative work, manages the distributed nature of problem solving using transient representations across multiple sessions of work.

Questions may arise about the validity of using laboratory studies in my thesis. The use of laboratory studies has not been common in previous research that employed the Distributed Cognition framework. This could be because the key premise of the framework is based on the notion that real world settings offer cognition a wide range of resources and structures that are not possible to fully reproduce in a laboratory. However, the idea of employing the Distributed Cognition framework in a laboratory environment has never been dismissed and in fact has been encouraged (Hollan, Hutchins and Kirsh, 2000). Indeed, Holder (1999) formulated her findings about the cognition of a cockpit system based on observations conducted of pilots in flight simulators. This can be considered as studies made in an artificial setting because flight simulators are not the same as flying a real helicopter or airplane. My laboratory studies can be said to be a starting point for research in determining how new forms of support can be envisaged for a domain that currently does not use Information Technology as part of the process of work. The findings of my field work and first laboratory study provide a rationale for the introduction of a shared work space. The second laboratory study describes how the shared work space changes the way knowledge is represented and distributed.

The methods of data capture for the studies include video recordings of observations of musicians in rehearsal sessions, interviews and conversations with musicians and rehearsal studio workers, collections of recorded material created in the processes of work, observation notes, sketches I made of room layouts, and inventories I made of artefacts available in rooms where observations were took place. The first laboratory based study also involved my participation, which provides a view from within of the process of Joint Music Composition. In addition, the second set of laboratory studies incorporated questionnaires, which helped to create an understanding of what participants themselves said about issues that mattered to my research.

The framework for analysis is significantly influenced by existing research conducted using the Distributed Cognition framework (Hutchins, 1995a & 1995b; Halverson, 1994b; Rogers, 1992; Furniss & Blandford, 2006; Perry, 2003; Holder, 1999; Flor & Maglio, 1997; Gruen, 1996) to name but a few. Discoveries about the way Joint Music Composition functions are made in the

descriptions and analysis of how knowledge is represented and distributed within and between rehearsal sessions. This is in line with Halverson's (2002) assertion of how the Distributed Cognition framework produces results. It must be noted that my ideas are also shaped by concepts that relate to how people achieve understanding through language (Clark, 1996; Reddy, 1979; Schegloff, 1992). In addition, research into creativity (Sawyer, 2003; Boden, 1992 & 1994; Wallas, 1926; Fischer, 2004 & 2005), and musicology (Rosenbrock, 2003; Kent, 1976; Berger, 1999) also helped me to create a context for Joint Music Composition and how it can be studied.

1.4 Overview of chapters

Chapter one is an introduction to the thesis outlining an overview of the key issues addressed in the dissertation.

Chapter two is a review of literature that creates a context for my research. I formulate a definition of Joint Music Composition and discuss the cultural and technological influences that have helped shape it. In addition, a review is made of different methodologies for studying Joint Music Composition, including the suitability of Distributed Cognition as a framework for analysis. A number of considerations are highlighted about the application of Distributed Cognition to Joint Music Composition.

Chapter three describes the findings of a two month study that I conducted at Westbourne Rehearsal Studios. I outline an analytical framework based on the *Physical, Information Flow and Artefact Model* (Furniss & Blandford, 2006). I use my findings to create a context for the types of resources a band exploits in its rehearsal sessions. I give an illustration about the way a band attempts to distribute knowledge about compositions in development, and the cognitive burden associated to this process.

Chapter four describes the findings of a three week study conducted in a laboratory setting with four musicians. The key theme I discuss in this chapter relates to the way information created at the local level is distributed across the system to support progress in Joint Music Composition. My study findings suggest that ideas proposed in composition development, for example new musical notes or chords, or changes to the structure of the composition were often initiated by one person but involved many people to bring to realisation. This is one of a number of examples that highlights the distributed nature of problem solving within Joint Music Composition. Other key findings relate to the way knowledge about existing compositions is

reconstructed across the system. In the main, I describe the reconstruction of knowledge to occur at different times involving a number of activities that overlap across a number of individuals and artefacts. I pose a question about whether an information trajectory that enables recorded information to flow across the system at the same time will help support the distributed nature of problem solving in Joint Music Composition.

Chapter five describes two studies where I provided a shared written space and audio recorder/playback device for two different rehearsal set ups. My findings suggest that the availability of recorded information created in a shared context augments the groups' current abilities to distribute and build on existing knowledge. This creates a different way to manage issues highlighted in chapters three and four (i.e., managing the cognitive burden associated with compositions that are in development and supporting the distributed nature of problem solving). For example, the ability to create representations that are reused across sessions is seen to facilitate a shared understanding of new and existing ideas across time. The opportunity to represent certain details in recorded form is also seen to help ease the cognitive burden of processing long streams of transient information in real time. Finally, the ability to disseminate recorded inscriptions across the system in real time is seen to facilitate the means through which knowledge propagates across the system from the local level. One of the key findings of the chapter relates to the different uses of inscriptions and audio recordings. The inscriptions created in a shared context are seen to be useful to support coordination when the composition structures and ideas are emerging and changing frequently. Audio recordings are seen to provide more details about what is played within different performances, which can support musicians to remember the finer details of compositions.

Chapter six summarises the findings of my three studies. This includes highlighting the means through which improvisations are developed to become compositions, the key challenges in distributing knowledge in Joint Music Composition, and how the distribution of knowledge appears to be supported when recorded representations are used in a shared work space. I go on to discuss the theoretical implications of the research. In addition, I provide a set of high level design considerations that become the starting point to identifying what is necessary to support in Joint Music Composition. In addition, I present a critical reflection of the studies and outline possible future research directions.

Chapter Two: Literature review

2.0 Introduction

To date, few computer based applications and systems have been commercially or academically developed to support Joint Music Composition (JMC). One of the most challenging aspects of designing support in this area is that there is little direct research about the way music composition is conducted collaboratively in real life settings. I will draw on a number of research domains, including musicology, to create a definition of JMC and what it is likely to entail. I will also briefly review a number of existing computer applications that are music related in order to discuss their suitability for supporting JMC. I will then turn the focus of the chapter to discuss the broad range of possible research methodologies that can be used to study JMC. This will include reviewing research techniques associated to the fields of creativity, social sciences, and Computer Supported Cooperative Work and broadly outlining what they can offer a study of JMC.

Throughout the chapter I attempt to highlight areas that contribute to the understanding of the process of JMC, as well as issues that remain open to research. Based on this knowledge, I attempt to highlight why certain methods are likely to be more suitable than others to understanding JMC. In particular, I discuss the potential of using Distributed Cognition, which is a framework often employed to describe the way human performance is influenced by social and technological factors. I propose that this framework can be used to provide insight into potential ways to support and improve the collaboration and coordination of work activities in JMC.

2.1 Background

In this section I will introduce the background of JMC by referring to relevant literature in the fields of creativity, music and musicology. In particular, I will provide a definition of JMC, the cultural and technological influences that have shaped it, and the processes associated with music composition. I will also describe the role of collaboration in composition, review some of the current music applications and outline why few are suitable for JMC

2.1.1 Definition of JMC

The term JMC consists of three elements:

1) *Joint,* as an adjective, refers to a situation involving two or more components

2) *Music* can be defined as sound that is organised in time. It can be broken down into a number of elements including rhythm, melody, harmony, dynamics (i.e., volume or intensity), or even the physical characteristics of the sound itself

3) *Composition* (in this context) refers to the act of putting together elements of music in a specific structure

JMC in Western Contemporary music is a peer led form of collaborative work (McGillen, 2004) and is mainly conducted in co-present environments, such as rehearsal studios, where musicians meet to create and practise compositions. Western Contemporary music can be subdivided in to tens of genres of music, each with its own sound, cultural conventions, audiences, etc. Some of the most common labels applied to Western Contemporary music are Pop, Rock, Jazz, Rhythm and Blues (R&B), Hip Hop and Dance. However, as new sub genres are created, it is becoming increasingly difficult to describe musical groups. For example, “dance music” today refers to a specific type of electronic music whereas, in the 1970's, any music that made people dance was described as “dance music” (Bayton, 1998). I will focus on genres such as Rock music that use conventional instruments such as guitars, keyboards and drums rather than electronic music which is created using sampled sounds using computers. I assume studying Rock bands is likely to create more obvious instances of collaboration because it usually entails more than one musician, whilst a composition in electronic music can often be created by a single musician.

The work process of most Rock bands can be traced to seminal eras in Western Contemporary music when JMC began to arise (i.e., 1950s and 1960s). For the purposes of my research, I will focus on original *bands* since they have a distinct reliance on the whole group to perform in co-ordination in order to write and perform *original* material (Middleton, 1990). I describe the activities and work of groups who write original material as JMC. I use the term 'composition' instead of 'song writing' because the latter can imply that collaboration in popular music is essentially based on lyrics and vocals in the first step. By referring to the activity as composition, I am able to broaden the definition to include more general instances of music collaboration that also include cases where music is created before lyrics, as well as cases where songs have no lyrics at all. Whilst in the dictionary a *song* is defined as a "composition intended for singing" (Paperback Oxford English Dictionary, 2006) based on lyrics, in reality people may refer to many forms of compositions as *songs*. Therefore, throughout the thesis I use the term composition and song interchangeably.

2.1.2 Cultural and technological influences

The Beatles, The Rolling Stones, The Kinks, The Yard Birds and The Who were all 1960s British bands that influenced a generation of new bands both in the UK and throughout the world, especially the USA. They wrote their own songs, which were based on American R&B music and further popularised the use of technological advances in musical instruments at the time. They used solid-body guitars that were widely available and inexpensive since they were mass produced; electric amplifiers that could amplify and manipulate guitar sounds; distortion; and wah-wah pedals, all of which enabled groups of four or five to generate as much sound as a traditional ten piece R&B band (Kauppila, 2005). The sound effects generated using the new technology produced a different atmosphere, energy and way of working. "For guitarists the practise of developing ideas may just as frequently involve the creative adjustment of equipment as it does the manipulation of note choice" (Berger, 1999). It also changed the way songs were created: "Rock 'n' Roll functioned to demystify the music making process...removing the need for formal music tuition" (Bennett, 2001). It became a less expensive form of expression available to more people. In addition, it became a business of mass production and consumption (Frith, 1981) aided by a wider availability of broadcasting media such as radio, television and record players. Parallels can be drawn to how music is produced and consumed today, with cheaper methods to record (for example using *CuBase* software (Steinberg, 2009) for editing and production), home recordings, and distribution through social networking sites such as Myspace[1].

[1] www.myspace.com

Burkholder et al. (2006) describe how technological advances have historically been at the root of how music is shared with audiences, performers and composers. Prior to 1450, music was notated by hand or carved in wood. It was expensive to produce and purchase. The printing press enabled music notation to be mass-produced, making it more readily available for people to use at home. Early music printing has existed since 1450 and it revolutionised how music was consumed at the time. The next major technological breakthrough for the consumption and distribution of music was the advent of recorded sound. Record players were in existence as early as the 1890's when famous opera singers of time sold recordings of their performances. In addition "the new technology allowed performers to achieve for the first time immortality previously only available to composers" (Burkholder et al. 2006). Though these technological advances change how music is consumed, their impact on music making is less obvious. One can state that the availability of recorded material creates the opportunity for more people to be influenced by what is available. Imitation has always been a part of the creative process, even for the great composers before they defined their own style. "The earliest stage of an artist's work is essentially imitative – not directly of life but of the artistic work of other artists…early Beethoven so closely resembled Mozart; and the early Wagner, Beethoven" (Sasso, 1980).

Other technological advances such as loud speakers[2] have contributed to how JMC functions in the present day. The loud speaker, "which by its very nature is primarily a technology of reproduction, has played a significant role in the evolution of modern Popular music", since it is the most predominant means for music to be heard (Knakkergaard, 2000). As a result, a recording industry has developed in which skilled technicians, such as music producers and engineers, operate in purpose built recording environments called *recording studios*, with the aim of delivering an artist's songs into sound that is suitable for consumption through most loud speaker systems.

The technologies of the recording studio create a vast array of possibilities for composers and arrangers, and hence the "studio became a part of scoring", helping to shape the music, using techniques such as "dubbing, cutting and splicing" (Knakkergaard, 2000). Indeed as the decades progressed, new techniques have become part of the compositional process of musicians to the point that in electronic music "performances become mere inputs that can be manipulated and regenerated to suit the ideas" (Knakkergaard, 2000). However, using a recording studio is a costly activity that generally comes at a stage when a composition is more fully developed, especially for amateur bands. The recording studio facility is therefore not a

[2] A loud speaker is a filter which amplifies sounds (Knakkergaard, 2000).

part of an amateur band's composition process as much as it is for artists with a recording contract who can afford to spend significant amounts of time and money composing songs in the recording studio environment. However, computer technology is becoming far more sophisticated and affordable. This means that musicians now have more opportunities to use computer technology in their process of work, without being constrained by cost.

2.1.3 Process of composition in JMC

Music composition is an iterative process of idea generation, evaluation and development until all the details are set out (Abrams et. al, 2002; Schihorst et. al, 1990). It is an activity that involves building a product over a period of time. The music composition process is a "balance of opposites: inspiration versus perspiration, broad formal approaches versus minute detailed work, and macro-level (or structural) conceptualisation versus micro-level (e.g., note level) editing" (Abrams et. al, 2002). Improvisation, sometimes referred to as *jamming*, is often a critical aspect of generating ideas in popular music such as Pop, Rock and Jazz (Green, 2001) as well as in Classical music (Cook, 1998; Kent 1976; Tillman 1987). In terms of describing how musicians interact and innovate, there is very little to distinguish between the term improvisation and composition. In both cases it is a collaborative approach to the process of innovation, for it requires that the "invention, adoption and implementation of new musical ideas by individual musicians occurs within the context of a shared awareness of the group performance as it unfolds over time" (Bastien & Hostager, 1988). Perhaps the key difference is the notion of how they each unfold over time. Composition in Western Contemporary and Classical music affords the opportunity for revision to be made over long periods of time and across a number of sessions where "unlimited (cognitive) processing capacity" is available to create complex musical structures (Johnson-Laird, 1988; Sawyer, 2003; Sloboda, 1985).

Music creation in Popular music such as Rock or Pop has been denied "composition status" by historical musicology as it "neither notates, nor does it create the same kind of musical hierarchies as art music composition" and is deemed as less creative than Classical music because it is often the regeneration of "pre-shaped musical clichés" (Rosenbrock, 2003). Some scholars view this form of composition as "music artefacts" where typical forms such as intro, verse, bridge, chorus, solo, and outro become "place holder" in which ideas are "mechanically slotted" (Rosenbrock, 2003). However, the creation of a composition, for the practitioners at least, is far from mechanical and indeed in many of the groups' sessions that I have observed (Nabavian 2002), the ideas tended to drive the composition form, or structures, and not the other way round. In this type of composition "we see that the musicians creatively interact with their knowledge of form, orienting their overall design of the song to their expectation of the

listener's interest" (Berger, 1999). This illustrates that the composition is shaped in collaboration rather than planned in advance of performance. JMC can be considered a form of multi-session creative collaborative work, where knowledge about musical form of the composition can help to "design" the song to the listener's expectations. (Berger, 1999)

The product of composition, such as a song, usually has concrete and limiting musical structures that embody particular patterns and chords[3] and chordal progressions. Bastien & Hostager (1988) state that g*roup performance* in live Jazz "largely consists of the reproduction of previously innovated musical ideas", which are based on *rehearsal* "a means for working out an authoritative version of a musical innovation during performance". Bastien & Hostager (1988) believe that songs allow for inventive variations on such core musical patterns as chords and chordal progressions because "musicians who know the song have immediate information concerning these and other musical patterns". How this knowledge is formed and used remains open to research. Rosenbrock's (2002a) observation of five local amateur Pop and Rock groups provide similar accounts of the compositional processes to work conducted by other ethnographic studies of the same types of bands (Berger, 1999; Cohen, 1993; Devris, 2005; Nabavian, 2002; Shank 1994; Campbell 1995). These studies suggest that the conventions of Popular music such as Rock and Pop transcend geographic boundaries. Studies of bands in Australia, Germany, UK and the USA show similar accounts of work. Collective jamming (collective improvisation; the musical version of collective brainstorming) or individual jamming can be regarded as the inspiration of initial ideas for a composition. Evaluation of musical parts across the group is common, and cooperation is a critical aspect of collaboration in JMC. Whilst the research findings create an outline of the process of composition, there is little information describing what actually occurs within each element of work. For example, what does collective jamming entail and how do the outputs of this activity proceed to become a composition? What resources are used in this process? How do musicians collaborate in JMC?

2.1.4 Collaboration in JMC

In Western Classical music there is usually one composer or song writer. In Western contemporary music, there is often more than one *songwriter,* making composition collaborative. A songwriter in the Rock tradition is different to a Classical composer in the sense that he or she is not always expected to write the instrumentation for the performance. Indeed most musicians in the Rock tradition are expected to write their own musical parts: "While in most bands one or two individuals produce most of the lyrical, harmonic, and melodic content of

[3] Simultaneous combination of three or more tones that constitute a single block of harmony (Kennedy, 2006).

the songs, almost every band expects each musician to develop her or his instrumental part, to contribute to the arrangements" (Shank, 1994). There is currently little research on how musicians develop their own parts and contribute to the arrangement of the song. Therefore, there is no information on the mechanisms that groups use to develop and remember a composition across time.

Rock bands can regard the process of JMC as a "creativity space for everyone" involved in the band (Bayton, 1988). Abrams et. al, (2002) state that traditional music composition, like other creative workflow, is an iterative process where musicians often switch between the macro and micro level modes, for example inspiration, when an idea pops up, to perspiration, when it is captured, analysed and developed. This process involves many iterations until the work is deemed to be complete. In JMC, the cycle of creation and evaluation would be regarded as a group process or at least a process that often requires interaction between two or more group members (McGillen, 2004; Powell, 1995; Zollo, 1997, Lilliestram, 1996, Dalton, 1980, Devris, 2005; Rosenbrock, 2002a; Campbell, 1995).

JMC may restrict personal creative choice because it shares the responsibility of generating, evaluating and remembering compositional information, but often music collaboration is believed to help create ideas beyond what a single individual is able to do (Dalton, 1980, Devris, 2005; Rosenbrock, 2002a; Zollo, 1997). Creating an idea is one element of music composition. The idea has to be developed beyond its initial state in order for a composition to be created. The question of how JMC develops and remembers a composition remains open. In the case of Rock bands, an idea can be inspired by one person, but it has to be communicated to others during an *elaboration process* (Rosenbrock, 2002a) in order for the idea to develop (Lilliestram, 1996, Campbell, 1995). However, research has so far not outlined what an *elaboration process* actually entails.

It is important to note that not all musicians work to the same musical structures or social practices. For example, in classical music one would expect a conductor to 'lead' the musicians through a composition that is performed from sheet music. Jazz musicians have certain practices that make the musical innovation in jazz neither 'entirely random nor entirely determined'; new musical ideas are invented, adopted, and implemented through rules for musical grammar (Bastien & Hostager, 1988). There are also certain accepted and expected social practices in Jazz for example, a nominal leader may be appointed to structure which musician plays a solo at which portion of the song. Shank's (1994) description of an Austin Rock band demonstrated little behavioural norms. It suggests that composition in Rock bands

involves groups developing their own social and musical structures based on their own unique group dynamic, their genre of music, group history and personalities. This has implications on how JMC is studied because the mechanism used to develop and remember a composition may differ from one group to the next.

2.1.5 Computer technology use in music composition

Whilst the design and application of computer based systems have been employed in music, film and dance composition (see Abrams et al., 2002; Forsberg et al. 1998; Schiphorst et. al, 1990), remote music collaboration (see Gurevich, 2006; eJamming Audiio, 2009; Idabamusic, 2009), as well as research into the nature of music collaboration through novel forms of human interaction (see Blaine and Perkis, 2000; Leach, 2001; Bryan-Kinns, 2004), there has been little focus on creating computer applications for JMC in a co-present environment. The applications that are designed to record music have focussed on supporting product outputs and potentially less focus on supporting the process in which the outputs are created. For example, there are many sophisticated music recording packages such as Cubase (Steinberg, 2009) and Pro-Tools (Digidesign, 2009) which Rock bands can use to record their composition. However, the packages are designed for recording a composition that is more formulated. One possible reason for the lack of computer applications designed to support the process of JMC could be because little is known about the way compositions are collaboratively created in groups. For example, there is little direct evidence in the literature that illustrates how composition information is represented, how it developed, and how it is remembered across a number of people.

Whilst the recording and externalisation of information in a physical form appear to be part of music composition in Western Classical music (Cook, 1998; Kent 1976; Tillman 1987), few proposals have been made to apply this as a form of support to JMC. Computer applications for composition often focus on supporting composers or musicians who use musical scores as part of their work process. Music notation and music sequencer software serve this purpose, but in different ways. Whereas the goal of sequencers is to enter and perform synthesized music, music notation software is primarily used to create high-quality printed scores. This type of notation software enables users to fill out scores as they would on paper, except the input is achieved using computer peripherals like a keyboard or mouse. Alternatively, the *Music Notepad* (Forsberg et al. 1998) provides a facility that allows a user to enter hand written musical information using a stylus on a graphic tablet. It is not clear how this supports collaborative composition in a Rock band. There is so far little evidence that suggests written music scales are used in band rehearsals.

It must be noted that computer applications *have* been developed to support JMC but only for working in remote locations. Applications such as *JamSpace* (Gurevich, 2006), *Ejamming* (see http://ejamming.com/home/) and *Idabamusic* (see http://www.indabamusic.com/) provide the opportunity for musicians in different physical locations to play music or contribute to a composition over the internet. This is unlike typical JMC because the musicians are not sharing the same physical space and therefore are unable to exploit many features of face to face collaboration, including visual and physical access to other people's work areas and performance. However, the aim of the group remains the same: to create a composition collaboratively. Most of the features of these applications are to support collaboration from remote distances. However, the applications tend to provide a mix of support for connecting people in remote locations with support for remote music recording. For example, applications such as *Indabamusic* support collaborative composition by allowing musicians to make individual contributions and add their contribution to an existing recorded piece of music. This is similar to how music is recorded in a recording studio; it is an asynchronous form of interaction. Out of all of the applications that I reviewed, *Ejamming* is one of a few applications that aims to support collaboration in real time. It allows collaborators to play music and speak over an audio channel during their sessions. The *Ejamming* interface allows musicians to control the volume of the instruments as they play and allows them to adjust or edit recordings after they finish playing. The capability to edit a recording may provide opportunities for remote collaboration to revise and reformulate compositions in a different way to JMC in a co-present environment. Computer technology therefore has the potential to provide musicians with opportunities to work in ways that may change current JMC practices. However, I must consider the implication of introducing computer technology in an area that currently does not employ it. Before I can think about the design of new technology, I must first explore the role it may fulfil in the context of JMC.

2.2 Considering design methodologies for JMC

Design considerations to support collaboration at work (Stefik et. al., 1987), creativity (Couger (1996), and musical collaboration (Bryan-Kinns, 2004a) have involved using a number of methodologies which consider different angles of research. The field of Computer Supported Cooperative Work (CSCW) has been dedicated to finding ways to help people work together using computer technology (Greif, 1988; Coovert, Thompson, Foster, 2000). The researchers in this field have employed a plethora of research methodologies in order to better understand the way people coordinate their activities with each other, as a basis to inform design. Indeed, one of the notable features of CSCW is the interdisciplinary nature of the research methods that can be used to inform the design of computer technology. This includes methods associated to

computer science, artificial intelligence, psychology, sociology, organisational theory, and anthropology (Greif, 1988).

The types of methodologies that can be used to study JMC varies. Contextual research methods such as ethnography have become popular in CSCW because they provide direct evidence about people's approach for doing things in real life contexts (Garfinkel, 2002). Researchers in CSCW have also employed theoretical frameworks that help to structure the analysis of data captured in ethnographic research in order to examine human actions, decision making and interaction in complex work situations (Halverson, 1994b). In addition to considering these areas, I will look at the domain of creativity and what it has to offer a study of JMC. Part of the rationale of reviewing creativity literature is to highlight why certain contextual research methodologies and theoretical frameworks are more suitable for my research.

2.2.1 Creativity research

In the past fifty years there have been growing efforts to understand human creativity in order to help designers create support for individuals and groups to be more creative. Examples of this include the work of Candy, Edmonds & Mamykina (2002), Csikszentmihalyi (1997), Schneiderman (2000) and Fischer (1999) to name but a few. Creativity can be considered from an individual's perspective or from a social perspective. For example, creativity from an individual's perspective concerns ideas that are fundamentally novel with respect to the individual mind, regardless of its significance to a wider social context. Boden (1994) describes this as psychological creativity (p-creativity). Creativity - whether it is science, needlework, music, painting or literature - must be fundamentally novel with respect to human history to have social significance, and this is known as historical creativity (h-creativity) (Boden, 1994). Another social dimension in which creativity has been studied is highlighted in Sternberg (1999). This relates to how multiple people work together to produce something creative, like an idea or product, together as a group. I refer to this as g*roup creativity*. Sawyer (2003) uses this term in his research on the group processes of Jazz musicians and improvisational theatre ensembles. He states that traditional psychology often ignores the process of creativity which to him, as a social psychologist, is imperative to understanding how groups create.

The importance of social interactions and collaboration in creative work are highlighted in a number of papers (Bodker, Nielsen & Petersen, 2000; Candy, Edmonds & Mamykina, 2002; Fischer, 1999; Schneiderman, 2000). Whilst collaboration is part of the process, many of the perspectives illustrated in the research papers relate to how individuals are supported in being

creative in their own activities. Candy, Edmonds & Mamykina (2002) state that the last fifty years of research into creativity has raised many questions but it is only recently that human creativity is seen to arise from activities that take place in a social context where interaction with other people, as well as with artefacts that embody group knowledge, are important contributors to the process. Indeed this view is supported by many contemporary researchers in the field of creativity. Csikszentmihalyi (1997) states that "…creativity does not happen inside people's heads, but in the interaction between a person's thoughts and a socio cultural context".

Fischer (1999) believes that the power of the unaided, individual mind is highly overrated; without external aids, memory, thought, and reasoning are all constrained; "Human beings have a bounded rationality: there is only so much we can remember and there is only so much we can learn". Fischer goes on to state that much of our intelligence and creativity results from the collective memory of communities of practice and of the artefacts and technology surrounding them; collaboration will become a necessity, and practitioners will make increasing use of reference aids, such as printed and computational media supporting external cognition. Creative activity grows out of the relationship between an individual and the world of his or her work, and out of the ties between an individual and other human beings. In order to comprehend how the socio-cultural context impacts on individual and group creative processes, researchers are encouraged to examine how creative acts take place in a holistic and emerging context (Fischer, 1999, 2005; Sawyer, 2003).

Whilst there is growing consensus on researching creativity from a social perspective, there are surprisingly few researchers who have looked at co-present creative collaborative work, like JMC, that spans multiple sessions. Often, researchers who have used creativity to inform design principles base their findings from an individual's perspective.

Design principles based on creativity research

Design principles based on creativity research often provide high level guidelines on how to support creativity, but they are typically presented in theoretical rather than practical terms, which may not provide the detail needed to examine JMC. For example, Wallas' (1926) *preparation*, *incubation*, *illumination and verification model* is based on the stages that occur when a person is involved in a creative act. It is unclear whether the four phases apply to every creative act, or if it is a description of major creative work. Nevertheless this is a convenient way to hypothesise the role of the subconscious in the creative process and where design can potentially look to support creativity. The *preparatory phase* involves conscious attempts to solve the problem, by using or explicitly adapting familiar methods. The *incubation phase* may

last for minutes or for months and it is here that “fruitful novelties are initially generated” (Boden, 1992). This is a stage between the initial definition of a problem and the moment an insight into the problem is made. Even though nothing appears to be happening, it is likely that internal processes are in motion (Wallas, 1926). *Illuminatation phase* is the stage where the individual becomes conscious of the idea; it is the stage where the discovery of the idea becomes realised. Finally, the *verification phase* is where an idea is elaborated upon and applied into a context. Whilst it is insightful to learn that creativity can be described in a series of stages, it is unclear how observations of real world activity can be attributed to each phase. At what point can I study preparatory or incubation phases? More practical problems may be attributed to how to track subjects of study to determine how these phases are actually occurring over time. One cannot assume that these phases will occur when researchers are observing activity. Finally, creativity models are usually based on an individual’s psychological processes, meaning they may not take into account the perspective of how creativity occurs in groups. Similar issues can be attributed to more recent research into using creativity as the basis for design guidelines. Schniederman (2000) describes *Genex*: a 4-phase framework to help “generate excellence”. It is an attempt to build on Csikszentmihalyi’s (1993) principles of supporting access to the domain and consultation with the field. The phases for the Genex framework are described to be:

1) Collect: learn from previous works stored in libraries, the web, etc
2) Relate: consult with peers and mentors at early, middle, and late stages
3) Create: explore, compose, and evaluate possible solutions
4) Donate: disseminate the results and contribute to the libraries.

Whilst the rationale of the framework is clearly defined, it is unclear how designers can use the *Genex* framework to create design principles for JMC. There is little direction in how to learn about the mechanisms that groups use to develop compositions, which may relate to the *Create* element of the Genex framework. Also, how does the donation of results support how JMC produces excellence?

Psychological creativity models are not the only means to study creativity. Mayer (1999) reviews a number of research methods used to study creativity over the last five decades including psychometric methods, experimental methods, biographical methods, biological methods, computational methods and contextual methods. Whilst each method looks to define creativity from a particular perspective, Mayer (1999) states that no single research method can be said to be superior in the outcomes of researching creativity. Different methods are designed to look

for different types of information. For example, psychometric research methods involve a number of psychological tests being conducted in controlled conditions to assess various traits or characteristics of creative people. Whilst this type of research method is well established, it does not take into account real life situations in which social, cultural, technical, and environmental factors can influence how people think and work. Similar issues occur when studying creativity using computational modelling. In computational modelling, human cognition is often represented through an executable computer program (or a theory) which is designed to output the outcomes of various test cases (Boden, 1992). This creates a limited view of real world situations. Instead, contextual methodologies such as field work and ethnography put personal, social, and cultural factors at the heart of the analysis.

2.2.2 Contextual research methodologies

The importance of understanding human behaviour in context is considered to be a major consideration for the design of usable computer system (Winograd & Flores, 1986). Research methods such as ethnography have sometimes been employed to understand the social organisation of work in real life contexts (see Heath & Luff, 1991). Ethnographic research often involves the observation, participation and collection of information about real world situations. Its origins are traditionally rooted in anthropology and sociology. In short, ethnography aims to explain what people do and why they do it (Richardson, 2000). Other contextual research methodologies, such as ethnomethodology, aim to highlight the procedures that social order is produced and shared (Garfinkel, 2002). An example of an ethnomethodology technique is Conversation Analysis (Sacks, Schegloff, Jefferson, 1974), which helps to examine the local organisation of interaction. Linguistic models of *breakdown* and *repair* analysis (Schegloff, 1992) display evidence that people understand each other only through the identification and understanding of misunderstandings that occur. These types of techniques help to build a picture of how social order is produced.

One of the key considerations of using contextual research methodologies to study JMC is the role of *intersubjectivity* in group creativity. Sawyer (2003) states that one of the reasons group creativity has not been keenly analysed by psychologists until very recently may be because of intersubjectivity within groups. Sawyer explains that the meaning of an action is often only determined after a response by another group member. Therefore, social psychology looks more toward the process of achieving progress through interaction; “The key question about intersubjectivity in group creativity is not how performers come to share identical representations, but rather, how a coherent interaction can proceed” (Sawyer, 2003). Matusov (1996) states that intersubjectivity can be “a process of co-ordination of individual contributions

to joint activity rather than a state of agreement". Lefford (2000) explains that creative collaboration can involve multiple participants negotiating an interpretation and ascribing meaning to representations collectively. These conclusions imply that the analysis of actions and activity in JMC might be better suited to human interaction methodologies of analysis rather than studying it from a creativity perspective. For instance, The Grounding Model (Clarke, 1996) applies principles that help establish how people come to understand each other in conversation. This is illustrated by studying how humans manage errors in conversation and how they add to their mutually shared understanding, otherwise known as *common ground* (Clarke, 1996). This form of research avoids the analysis of psychological processes and instead evaluates the observable actions of the participants involved in a conversation.

In my study, as in many others such as Sawyer (2003), it is not the phenomenon of *creativity* itself that is of interest but the process of progress associated with it. This means that studying how people create shared understanding in collaborative work is important. However, whilst the analysis of local interaction is likely to provide useful insight into how shared understanding is achieved, I must also form an understanding about the overall process of JMC. Can JMC be adequately described in terms of a series of conversations alone? If so, which conversations should I analyse to provide an adequate analysis of the JMC? Conversation analysis is likely to become useful when more domain knowledge about JMC has been compiled. Ethnography therefore is the first step in creating the domain knowledge required to create a deeper understanding of JMC.

Using ethnography to study people making music is an established research area in itself. Ethnomusicology can be described in terms of studying people making music (Titon, 1977). Whilst, much of the focus in ethnomusicology has been on looking at non-Western music, there is a body of work dedicated to studies of Western contemporary bands. This includes the works of Campbell (1995), Bovey (2006), Cohen (1993) and Dalton (1980). However, these works are mainly concerned with the study of music in its cultural context. There are few details of how bands manage to actually create a composition in their sessions. Any account of work of this kind may be given in passing and certainly not in enough detail to help understand how knowledge about compositions is created and shared. Therefore, using ethnography to study people making music can bring forth many forms of findings. This is because ethnography does not provide an evaluation technique from a philosophical or theoretical standpoint (Richardson, 2000). Therefore, data captured within the field work can be evaluated in a number of ways. Since, an analyst is directly involved in the environment where observations take place, he can evaluate his contribution to the shaping of the research findings. *Reflexivity* through self reflection is therefore one way to make evaluations of ethnographic research (Richardson,

2000). However, this technique alone may not help to explain how complex systems work. Whilst ethnographic research methods can capture information in real life contexts, the lack of a theoretical standpoint can make the analysis of data less focussed on a specific research concern. To counter this, a theoretical framework can be used to provide focus to the analysis.

2.2.3 Theoretical frameworks

Theoretical frameworks by themselves do not always provide design solutions in CSCW (Halverson, 2002). Nonetheless, they can guide an analyst to form an understanding about a given problem situation being studied. I will briefly review four frameworks, including Task Analysis, Situated Action Models, Activity Theory, and Distributed Cognition, and assess their suitability to my research. I have selected these frameworks because they each raise questions about how JMC can be studied. Since my main research concern relates to the way knowledge is created and developed within groups over multiple sessions, I have to consider the merits of studying JMC through the analysis of tasks, situations and cognition.

Task Analysis

Task Analysis (TA) is used to understand how people achieve certain goals and tasks in a given situation. The key premise in TA is to break tasks down into subtasks, and then break these into sub-subtasks until an appropriate level of analysis is reached (Kirwan & Ainsworth, 1992). The main aim is to create a step by step construction of the actions taken to achieve a specific high level task, from beginning to end. Within each task, analysis can look at the resources used to determine current ways in which a system works. These can form the basis for determining how a new system can be used to improve the way certain elements of the high level tasks are implemented. In the past TA had been successful at modeling individual work; however, in recent years it has been used in group work (Johnson & Hyde, 2003). Research using TA in collaborative work has been used to discuss cognitive and meta-cognitive processes (Zachary et al., 2001; Klein, 2000), cognitive constructs and mental models (Annett & Cunningham, 2000), and team knowledge (Blickensderfer et. al, 2000). However, there are certain issues that may appear problematic for my research. Firstly, I have little understanding of the nature of tasks in JMC, and subsequently how they may be subdivided. Focusing on defining tasks is likely to be extremely time consuming and may not be desirable if the nature of the object of study is not known in the first instance. Also, TA assumes that creating a certain outcome can usually be determined through a set number of ways. This is clearly suitable in situations which may have a finite number of conditions in order to achieve an outcome. For example, using TA to analyse how a jigsaw puzzle is completed (Johnson & Hyde, 2003), is suitable because the task of creating the puzzle can be relatively straight forward, and is based around a physical

object (i.e., the puzzle) which changes states according to actions taken. To a certain extent, TA assumes that an analyst can observe the manipulation and interaction of artefacts in a manner in which he or she can derive a description about the behaviour of the user in a task. However, *taxonomic structure* (Johnson & Hyde, 2003) (i.e., jigsaw objects and actions) may be difficult to analyse in JMC, as JMC does not appear to represent the outcomes of work on physical artefacts. In addition, TA is particularly useful in investigating existing systems and situations, but possibly "not to envision new systems or devices" (Preece, Rogers & Sharp, 2002). My aim is to determine the suitability of possible computer technology which currently does not exist. It is therefore not desirable to expend effort to understand the nature of tasks which may be completely changed once a new element is added to the work activity.

Situated Action Models

"Situated Action Models emphasise the emergent, contingent nature of human activity, the way activity grows directly out of the particularities of a given situation" (Nardi, 1996). The key premise of Situated Action Models is to view a situation as "an emergent property of moment-by-moment interactions between actors, and between actors and the environments of their actions" (Suchman, 1987). The outcomes of tasks may have a number of ways to be completed and therefore may not always be restricted to set pre-determinable sub tasks. The same high level task may be completed in different ways using different types of resources available at the time an action is being taken. Therefore, actions can be driven by the situation and context in which a person is situated, not always by plans and goals (Suchman, 1987); people can take opportunistic advantages of resources available to them which may not have been predictable before they carried out the action. Indeed, Situated Action theorists regard goals as retrospective constructions of actions people believe they perform in a situation (Lave, 1988); goals and plans are something that people would have been unlikely to be able to describe before they carry out an activity.

One of the key criticisms of Situated Action Models is that neither the theorist nor the subjects being studied can account for an object of study. This can be problematic because the descriptions of situations may not account for variable response to the same environment (Nardi, 1996). This means that it is possible to describe people as doing the same things even if they have completely different goals. For example, two people looking at the same object may use the information in different ways to solve very different problems in their mind. Without looking at the objectives of the people being studied, a Situated Action analysis will not provide conclusions beyond what the analyst can observe; what occurs internally to a person is, after all, invisible to an analyst. Therefore, Situated Action theorists describe *situations* as they occur, but do not always look to formulate a theory based on the findings. This may have limitations in

informing design, because an understanding of goals and objectives is likely to provide more details about work activities, which cannot be solely available in ethnomethodological studies (Nardi, 1996). Indeed it may be difficult to use the outcome of a Situated Action analysis to create generalisations and comparisons to similar studies, because the focus is very much on the description of what is done and said in the specific situation being studied.

Activity Theory

In Activity Theory (AT), unlike Situated Action, the notion of a goal or objective plays a central role. The object of study or unit of analysis in AT is an *activity*. The AT framework of Engestrom (1987) built on the work of 1920s and 1930s Soviet Union psychologists Vygotsky, Leont'ev and Luria, and proposed that an activity can be composed of six elements: the subject (i.e., a human participant in a given activity), object (i.e., an objective or outcome to be achieved through the activity), tool (i.e., artefacts used in the activity to help create an outcome), rules (i.e., conventions and cultural factors that shape the activity to be performed in a certain way), community (i.e., collaboration with others in the activity), and division of labour (i.e., distribution of physical and cognitive labour involved in the activity). Understanding how these elements are organised within an activity provides a means to study situations in more granular detail at different levels. Overall AT aims to be a unified framework that accounts for technical, social and cognitive considerations. The framework is supposed to help analysts consider how artefacts, such as physical tools and language, mediate activity that help shape and constrain human actions, and context is both internal to people (i.e., objectives and goals) and external to them (i.e., artefacts used, work environment, other people in the work activity) (Nardi, 1996).

I can create a superficial view of JMC using AT to illustrate how it might take shape. This can be in the form of a subject (a musician) motivated towards an object (writing a song) in collaboration with community (other musicians in the band) mediated by tools (instruments, paper, etc) cultural factors such as rules (convention of music, code of conduct within a band) and division of labour (different musicians playing different elements of the composition using different instruments). However, there are numerous challenges in using AT for the purpose of understanding how information is shared in JMC, and how the group develops and remembers a composition. Gruen (1996) suggests AT does not provide adequate criteria to delineate activities because “it is often hard to identify the goal that motivates an episode of behaviour” and that goals and activities often do not share a “one to one” mapping. Because AT places the human actor in the centre of the framework, the objective and use of artefacts in an activity are based on the human actor's perspective. I have to consider how an AT analysis would take shape if the human actor did not view the world (i.e., did not have objectives) in the same way as I position my questions. For example, what does composition development and remembering

actually entail in the real world? Whilst it is a logical assumption that compositions that develop over sessions are remembered in some way or another, is there a specific activity that can be associated with development and remembering? Do musicians involved in a JMC use certain artefacts explicitly to *remember* a composition? I have to be open to the possibility that my concerns may not be exactly in line with the objects of an activity in an AT analysis, but by-products produced in the process of work.

Distributed Cognition

Distributed Cognition (DC) emphasises that the heart of intelligent human performance is not the individual human mind but groups of minds in interaction with each other and minds in interactions with tools and artefacts (Hutchins, 1995b). DC has been used to help researchers describe work situations and problem solving tasks, in the context of experiments and actual work practices, from an information processing perspective. DC as a framework for analysis was made prominent by the work of Hutchins (1995a), who used extensive ethnographic research of the work of a navigation team on board a naval ship to demonstrate that cognition can be viewed as transcending the boundaries of the individual person and be seen as a distributed phenomenon coordinated between the practitioners of work and the artefacts that they use in a given context.

DC helps describe the co-ordination between people, as well as individuals' interactions with artefacts (both high and low tech), as a *functional system*. The functional system consists of the "representation carrying and representation-transforming entities involved in a problem solving activity" (Perry, 1999). The word *representation* in a DC context can be described as "the way in which a system stores knowledge about a domain" (Perry, 2003). The key focus of a DC analysis is based around how information propagates and transforms between the different media used in problem solving activities within the functional system. This is known as the "propagation and transformation of representational states" (Hutchins, 1995a) where information moves from one medium into another, and as a result becomes transformed as a re-representation within the medium it propagates to. The media can refer to internal representations such as an individual's memory, as well as external representations, for example markings found on paper. Hutchins (1995a) refers to the cognitive activities involved in the propagation of representational states as *computations.*

DC describes the functional system as a computational system in the same language as cognitive science describes an individual's internal processes. Since the unit of analysis in DC is external to, and inclusive of, the individual, the activities of how representations are brought into

co-ordination during the problem solving task can be observed directly, which means it allows researchers to “step inside” the cognitive system (Hutchins, 1995a). Indeed, one of the key achievements of Hutchins’ DC work was that it helped dissolve “the traditional divisions between the inside/outside boundary of the individual and the culture/cognition distinction that anthropologists and cognitive scientists have historically created” (Rogers, 2006). Since many of the representations that are used to conduct activities are “manifested in artefacts” (Perry, 2003) and the communication conducted between the human components of the system, I am well placed to observe how a cognitive system works.

Like most collaborative work situations, JMC will involve representational states to propagate across media, including the musicians themselves. However, given the complex nature of how people make sense of the world, many things can be called a *representation*. For example, a person placing their hand on a piano and playing it creates at least two types of representations: 1) the sound created by the instrument when the keys are pressed 2) the chord shape outlined by the position of the hands of the piano player when they press the keys. The piano can be regarded as the medium, whilst the sound and chord shape become representational states. When the sound travels through the room to other musicians they process it and transform the information by playing something based on what they hear. In addition to hearing, the action of playing an instrument may also be based on what they see, namely the chord shape made by the hands on the piano.

Describing how the transformation carrying and representation transforming entities are brought into coordination creates a level of description that could not be achieved if one was solely relying on describing the content found in ethnographic research. The outcomes of a DC analysis are therefore very different to the outcomes of a Situated Action analysis. For example, ethnographic research may show that a guitarist sometimes looks at the neck of a bass player's instrument during a performance. Using DC, an analyst may try to describe whether the ability to look at the hand position of other musicians helps people remember information about the composition. This is because DC provides the potential to define the possible ways in which information propagates and transforms to serve a specific goal in that context. This form of analysis also overcomes the need to define tasks, as in the case of TA, giving the analyst a broader scope to define a unit of analysis. For example, remembering a composition may not be attributed to definable tasks or activities because it may consist of a culmination of actions. In addition, remembering a composition may not be an objective that is defined in the rehearsals, but may simply be a by-product of the actions taken that is wholly or partially represented in human memory. Design insights can arise from identifying the potential strengths and weaknesses in the way work is carried out based on the description of how representations are

transformed between people and people with artefacts in problem solving activities.
There are many similarities in the objectives that AT and DC aim to serve. Above all, both theories are about cognition and therefore "what they can say about group interaction is based on what they say about cognition" (Halverson, 2002). Both AT and DC can be said to be concerned with describing how cognition can be viewed not as a phenomenon within an individual's mind, but also in the context of activities undertaken by a group of people using mediating artefacts in a context that is governed by certain conventions of a community. Therefore, both theories aim define the relationship between the practitioners of work, the artefacts used in the context of work, cultural practices, and any aspects that can be described as accounting for the cognitive activities involved in a particular area of study. I find DC to be a more appealing framework to use because constructing a view of work activities from an information processing perspective can help me define the scope of the unit of analysis without needing to take into account whether we are able to precisely delineate activities. Therefore, DC provides more flexibility than AT in terms of defining the object of study (Halverson, 2002).

2.3 Using DC to inform design

DC has been employed for the purpose of analysis in numerous workplace studies, including air traffic control (Halverson, 1994a & 1994b), air craft cockpits (Hutchins, 1995b; Hutchins & Klausen, 1996), SH-60B Seahawk helicopter cockpit simulators and training centres (Holder, 1999), ship navigation (Hutchins, 1995a), an engineering design and construction company (Perry, 2006), trouble shooting in an engineering firm (Rogers & Ellis, 1994), London ambulance emergency medical dispatch team (Furniss & Blandford, 2006), management of everyday activities in an office (Gruen, 1996) and music band rehearsals for a covers band (Flor & Maglio, 1997), to name but a few.

Whilst the domains of research remain distinct from each other, the application of DC analysis can serve a unifying purpose. One of the objectives of using DC as a framework for analysis is to examine existing technology and work practices, and subsequently suggest "recommendations as to what needs to be preserved and what systems and work practices need to be redesigned to support and improve the collaboration and coordination of work activities" (Rogers & Ellis, 1994). However, it must be noted that in many of the studies that used DC as a framework, design recommendations were rarely presented as standalone guidelines that could be used outside of the context of the research report. For example, Holder's (1999) intentions are to apply her findings to help reduce errors in cockpit simulators at a military helicopter training centre. The recommendations that she makes mainly reflect the findings of her study. What is highlighted is new knowledge about a domain that can then be

used to formulate stand alone design recommendations. However, more work is required after the reporting. Similarly, the outcome of Furniss & Blandford's (2006) study is new knowledge about the way work is coordinated within the London Ambulance Service. Design intentions are presented but more as a way to discuss the theory of how a DC analysis can be used to suggest improvements. The fact that ethnographic research and DC analysis is a time consuming and complex task means that considerable work takes place before any recommendations can be made. Therefore, the first insight is often based on the description of how a particular system works. This by itself is a major undertaking, which can be considered a contribution in its own right. Therefore, using DC to inform design may not always mean that design will be the primary contribution in the first instance.

Like AT, DC does not offer a single unified or off-the-shelf methodology for researchers and designers to use. Additionally, there are no specific guidelines in how to conduct DC analysis. The best way to view this is to find some form of common practice in existing research.

2.3.1 Cognitive Ethnography

DC has been described to be an observable phenomenon in terms of how information moves through the system based on the analysis of *cognitive ethnography* (Hutchins, 1995a). Cognitive ethnography emphasises "the representational and representation-transforming characteristics of the system under observation" of the fieldwork (Perry, 2003). Whilst the techniques of data collection are not radically different to typical ethnographic research (i.e., interviews, surveys, observations, video recording), cognitive ethnography is an "event-centred ethnography" (Hollans, Hutchins & Kirsh, 2000), which goes beyond describing what people know and focuses on how people go about knowing what they know. Because the focus of study is based around a larger cognitive system that involves multiple individuals and artefacts in a given context, the analyst can describe the cognitive properties of the larger system based on the actions and interactions that are directly observable between the different components of the system (i.e., individuals and artefacts). This will invariably involve transcriptions of actions and communication including the description of the use of artefacts in a given context.

Perry (2003) gives a high level characterisation of how to conduct cognitive ethnography:

1) describe the background to the activity—the goals of, and the resources available to, the functional system
2) identify the inputs to and outputs from the functional system

3) identify the representations and processes that are available
4) identify the transformational activities that take place in the problem solving when achieving the functional system's goal.

Once these have been identified, the analyst must report back the findings in a manner that is relevant to a specific question that is being posed. It is often likely that DC research is initially a problem finding type of research. In other words, an analyst may not have a specific notion of how a system works, unless there is some research available in the field from which the analyst can draw conclusions. Whilst there are no specified methodologies on how to conduct DC in a broader context beyond a specific field, there are common features that can be used by analysts.

2.3.2 Physical, Information Flow and Artefact Models

Furniss and Blandford (2006) present a methodology or a "reusable representation that supports reasoning about an interactive system from a Distributed Cognition perspective". This is based on three models which help to categorise and describe details of the ethnographic research:

1) Physical model - "the Physical Model describes those factors that influence the performance of the system, and of components of the system, at a physical level". The focus here is very much on the impact of the environment to the access to resources and flow of information.
2) Information Flow Model - "the Information Flow Model provides a description of how information flows around the system" especially in the communication between "participating members" in a sequence of work.
3) Artefact model - "the influence of artefacts on the performance of system components, and hence the system as a whole".

These models have been inspired by Beyer & Holtzblatt's (1998) models of characterising work, as well as over twenty-two common themes identified in previous DC research. These include access to resources (i.e. visual or physical access to artefacts and information), situation awareness, information movement, information transformations, coordination of resources and more. Whilst these are not formalised in all forms of DC research, I can highlight how these areas can be seen to shape DC analysis outcomes in general. For example, the physical

placement of objects helps the management of everyday activities by being spatially arranged to be used in appropriate times (Gruen, 1996). Gruen does not describe his analysis in the way Furniss and Blandford present theirs, however, his findings also analyse the influence of the physical environment including the artefacts within it. Similarly, Holder (1999) describes her analysis to include "a trajectory of representation analysis" which tracked the "flow of representations through the system in the context of activity" and an "interaction analysis" which includes the interaction between the crew and the representational media (i.e., instrument panels, speech, flight controls, and check list). This is essentially addressing the concerns of the Information Flow Model combined with the Physical and Artefact models, although Holder provides her own means of demonstrating how representations flow between different media.

2.3.3 Marr's three levels of description

One of the key considerations that I have to make in terms of how to research JMC is the characteristics of the system of work. Central to Hutchins' particular brand of DC is Marr's *three levels of description*. Marr (1982), states that three levels of description are necessary when describing a cognitive system. Marr's example of a cash register in context of an information processing task can be described in the following manner:

1) *Computational theory* – refers to the "what" and "why" of the device in context of the activity. In the case of the cash register, arithmetic is the key process. Therefore, at this level, a description of the theory of addition is necessary; this constitutes the *what*. Also at this level, an explanation is required of *why* the cash register uses addition over other operations such as multiplication. The *why* can be described as a set of *constraints* which have to be satisfied in order for an operation to be deemed a success and should help describe the rationale of using one set of operations over another

2) *Representation and algorithm* – constitutes part of the *how* of a process. Representation refers to the description of the input and output, whilst algorithm refers to how the transformation takes place between the input and output. It is important to note that input and output may not be the same type of representation (for example, input may be a particular type of numbering system but output could be verbal). In the case of the cash register, both input and output are numbers and the 'rules of addition' form the algorithm

3) *Hardware implementation* – refers to how the algorithm is physically carried out with the representations. One can use a calculator, a piece of paper or carry out addition mentally. The same algorithm is implemented in a different way depending on the *technology.* Choice of representation depends on the context of the information processing task

It must be noted that these levels of description appear to be suited to certain contexts of work, but may not be so easy to use in all types of activities. For example, these levels of description formed a critical aspect of Hutchins' description of the operation of a naval ship's navigation team (1995a). This was possible because the *unit of analysis* was relatively constrained during certain episodes of work, which could be systematically described in context of the three levels of description. However, work situations of JMC as described in the literature, suggest that working on a composition may take more than one session and may not always occur in the same space. Therefore, I have to consider whether I can describe creative multi-session work in peer led collaboration in the same way as describing the activity of a cockpit. For example, can the methods used by the members of a music band to remember their musical parts be described in the same manner in which Hutchins explains how a cockpit crew remembers its speeds?

2.4 Considerations of applying DC to JMC

A DC framework has never been applied to studies of JMC in previous research. There are a number of considerations that can be taken into account based on the understanding of music composition and DC research. In particular, what existing DC research in music playing can inform my research into JMC, the differences between typical DC research domains and JMC, and the use of field studies versus more controlled laboratory settings.

2.4.1 DC studies related to Western Contemporary music playing

The fact that DC has been applied to domains such as guitar playing (Flor & Holder, 1996) and the playing of compositions in a *covers band*[4] (Flor & Maglio, 1997) is encouraging for my research. Whilst the object of study is different to the research questions explored in my thesis, there are similar concerns that are relevant. For example, Flor and Maglio (1997) used DC to demonstrate that external resources that are emerging properties of performance of a composition can be used by musicians to determine cues for action. This replaces the need for musicians to perform a range of calculation such as counting the number of times before they have to change what they play. Global cues such as a composition's lyrics performed by a vocalist are a critical aspect of how musicians remember when to change the sequence of what they play during performance. Instead of internalising the structure of the serial composition and keeping count throughout the performance, musicians use a *repeat until cue* policy (i.e., playing a set part until they pick up a cue to change actions). The more complex the structure the more

[4] A music band that plays other, more well known artist's compositions as opposed their own original material.

reliant musicians becomes on cues. This means that instead of thinking about a song as a single stream of information, the composition is *chunked* (Chase & Simon, 1973) into sections. The musicians have an internal notion of each section but do not need to calculate when to play the next section. This calculation is replaced by a recognisable cue. This is a *behavioural trigger factor* (Hutchins, 1995a) in the performance of a song whereby musicians need only know what to play at the *local level* whilst waiting for the cue to change at the *global level*. This finding highlights a mechanism used by musicians to remember when to play a particular sequence. This type of finding can be used to inform design because it demonstrates that musicians already have a system in place for real time structuring of the memory of a composition during performance. A designer may look at complementing this type of behavioural trigger factor by providing musicians the opportunity to visually represent local cues through some form of visual and real time representation of the composition as it progresses.

It is clear that the use of DC as a framework for analysis in a music rehearsal room has already provided important insights into how I can study JMC. A music band consisting of four musicians each playing an instrument can be regarded as a system consisting of four functional systems. The global system refers to all four functional systems whilst the local level refers to the individual sub systems or local functional system (Hutchins, 1995a). For illustrative purposes I propose that this can consist of a musician, their instrument and anything they use to create an output. The outputs of a band when playing a composition are the sounds that are generated by all musical instruments and artefacts that amplify the sounds of those instruments. Therefore, the output of the larger functional system is based on the co-ordination of the output of the different local functional systems. This concept can highlight how observations of global cues discussed by Flor & Maglio (1997) can be used to describe the way memory works with JMC. For example, musical parts can be created to highlight cues for change (i.e., a drum roll or guitar notes played a certain way[5]) (Berger, 1999). I assume that this means musicians store internally a resource of cues that trigger action at appropriate moments instead of calculating how many times they played a sequence each time they perform. This illustration demonstrates that the properties of the group as a cognitive system are different to those of the individual, since the individual would need to employ a different strategy if they were to remember the information by themselves.

Reliance on the system in this way can be thought of as a form of computational offloading (Scaife & Rogers, 1996) since the individual creates structures in order to reduce the cognitive burden of remembering what has to be played and when. This view of memory is supported by

[5] It is common for *metal* bands (a sub genre of Rock music) to create musical sections based on the cues required to overcome complex structures (Berger, 1999).

Mayes et al. (1988), who noticed that expert user interface users were able to carry out tasks without needing to commit certain information, like menu names, to memory; users tended to rely on cues such as menu displays to trigger the correct menu selections. Group performance in rehearsals provides many opportunities to obtain perceptual information during performance or process of work (Bastien & Hostager, 1988).

One issue that is perhaps more complicated to describe is the way a JMC as a cognitive system works when cues in composition have not been established. When a composition is being developed, cues for changes are themselves in development and therefore not predetermined. How does the cognitive system remember its musical parts if it does not have predetermined cues to work from? Does this mean there are more calculations in the development stages of the song? These questions demonstrate that studying a band that covers an existing composition is different to studying a band creating a new composition. The former has a product that can be referenced using different recorded material (e.g., audio recordings, music transcriptions of the composition), whilst the latter does not have such resources. In addition, the activity of JMC is creative collaborative work, which requires new information (i.e., ideas) being generated, developed and remembered across sessions. Covering other people's music is not a creative act; it is more about learning and rehearsing an existing composition.

Whilst DC has been shown to be applicable to studying musicians in a rehearsal room (Flor & Maglio, 1997), there are a number of challenges in applying it to JMC. In the main, JMC involves less predictable resources and structures in creating compositions than the activities of a covers band. Indeed, this element is a key differentiator between studying JMC and the domains in which DC have traditionally been applied.

2.4.2 Traditional DC domains of study versus JMC: Closed vs. Open system

Previous DC studies such as (Hutchins, 1995a, 1995b; Halverson, 1994a) give examples in which human cognition in the workplace is influenced by pre-rehearsed routines that often involve the configuration of a specific set of resources in a specific manner. The challenge I face in studying JMC is that I are using DC in a context where human cognition may not always be based on predetermined cycles of work that use a specific set of resources in a specific manner. It is unclear whether JMC has predetermined cycles of work that configure specific resources in specific manner. Whilst compositions that have been rehearsed a number of times will have actions that can be regarded as more pre-rehearsed because they are likely to involve the configuration of a specific set of resources in a specific manner (i.e., musicians playing

instruments in a particular sequence in coordination with each other in a specific way), such scenarios may not exist when compositions are in development. This is because musical structures have not been created and hence there is no common understanding which can help cue action in a predetermined way.

A cockpit system or ship navigation can be described as a *closed system* (Rogers & Ellis, 1994) because both are "well structured systems, in which all of the problem solving resources are initially known to the 'functional system'" (Perry, 1999). The seminal research that helped make DC prominent was based on systems that can be described to have the characteristics of a closed system. However, many workplace activities may not be as tightly constrained as those described in certain aspects of navigation. The ethnographic research of music bands described earlier does not indicate the existence of the types of social and organisational structures that Hutchins (1995a) describes about navigation on board a US naval ship. Unlike a closed system, an *open system* may be regarded as "ill-structured, or 'messy' systems, in which the participants, processes and artefacts involved are initially under-, or unspecified" (Perry, 1999).

Whilst the comparison between the characteristics of a closed system, like navigation, and an open system is made for illustrative purposes in Perry & Macredie, it is nonetheless a useful summary of the types of differences that exist between systems that analysts study. Table 2.1 illustrates the difference through five key DC dimensions that involve access to resources, problem structure, organisational structure, cyclic duration for problem solving, and problem dynamics. These differences are likely to highlight certain challenges that an analyst may face when researching open systems. For example, access to resources may be less easy to specify in open systems than closed systems. Similarly, problem structures within open systems may have a far higher degree of uniqueness, meaning it may be more difficult to create generalisations about findings.

Based on the details of the comparison between open and closed systems I have to consider how to study JMC, especially in terms of drawing the unit of analysis. Is it the group conducting the task, the room in which the task takes place or both in the time span of the product creation? Even if I were to focus on one activity (for example, remembering musical parts), I may still have to follow the process until the composition is deemed complete. In an amateur Rock band, one composition may be created across a period of time, in different rooms, with different artefacts, and work situations (i.e., rehearsing or writing other songs). Ideally I would draw the unit of analysis around the members of the group both inside and outside of sessions for the duration of a song's creation. However, researchers would find it nearly impossible to

track individuals outside of the sessions unless group members use self reporting (i.e., diaries) (Nabavian, 2002). Such methods are an addition to the labour of a group, and questions have to be asked as to whether this would be taken on by the study participants.

Key Dimensions	Navigation System	Organisational Systems
Access to resources	Closed systems where the types of actors and information artefacts are restricted to a predetermined set	Open systems, where the actors and information artefacts are more fluid, less easy to pre-specify, and may change over time.
Problem structure	Well-structured, identifiable and expected problems which are likely to be recurrent.	A tendency toward ill-structured problems which have a much higher degree of uniqueness.
Organisational structure	Organisation has pre-specified modes of operation, characteristic of tightly constrained and managed organisations with rigid modes of operation. Division of labour is well understood and 'standard operating procedures' underpin normal work.	Organisation's operation is only partially pre-determined, with established work processes augmented by ad-hoc approaches which may become institutionalised over time by the organisation as appropriate. Division of labour is less formally defined and enforced.
Cycle duration	Relatively short cycle for problem solving, tied tightly to the type of task being undertaken	Problem-solving cycle tends to be much more variable, with different classes of problem in the same workplace system taking place over widely different time scales
Problem dynamics	A relatively stable and unchanging/static process for problem solving.	More pragmatic and less-constrained problem solving.

Table 2.1: Perry & Macredie's comparison of key dimensions in workplace setting

Whilst defining the rehearsal room as the unit of analysis is not quite the same as defining the cockpit as a cognitive system, it is likely to provide the best opportunity to access the majority of data about JMC. Since there is a distribution of labour in the instrumentation of the group, all members need to co-ordinate their actions with others. The session or rehearsal is where this co-ordination is created (Bastien & Hostager 1988; Berger, 1999). Whilst there is literature on how to write a song (Cauty & Drummond, 1999), there are no books on how to conduct activities within a rehearsal room. Therefore, there are no manuals or standard operating procedures that musicians can study or base their actions on.

In addition to the differences that I have described between closed and open systems, JMC has a distinct feature that systems which DC has traditionally been applied to do not have. Holder

(1999) gave a simple illustration of the possible inputs into a cockpit system which included a mission plan, weather, flight environment and engine failure.

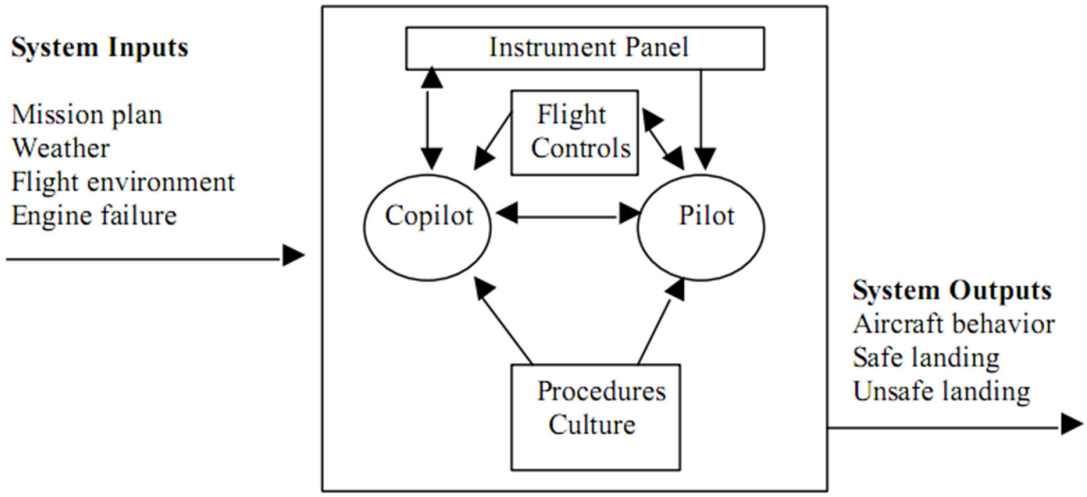


Figure 2.1: Holder's (1999) information processing model applied to a distributed cognition system. Here the system is a helicopter cockpit. The density of representation flow within the system may change over the course of a flight

Psychological creativity models such as Wallas' (1926) suggest that idea generation, incubation, development and verification are part of the human psychological process. If I use this as a basis for how JMC constructs compositions then I assume that the input to a JMC cognitive system may be mainly generated within the system rather than external to it. This is different to a cockpit system which uses inputs such as the weather as an aspect outside of the cognitive system's control. Similarly, the mission plan may have been constructed before the flight by air traffic controllers or the airline. It may not have been constructed by the cockpit system. The cockpit system may implement the mission plan but they may not generate it by themselves. It is unclear what the inputs, outputs and processes are in JMC because there have been few studies of this type of domain through a DC perspective. Therefore, it is important to consider how an analyst can determine such parameters when studying JMC.

2.4.3 Field studies vs. Laboratory studies

Studying JMC from a DC perspective can occur in two ways: 1) study groups in their natural environment (in the field) 2) study groups in an environment that is set up specifically for the

purpose of the research (in the lab). There are pros and cons to both approaches, and it is likely that both can be used at different parts of research.

DC has traditionally focussed on real world settings to explain "socially distributed, cognitive work activities that are mediated by the rich assortment of technological artefacts found in the workplace" (Rogers & Ellis, 1994). One reason to study cognition as it occurs in the real world is to determine the structures and resources available to practitioners of work in their actual work settings. There may be many by-products created in the interactions within the system which can be used in the context of the workplace that may not be reproduced when one attempts to study the system in a different context (i.e., laboratory setting). For example, two people sitting close to each other may cue their actions based on overhearing the other speaking on the telephone, as in the study of London Underground control room staff (Heath & Luff, 1991). The cue may be based on verbal content of the telephone conversations and overlapping knowledge shared between the two people working, which results in an action being executed. Studying the manual in carrying out work in the control room may not account for this form of action because it is an emergent property of the performance of work and the workplace. If the workers in the underground control room did not see or hear each other, they would not have produced the same actions. Without understanding the system, one could assume that the action is triggered solely by one person or that a more elaborate system helps cue the event.

Whilst observations of work in the *wild*[6] can be used to describe the nature of human cognition in real workplaces "the richness of real-world settings places limits on the power of observational methods. This is where well-motivated experiments come in" (Hollan, Hutchins, Kirsh, 2000). On one hand there is a vast array of information that an analyst can analyse and describe, yet on the other the analyst may not have access to every aspect of work in the wild. Indeed many important aspects of questions that an analyst is looking to answer may lie outside of what he or she can observe.
In the context of my study, there are two main criteria that are critical to determining whether a domain is suitable to study both in the wild and in the lab:

1) Inputs, processes and outputs should typically be generated by the cognitive system being studied both within the wild as well as the lab

2) Study must take place in an environment that accommodates what the system typically requires to create an output

[6] Hutchins' (1995a) terminology to describe real world settings as opposed to a laboratory setting.

Based on my understanding of music composition literature so far, JMC involves an iterative process of idea generation, evaluation and development, which is determined by the group in rehearsals through group performance and evaluation. Nothing in the literature suggests that there is an input that feeds into the *JMC cognitive system* that is generated by anything other the system itself. This implies that JMC meets my first suitability criterion for being studied both in the wild and in the laboratory. The second criterion depends on my ability to create a correlation between the lab based and wild environments in which JMC takes place. It requires me to learn about conditions in the wild in order to transform that knowledge into creating a lab environment that can support JMC to create an output.

Consideration of studying groups in the field versus in the lab is not just a DC concern. Numerous studies of Creativity Support Tools (CST) have been conducted with groups in laboratory settings as well as with groups in the field (Dennis, Nunamaker, Vogel, 1990; Fjermestad & Hiltz, 2000). These studies highlight a number of considerations that I must take into account when looking to create studies in the field and the laboratory. One key consideration in the study of group creativity is group characteristics. Groups created solely for laboratory studies have often had less familiarity with the task they have been assigned; they usually have no past history or foreseeable future. Field studies have typically used established groups, which have a history of interaction and cultural norms that they adhere to when conducting tasks. Bastien & Hostager (1988) reported that over time a group of Jazz musicians who had no previous history of working together, became more elaborate in their improvisation. The group became less reliant on external mechanisms such as visual cues and song structures. This suggests that groups with a history of interaction can potentially be less reliant on certain external structures than groups who have no history of interaction. In addition, Huber (1981) reports that decisions in established groups within field studies do not always follow a rational model because they may have a political dimension where individuals seek to influence decision processes in directions that will result in choices favourable to them.

2.5 Studying the role of communication and artefacts in JMC

In this chapter, I have suggested that ethnographic studies of JMC in the field and in the laboratory can help to provide much needed domain knowledge. I have also described the potential benefits of using DC as a framework to help focus the analysis of the way JMC functions. In this section I will discuss the role of communication and artefact usage in JMC. These two areas are essentially the key themes that my research will focus on through the thesis. The Physical, Information Flow and Artefact models described by Furniss and Blandford

(2006) emphasise the role of communication and artefacts in the description of how information flows around the system. This can be used to describe how a system performs in key sequences of work identified by the analyst. In the context of my study, the focus is to determine how communication and artefacts are used in coordination with each other to propagate and transform representational states in sequences of work relating to how the composition is being developed and remembered.

2.5.1 Communication and language use

Communication is a key area to a DC study because it governs how different elements of the system coordinate actions and exchange information. Language has an important function in communication because it can act as a mechanism that distributes the cognitive load of a problem across the system (Hutchins, 1995a). One way to study how language coordinates activity within the JMC functional system is to look at how musicians create shared references relating to the properties of a composition through conversation. Coordination is greatly impacted in a social activity when people build upon the common ground (Clark, 1996) that they share.

The properties of the composition (e.g., musical structures, musical notes, and any element that can help describe music) are likely to be some of the most influential pieces of information found in communication. There has been some analysis of the interaction that takes place between musicians during rehearsals and in the recording studio. Lefford (2000) summarises themes that were observed from a video of John Lennon (British pop musician) and his producer Sir George Martin in a recording studio setting. In the John Lennon and George Martin example the following features of musical objects were discussed or manipulated:

- The significance of each musical element: orchestration/parts, how the parts are performed (melodic/harmonic content)
- Primary and secondary elements controlled by determining dynamics and timbre
- The number of times a part appears
- Which instruments will solo? What does the solo instrument represent? (i.e. does the solo directly support the melody or provide contrast?)
- How the properties of each object are to be highlighted? (i.e. instrumental technique, signal processing, etc.).

The content of the conversation had major implications on how the composition was being shaped and recorded. The analysis of such situations is helpful in revealing the types of

representations that are used in JMC to develop and remember compositions. Analysing coordination based on language used to describe the properties of the composition should demonstrate what musicians appear to understand or misunderstand, and how they coordinate their activities with the knowledge that they demonstrate in their actions and communications. This can help me understand how information is shared, and how it is used to develop and remember a composition. Creating a shared reference of properties of the composition can involve the use of many forms of language (e.g., verbal, gestural, written). Each language represents the properties of the composition in different ways, which impacts how information propagates and transforms. Consequently, different languages have different *computational properties* which impact the coordination of information between, and within, different functional systems.

It is unclear how musicians maintain an understanding of the previously established perspectives of what they created through the process of establishing a shared understanding. This is particularly intriguing as JMC involves many sessions of work and therefore is exposed to, what Fischer (2004) describes as, *temporal* barriers to collaboration. These barriers are partly shaped by the attributes of group or organisational memories. In addition, JMC may face *conceptual* barriers because there is a division of labour in how compositions are created and performed. This means that there are likely to be different people with different expertise using different instruments working on a single composition. The different perspectives that exist within the division of labour can be a barrier to collaboration.

It is assumed that JMC is likely to be a less formal work setting than a cockpit and therefore unlikely to be regulated by an institutional code of conduct. This could impact how people communicate to each other and the language they use. For example, communication of information relating to JMC is unlikely to be as regulated as plotting a fix on a naval ship. Using Clark's (1996) definition of conversation setting, I am inclined to state that JMC is more likely to involve communication that is of a *personal* rather than *institutional nature.* This implies that verbal communication would be based on free turns of speech and may not be structured in a pre-rehearsed manner, nor formulated in a way that a pattern is followed in problem solving activities. In other words, although one may view the communication pattern of the fix cycle as relatively fixed, I suggest that communication in JMC would not be so structured. If this is the case, then the analyst must distinguish between general conversation and communication of information relating to a problem solving activity. Without closely following the flow, content and context of communication, an analyst may not always see an obvious separation between the two. Taking into consideration that the context of communication is important I must take into

account references that are based on a local *convention*[7] (e.g. using terminology that is more comprehensible to the local group rather than the community of musicians in general).

2.5.2 Language used to describe music

The properties of compositions in Western contemporary music can be described in terms of a sequence of chords[8], notes[9], rhythms[10], tempos[11], tones[12], harmonies[13] and more. It can be described using musical scale information, such as the pentatonic scale which is often employed in Blues and Rock music. A musical scale is a group of notes that are ordered in pitch[14] which can be represented in written form or described verbally. For example, the major pentatonic scale will include lettering such as *C, D, E, G, A, C* which represent notes. One of the main purposes of musical scales is to help musicians create a sequence based on a constrained set of notes. In other words, musical scales create boundaries that shape the choices a musician must make when they are performing a composition.

However, musicians do not always need to know scales or have an understanding of formal music theory in order to write or perform Western contemporary music such as Rock; it is open to even novice musicians (Rosenbrock, 2003). Therefore, music can also be described in language that does not require specialised knowledge of musical scales. Ethnomusicologist Thomas Porcello (1996) describes several types of communication that occur regularly in recording studio settings. Under these conditions, musicians, with or without technical or musical expertise, must convey to a recording engineer ideas about how they wish their instrument to sound. Porcello found six basic kinds of objects used to convey meaning.

- singing/vocables: “hmm”, “pts”, “dz”
- lexical onomatopoeias: words bearing a resemblance to the sounds being described.
- metaphor: words used to describe an acoustic characteristic (i.e. pitch bend, tight).
- association: taxonomy, making analogy to a specific genre or performer
- evaluation: collaboratively developing a vocabulary for a particular performer’s “sound”
- metaphor and association: naming sound qualities in the context of a particular performer, song or genre

[7] Convention in linguistics is a solution to recurrent coordination problem (Clark, 1996).

[8] Simultaneous combination of three or more tones that constitute a single block of harmony (Kennedy, 2006).

[9] Pitched sound (Kennedy, 2006).

[10] The controlled movement of music in time (Kennedy, 2006).

[11] Rate of speed or pace of music (Kennedy, 2006).

[12] Can relate to the high or low end of music (Kennedy, 2006).

[13] Simultaneous use of pitches or chords (Kennedy, 2006).

[14] The frequency of the perceived property of the musical tone of a sound (Kennedy, 2006).

These elements contain different representations of the properties of the composition. Instead of defining the compositional properties for each instrument using formal musical notation, Porcello (1996) suggests that musicians often use different elements of language to represent musical information and meaning. Whilst language based on musical scales has relatively fixed meanings, it is likely that the outcomes of the agreement that people come to share about non-musical scale information is largely based on a collaborative process where speakers and addressees work together to create a *common ground* of knowledge (Clark, 1996). Therefore, I suggest that the process of JMC is very dependant on participants working together to create a shared common ground on the representations of the composition. The process of how this common ground is achieved and maintained in JMC is open to research.

2.5.3 Musical instruments as communicational artefacts

Musical instruments are likely to be central to how representations are generated, propagated and transformed in the JMC. Musical instruments used in a Rock band such as guitars, keyboards and drums each have a role that takes into account the properties of the composition. For example, a drummer playing the drums will help provide the rhythm of the song whilst at the same time keeping the tempo. Guitars and keyboards can be used to create melodies, solos, harmonies, timbre, as well as supporting the rhythm (Middleton, 1990). The musicians who play those instruments become the mediators in transforming the knowledge of the properties of the composition into the physical implementation of playing the composition. Therefore, playing compositions requires physical labour (i.e., musician playing the instrument) and cognitive labour (i.e., musician knowing what to play and how to play it on the instrument). The musicians who operate the instruments may need to share knowledge of what they play with others, which means the information that musical instruments help to provide in communication is important to study.

2.5.4 Information artefacts and externalisation of composition information

In DC information that is represented externally is described as *external representations* (Hutchins, 1995a). Blackwell and Green's (2000) terminology of *Information Artefact* (IA) represents external representation in context of "the tools we use to store, manipulate, and display information". The properties of the medium that can also play a role in how a tool is used within a real work scenario have not yet been discussed. Green and Blackwell (1998) state that IAs comprise two classes:

- interactive artefacts, such as word-processors, graphics packages, mobile telephones, radios, telephones, central heating control systems, software environments, VCRs

- non-interactive artefacts, such as tables, graphs, music notation, programming languages, etc

My research focuses on artefacts used during the sessions of work where music composition takes place. Musical scores, informal inscriptions (e.g., written sketches) and audio recordings are three specific types of IAs that can be produced in music composition sessions (Berger, 1999; Kent, 1976; Tillman, 1987), all of which are non-interactive artefacts. These types of IAs can be used to serve similar purposes in both Western Classical composition and JMC in Popular music. In particular, they help composers to record, evaluate and revise composition over a period of time.

Musical scores enable a composer to notate chord changes, structures, melodies, harmonies, tempo etc. Modern notation in Western tradition represents “encoding of works, a guide to performers, and an object for analysis and comparisons for scholars and students” (Kivy, 2001). Scored music creates “a hierarchy between composers and interpreters as well as between art music and Popular music” (Rosenbrock, 2003). Creating written scores also requires skill and this can be seen as a barrier to entry for musicians who do not have a background in music theory. Even though music scores have limitations and cannot convey all the information about a musical piece (Middleton, 1990), it is nevertheless part of the means by which knowledge about a composition is transferred between musicians and composers.

Knowledge transfer is one of many reasons why music may be presented in written form. Whilst the final musical score may be regarded as an end product, written sketches made during the process of work form a critical part of how work is created and revised. This is especially evident in the study of the written sketches of Western Classical composers. English Classical composer Edward Elgar’s (1857 - 1934) transcripts “continually show commonplace ideas being regenerated” (Kent, 1976) for new compositions. Tchaikovsky states that the working out of sketches is of “primary importance...what has been set down in a moment of ardour must now be critically examined, improved, extended or condensed, as the form requires...only after strenuous labour have I at last succeeded in making the form of my compositions correspond, more or less, with their contents” (Tillman, 1987). In these two examples, the written information enabled the composers to revise and evaluate work. The externalised information enabled composers to resume work on the composition without needing to internalise all the information. In addition, musical scores could aid the verification stage, where the idea is consciously evaluated. Elgar's case study is interesting as he often asked close friends to give him feedback on his work, based on the sketches that he gave them. Elgar “often passed his sketch books to

friends once he had finalised a piece. They served to illustrate the process of how things were created". His sketches also showed evidence of self criticism with remarks such as "no", "not!" and "not concise" being present. Studies of the sketches of other composers such as Beethoven and Mozart also show evidence of reformulation and revision (Cook, 1998). Therefore, the work of a composer, as seen through their sketches, can be regarded as a process of creation and reformulation, or "inspiration and elaboration" (Rosenbrock, 2003).

I assume that the consequence of externalised information to composition is the same for Contemporary musicians as it is for classical composers. For example, it is likely that Rock musician Jimi Hendrix (1942-1970) also evaluated and revised his songs. And this cycle was likely to have been affected by IAs that he used. However, Hendrix may not have used written scores or sketches during his process of work as much as Elgar would have. Hendrix lived in an era of technological breakthroughs, a time in which audio recording was becoming an integral part of the music making process. "On stage, Hendrix music was bound by time and place, but in the studio – insofar as the costing of studio time allowed (and eventually Hendrix built his own studio) – the music could be lifted out of time, captured and contained on tape, made into an aural raw material which could then be added to or manipulated" (Clarke, 1983). Audio recording facilities provided an alternative means to aid the compositional process for Hendrix.

Audio recordings and written scores are produced and employed using different media with different properties that induce different responses. I must therefore consider how the properties of the media actually impact the process of work; "it is a dangerous assumption to believe that written and unwritten transmission are both processes that do the same sort of thing, that is, to transmit something – and an opposition – that they do so in different, mutually exclusive ways (as one might speak of conveying a message by telephone or by email)" (Kivy, 2001).

Evidence from ethnographic research of Rock bands (Berger, 1999; Campbell, 1995; Cohen, 1993; DeVries, 2005; Green, 2001) suggests that formal musical scores and written sketches were not created by the bands. In addition, there was little evidence to suggest audio recordings were used in every rehearsal sessions, if at all. However, some evidence exists that illustrates the role of audio recordings by musicians outside of a rehearsal. Berger's (1999) account of the lead song writer of *Dia Pason*'s (Cleveland, Ohio Rock band) use of cassette tape suggests that ideas recorded outside of a band rehearsal session helped him develop the composition in preparation for the rehearsal; "ideas for vocal melodies and bass parts would occur to him while practising by himself, driving, or falling asleep. Recording these on cassette, Chris would come to the rehearsal with bass parts, lyrics, and a sense of the song's overall form" (Berger, 1999).

The cassette as an IA clearly serves a dual purpose:

1) For the benefit of the individual's creative process (i.e., external record for recall and evaluation)
2) For communication of ideas to people who will be involved with the compositional process.

Scaife and Rogers (1996) highlight three characteristics that external representations such as IAs can offer cognition in certain contexts:

1) *Computational offloading* - reduces computational effort by representing a problem state in a manner that can, for example, be “read off” rather than require sentential descriptions which are “implicit” and have to be “mentally formulated”.
2) *Re-representation* – refers to the cognitive benefit to problem solving of different external representations that have the same abstract structures. Certain external representations are likely to help problem solving over other external representations, even if they both represent the same abstract structures. This can depend on the experience and expertise of the individual.
3) *Graphical constraining* - refers to the way elements of the graphical representation constrain the kind of inferences that can be made; they “restrict (or enforce) the kinds of interpretations that can be made”.

IAs support the distribution of cognition and change the nature of how tasks are carried out (Hutchins, 1995a). A musical score used in Western Classical music can be thought of as a representation of musical information that includes certain *pre-computations* performed before a performance. “Pre-computations are saved representational structures that transform the nature of the task performance. They aren't just doing part of the task ahead of time, they are doing things ahead of time that make the task easier to do” (Hutchins, 1995a). The task of the musician is to transform the information that they read into the action of playing. The task of reading, interpreting and playing occurs usually at the same time. The task of the musician is therefore transformed from remembering or creating musical information to reading information and transforming it. Similarly, speed bugs are a part of a cockpit system's ability to remember speed by providing an external representation of a computation that pilots would otherwise have to internalise or calculate by themselves. In addition, looking at whether the “air speed indicator” needle is lined up with a “salmon bug” tells the pilots whether the aircraft is at the appropriate speed without actually needing them to perform other computations; “a memory and scale reading task is transformed into a judgement of spatial adjacency” (Hutchins, 1995b). The existence of such an IA therefore contributes to the cognitive system of the cockpit by transforming the activities the pilots have to perform into actions and tasks that are less challenging (i.e., they ease the burden on the system).

The IAs in music composition, such as audio recordings or written notation, offer computational offloading in different ways with different re-representational benefits and constraints attached. For a start, information in external representations can be detected and processed by perceptual systems alone (Zhang, 1997). Therefore, in theory supporting perceptual judgement over recall from internal memory would be beneficial. However, this depends on the appropriateness of the representation and the mechanisms that support the transformation that it infers (Norman, 1998). For example, listening to a guitar riff or reading the riff notation from paper requires different cognitive processes. They are both a representation of the same abstract structures, which can be used by a musician to play a riff on a guitar. In both situations, the guitarist has to translate the information before playing. The written format requires expertise in translating written musical notation whilst the audio requires an understanding of how to transform the audio into the knowledge required to perform the riff. Therefore, experience and expertise will be critical in this transformation and must be a key consideration to design. A successful design is likely to support existing knowledge and expertise by providing a representation of structures that can be used without adding to the cognitive burden during task performance.

In a group context, IAs can be used as a means to create shared understanding and transfer knowledge. Bodker, Nielsen, and Petersen (2000) attempted to create a physical environment where members of interdisciplinary groups were able to 'wander' round stands (IAs) set up to demonstrate the work of each group participating. In this study three stands were set up that included the voice of the users presented by researchers, the prototypes of the technicians and the products of the designers. It enabled participants to generate and share ideas with other departments as they learnt about each field under their own initiative. In this instance the use of workshop stands and artefacts generated constructive interaction between people on areas that were out of their field. By externalising the process of how something was created, the rationale for the design was amplified to others with little or no knowledge of the concept. In essence the environment became a deliberate support for cognition across a group of people engaged in related activities. This is linked to one of the key premises of DC which states that human beings create their cognitive powers in part by creating the environment in which they exercise those powers (Hutchins 1995a). Furniss and Blandford's (2006) Physical, Information Flow and Artefact Models help analysts consider how the environment supports access to resources and how the resources shape the cognition of the people working together in a problem solving activity.

2.6 Summary

I have illustrated that a high level view of JMC can be pieced together using research from creativity, music and musicology. This literature suggests that cycles of creation, evaluation and reformulation are at the heart of the activity regardless of the genre of music. I illustrated that there has been little focus on creating computer applications for JMC in a co-present environment, despite the fact that design has been considered for supporting and understanding music, film and dance composition. The lack of design for JMC may be linked to the lack of evidence that is available about what actually happens in JMC.

I have identified that group performance in rehearsals is a means to work up ideas into a performance of a composition. Therefore, studying the rehearsals is likely to lead to an understanding of a number of mechanisms that help groups to develop and remember a composition. These include learning about how musicians use musical structures of the composition to help determine what they play and when. However, there is little research to explain how musicians manage their collaboration when cues and musical structures have not been created (i.e., when compositions are in development). This means that JMC involves less predictable resources and structures in creating compositions than the activities of a covers band who have an existing composition to use as reference.

The overarching question that JMC poses to my research relates to how ideas created in improvisation develop to become a composition over time. The process of how this happens will be my main subject of enquiry. In particular, I seek to learn about the way musicians involved in JMC develop and share knowledge about the composition. Additionally, how do they remember the musical parts in order to come back and continue to work? To investigate this I propose using DC as a framework for analysis, which has previously been used to help researchers describe work situations and problem solving activities from an information processing perspective.

Chapter Three: Studying the JMC Cognitive System in the wild

3.0 Introduction

In this chapter I describe an analytical framework that I developed to focus the analysis of data captured in my field-work study. The motivation behind studying musicians in their natural rehearsal environment was to gather data to analyse for my research into JMC. One of the purposes of the chapter is to illustrate how I bridge the gap between data captured in the ethnographic studies and the theoretical concerns presented by the analytical framework. One of the outcomes of the data analysis is a description of what the JMC cognitive system is set up to achieve.

In the findings section of this chapter, I provide illustrations of some of the analysis that was carried out. In particular, I illustrate the way resources are organised to create mechanisms that support the distribution of knowledge within the group, albeit with certain limitations to how knowledge is maintained. The findings that I present are designed to create a theoretical foundation on which I can be build on in subsequent chapters.

3.1 Ethnographic research at Westbourne Rehearsal Studios

In chapter two I stated that a body of work in ethnomusicology was dedicated to the study of Western Contemporary music bands. However, few details were available about the way compositions were created. In order to gather data about the way bands created compositions, I conducted ethnographic research at a music rehearsal studio. A rehearsal studio is a space where JMC often takes place. A rehearsal studio hires out soundproofed rooms that are equipped with facilities suitable for Western Popular music bands (i.e., microphones, amplification for guitars, lighting, heating, electricity, etc.). For a period of two months, I made daily visits to Westbourne Rehearsal Studios, which is located in London W2. I had used this studio with two of my own bands at different periods, from 1993 to 1997 and from 2005 to 2006. Between these two periods I also used the studios for research (see Nabavian, 2002). Part of the reason I selected this studio was because I had firsthand experience of using the facilities, as well as background knowledge of the people who hire the rooms and the people who have worked at the studios over the years. However, I had never formally recorded data that I could use for the purposes of my current research.

My main motivation for visiting the studios was to recruit bands for observations, make observations of bands in their rehearsal sessions, gather details about how bands used the studio facilities, and understand the rationale of why the studios were designed the way that they were. In particular, I wanted to know how the physical environment took shape within rehearsal sessions, and what artefacts were provided by the studio to support the people who hired rooms. I use the findings of this study to form the definition of what a JMC cognitive system is set up to achieve.

3.1.1 Recruiting bands for observations

Four bands were recruited for rehearsal room observations; two of which responded to a poster advertisement placed in the studios. The other two were recruited through direct conversations that I had with band members when they were in the common areas of the studio.

Initially, five bands responded to the poster that was placed in the rehearsal studios. The groups were told that they would be paid £10 per session that I was allowed to attend and video. They were given guarantees that the material would be used for academic purposes only. Out of the five callers, two agreed to be involved in the studies.

Outside of the periods I was making observations, I would spend time in the common areas of the studios striking up conversations with different musicians who happened to walk by. If the person who I was speaking to belonged to a band that was writing original music, I would describe my proposal and ask whether they would be interested in taking part. Many declined but this approach resulted in two bands agreeing to be observed; one of which was the band I based my analysis on in this chapter: *Young Band.*

3.1.2 Study participants' understanding of the studies

I was mindful about what I said about the studies because I wanted to minimise my impact on the process of work. I mentioned that this was "academic research into how people work together". I tried not to give any more details unless questions were asked. The most detailed explanation was given to a member of *Young Band* who engaged in a discussion about my work. He asked "are you looking at how we communicate with each other?" I explained that that was part of it but mainly "how people make songs, rehearse, what they say and do in the room". The other people being observed did not talk to me about the exact purpose of the observations.

3.1.3 Data capture

I gathered data for two distinct purposes. One purpose was to create an overview of Westbourne Rehearsal Studios as an environment that provides a service to customers such as bands. This constitutes the view from outside of the rehearsal. The second purpose for our data capture was to look at the view from within a rehearsal room where a band works. Although there is a relationship between the two, the view from outside mainly serves as backdrop to how a band comes to work in a rehearsal room. Within this chapter, I focus on the view from inside the room.

Interviews and casual conversations at the studio

Throughout the two month study, I conducted many interviews and had many conversations with bands and employees of the rehearsal studios. This helped me to become familiar with what goes on in the rehearsal rooms to a level where I was able to determine whether findings for one particular session with one particular band could be representative across a wider number of bands. Findings from this chapter are based on a number of key interviews including:

- An interview of the studio owner, which helped me understand the rationale of why the rooms were designed in the way they were and why they contained the equipment that they did

- A conversation with two members of *Young Band* in their rehearsal session, which gave me insight into the way two members think about the way they made songs
- Conversations with musicians in common areas, which informed me about the types of activities that occurred in rehearsal rooms
- Numerous conversations with studio employees, which helped to create a picture of what types of support bands asked for and what equipment they used.

Room observation and notes

Bands that took part in the observations agreed to have me sit in on the sessions. I would usually arrive in the rehearsal room in the beginning of the band's room booking time. I would greet band members who had already arrived and strike up a casual conversation. I would then ask where I should be situated. I wanted to minimise my impact on the environment and the way bands worked. I made a conscious decision to sit in a corner of the room on the floor and not on a chair; I did not want to be in the line of vision of the musicians especially the drummer who would also sit at the height of a chair. I assumed my movements, if I sat in the band members' lines of vision during performance and conversation, could be distracting.

I made hand written notes about the sessions. I roughly sketched the room layout and attempted to note down the room's inventory. I also made notes on events that I felt I may want to highlight on the video. These were usually areas that were of interest to the analytical framework that I discuss in section 3.2.

Video

Given the one off nature of each session[1], video provided the only way to revisit a session of work. I recorded videos of every session that I observed. Each video lasted up to two hours and two tapes were used per session. I used a single Sony digital camera that was mounted on a tri-pod. The single camera captured the sounds of the room relatively well and most conversations could be heard. The camera view was generally useful as it captured the majority of people for the majority of the time. However, it did not always capture everyone at every moment. For example, sometimes members of *Young Band* would stand in front of the camera, blocking the view of the rest of the band. In these instances I adjusted the camera so that the majority of the band members could be seen.

[1] The physical layout and the problem solving activities for each session were not presented in the same way.

The videos were important because they enabled me to review people's actions and conversations, often focussing on specific areas where I could pause, rewind and playback sections of the session. This ability to revisit the observed session was critical in conducting a comprehensive analysis of action and communication.

3.2 Analytical Framework

In chapter two, I stated that one of the key aims of using DC as a framework for analysis is to help examine existing work practices and technologies in order to make recommendations about what practices and systems of work need to be preserved and what needs to be improved (Rogers & Ellis, 1994). For this to happen I need to define what a JMC cognitive system is assembled to achieve. Marr (1982) states that a computational level description of a cognitive system must specify the constraints that needs to be satisfied in order for a *successful operation* to occur within the system. Whilst I can observe musicians playing instruments and interacting with each other, I need to determine how this works towards a successful operation. Once this is determined, I can then explore the different elements of the data that is captured (i.e., the implementational level of work) keeping in mind how it contributes the overall system goals.

JMC does not have institutional regulations, staff handbooks or standard operating procedures which I can use to formulate a basic understanding of what constitutes a successful operation in computational terms. Instead, a computational description can only be made once there has been some penetration in the area of research. In particular, it can be made once I have formulated an understanding of what musicians appear to be achieving in their sessions of work. This needs to consider the types of issues that the DC framework is seeking to analyse (i.e., how resources are brought into coordination to achieve a successful outcome to a problem solving activity). However, it can initially focus on gaining an understanding of what changes have visibly taken place in the session of work. Tracking the use of artefacts, observing changes in the physical layout of the sessions and looking at interactions between musicians helps to create a picture of what is being created or achieved.

I used Furniss and Blandford's (2006) Physical, Information Flow and Artefact Models to focus my analysis and data capture. These models are representative of key DC concerns, and helpful to focus field-work data into features that are relevant to a DC analysis. The models require describing the factors within the physical set up that influence the performance of the system, the flow of information that is observed in communication between people, and the

influence of artefacts on the performance of the system as a whole. The models do not prescribe how descriptions should be created. Like most DC research, this is defined by the analyst. Table 3.1 highlights the relationship between my method of data capture and the questions that I looked to answer in relation to the three models. For example, interviews with the studio owner and designer were aimed at answering questions related to the Physical and Artefact Models (i.e., what was the rationale for the purpose and design of the studio layout and the artefacts that were provided in rooms). The interviews with *Young Band* were aimed at understanding how bands developed compositions and how they remembered them. Observation notes within the sessions attempted to capture details of musicians' access to resources, the primary communication channels, and types of communication errors that occurred in composition development. Observation notes also looked at how the musicians used the artefacts to communicate, develop and remember information.

Method of data capture	***Physical Model***	***Information Flow Model***	***Artefact Model***
Observation notes	Can people access resources (i.e., other people's speech, actions, artefacts that they are using, etc.)?	What are the primary mediums to communicate information? What are the properties of the communication that is produced (i.e., is it written, verbal etc.)? How is composition information generated, developed and remembered? What types of errors (i.e., misunderstandings) occur?	What are the artefacts set up in the room? How do the musicians use the artefacts to communicate, generate, develop and remember information?
Interviews with studio owner	What is the rationale for the purpose and design of the studio layout?		What is the rationale for the artefacts that are provided in the rehearsal studio?
Interviews with Young Band		How do band members describe how they develop compositions, including how they communicate and remember it?	Do they use recording equipment or written notes as part of their work?
Informal discussions with studio workers	How do they set up a room?		What equipment do they set up and why?
Drawings of environment during each session	Identify patterns in physical arrangement of the band in each session.		Identify arrangement of artefacts used in the session
Pictures of rooms	Helps to identify the physical		Helps to create an inventory

Method of data capture	***Physical Model***	***Information Flow Model***	***Artefact Model***
and artefacts	positions of people and artefacts in different situations.		of artefacts used before and during the session
Video analysis	All of the above but in more detail where possible and necessary	All of the above but in more detail where possible and necessary	All of the above but in more detail where possible and necessary

Table 3.1: Analytical framework and methods of data capture

The different methods of data capture were aimed at bringing together information from a number of sources to help inform an understanding how JMC works in a rehearsal studio.

3.2.1 Stages of analysis

One of the main reasons I chose to use a DC framework was to overcome the need to define tasks as the unit of analysis. However, as expected, JMC as an open system does not clearly outline where one problem solving activity ends and another begins. This makes it difficult to determine what to focus the analysis on without first attempting to work through large sections of the data. This invariably involves transcriptions of actions and communication, including the description of the usage of artefacts in a given context. This is because, as described in chapter two, cognitive ethnography requires the analysis of the representational and representation-transforming characteristics of the system under observation. This analysis outlines cognitive properties of the larger system in sections or as a whole, based on the actions and interactions that are directly observable between the different components of the system (i.e., individuals and artefacts).

Analysing actions and interactions among individuals and between individuals and artefacts is a time consuming task. For example, it took me approximately 21 minutes to fully transcribe the communication and actions of musicians in a minute of video, which is comparable with the 1:25-1:29 ratio reported for analysis of video data in other research (Barendregt et al., 2006). Therefore, careful consideration was made in the level of transcription and the sections to transcribe. My approach included reviewing all observation notes and determining which bands' sessions appeared to involve music composition and improvisation, rather than rehearsals of existing compositions. Whilst rehearsing is an important element of JMC, my research focus is more on the way compositions are developed. I chose to centre my analysis on a band I labelled *Young Band* because they were the most typical example of a group involved in JMC.

They played Rock music and they were involved in rehearsing and developing their own songs for recording and a concert (also known as a gig).

I transcribed the majority of *Young Band's* first session because it was important for me to understand the types of problem solving activities that can occur in a session. I transcribed the group's communication and their actions, making a distinction between activities relating to performance of a composition and when the band was not performing the composition. During the performance of the composition, I looked for cues for action such as gestures and verbal communication to determine what mechanisms were used to support cognition during performance. This was inspired by Flor & Maglio's (1997) research which highlighted that musicians can often use external resources that are emerging properties of performance of a composition to determine cues for action. Here is an example transcription:

Session 3

13:44: G tries a little change and looks at D who also looks across to him. G then slightly shrugs shoulders and screws his lips whilst he plays whilst looking at D. This seemed to be a way of communicating something like - "I am trying this idea out". It is almost like G is not sure and might be inviting some feedback. There was no visible response from D.

During the communication outside of performance, I examined how the properties of the composition were represented and how shared understanding was achieved in order to develop or remember the composition. Here is an example transcription:

Session 1

16:02 (Group jam ends – G's guitar sustains a note for four seconds after everyone stops playing)

16:10 G: what does it need?

16:12 V: it needs to go a tiny little bit faster and - ermm - that's it

16:18 G: yeah?

16:19 V: mmm

In subsequent sessions, I focused the analysis at the compositional level. For example, I would look to see how the band started playing the same composition for the first time in each session in order to determine whether there were any observable mechanisms to how it was remembered. I would track each performance of the composition until the band stop playing it and moved on to another composition. Within each observation I would again look at what the group was doing during the performance and what they were saying outside of it.

The outcome of the analysis was that I had the opportunity to step inside the JMC cognitive system and observe firsthand the way musicians in a group were continuously working on a number of compositions combining rehearsing and development in each session of work. By using Furniss and Blandford's (2006) models to focus the analysis of data, I gained an understanding of the physical set up and key artefacts that were used to support the distribution of knowledge. In particular, how different resources were configured to support the creation and propagation of representations within the rehearsal room. Special attention was given to episodes where the use of transient representations appeared to cause problems. Within these episodes of work, the flow of information was more thoroughly examined through an analysis of how representational states propagated through the system. As a consequence of describing how representational states propagated and analysing the misunderstanding that occurred in the communication of the group, I was able to create an understanding of the way transient representations were used and the potential issues that appeared to affect the performance of the system.

3.3 Findings

I created the definition of what the JMC cognitive system is set up to achieve through many iterations of analysis. I suggest that the main constraint that needs to be satisfied for a successful operation in the JMC cognitive system is the emergence of a composition that preserves a structure which is remembered and performed over many sessions; see appendix F for a further description of how this was formulated. Therefore, the activities of the functional system work towards the shaping of knowledge about a composition. This is an important consideration because it brings to light what the JMC functional system is working towards. My computational description provides an angle of research through which to focus the analysis of data. The focus of analysis at the implementational level should be placed on looking at how knowledge is shared and maintained in order to gain insight into how the JMC cognitive system functions.

Identifying the representation carrying and representation-transforming entities of the system was perhaps not the most challenging aspect. What was more difficult to explain was how the representations propagated across several sessions. Whilst a cassette tape was recorded, I never observed it being used. Therefore, there was no externalisation of information in recorded form. However, knowledge *was* maintained; I observed musicians walking into each session and playing songs without referring to any recorded information. What was perhaps equally important was the number of times I observed musicians forgetting elements of the compositions that they had performed on many occasions before. Another interesting element of the findings was the misunderstanding that occurred when musicians attempted to describe the sections of the composition to each other. These areas became a bigger feature of my research. Through the analysis I was able to observe numerous episodes of work where ideas seemed to be forgotten or disputed between members.

Within the data that I captured there were many examples of how knowledge was organised in JMC. The scope of illustrating all findings is too broad to present in a single chapter. Instead, I will illustrate how elements of the analysis led to specific findings about the way musicians used transient representations within a rehearsal session. In particular, I will give simple examples of how musicians use musical instruments and verbal communication in a number of different configurations to propagate representational states. I suggest that the mechanisms associated with how the composition is developed and remembered are mainly influenced by the way the system is able to configure itself using language and artefacts such as musical instruments.

3.3.1 Brief narrative of session one

In order to give the reader an overview of what happens in a session, I will present a brief narrative based on my observational notes of a *Young Band* rehearsal session.

Summary of research notes:

Research name for group: Young Band
Number of members: Four
Research names for members: D (drummer), B (bassist), G (guitarist), and V (vocalist)
Instruments used when playing: Drum kit, Bass guitar, electric guitar, vocals
Average age: 23
Gender: All male

Group members arrived at the rehearsal room at different times. The members that arrived earlier would set up their equipment and chat. They would also play their instruments together. It was not until all four members were in the room that the session would begin.

It was clear from the discussions between members that they knew that there was to be a "recording" the next day. As the rehearsal unfolded it became obvious that the main objective of the session was to rehearse three songs they wished to record. However, there was no clear outline or schedule for the session. In the beginning of the session no one mentioned which three songs were to be recorded and how they should rehearse them. The first song was played as a warm up jam between D, G and B whilst V was out of the room. As matter of coincidence, V walked in the room with a cup of tea in his hand and went straight to the microphone in time to sing the first verse. I believe it was a co-incidence because the kitchen where V made his tea is some distance from room one, where the band was playing. Therefore, he would have only started to hear the sounds when he was near the door to the room. After the first jam, G left the room to buy a cassette tape. Upon returning he put the cassette in the recorder supplied in the room and pressed a button, which I assumed is the record button.

The band played the first song several times, making comments after each performance about what was performed. For example, if it was "speeding up" or whether something sounded "good" or not. Some mistakes occurred during certain performances, for example, V singing over a guitar solo when he should not have or G forgetting to play a guitar section. It was also evident that some sections were being reworked, for example when B told G how G should play the guitar in a certain section. The band moved on to the next song when B stated: "let's do the next one". This was either initiated because the group were satisfied with their performance or they were tiring of it. The second song was selected when one member states "shall we do *She's so hot*?" A similar cycle of playing and commenting occurred. For the third song, the group has a mini debate which is swiftly resolved when B starts to play a riff on the bass, which triggers the others to join in.

For the remainder of the session, the group play several other songs which I assumed would not be played in the recording session. They also conduct a number of jams that did not sound like well rehearsed songs. They have one official break, where V and G briefly leave the room. The session draws to a close when the group appear to tire. Approximately ten minutes before the end of the session the group decide to pack up. They start to put their guitars in their cases but do not put any of the amplification or drum kit back in their default places (i.e., against the wall). G takes the tape that contained the recording of the session. The group members pick up items that belong to them and put on their coats. They discuss how much money they have to

pay and question why they supposedly owe the studio £28 from the previous session. As the session ends, other casual conversations take place.

3.3.2 Reflection on narrative

It is perhaps difficult to say exactly what the band achieved as an outcome of the session. A cassette recording was made but this may not be useful for the recording session the following day. In general, the musicians could be said to be better performers of the songs, or that they better coordinated the playing of the songs with each other, or that they changed the form of the songs. Regardless, the main change that has taken place since the beginning of the session is that certain artefacts have been used in the room, a tape recording of 90 minutes of the session has been made, and I assume some changes have taken place within the musicians themselves in terms of their knowledge and how they perform songs as well as how they use the equipment within the room. The session may have had some impacts on the social relationships between members, for example the musicians may feel happier about working in the group or they may feel that their friendship is stronger. These elements can be by-products of collaborative work even if they do not appear to be the most obvious outcomes.

The narrative also illustrates that, whilst there is no clear plan presented in the session, there is little conflict about what songs are to be rehearsed. It is clear that some of the decisions made in the session were already discussed previously (i.e., to record three songs). In addition, it shows that each member knew how to perform what they had to perform. They did not read anything like a musical score or written notes, nor did they listen to anything other than what was produced by the musicians, and the instruments and amplification.

There were several problem solving activities that could be used to illustrate the way knowledge is seen to be affected as a consequence of work activities. I will outline the physical set up of the room, including all the artefacts that were available. I will also outline a simple view of how information can flow in the session. I will finally focus on a specific problem that helps to illustrate the cognitive burden associated to compositions that are in development.

3.3.3 Physical setting

The main outputs of describing the physical setting are:

- To highlight whether people can access resources (i.e., other people's speech, actions, artefacts that they are using)

- Describe why the group set up a room in a certain way, especially the physical positions of people and artefacts
- Describe how the physical set up helps *Young Band* develop, evaluate and remember a composition.

The rehearsal rooms at Westbourne Studios

The studio was set up in 1988 and is located under a residential building. In 1987, the owner converted the basement of the building into four sound proofed rehearsal rooms (studios 1 to 4), one toilet, a storage area, and at a later date, a production room (studio 5) which he hires out to a producer.

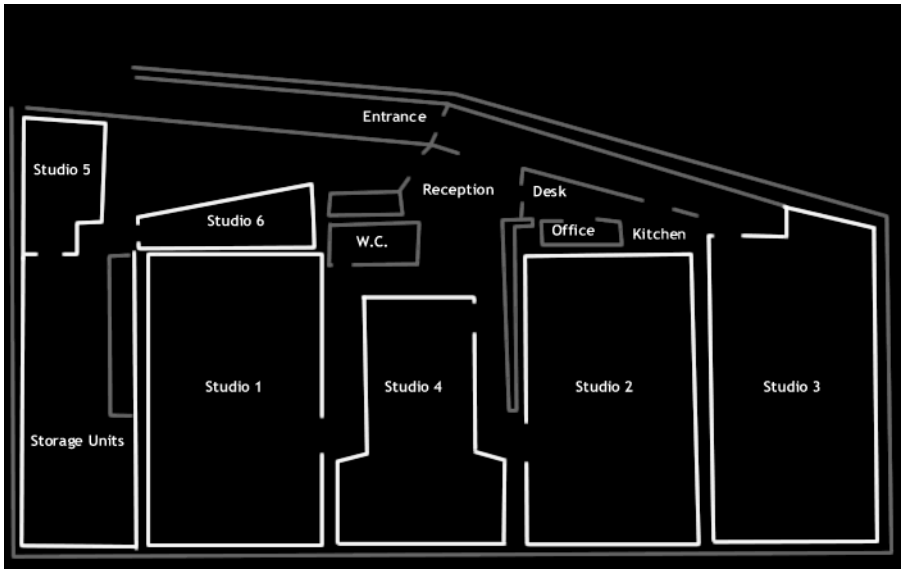


Figure 3.1: Westbourne Rehearsal Studios floor plan

The room sizes vary from 200 to 450 square feet. At present, each of the four rehearsal rooms contains the following equipment:

1) two personal announcer speakers (PAs)
2) a mixer (for adjusting volumes and audio manipulation of signals inputted from microphones and other media)
3) tape player/recorder
4) CD player
5) microphones on the wall and ceiling
6) heater
7) blue carpets
8) mirrors and curtains

9) amplification (to amplify and manipulate the sound of electric instruments like guitar and bass)
10) microphones
11) microphone stands
12) drum kit (unassembled)
13) couch
14) several fold out chairs
15) small bin
16) monitor
17) lighting

From the list of above, I classify items one to eight as objects that are in a fixed position and cannot be moved. Therefore, these items are always in the same place at the beginning of a session as they are at the end of a session. Items nine to fifteen can be moved around the room.

Figure 3.2: Westbourne rehearsal "room two" view one

Figure 3.3: Westbourne rehearsal "room two" view two

The studio owner stated that he provided amplification in the room without charging customers because he wanted to encourage people to use the studio equipment rather than their own. His reasoning was that the medium sized amplifiers he provided did not make excessive noise, which could travel to the residential block above. He also explained that the microphones on the wall and the tape recorder were installed so that people could "take their ideas away with them". By this I believe he meant people can record what they play and take that recording away with them. This is the one aspect of the rehearsal room that I believe has been specifically designed for the purpose of JMC, because taking ideas away usually means that it is part of a process of development and evaluation.

Physical arrangement of Young Band and artefacts in session one

The physical positioning of members in the room was partly dictated by the placement of equipment in the room and partly by functional requirements of how musicians operated different instruments. However, this cannot be described as pre-determined in the way the physical layout of a cockpit is pre-determined and fixed. For example, when B walked into the room, the others had already set themselves up in certain positions. B went straight to the bass guitar which was placed (I assume by G or D) next to the bass amp. The bass amplification was probably in the original position that D and G found it when they walked into the room. They had the choice to move it, but they chose not.

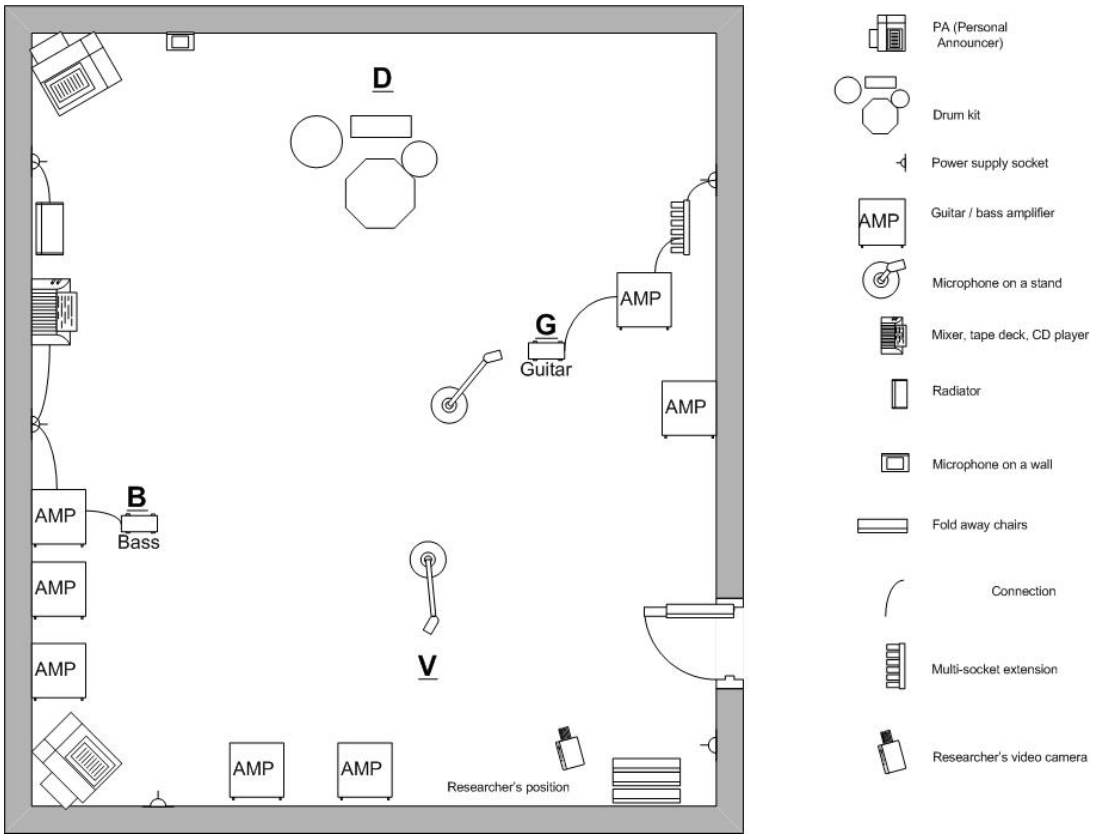


Figure 3.4: Position of Young Band members and equipment in the rehearsal room

Figure 3.4 illustrates that an effort may have been made to position the band members in a circle, so that all members could see each other. Overall, the group maintained a circular face to face position for the majority of the sessions that I observed. Appendix A visually depicts the positions of the band members within each session. However these positions where not held in exactly the same way through the sessions. The positions of people changed on a number of occasions. V, who did not play an instrument, would cover more areas in the room and in fact left the room more than anyone else. B and G swapped instruments and hence swapped places for certain compositions. B actually breaks the circular position of the band approximately an hour and fifteen minutes into the session because he could not hear himself play through the amplifier he was standing next to: “It is fuckin’ loud but I can't hear myself at all”. B and G were the only two who were using amplifiers and they would normally stand or sit a yard or two away from the amps, either to the side of or just in front of the amps).

The most obvious implication of the physical layout of the group in a circular or face to face set up is that it gives visual access to other people's performances. Giving visual access to the performance of others helps to cue actions (Bastien & Hostager, 1988). This visual information may not be as accessible when people are in the types of position that they would hold when

performing a gig because they are mainly facing the audience and occasionally towards each other. Appendix A (session four, positions 1) illustrates the position the bassist and guitarist hold when they are rehearsing for a gig in session four. This is possibly the way they would be facing when performing a gig. Appendix A (session four positions 2) illustrates how the band returned to a circular face to face position in the same session when playing compositions that were less formulated.

In the gig positions there is potentially less opportunity to look in another person's direction and notice cues for action. I therefore concluded that there was a functional purpose to people standing in circular position during rehearsals. There was also a functional reason as to why V stood away from the drums and guitar amplifiers, rather than in the middle. The loud noise could make it difficult for V to hear himself sing. In addition, the microphone can cause excessive noise if it is facing amplification. In terms of developing and remembering a composition, there was no particular reason why one member was located nearer to another member. There was no process that required a certain physical arrangement in order for it to be completed successfully. For example, there were no physical artefacts that needed to be passed around as part of work activities. In addition, there were no shared artefacts that required people to gather around one area. Therefore the group could afford to stand or sit at a proximity that was not within touching distance. It appeared that as long as people were able to make out the majority of what they heard and saw, they would carry on working.

3.3.4 Artefacts used

Figure 3.4 highlights many of the artefacts that were used within the session. Two categories of artefacts used: 1) artefacts used to coordinate activities relating to JMC (e.g., musical instruments, tape recorder etc.) 2) artefacts used to support the artefacts described in point number one (i.e., amplifiers, personal announcers, leads, multi-socket extensions etc.). Whilst both sets of artefacts are necessary, my interest lies with artefacts that help create and carry representations in JMC. This mainly occurs with artefacts such as musical instruments and IAs like tape recorders.

Musical instruments

Young Band used three musical instruments including a six string electric guitar, a four string electric bass guitar and a drum kit. These instruments are quite typical to what Contemporary music bands use. Whilst musical instruments can be said to mainly produce one output: sounds created as a result of manipulation of the instrument, the context in which this output is used

was different in our study of *Young Band*. For example, output produced during a performance can be used in different ways to when musical instruments are used in supporting communication outside of performance. The former is an output of group performance whilst the latter is a supplement to verbal communication in helping to propagate representational states and create shared understanding. This will be illustrated when I describe how Information Flows in the system.

Cassette

Young Band did not make written notes but did record a cassette tape of two of their sessions. In the first session G asks the group "shall we get a cassette?" 5 minutes,28 seconds into the video; this was after the first group jam. It is assumed the performance of the jam is the main trigger that initiates the recording. Subsequently when G places a cassette in the tape recorder and presses the record button, the group records everything indiscriminately (i.e., the recording was not stopped between takes of jams). The tape also included the conversations in between the jams. G stops the tape during their official break and presses record at 01:03:59 on resumption of work after the break. The audio tape that G bought from the studio counter would have recorded 45 minutes per side, making a total of 90 minutes of recording. G is seen to turn the tape over during the break at 52:04 into the video. Bearing in mind the session booking was four hours, I believe that the tape did not record everything about the session.

I did not observe *Young Band* referring to the cassette tape within the session. Therefore, I could not describe how the tapes contributed to the way compositions were developed and remembered. Since my unit of analysis was focussed on what occurs in the rehearsal room, I had to rely on interview[2] excerpts to create some form of understanding about how the cassettes were used.

[2] The researcher conducted a brief interview with two band members during the second rehearsal session. See appendix B for interview transcript.

Interview excerpts of session two:

Me: What is the tape for?

G: [The tape] is for reflection .... to see how good we really are, what we really sound like, because - you know - you can't listen properly when you are playing

Me: Is it because of the volume you can't listen to yourself?

D: When you are playing you are focussing on what you're playing, you are not really hearing everyone else's parts as you would when you are playing back, and that's one of the best things about recording the demo thing on Sunday, and now we have a good quality recording of us playing so we can really listen to it clearly and pick out what everyone is doing.

D: Especially in places like this where the vocal volume never seems to be loud enough.

G: I can't hear myself when I was just singing then.....and eh with the tape is like ah that's what you're doing V.

G: Because I'll hear the drums I'll hear the bass...not in so much detail as you come when you listen back to it but the vocals it's like ahhh I understand now.

The recording of the audio is made through the microphones on the walls, which input signals from the whole room and subsequently help to record sounds as inputs that are more clearly defined as outputs of what is being played. When musicians are in the rehearsal room, they are likely to be exposed to outputs from media that is perhaps closest to their location. The tape recording seems to aid the problem of not hearing "vocals" or not hearing instruments "in so much detail". In addition, the recording is a way to help the group overcome the issue of being unable to pay attention to the full details of what the others play because they are busy with their own performance.

Listening back to the recording of parts of the rehearsal session on cassette tape is a mechanism that helps *Young Band* partly suspend judgement on the output that they create as a band within the rehearsal session. The cognitive burden of playing an instrument whilst listening to other instruments in the room may be too much at certain points and therefore musicians appear to make a trade-off between taking in inputs from every possible means, and creating outputs themselves.

3.3.5 Information Flow

In the rehearsal sessions, information flowed between musicians verbally like in conversation, and gesturally like when G nodded at D during a performance or when B gestured a rhythm with his hands to G. Information flow in the room also involved sounds that were outputted from the drum kit, two amplifiers, and the two PA speakers. The guitar and bass could also make sounds without the amplifiers but they would only be heard if there were no other instruments playing. Figure 3.5 is an illustration of the types of information that I noted flowing towards V in session one. I was situated directly behind V, and therefore had a clear perspective of the Information Flow, which was useful in constructing figure 3.5.

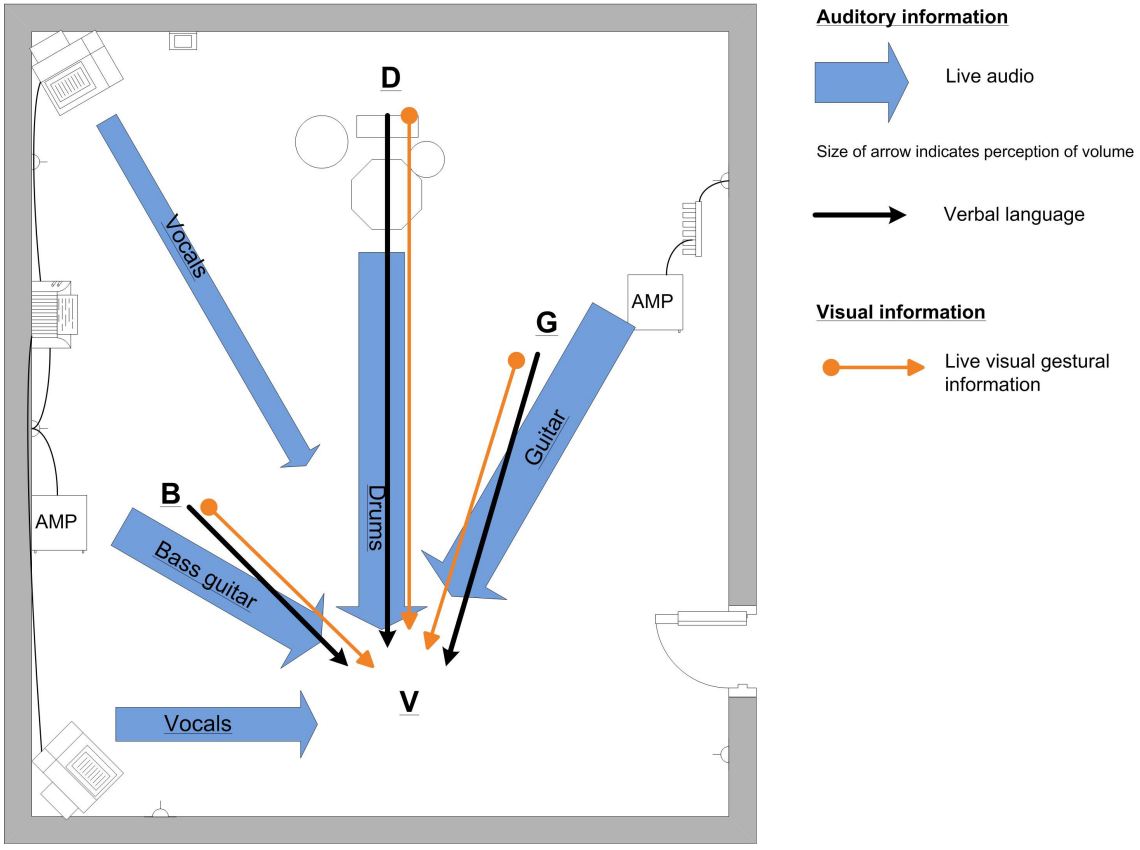


Figure 3.5: Information Flow to V

Verbal and gestural language was often used in coordination with other artefacts, such as musical instruments, to help coordinate the flow of information and create a shared understanding between functional systems. Therefore, the mechanisms that helped develop the composition were based on how language was used in communication and in coordination with artefacts like musical instruments. As an example, I will use two communication excerpts that demonstrate how different configurations can be envisaged. In the first excerpt, B is attempting

to explain to the others how much slower the tempo of the composition was becoming during their performance:
B: It's slower going back into the verse...I start off like this <plays bass guitar> by the second verse I am like this <plays bass guitar> (B plays the bass guitar riff slower the second time).

Figure 3.6 illustrates that B essentially represents the same abstract structures in the above communication using two different resources. The first is a resource based on language (i.e., "It's slower going back into the verse"), and the second is a resource based on outputs created form the bass and amplifier.

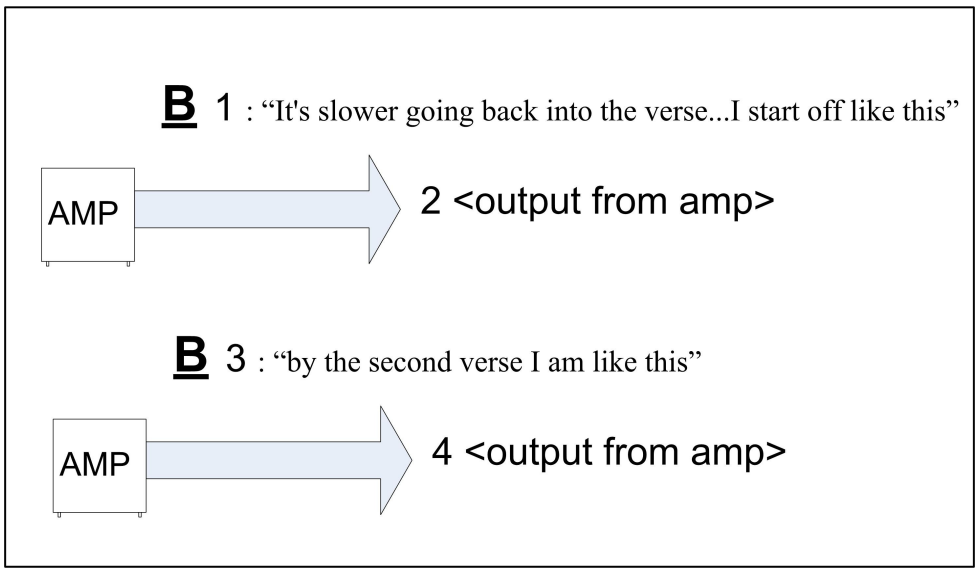


Figure 3.6: Resource configuration example one

The following excerpt demonstrates the fluid nature of how representational states can propagate through different components of the system. In this excerpt B is talking to V whilst G listens and plays guitar at a certain point of the communication.

B: [to V] Shall we do the change dadadad da da (imitating the guitar part)
G: <plays guitar> (G plays guitar that B verbalised)

The representational states propagate from B to G, who in turn transforms it into the action of playing the guitar which in turn propagates signals from a lead connected to the amplifier which outputs the sound of what G plays. I propose that the configuration of resources can involve any

combination of communication from the four musicians, and output from the three instruments including two guitar amplifiers and PA, as well as play back from the tape player; (see figure 3.7 as a simple visual illustration). This example illustrates that there may not be a structured or predetermined manner in which Information Flows in a problem solving scenario. For example, there was no pre-agreement that outlined G should play the guitar when B was speaking with V; he decided to take this action by himself to support B's verbal statement. This was unpredictable and unrehearsed.

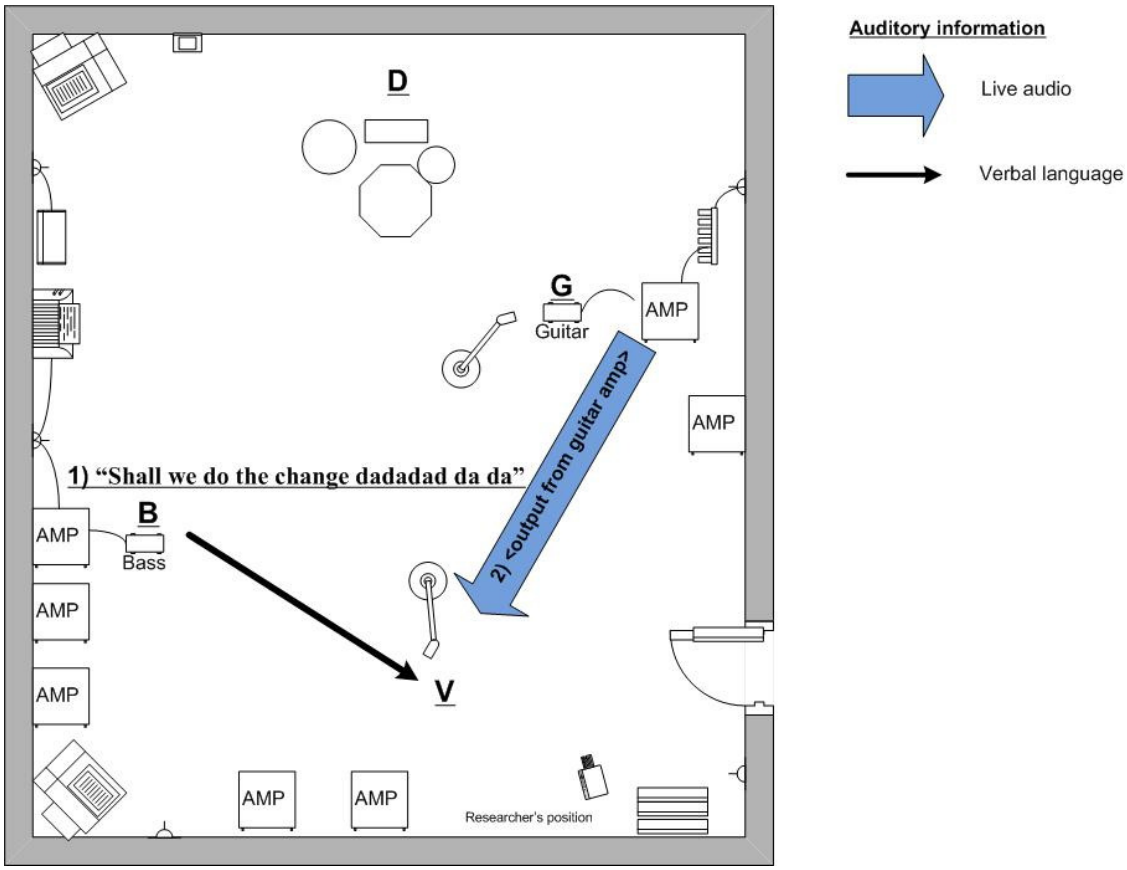


Figure 3.7: Resource configuration example two

My intention is not to show all possible configurations of the functional systems but instead highlight the most common mechanisms that I observed. Throughout the videos of the sessions, the group use verbal and gestural communication along with musical output as a means to demonstrate something that they want to communicate or demonstrate to others. This suggests that the structure and content of language used in communication can contain different computational properties. In both examples, the output from the instruments and amplifiers helps to create a representation that is perhaps closer to an output that can be used

by other musicians because it is a musical reference using sound. In both examples the musicians who could interpret the verbal language often used their instruments to support the verbal reference. Norman (1995) argues that cognition is aided if what is being represented has the same properties of what it is representing, because it reduces the burden of mental transformations that people have to make. However, as the next section illustrates, musical instruments cannot be used in every problem solving activity, for example remembering the composition's structure.

3.3.6 Cognitive burden associated to compositions in development

The summary of findings presented in the Physical, Information Flow and Artefact Models create a context for the types of resources used by *Young Band* in their rehearsal sessions. This can be used to illustrate how the band attempted to manage JMC. For example, one issue was how the band attempted to distribute knowledge about compositions in development. One of the key features of studying *Young Band* was that they did not use IAs within the sessions. They also did not use musical scale information very often. Members often used their own terminology to describe properties of the composition, such as the structure of the composition. Therefore, their language was often of a personal nature which was not always universally understood; the language was often expressed more in terms of what the speaker could formulate at the time of speaking. Below is an example:

Session one:

1:19:20 V: "if I come in right on time three three for low verses and eh yeah that's it...so if I've done that that means another break and then change....four with me four break"
1:19:24 G: "well shout out when it is time to change"
1:19:26 V: "well just listen to the three verses and then treat that as the break I've given between the verses on that change so then it's four four...it's four with me four break four four break four four four break finish
1:19:45 B: "khhhh (clearing throat)
G: "ahhh" <laughing> (sarcastically)
1:19:52 V: " just keep contact with each other"
1:19:53 G: "someone just give me a shout

The excerpt demonstrates that V has formulated a structure for the composition and wants to communicate this to the rest of the band. G faces a number of cognitive challenges:

1) he has to interpret V's terminology about the composition
2) he has to do this interpretation quickly as V speaks because the instruction is transient in nature
3) he has to remember and execute his interpretation when the group next perform the composition

G's task is made particularly difficult because the structure of the composition is in development. There were no artefacts used in the room to help externalise the type of information that V was outputting and hence little opportunity for G to offload the burden of what he had to remember and learn. This is potentially where an IA might have served a purpose. If the cognitive system was able to represent the information that V verbalised in a manner that G could reference in sections (i.e., chunk) and potentially manipulate, then it would have relieved the burden on G to fully formulate the verbal instructions internally. This could be a form of computational offloading because it would have helped G to reformulate the problem state in a way that was more manageable to interpret. In addition, the IA could potentially have helped V and G create a shared understanding and support the transfer of knowledge much like the way Bodker, Nielsen, and Petersen's (2000) physical environment helped interdisciplinary teams create understanding of each other's activities.

Young Band illustrated that they were not reliant on IAs to resolve the types of problems associated with compositions that are in development because they employed the mechanisms outlined in Flor & Maglio's (1997) study. G illustrated that he was looking for a global cue to come from V who had knowledge of the structure; "someone just give me a shout". The cue would replace the need for G to make any calculations, and instead his task would be to play what he knows until he hears the cue to change. Indeed this appeared to be a common strategy within the band. An excerpt from the *Young Band* interview (see appendix B *Young Band* interview) demonstrates that the word "change" can mean different compositional sections at different points it is used:

Excerpt from appendix B - Young Band interview:

> D: Every song has a change (laugh).....every song has one bit called the change and 'yea that's just before we do the change' (simulating conversation within band)
> G: (simulating conversation within band) 'and then it goes the small change' 'oh the small change' 'then the big change' 'then the other change on the mic like other change' .... 'on stage we're like other change' and we're like what the fuck is that? It's all part of the fun I suppose

For this band the word *change* refers to changes in sections of compositions. In theory, when the word *change* is sounded out it propagates across the system initiating a number of different transformations to take place (i.e., different musicians performing different actions on different instruments) but ones which produce an output that is coordinated with each other. Calling out *change* works as a global cue for the musicians to coordinate their actions to play a particular section of music. Since each member plays a different instrument, they would each need to understand what the word *change* means to what they individually have to perform. At some stage during their sessions of work they create a shared understanding of what *change* implies in context of the composition and section of composition it is being used.

The word c*hange* is not a carrier of information, but a cue to action based on the shared understanding of the context it is being used. This mechanism supports the distribution of knowledge about the structure of the song because one member is able to instruct others when to change rather than for every member to calculate the change by themselves. However, this strategy can have shortcomings especially when the group cannot use the external cues to propagate knowledge of potential points of change. This can occur in a gig where the band may be facing the audience instead of each other and in situations when they cannot communicate verbally with each other. For example, in session four, G does not understand what B is shouting during the performance. After the performance ends (1:17:18 of video) B declares "that's something we need to work on because I need to know how long I am gonna hold that at the end"; G replies "oh is that what the shout was for?"

If the group members do not all have knowledge of the composition components, including the structure, there is likely to be a breakdown within performance. In session four, many breakdowns were observed in the performance of compositions that had been played in full in previous sessions. The song *Bit on the side* had been played in every session that I had been present and was one of the three songs that the band recorded as a demo. This means that they should have been performing the song without any issues. The excerpt below illustrates the difference between the knowledge of the group.

Session four:

(Performance breaks down near the end of the song)

00:49:49	G: (ushering others to continue with his hands)
00:49:51	G: [to D] that's the one where we carry on longer
00:49:53	V : [to G] I thought that's the one before?
00:49:55	G: was it?
00:49:46	V: yeah it was the one before we do two of me and then its two of yours and then we end
00:50:00	D: I didn't know we were going to end there
00:50:01	B: hold on a minute before we we…do that big change how many verses do you sing before we go to start to put that in?
00:50:09	V: what the extra one? That's what I am saying. Two

Whilst this song has been played on many occasions before, it is clear that there is a breakdown in knowledge between the group members, which has not been resolved over time. All four members appear to display different understanding of what the composition should be doing at the end. Even though the group resolve the matter through further clarification and performance, it is obvious that the distribution of knowledge about compositional properties is not always remembered or fully agreed over time.

Whilst *Young Band* illustrate that they do not need IAs in their sessions to resolve problems associated to the evolving compositional structure within a session of work, it is clear that many sessions can pass without knowledge about the structure of the composition being fully attained at the local level (i.e., by the individual musicians). Reliance on external and global cues can be a barrier to how a composition is remembered on a long term basis at the local level.

It is fair to say that the group did not appear to rely on visual cues or someone to shout change for the song *Bit on the side*. However, another composition which was not played as much appeared to require more coordination (i.e., more visual and verbal cues to initiate change). During the session four video, between 01:08:17 to 01:17:30, shows the band members exchanging far more cues to change than the song *Bit on the side* that was also performed in the same session. The extra cues are obviously a consequence of the unsettled structure and/or a lack of knowledge about the structure among all members.

Young Band used a circular position in most sessions during rehearsals to provide visual access to other people's performances and consequently support the distribution of knowledge of the song structures during performance. It was important that people could see and hear each other for a significant period of time during and in between performances because this was where information about new ideas was expressed and implemented. The main representations created in this interaction were based on a combination of verbal and gestural communication as well as musical output generated from musical instruments and supporting artefacts such as amplifiers. All representations associated with the activities of composition development were transient in nature and consequently members of *Young Band* were tasked to distribute knowledge about the composition within and between performances. Whilst this JMC cognitive system functions without using IAs, there is potential to investigate the nature of the problems that musicians face in more detail in order to determine how IAs can be employed to support cognition at the local level, especially to create shared understanding and support the distribution of knowledge.

3.4 Summary

In this chapter I have described ethnographic research conducted at Westbourne Rehearsal Studios as a way to position the unit of analysis within a rehearsal room. The study helped to define high level overviews of JMC as a functional system. This system consists of multiple musicians, a room, and artefacts used to coordinate activities relating to JMC (i.e., musical instruments, tape recorder etc.), as well as artefacts that support the artefacts used to coordinate activities relating to JMC (i.e., amplifiers, PAs, leads, multi-socket extensions etc.). I propose that the shaping of knowledge about the composition is one the most important outcomes of a rehearsal session and constitutes the key output of the JMC functional system. JMC, as demonstrated through the sessions I observed of *Young Band,* may have some observable physical consequences, but these may not be the main products of the session. The main products could be the changes that take place within and between the musicians.

At the local level, musicians need to know the properties of the composition in order to transform it into the physical implementation of playing an instrument. Whilst each musician may perform different actions because they each play different instruments, they have to coordinate what they do with each other in order to create and perform a composition. I illustrated that the functional system can be configured in a number of ways using musical instruments and verbal and gestural communication. Musical instruments played a central role in how outputs were created by local functional systems. They were also featured in the language used within the system which contained different computational properties. The

configuration of the different resources helps to demonstrate how the system resolves issues arising in different situations.

The findings in this chapter indicate that there is scope to investigate how cognition can be supported at the local level, especially when knowledge is being shared within the group and over time. Whilst reliance on global cues is critical to the way musicians coordinate the performance of compositions in development, it also means that many sessions can pass by without musicians understanding structures independently.

Chapter Four: Distributed nature of problem solving in JMC

4.0 Introduction

A band's ability to create a shared definition of compositional information at various points throughout a rehearsal session is an important feature of JMC, enabling compositions to become more structured whilst allowing new ideas to be introduced. In this chapter I illustrate how the distributed nature of problem solving in rehearsal sessions requires the outputs of local activities to be disseminated across the group in order for progress to be made in JMC. The findings are based on a three week study conducted in a laboratory setting with four musicians.

I will use the chapter to describe the set up of the study and illustrate the means by which knowledge is distributed across the system through the propagation and transformation of representational states in a number of different work episodes. One key work episode relates to the reconstruction of knowledge from Session One to Session Two. An activity chart is used to highlight how knowledge is reconstructed across the group at different times using different external resources. The overall findings of this chapter suggest that no central resource or system was in place to support the dissemination of information in a non-transient form. This meant that, while compositions were in development, there were few opportunities for the musicians to offload the cognitive burden of what they had to remember and learn. Ultimately, the musicians needed to internalise information, which was problematic in episodes of work where there were conflicting views of the composition from the previous session.

4.1 Studying JMC in a laboratory setting

A laboratory (lab) based study was conducted at Queen Mary University of London (QMUL), which involved the analysis of a group of four musicians engaged in JMC over three weekly sessions. Unlike the studies of bands at Westbourne Rehearsal Studios, my lab-based study allowed certain important observations to be made. These included:

1) data capture from the inception of a group
2) data capture from the inception of a composition
3) data capture from the inception of an environment
4) access to all artefacts used in the development of a composition
5) having an *insider's* knowledge by being part of the activity

In order to accurately make these observations, I put together a group of musicians, including myself, who knew each other but had not worked together as a band. My goal at the time of the study was to put together a group of competent musicians whose instruments could be used to write a Western contemporary music composition. I put together a guitar player, bass player, violinist and a keyboard player who also played the flute. From the outset the group knew that rhythm instruments like bongos or drums would have been an ideal component, however a percussionist could not be found to take part in the study.

Though it is stated that this is a lab based study, in reality I did not create a totally artificial situation. Musicians can work together on a short term basis without long term commitment. For example, session musicians may be paid to perform on a record or to play a single gig with a group. Musicians may also meet and play for fun without having any long term commitments. Therefore, the set up of the study was not totally out of context to how groups of musicians meet and play music. In all these situations musicians are exposed to new people, compositions and environments. The critical difference between this study and the types of bands that I described in the previous chapter is the context and culture of work. The aims of the majority of groups I spoke to at Westbourne Rehearsal Studios involved creating and recording compositions with a view to promoting them through live performances to an audience, obtaining radio airplay and magazine reviews. The ultimate goal of these bands was to obtain a professional record contract that would enable them to earn a living through the outputs of the band. The group that was put together for the lab based study did not have any intention of working on a long term basis or promoting the material. I assume the primary motivation for the members of the group (other than me), was to play music with others, and their secondary

motivation was to be paid five pounds sterling per session[1]. My personal motivation was to be part of a group and make songs in order for me to later reflect back on the process. Even though the motivation of the group that I assembled did not match the bands I observed previously on every level, we did share an important motive: the desire to develop a composition and play music with others. Bands who try to promote their music often start off developing compositions before deciding whether to promote them. Therefore, the motivation to play music with others and to make compositions is likely to be the first step for any band.

4.1.1 Study Set up

Subject Recruitment

I recruited expert musicians instead of novice or non-musicians. I classed any musician as expert if they had played their instrument for over five years and had regularly been part of a composition writing or improvisational set up. I gave consideration to musicians who had formal / classical musical training and had achieved grades. I assume the inability to play an instrument would impact how the group works. I cannot state for sure that it is a major stumbling block in creativity, but it is likely to add a dimension to an already complex work setting. Any musician may encounter problems when developing and playing a new composition because they misunderstood communication within the group. However, a novice musician may have a problem playing a new section of music because they cannot play their instrument. In addition, the time it takes for them to learn and perform efficiently can impact how the group works because others may have to wait until the novice learns how to play a section.

A summary of the background of the participants can be seen in appendix C. Participants C, H and S (me) knew each other because we were all postgraduates at Queen Mary University of London. Participant A was a friend of H and was introduced to us for the first time at the beginning of the first session.

Task (objectives and time frame)

An information sheet about the study was sent out to all participants two weeks before the study. In the information sheet the participants were informed that they would be asked to write at least one composition in the sessions that I organised at QMUL. I also outlined a time frame to write a composition: three sessions each lasting two hours. Participants were asked to bring

[1] I offered payment as means to cover their travel costs. I was not paid to be part of the study.

anything that they required to create a composition in a group, including musical instruments. They were told to inform the researcher beforehand if they required items to be provided for them. The participants were informed that they were welcome to bring any composition ideas that they wanted to develop to the session. The group was free to decide what type of composition to create, how to create it, how to structure the sessions etc. The idea was to give the group as much control as possible and the only restrictions were those that bands would normally encounter in real world situations (i.e., to write compositions within a rehearsal space that can only be used for a limited time).

Session set up

We met as a group on three consecutive Mondays at 7pm in the Electronic Engineering music lab, on the QMUL campus. The time and location were agreed upon by the group before the studies commenced. The sessions usually finished between 9pm and 9.30pm. I set up and packed up the cameras for observation and participant C helped me to set up the equipment in the room (i.e., amplification, microphones, midi keyboard effects).

Physical layout & supporting artefacts

Figure 4.1 illustrates the physical set up of the study. Other than the chairs, the two microphones and the two cameras that we set up, all other pieces of equipment were situated in the positions where they were found before the study began. The group did not change this layout as the equipment was working satisfactorily where they were situated. The members of the group had a choice to change the layout, provided they were within the line of vision of at least one of the cameras.

I positioned the chairs for people to have access to the equipment that they were to use. Based on the findings of chapter three, I made an assumption that participants would like to be in the line of vision of each other and be positioned close to equipment that they were likely to use during work. Participant A was positioned behind the keyboards, C next to the guitar amp, S next to C and within distance of the bass amp, and H was positioned in a way that was in the line of vision to all members and at least one of the two cameras recording the study. Each member was within touching distance of the person next to them because of the space restrictions of the room and the necessity of having everyone in a cameras' line of vision.

No one reported being unable to see or hear other members of the group and no reports about people not being able to hear each other's instruments were made. There were also no reports about any discomfort as a result of the positions set out.

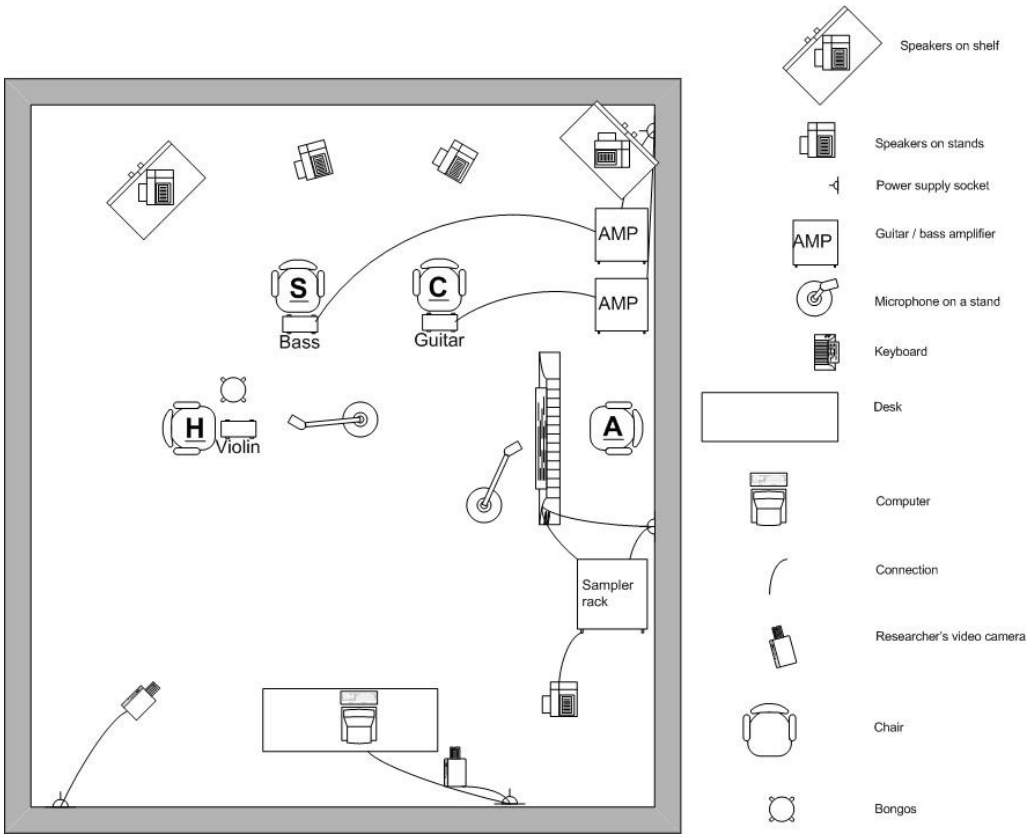


Figure 4.1: First lab study Session One physical layout

In part, I helped to shape the culture of work and the environment that people worked within. The subject recruitment, my involvement, the task, timetable, the session organisation and much of the physical layout of equipment and seating were aspects that I influenced. However, what occurred within the sessions, including how group members introduced themselves, developed concepts, communicated and attempted to record information was shaped by all members of the group. For example, participants A, C and H used written notes at various points within the session. These notes were created by the participants using material that they brought themselves. The use and placement of the written notes was also determined by the participants.

4.1.2 Data capture

Within this study there were two methods of data capture: video recordings of the three sessions and my diary as a participant.

Video

Since I was involved as a participant in the study, the main methods of data capture were the video recordings of the sessions. Two videos were recorded covering different angles of the rehearsal space capturing all musicians for the entirety of each session. Each video lasted two hours which was approximately 10 minutes short of the sessions, which usually overran.

My participation

In chapter two, I highlighted the potential of using the reflexivity as a research method to provide subjective reflections gained from participation within studies. As a participant within the study, I was able to feed into the research findings by providing insights that would otherwise not have been possible. Being part of the process helped me map high level structures of the sessions, enabled informal channels to extract information from other participants when necessary and provided an understanding of the compositional information including how they developed over the three sessions. In addition, much of the informal interaction between group members played an important role for me when establishing the beliefs and understanding of group members. An outsider would need to rely solely on the participants to provide details of their interaction outside of the sessions.

It was particularly helpful to be able to reflect back on the findings both through the analysis of videos and as a participant who was integral in many elements of the compositional process. It must be noted that I did not avoid being involved in the sessions; I behaved as I would in any of my own band's sessions. It was important to experience the compositional process from a participant's point of view because I was also able to reflect back on what I was thinking about when certain events where taking place. The findings will illustrate that some of the perspectives are described from a person involved in the process. For example, diary entries such as "sometimes in our group improvisations variations of the same themes emerged where we did not all play the same things" describe insights that were noticeable mainly because I was deeply involved in the process of performance. Sometimes variations in performance affect what others play but may not be noticeable when reviewing video recordings. Being a part of the process helped me to be able to refer back to these instances when it was required in the analysis.

4.2 Analytical Framework

In chapter three, I stated that the focus of analysis should be placed on looking at how knowledge is shared and maintained in order to gain insight into how the JMC cognitive system functions. This is mainly because the key outcomes of a session of work are observable in the way knowledge is distributed within sessions and reconstructed across time in different sessions. Whilst the analysis of chapter three data was partly exploratory, in this chapter I focus on describing the way knowledge can be seen to propagate within the system on a much more granule level. In particular, I will outline some of the mechanisms that support the distribution of knowledge. In addition, I seek to explain how knowledge is reconstructed about a composition in different sessions. Through this description, I aim to highlight challenges that musicians face when working with transient representations.

As in chapter three, I used Furniss and Blandford's (2006) Physical, Information Flow and Artefact Models to focus my analysis and data capture. In order to describe how knowledge is distributed across the system through the propagation and transformation of representational states, I had to focus the analysis on a number of key work episodes that can be described to contribute to a *successful outcome* in JMC. To determine which episodes were important to describe, I formulated a framework which focused on three areas:

1) Transferring knowledge of musical properties and composition structure from one musician to another
2) Developing the composition beyond its current state
3) Re-constructing knowledge[2] distributed across the group and across time

The framework (see table 4.1) creates a relationship between the salient points I am looking to analyse, the knowledge the system appears to have about the composition in the instances of the salient points of work, observable actions within the system that indicate implementation of the salient points, and my rationale about analysing each point. For example, one salient point is based on instances of work where composition information is being introduced to different musicians for the first time, or at a point where not all musicians know what they are playing. This usually means the system's knowledge of the composition is beginning to develop, most likely when musical components exist for some of the instruments but not all instruments. Each salient point will have an observable action within the system. Studying language and artefact

[2] I cannot demonstrate the exactness of how much knowledge is re-constructed but instead imply that knowledge is re-constructed which is suitable for *current purposes* (Clark, 1996).

use in these areas provides clear examples of the propagation and transformation of representational states relating to compositional information across different media. This is because the system has to transfer knowledge across the system so that some consistencies exist in terms of what should be played and when.

Salient point	***System's knowledge of composition***	***Observable actions in system***	***Analysis rationale***
Composition information is being introduced to different musicians for the first time, or at a point where not all musicians know what they are playing	Early stages of composition writing where performance is not coherent. This is where musical components exist for some of the instruments but not all instruments within a composition	Transferring knowledge of musical properties and composition structure from one musician to another	Analysis should provide clear examples of propagation and transformation of representational states often for the first time in the composition, or during periods where there is misunderstanding
Composition is being developed beyond its current state. This involves: 1) suggestions and amendments to existing musical sections 2) creation and amendment to composition structures 3) creation and suggestion of new musical sections	Creation of composition has significantly progressed and performance is more coherent. Main purpose is to refine and reformulate composition	Developing composition beyond its current state	Analysis should provide examples of existing representations including boundary objects and products of a local convention developed during collaboration
Composition is being discussed or played for the first time in a new session	Composition development is in progress but interrupted by many days. The performance is dependent on what the system can remember	Re-constructing knowledge distributed across the system and across time	Analysis should demonstrate the means in which the system remembers the composition across sessions. This is likely to include examples of how existing representations including boundary objects and products of a local convention are used when there are several days gap between sessions.

Table 4.1: JMC analytical framework

4.2.1 Stages of analysis

The first stage of analysis required the review and time stamping of sections of the video that appeared to be relevant to my research objectives. For example, the beginning of each session was time stamped and tracked up to a point where problem solving activities in between performances were less about one salient point and more about another. Once I had time stamped areas of interest, I commenced transcribing actions and communication within and between performances, as described in chapter three. One of the outcomes of this was that I was able to identify the most common means through which compositional information propagated. This helped me to understand how musicians come to know what they know about compositions (i.e., how they came to learn and remember where to place their hands on their musical instruments within each rehearsal session). In order to bring my findings together to form a view of the cognitive system, I formulated a visual representation of the activities of the system during specific points in time. For example, I created an activity chart which visually illustrated where musicians made verbal comments, played an instrument and when they came in contact or looked towards their written notes during an episode of work. This chart was a way to bring together several different sources of information into one snap shot of the system, which helped to illustrate the fragmented nature of how knowledge was reconstructed across time. I also referred to my session diary as a way to extract information relevant to episodes of work being analysed. This served as a reminder of what I, as a participant, was thinking about at a certain point. In addition to the analysis undertaken for specific episodes of work, I also tracked the use of written notes across all three sessions in order to investigate how they impacted the distribution of knowledge across time, especially as the Westbourne Rehearsal Studio study did not have many bands that used IAs. I noted down the instances where musicians looked towards and touched their written notes. I then reflected on the context in which this was occurring, forming a judgement on how the written information was impacting the distribution of knowledge.

4.3 Findings

In this section I present findings most relevant to illustrating how participants in JMC develop and remember a composition. My findings are based on describing the way information flow supports the organisation of knowledge. One of the key findings of my analysis is that a single person often plays a more active role in helping to distribute knowledge about the composition. For instance, a person can give a cue to change during a performance of a composition, suggest changes to sections of music, or describe new ideas using musical instruments accompanied by verbal and gestural communication. The main theme that I develop in this chapter is based on how the distributed nature of problem solving in JMC is managed in rehearsal sessions.

4.3.1 Overview of the three sessions

The group met together for the first time in the first session. Participant A had not met participants C or me prior to the first session. I was asked about the objective of the sessions, to which I replied that the group should aim to write at least one composition in the three rehearsals. An information sheet was sent out to A, C, and H before the session, which outlined the objectives of the sessions and asked participants to bring any items that they required to create a composition. Participant A brought a flute and asked for a keyboard to be provided. In Sessions Two and Three she also brought paper and pen, which she used to write down composition information and refer back to from time to time (see figures 4.13 and 4.14). Participant C brought an electric guitar and used the amplification within the room. He also brought paper and pen and used it to write down composition information (see figure 4.12 as an example). Participant H brought her violin and did not need any supporting artefacts such as amplification. In Session One she brought a book containing various musical notation and ideas (see appendix D for an illustration). She also referenced and wrote in the book at different points in the sessions. I brought my bass guitar and used amplification within the room. I had rarely used pen and paper in my previous experience of working in a rehearsal session, so I did not make or use written notes.

We sat in the same places each session, but our movement was not restricted (i.e., we could stand, adjust our seats and so forth). We had the choice to listen to a recording of the session's audio in between rehearsals. I distributed audio recordings of each session by posting them on a website for the others to download outside of the sessions. I personally listened to most of the sessions, whilst C and H stated that they listened to elements of Session One and Two. Participant A stated she could not download the files and therefore did not listen to any recordings. By the final session, we created a number of musical sections for two different compositions which we could perform as a group, although without fluency; some members could play some sections better than others. Therefore, the compositions cannot be deemed to be fully complete in the sense that all members have a part to play which they can play well.

The ideas for the two compositions first started to be developed in the first session and progressed in sessions two and three. In the beginning of Session One, participant H proposed a composition idea that she had created at home. The book that she brought to the session contained some information about the composition. The second composition was introduced as a result of a conversation between C, H and me, which resulted in C playing a guitar riff based on an audio recording that he had heard of my bass line outside of the session on an audio file. This prompted me to introduce the bass line to the group. In both cases, initial ideas were partially created outside the session. The sessions were used to introduce the ideas to every

member and for the group as a whole to develop the ideas into compositions which had musical contributions from the different participants.

As with *Young Band* in chapter three, the main change that took place within the three sessions was the shaping of knowledge between the participants about two compositions. In this study, audio recordings and written information were created, but neither can be considered the main output of the session. These outputs were by-products of work activity.

4.3.2 Local actions supporting group activity in JMC

The study findings suggest that ideas proposed in composition development, for example new musical notes or chords, or changes to the structure of the composition, were often initiated by one person but involved many people to bring to fruition. This meant it was often the outputs of local actions that were critical to how the group was able to make step by step progress in JMC. Therefore, the group as a whole did not always help the progress of activity at the same time; often the process revolved around one or two individuals who resolved an issue and distributed the knowledge across the system. In the following excerpt, the group had performed a jam based on an idea that H had introduced. After the jam, participant A asked participant C about the chords of the performance that the group had been conducting. Even though participant A was part of the performance, it is clear that she did not have the same knowledge as participant C in playing the sequence that was performed.

Session One:

At (0:43:02) participant 'A' plays two chords on the keyboard and looks towards participant 'C' asking "E flat?" and then plays more chords. 'C' attempts to verbalise the notes that he plays to 'A'. (0:43:09) "So that, erm, B flat major over a B flat chord I am sure there is better name for it". 'H' states "it's diminished" to which 'C' replies "yeah half diminished or something?". 'A' then plays a chord and asks "isn't it just major 7th's?". 'C' replies "yeah erm" then looks at his guitar carefully as he plays. 'H', 'C' and 'A' then all play a series of notes, possibly the chords that 'C' is talking about. At (0:43:43) 'C' declares "eh it has a. Ahh. what it is it's a" <plays the same chord twice> "it's kind of ambiguous because it doesn't have a 3rd in it does it?". 'A' puts her hands on the keyboard and says "oh does it not?" and plays a chord as 'C' plays guitar, but not quite in unison. 'C' carries on working out the chord before declaring (0:44:02) "it's got a, oh, it's got a 9 in it".

As the excerpt illustrates clarification was often collaborative but definition was usually led by one person. Participant C was involved in working out the actual note names in order to share the knowledge with participant A. Therefore, the distribution of knowledge from the local level to the rest of the system was a key feature of how the JMC system was able to bring an idea to fruition more precisely. Figures 4.2 to 4.6 illustrate participant C's involvement from the initial performance of the piece where Participant A was not playing along with his guitar line, right through to the point Participant A plays more in line with the guitar.

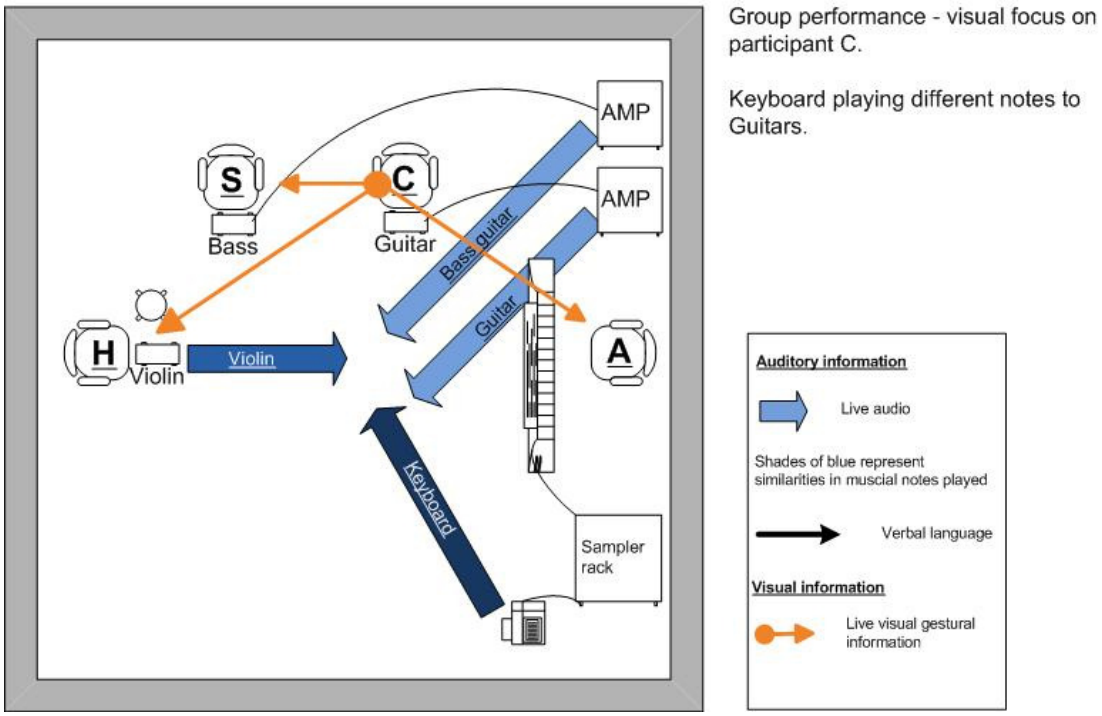


Figure 4.2: Group performance one

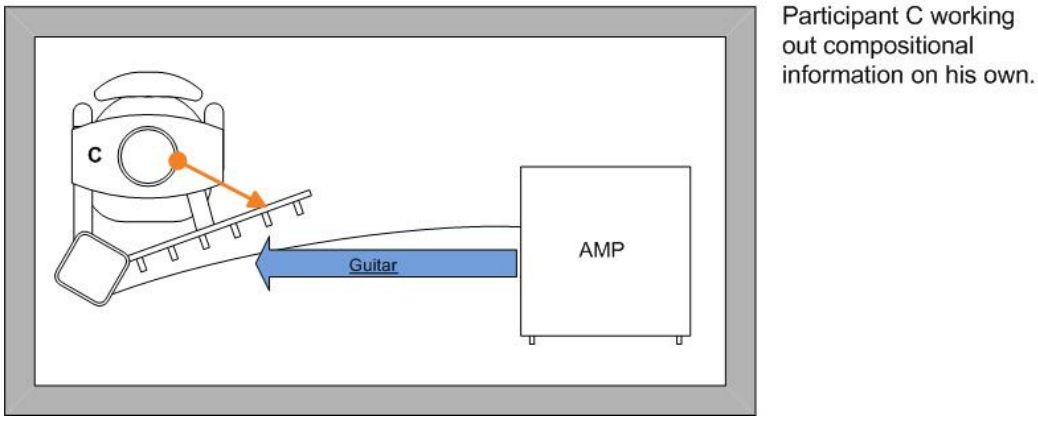
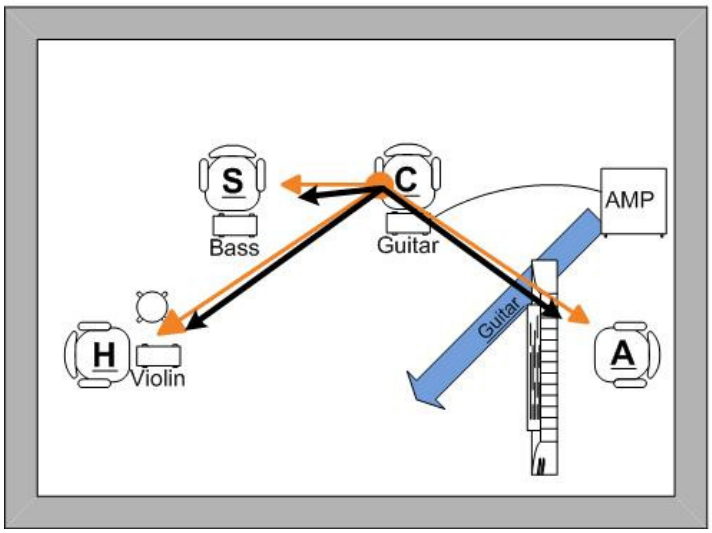
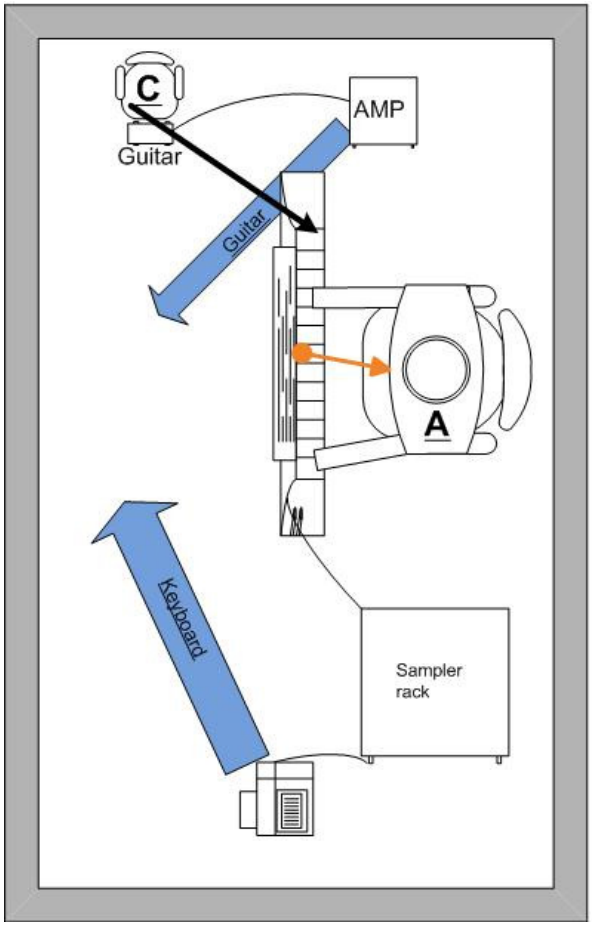


Figure 4.3: Definition at local level



Participant C communicating compositional information to others.

Figure 4.4: Dissemination of information



Participant A transforming information into playing what participant C is communicating.

Figure 4.5: Transformation of information

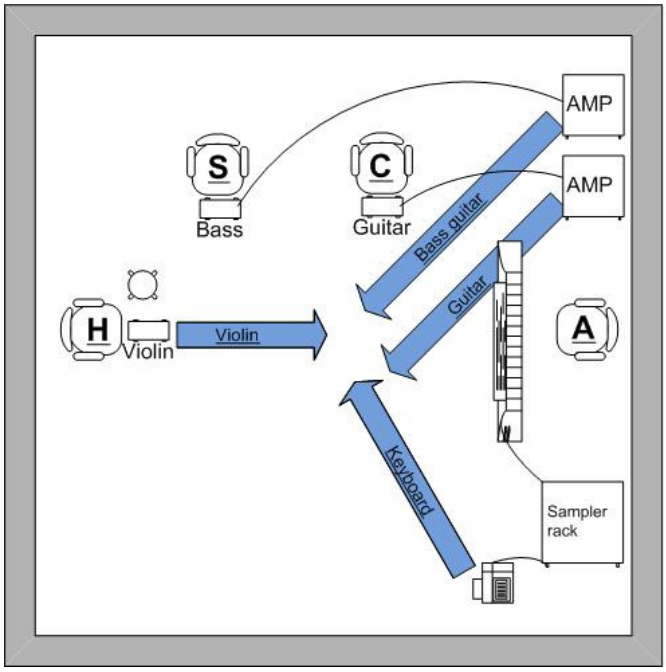


Figure 4.6: Group performance two

Figures 4.2 to 4.6 provide a simple breakdown that typifies how progress is made in composition development. Whether an idea is based on a group or individual performance, or expressed verbally, it has to propagate and transform across all members in order for a composition to emerge out of improvisation. Sometimes in our group improvisations, variations of the same themes emerged where we did not all play the same things; two people may try new things at the same time. Alternatively, one person may deviate from previously established compositional ideas. At one point we had to make a decision to go with one particular direction, though this was not formally arranged. It was often based on one member stating that they liked something in the performance and sometimes asking for more clarification of what was played, like A in the excerpt above. This type of process helped the group evolve ideas and develop compositions.

In Chapter two I stated that the distinguishing feature that makes composition different to improvisation is that it affords musicians the opportunity to make revisions over longer periods of time, especially in between performances. Figures 4.2 to 4.6 illustrate one particular way in which this occurs. However, there are a number of ways that information can be defined, disseminated and transformed to support the distribution of knowledge. I will illustrate the key ways these occurred in this study.

4.3.3 Propagation and transformation of representational states in JMC

I will use participant C as an example of how musicians use their internal knowledge and their musical instruments to represent knowledge; this is related to figure 4.3 (definition at local level). Participant C only attempted to understand the names of the notes that he played in order to communicate it for the benefit of others in the group. He showed he is not able to describe the chords as quickly as he can play them. Often it was a matter of looking at the chord shapes being played and attempting to describe the individual components of the chord.

Session One:

At (0:38:04) C is looking down at the guitar and asks himself (or the group) "erm what is that? that's a" <plays a chord on the guitar>. After a couple of seconds of the chord ringing 'H' states something that resembles the word "arpeggio?". 'C' is looking at the chord shape he is holding but without playing he replies "no it's a B flat major over" < plays a chord on the guitar > "E flat". He then plays the chord again and declares "Just think of it as a B flat major" <plays a chord whilst plucking individual notes> "and that's the E flat" <plays chord with a strum>.

This example, illustrates the internal knowledge being mapped to his guitar. Not only was C listening to what he played but he was also looking at the shapes his hands were making. Figure 4.7 shows a very basic guitar chord chart. This helps to illustrate how the information that he is representing verbally can be used to make decisions about where to place fingers on the guitar neck.

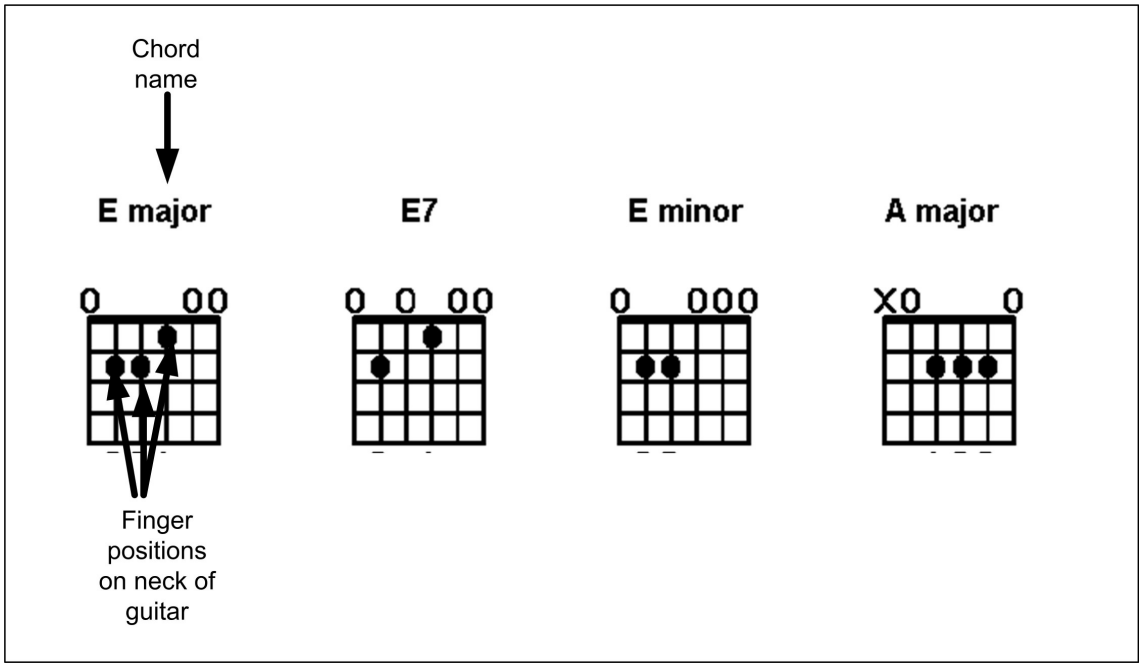


Figure 4.7: Example of guitar chords

Figures 4.8, 4.9 and 4.10 illustrate how the labels for the musical notes can be visually mapped on to other musical instruments such as the violin and keyboards. It is possible to see how the information within the language that C uses can be used by A and H to make decisions about where to place their fingers on their instruments.

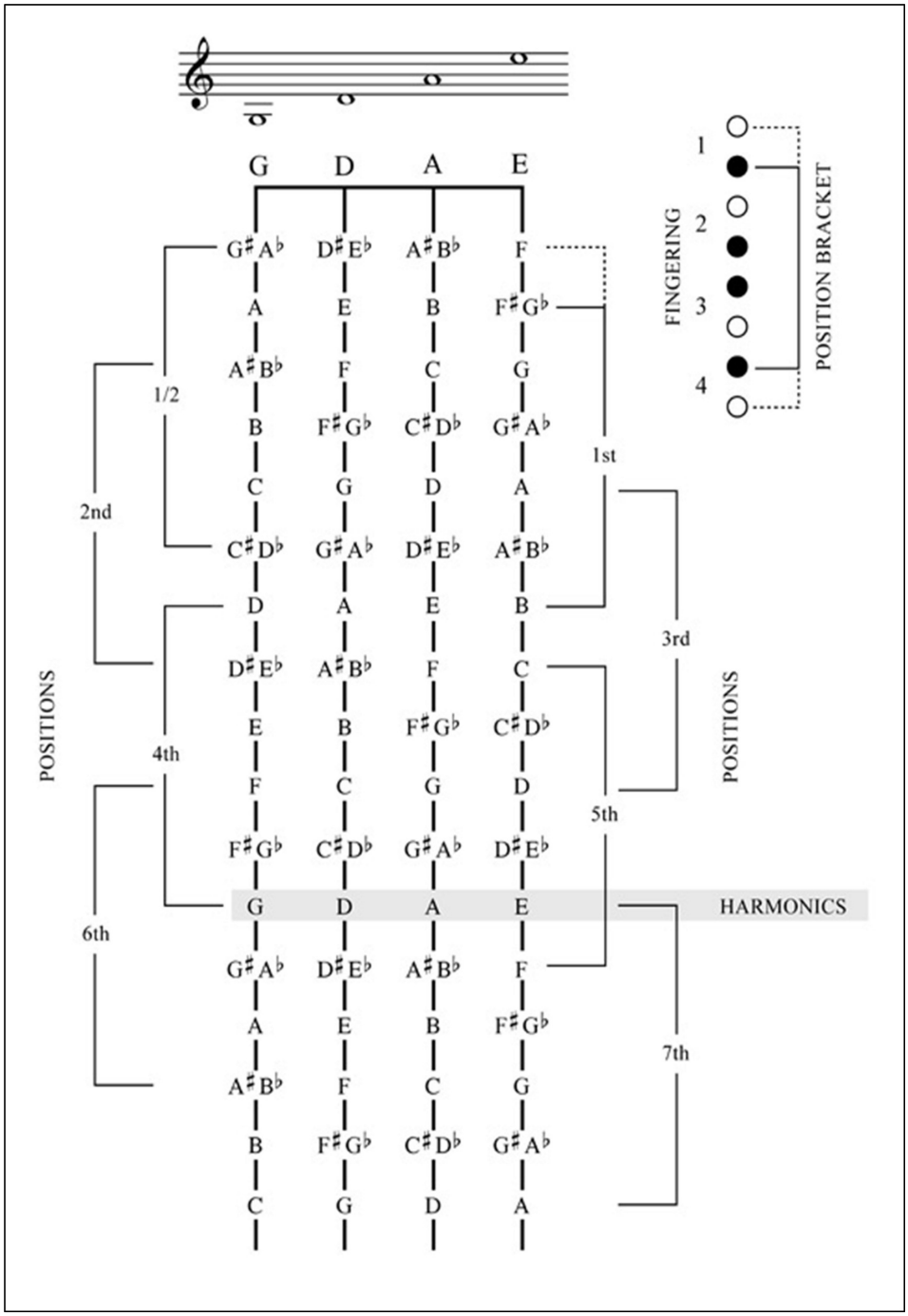


Figure 4.8: Violin fingering chart

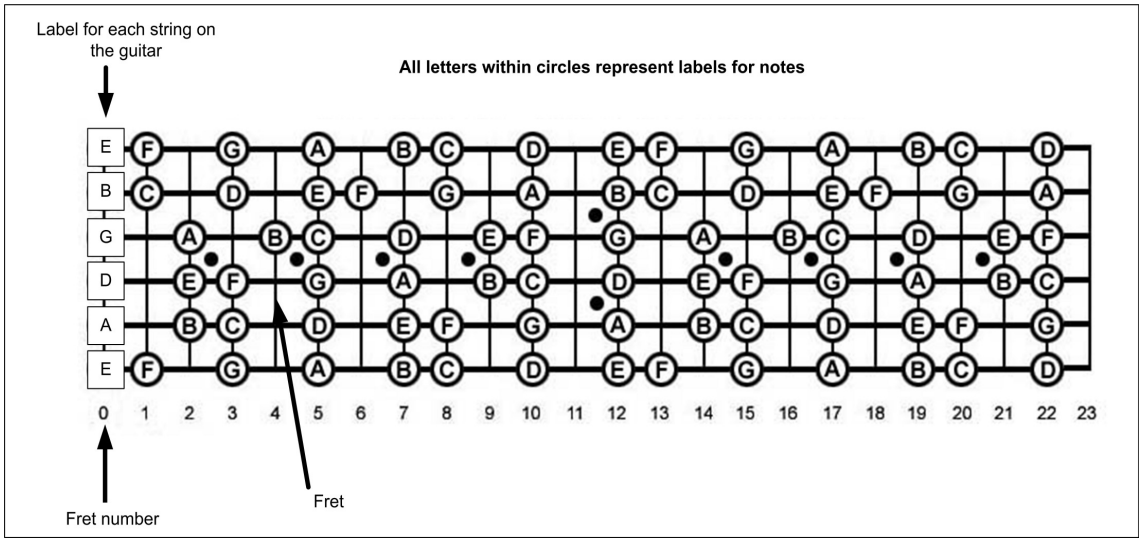


Figure 4.9: Guitar neck

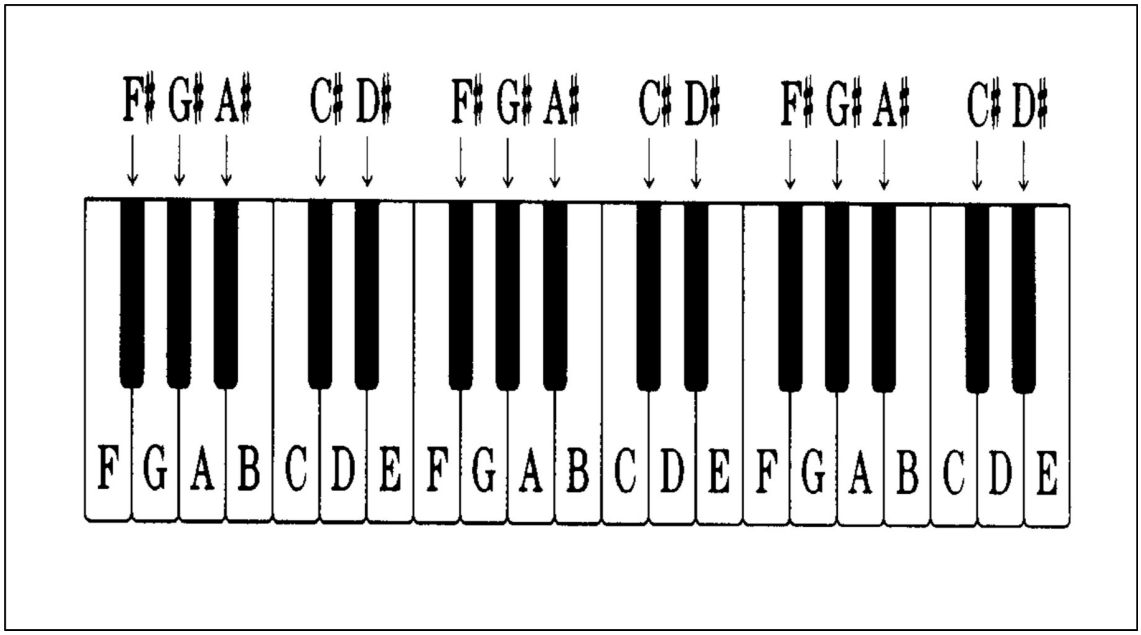


Figure 4.10: Keyboard / Piano

The three figures show that there is a common set of information that unites the instruments, even though physically playing them requires different skills. Therefore, whilst the physical implementation of playing the guitar, violin and keyboard is different - hence transforming the information is different- the information that is presented in the language is actually the same. Figure 4.11 gives an example of how a guitar can be tuned to a piano. This figure is a very simple way to illustrate how some parts of the guitar relate to the keyboard.

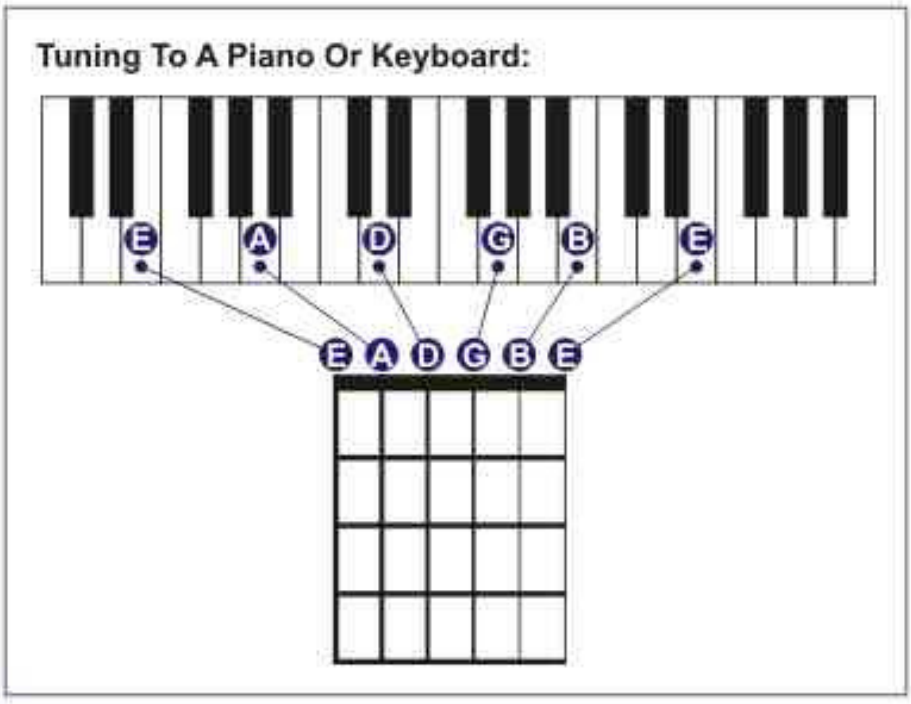


Figure 4.11: Tuning guitar to keyboard

One can see from the figures above how information described in the communication of the group is related; however, in reality musicians do not use visual charts like figure 4.11. The transformation of C's statement "*B flat major over a B flat chord"* in the first excerpt requires the other participants to map what their understanding of those terms on to the instrument that they play, using their own internal knowledge, similar to what figure 4.5 is illustrating.

Figure 4.5 shows participant A using C's verbal language along with the outputs of the guitar amplifier to decide what to play on the keyboard. Chapters two and three suggest that musical scale information is not always employed; therefore the content of the verbal language may not support knowledge transfer in the way musical scale information helps propagate representational states. There are other ways through which compositional information propagate.

Mimicking: Mimicking what someone else plays is a common way to the propagate knowledge across the system without using musical scale information. As the bass player, I introduced a bass line as a proposed idea for a composition (video one 00:57:54), which consisted of three different chords, each containing at least three notes. In the excerpt below, C attempts to learn and play the bass line progression on his guitar.

Session One:

00:57:54	S: there's a different chord progression…at first it goes <plays bass> (he plays the same three notes twice back to back)
00:58:00	C: oh <looks to his guitar and plays>
00:58:02	C: <looks towards S whilst playing>
00:58:03	C: eh
	S: <plays bass> (S plays the same three notes and has held the same hand position on neck of bass since he first played it)
00:58:04	C: <plays guitar then looks at S> (this is the correct three notes S plays)
00:58:06	C: then you <looks to his guitar and plays> (C plays next set of notes he thinks S will play)
00:58:07	S: yeah it's <plays bass>
	C: <plays guitar> (attempting to mirror what S plays)
00:58:10	C: <leans forwards to look at S's hand on neck of bass> (as he leans back S plays the third chord of the sequence whilst C plays two notes of it)
00:58:11	C: what's that second one? (C referring to the second chord)
00:58:12	S: <plays bass> (plays first chord)
	C: <looks to S and plays guitar>
00:58:14	S: <plays bass> (plays second chord)
00:58:15	C: <looks to guitar and plays> (plays second chord)
00:58:16	C: <looks to S>
00:58:17	S: <plays bass> (plays third chord)
00:58:18	C: <looks to guitar and plays > (plays third chord)

The implementation of how the representational states propagate in this excerpt is different from when group members communicate using musical scale information. In this excerpt, C looks towards me and leans towards the neck of the bass to obtain information directly from the musical instrument. The second difference is that I wait for C to see if he is playing the right thing before moving on, making sure there was no misinterpretation. Hutchins (1995a) states that a "good interpretation is one that is both internally consistent and in agreement with the available data. Evidence from the world makes some of the hypothesis of the interpretation more or less likely". I am not only a source where information is outputted, but I act as a mechanism that helps C to create a correct interpretation of the bass notes. The implementation of how the representational states propagate in this episode is different to when C and A were seen to work in earlier excerpts. Participants C and A used musical labels and musical instruments to distribute knowledge, which is not the same as C listening to the bass amplifier, looking at the neck of the bass and then mimicking what I play on the guitar. Whilst the implementation is different, the outputs are the same because in both cases knowledge about

the composition is distributed from one musician to another. This partly explains how music bands like *Young Band* share knowledge without using musical scale information, which may also explain why there are no IAs used to pass information from one person to another. The musicians can work directly with each other to transfer knowledge.

Playing by ear: Thus far, the excerpts demonstrate the need for musicians to unpack musical ideas created in performance (i.e., determine the names for elements of the sequence) in order for other members to coordinate what they play around the same types of musical information. This makes it more likely for the group to be working towards one unified goal. However, there is a method that dispenses with the process of unpacking musical ideas for the sake communication. Possibly the most effective method by which knowledge propagates in the rehearsal session is when musicians *play by ear*. The term *playing by ear* is used amongst musicians to refer to playing music with others, especially something they may not have played before, without needing to talk or write information about what to play. It is essentially a means of being able to transform information solely by hearing something played on another instrument. In principle, musicians who understand what they have to play do not need to communicate information such as “diminished”, “B flat major over a B flat chord”, “major 7^{th}s”, and “doesn’t have a 3^{rd}“. They also do not have to go through the process of learning from others in the way that C and I were described to work together (section 4.3.3.1).

Musicians in the study group demonstrated the ability to play by ear on many occasions. In Session Two (01:16:25) I was playing a bass line whilst H and A were in discussion. Without any notification participant A leant forward to her keyboards and played a set of notes that sounded harmonically in tune with what I played. H was also able to play a set of notes that was harmonically in tune with us, either as a result of what I was playing or what A played. Another example of this occurs earlier in the session (01:03:39) where C played a sequence that related to what A was playing at around (01:03:27). This is a good example, since what A played seemed to be spontaneous and different to what the group had been observed to be playing. There were no verbal communication or written notes passed between A and C prior this performance and there were no existing references within the two sessions and hence no internal notion of the piece of music. The musicians, therefore, showed that they can make choices about what to play simply by hearing what others play.

The biggest problem with playing by ear is that it is neither easy nor possible to do it all of the time. When musical notes are played individually, they are easier to determine than a chord that utilises several notes played simultaneously. The harmonies produced make it difficult to

distinguish between all the components. It may be possible to get some of the notes correct but possibly very difficult to get all of them, unless one has a good ability for it. In addition, as *Young Band* stated in Chapter three, musicians may not be able to pay attention to the full details of what the others play because they are themselves busy with their own performance and/or the volume of the sounds of some instruments are louder than others making it difficult to pick out what is being played.

Written notes: My findings suggest that written notes were used mainly to reference information when participants attempted to recall something they had previously played, and to communicate information about what was written to someone else. At the beginning of the first session, participant H read from her book to describe and play something she had created outside of the session. Participants A, C and H all looked at their notes in Session Two when it was time to play the second composition. Participant A in particular looked towards her notes frequently during performances.

In the main, the notes made by participants A, C and H were related to musical scale information. For example, C's written notes (figure 4.12) show the name of the composition *Jazz Tune* and a set of chords below it. The product of the conversation in Session One - when C declared *"Just think of it as a B flat major" <plays a chord whilst plucking individual notes> "and that's the E flat" <plays chord with a strum>* - can be seen in C's written notes. This is illustrated in the top right figure (Bb over Eb).

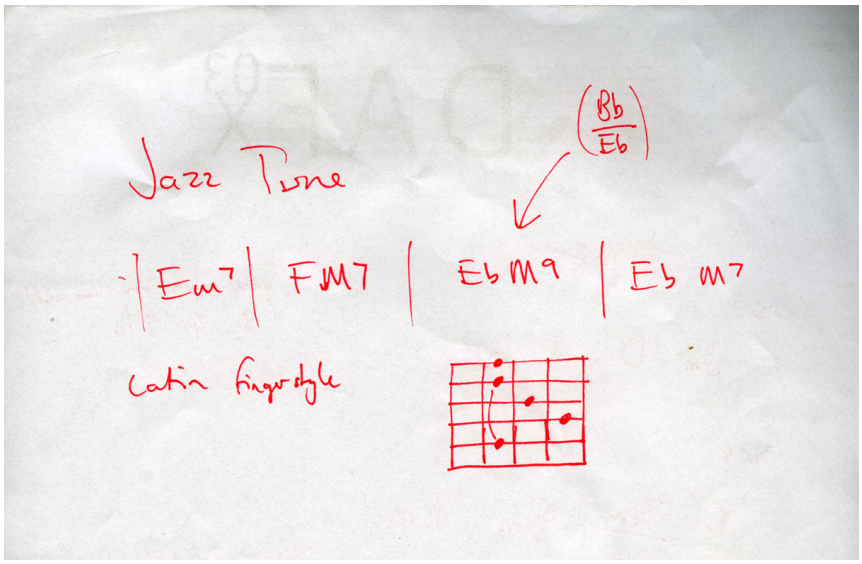


Figure 4.12: C's written notes

As a reader of the written notes, C can determine a set of chord names and their order (left to right) for the composition *Jazz Tune*. There is, however, no information about the other components of a composition (i.e., tempo, rhythm, structure and so forth). Figure 4.13 (participant A's written notes) has four chords written down which run across left to right and are meant to reflect figure 4.12 (participant C's written notes).

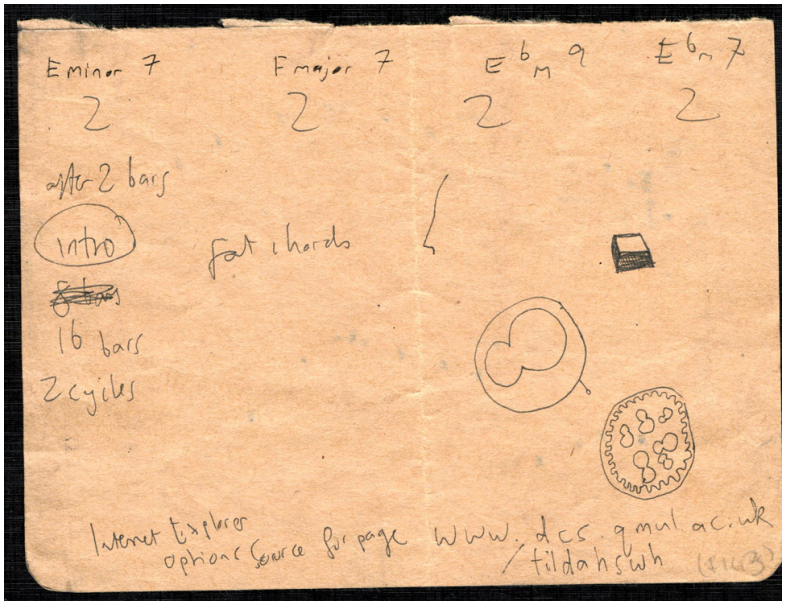


Figure 4.13: A's written notes in second session for composition 'Fritz B[3]

[3] The composition referred to as *Fritz B* is the same at *Jazz Tune*. The name was not settled on by the group.

There is a clear relationship between two sets of written notes because they contain the same chord sequences. There are also similarities between A's written notes in figure 4.14, which were brought into and amended in the final session, and C's written notes in figure 4.15, which were brought into the second session.

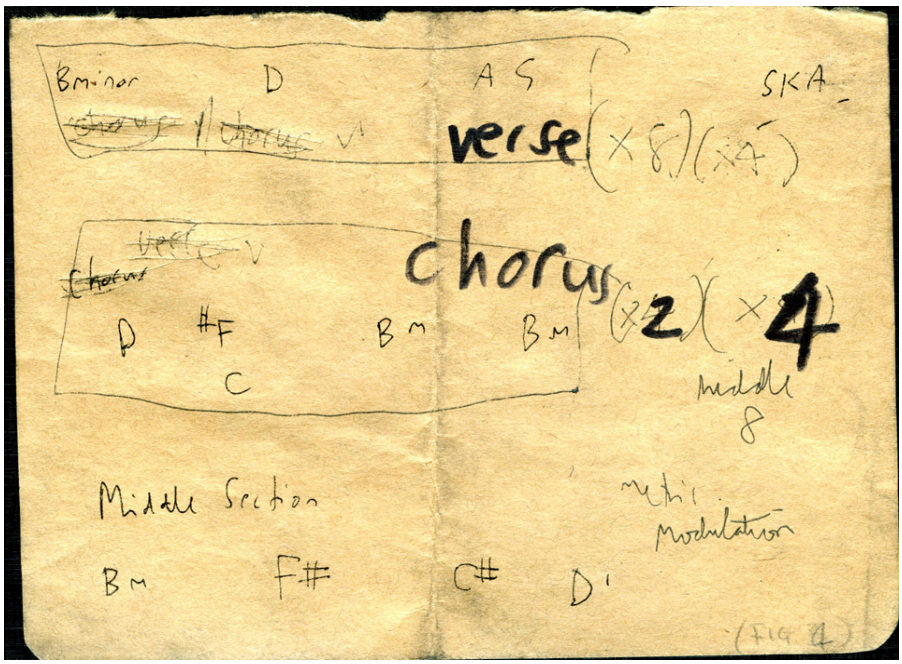


Figure 4.14: A's written notes in final session for composition 'Sha Tune' / 'Ska'

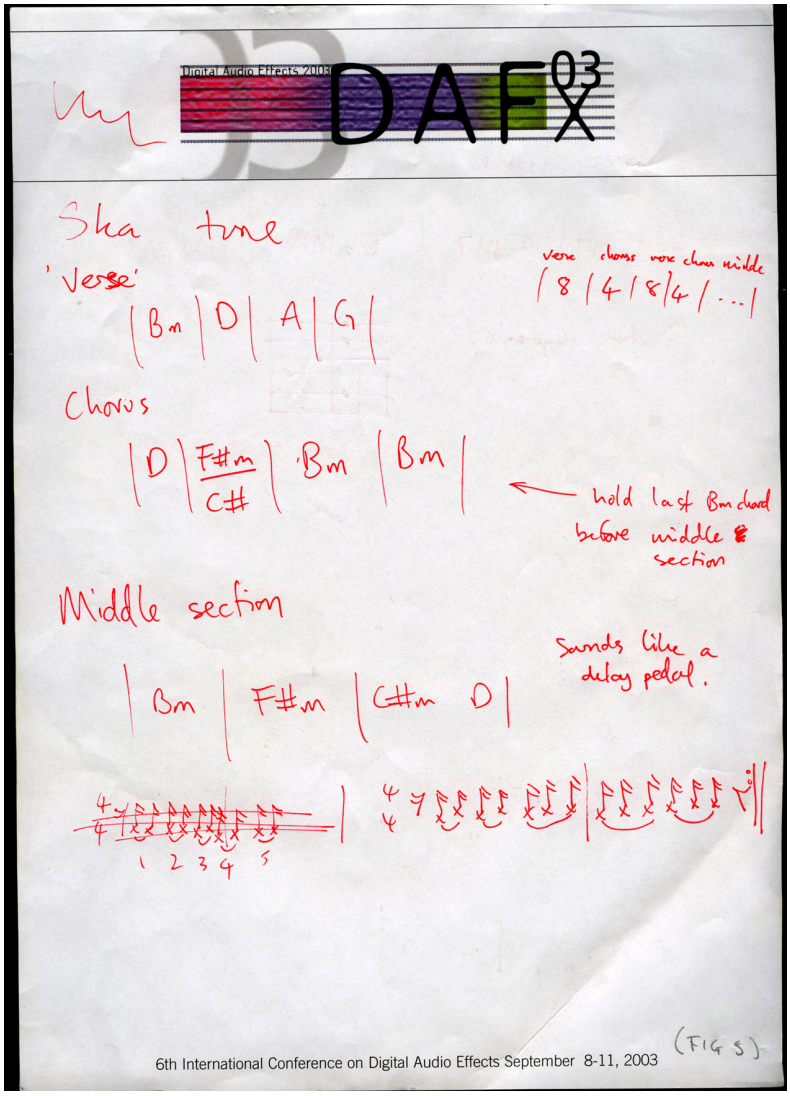


Figure 4.15: C's written notes part two

The similarities between the two sets of written notes shows A and C played roughly the same chord sequences. This reaffirms an earlier point that information may be described in the same way across the group even though the physical implementation of playing each instrument is different. However, information recorded on paper did not always help participants to determine exactly what was played; they simply helped to constrain the choice about certain positions musicians could place their hands.

Participants in the study usually referred to each other to fill the gap in knowledge between what was recorded on paper and what was previously played. For example, in the beginning of Session Two, C provided a guitar guide to A and H who were looking at his written notes (see figure 4.16). Whilst participant A had knowledge of musical scales and written notation, C's

written notes did not provide enough information for her; they simply describe the chord names. The written notes can be seen as saved representational states of guitar chords, which act as a pre-computed sequence of certain elements of the composition. The combination of a written reference along with the musical, verbal and gestural information was a means to help create a shared understanding of what was written down.

Figure 4.16: C illustrating what his written notes represent on the guitar

This illustration demonstrates that information on written notes used for the purpose of communication has limited function in JMC, unless there is a commonly shared notion of what the information represents in musical sounds. The same information given to someone outside of the room may yield different results even if they know how to read information relating to musical scales. Of course if some shared perspectives have been established, written notes can be physically passed around as IAs to propagate knowledge. For example, figure 4.17 shows H physically passing her written notes to A who asked to see the chords.

Figure 4.17: H passing written notes to A

I have outlined four ways in which representational states created at the local level propagate and transform. This includes musicians using musical scale information described verbally, mimicking what someone else plays without using musical scale information, playing by ear and exchanging information recorded on paper. Whilst the first three methods are common to most music bands that I have observed in the Westbourne Studio studies, the use of written notes, such as those created by participants A, C, and H, is far less common. However, their use highlights important influences in the cognitive system, especially when reconstructing knowledge that is distributed across the system and across time.

4.3.4 Reconstructing knowledge that is distributed across the system and across time

One of the defining features of music composition is that it can involve more than one session of work for a composition to be completed. In addition, in JMC the distribution of knowledge is not always structured in a particular sequence where one individual's task or need is addressed before knowledge reaches another individual. More often than not, a number of activities overlap across a number of individuals and artefacts in order for knowledge to be distributed. I will describe an episode that highlights how the system brings together local actions to support the reconstruction of knowledge about a composition in a new session. This example illustrates

how the mechanisms that supported the propagation and transformation of representational states described in 4.3.3 are used.

Reconstructing knowledge in Session Two

Figure 4.18 is an activity chart that illustrates how several local activities take place simultaneous to a single global guide. The outcome of these activities meant that knowledge was reconstructured about a composition that was last played in the previous session. The chart maps areas where the musicians made verbal comments, played an instrument, and when they came in contact or looked towards their written notes. Prior to 01:40:40, where the illustration begins, I, as the bass player, had begun to talk about the end section of the composition which was the last thing we were working on before we ran out of time in the previous session. I had started to play the bass lines that I remembered and was coordinating what I thought others were playing. The activity chart illustrates that information from one person was broadcast across the group, and whilst this information was broadcasted, others used paper and their musical instruments at different points to start to remember what they were playing in the previous session.

Figure 4.18: Activity chart for recommencing work

Figure 4.18 illustrates that the bass produces the most constant output throughout this episode. Whilst I played the bass, the other musicians were involved in activities that appear more relevant to what they have to know for themselves. For example, C does not play guitar between 01:40:55 and 01:41:15. He is seen to pick his written notes up from the floor and place

them slightly to his right. He also adjusts settings on his guitar and readies himself to play. I have coded his action as playing guitar at 01:41:15, but he is not playing along as he would in a real performance. Instead between 01:41:15 and 01:41:31 C is involved in working out what he should be playing, looking back and forth from his written notes. He is also playing softly and quietly, performing the section not confidently. During this section of analysis both A and H appear to be involved in similar type of activities similar to what C was doing (i.e., actions more associated with supporting local functional system). H only comes to play what she played in the previous session at 01:42:05 when she declares “Oh right right right”. She looked at her written notes and by 01:41:45 had failed to play what she played in the previous session. She picked up her written notes for a second time (at 01:41:51) and turned the page. By this time she had been exposed to the same set of chords being played by me for over a minute, accompanied occasionally by C and A. It is not entirely clear whether she recalled what she played from looking at the page, listening to others or a combination of both. Regardless, this shows that the system reconstructs something closely related to what was played previously, by having at least one global guide helping several local functional systems to negotiate what was previously played.

Figure 4.18 is effectively a visual snap shot of the system using verbal communication, and artefacts whilst in the process of reconstructing knowledge about a particular section of the composition that was played previously. This snap shot shows that knowledge is not reconstructed across the system at the same time. Participants A, C and H each appear to recall what they played at different times. In addition, they each referred to the written notes at different times, and in different ways. What was common was that they were able to play musical instruments, take in information at the global level (i.e., listen to me) and at the local level (i.e., reading their notes and looking at their instruments) in this process. IAs like written notes may not seem appropriate to look at during improvisation because improvisation is about exploration of new ideas which requires musicians to focus on what they play whilst listening to others. However, when ideas are starting to be defined there is more flexibility to use different sources of information, as illustrated in 4.18.

Whilst the episode described in 4.12 shows a number of external resources being used, the key resource used to reconstruct knowledge about the composition was the internal memories of the musicians themselves. The musical instruments and written notes only became useful when there was some agreement with what one of the musicians could remember about the composition. The following episode illustrates that problems can arise if there is a disagreement between musicians’ memories of what was played previously, regardless of the artefacts available.

Breakdown in knowledge: conflicting views of the composition

Studying the recommencement of the first composition in Session Two reveals that we had different notions about the properties of the composition from the last time we played. Part of the problem lay in the fact that the properties of the composition had changed during the first session, and we appeared to have remembered different aspects of it when we resumed work. When C and I started to play the composition together, we played the composition using the musical properties of the last jam of the last session. Participant H appeared to struggle to play her violin part over this because she actually never played it over the guitar and bass line we were playing. The problem was not resolved when she looked at her written notes; in the video she is seen throwing the notes on the floor stating “it's difficult to look at this” (00:16:23). Whilst C and I use the musical properties relating to what we played in the last jam of the previous session, H uses the musical properties of what she played in the beginning of the previous session. Therefore, we use different musical properties that relate to different jams, which do not work together. This finding was only made evident when I reviewed the videos of the sessions after the study was completed. Within the session none of us could figure out why the sections were not working together.

The notion of changing properties of the composition and what people can remember of it is important to the reconstruction of work session to session. Since the primary view of the properties of the composition appears to be represented internally by the musicians, the situation could only be resolved by reconstructing what we knew and agreed on through trial and error.

Session Two:

00:17:21 H to S: Ok right … you just do do first bar and the hold the last note for about … so it’s da da daaaaa” <clicking fingers to signify tempo>

The “da da daaaaa” was language that she also used the first time she attempted to introduce the bass line in Session One (00:01:28). After I played the bass line, H was able to play the violin part better than she did previously. At this point, we started moving towards H’s idea. The reconstruction of knowledge continued through communication.

Session Two:

00:18:30 S: alright ok…last last week it was 2 2 4 wasn't it so it was 8 wasn't it
00:18:33 H: yeah
00:18:34 C: yes
00:18:35 S: let's see
H: let's try it that way because even if you if you play it like that by the time C comes in with some chords and stuff then the last set of four won't be the same chords it would be two different chords

As this episode continues, information about the previous session is recalled that reveals we had made mistakes in the compositions structural information.

00:22:56 S <playing bass>
G <playing guitar>
00:22:59 S: I see I see we did 1 1 2 didn't we?
G <playing guitar>
00:23:03 H: Oh did we?
00:23:04 S: Yeah

Twenty three minutes into the Session Two video, and several jams and discussions later the sequence played by C triggers my memory about the previous session. The information represented in the language "2 2 4" was in fact "1 1 2". What this means is that we were playing the sequence twice as long when playing 2-2-4 than when we were playing 1-1-2. This meant that H's solo was not working correctly even though it sounded familiar. When we resumed the session, we mixed the details of each section and it took many minutes to come to an agreed resolution in how to proceed. Even when we did resume work, the videos show that we did not have a direct continuation of where we left off in the previous session, but instead fragments of ideas that are generated in Session Two along with what we could remember and agree of the properties of the composition from Session One.

4.3.5 Reflection on findings

The need to create a convergence on information at certain points of the session appears to be an important feature of how compositions progress to become more structured in JMC and how new ideas can be introduced. Information written on paper was one way that helped some musicians to converge on information at different points. Two sets of information seemed to be useful to represent on paper for three participants: information about chords and notes and information about the compositions' structure. However, information on paper did not cover everything that was played, certainly not every variation of each jam. Whilst the composition was potentially changing with every jam, the written information was relatively static. Participant

A did update the number of times each section of one of the compositions was being played as it developed, but this information was localised (i.e., recorded on her own piece of paper). The information could have been useful to others because we had to coordinate playing the same structure together.

As it stands, there is no central resource or system that supports the group as a whole to easily record and share information. Systems do not need to be complex. In Session Two H stated "where is a whiteboard when you need one?". Her comment was based on a conversation about one of the composition's structures, where she was faced with the type of issue that G in *Young Band* faced in interpreting V's instructions about the composition. As in the Westbourne Rehearsal Studios, there were no artefacts used in the room to help externalise information in a shared context which helped to offload the burden of what the musicians had to remember and learn together. There is scope for designers to look at supporting the dissemination of information created locally and to support the representation of the changing states of the composition more easily across the group. One way to bring the JMC system together to manage the distribution of knowledge is to create an information trajectory that enables recorded information to flow across the system simultaneously. At the very least this would provide musicians with new opportunities to create recorded information locally and be able to disseminate it to others, and to converge on certain information at certain points. In this study, information on written notes was created by three people. Whilst some of the written notes were passed around, they cannot be described to be created and used in a shared context. Indeed, the creation of written inscriptions in a shared context in JMC is unexplored. Can they be used to tackle the issues caused by the changing states of the composition, for example support a group when working without global guides or when there is a conflict of what people remember? These issues will be investigated in the next chapter.

4.4 Summary

A lab based study of a group of four musicians was set up to investigate JMC in a more controlled environment than sessions observed at Westbourne Studios. The key theme that I have discussed in this chapter relates to the way information created at the local level is distributed across the system to support the progress in JMC. My study findings suggest that ideas proposed in composition development, for example new musical notes or chords, or changes to the structure of the composition, were often initiated by one person but involve many people to bring to fruition. The process revolved around one or two individuals resolving an issue and distributing the knowledge across the system. This knowledge can be created and disseminated in a number of ways. In this study musicians used a number of representations

which required different forms of implementation for representational states relating compositional information to propagate and transform. Musical scale information represented in verbal or written form helped constrain the decisions that musicians had to make when playing their instruments. Playing by ear meant that musicians could rely solely on sounds created from instruments to decide what to play. Mimicking someone by listening and looking at what they play was also a way for representational states to propagate. Paper containing musical scale information was sometimes passed around to help information to propagate, even though it required someone to demonstrate what the notes sounded like. The written notes by themselves mainly helped to constrain the choice of where to place fingers on musical instruments for certain elements of the composition.

The activity chart of how the group reconstructed knowledge about something that was previously played illustrated that knowledge is not reconstructed across the system at the same time. In addition, the musicians used resources such as the global guide (e.g., the bass line), written notes and playing their instruments at different times and in different ways to bring about a memory of what they played previously. These external resources mainly became useful when there was some agreement with what one of the musicians could remember about the composition. Conflict between what people remembered caused problems in reconstructing knowledge about a composition in development. Since the primary view of the properties of the composition appeared to be represented internally to the musicians, the situation could only be resolved by reconstructing what the group knew of and agreed with through trial and error.

In this chapter I pose a question about whether an information trajectory that enables recorded information to flow across the system at the same time will support the distributed nature of problem solving in JMC.

Chapter Five: The impact of shared IAs in supporting the distributed nature of problem solving in JMC

5.0 Introduction

In this chapter I present the findings of two studies that were designed to investigate whether the use of shared IAs supports the distributed nature of problem solving in JMC, and helps musicians manage the cognitive burden associated to compositions that are in development. In particular, I aim to explain how IAs supplement existing mechanisms that help knowledge propagate across the system to support progress in JMC.

My findings suggest that whilst the two study set-ups were different, the groups had similar needs in converging on certain information in a visual and more permanent form at certain points of JMC. The ability to reuse representations created in recorded form, represents both abstract and more worked out information about the composition, and offload the cognitive burden of remembering long streams of transient information provided opportunities for musicians to distribute knowledge and develop ideas in a different way to what was illustrated in chapters three and four.

5.1 Studying JMC in altered rehearsal set ups

In chapter four I stated that information written on paper was used mainly when participants attempted to recall something they had previously played or to communicate information about the composition to someone else. This provided two main benefits to musicians:

1. It helped them visualise and externalise information that could be used at later point, a form of computational offloading.
2. It aided the transfer of knowledge about the composition, because written notes were passed around between participants. This was one of a number of ways in which knowledge was seen to transfer across the group, supporting the distributed nature of problem solving in JMC (i.e., where one person distributed knowledge about a problem that was solved at the local level).

In both chapter three and four I illustrated that certain information was important for all musicians to be aware of in order for the composition to progress. Whilst it was potentially not important for all members to be fully aware of all of the compositional information all the time, there were instances where musicians had to converge on a shared understanding of the compositional properties in order to better coordinate a performance or introduce new ideas. However, whilst the groups converged on information using musical instruments accompanied by verbal and gestural communication, there was no central resource that helped them visualise and externalise information in a more permanent form within a shared context. To investigate how such a resource impacts the way knowledge is distributed in JMC, I conducted two studies in two different lab based settings. In Set-Up A and Set-Up B the musicians were given a tool that enabled them to make inscriptions in real time on a shared digital notepad. Both groups also had a single audio recorder/playback facility that was operated by one member. There were variations in the set up of the two studies as described below:

- Set-Up A involved three musicians composing music in the same location who were able to see each other
- Set-Up B involved three musicians composing music in the same location, but without the ability to see each other

Set-Up B was very different to other studies I had made because the musicians did not have visual access to each other's performance. The main rationale for this set-up was to determine whether the musicians would use the shared written space in a different way to musicians in Set-Up A in order to compensate for the lack of visual information from other group members. Despite the differences between the two studies, my findings suggest that the groups had

similar needs in converging on certain information in a visual and more permanent form at certain points of JMC, regardless of the differences in human participants, musical instruments and even visual access to performance between musicians. I aim to highlight how this need is reflected in the technologies that are provided for them, and how it is used to support the distributed nature of problem solving in JMC.

5.1.1 Study Set-up

PC Tablets and OneNote application as a shared IA

In order to provide an IA that enables written inscriptions to be created and shared in real time, I used three PC tablets that were connected via a wireless network. I installed Microsoft OneNote software, a word processing application that uses stylus input. See figure 5.1 for a view of the interface. The application allows a session of work to be created across multiple tablets whereby each shares the same virtual work space on the tablet. Therefore, markings made on one tablet will be seen by people using other tablets. I provided a stylus as an input device which allowed participants to make inscriptions on to the tablets much like they would make inscriptions using pen on paper. This was inspired by the *Music Notepad* (Forsberg et al. 1998), which provides a facility that enables a user to enter hand written musical information using a stylus on digital tablets. OneNote potentially provided familiarity for participants as the interface looked like a notepad.

Since none of the participants were experts in using the PC tablets, I set up them up at the beginning of each session. To save time in connecting each tablet I opened the same page that the group had last saved in the previous session, making it easier for the musicians to find the information that they last worked on. Within each session, the group had the opportunity to work on the information that they had created from the previous session, scroll down the page, or open a new page in order to create a new space to work.

Each musician was given the same tablet to use for each session. In order to help me keep track of who made the inscriptions, I designated a colour to each participant, which I set up for them.

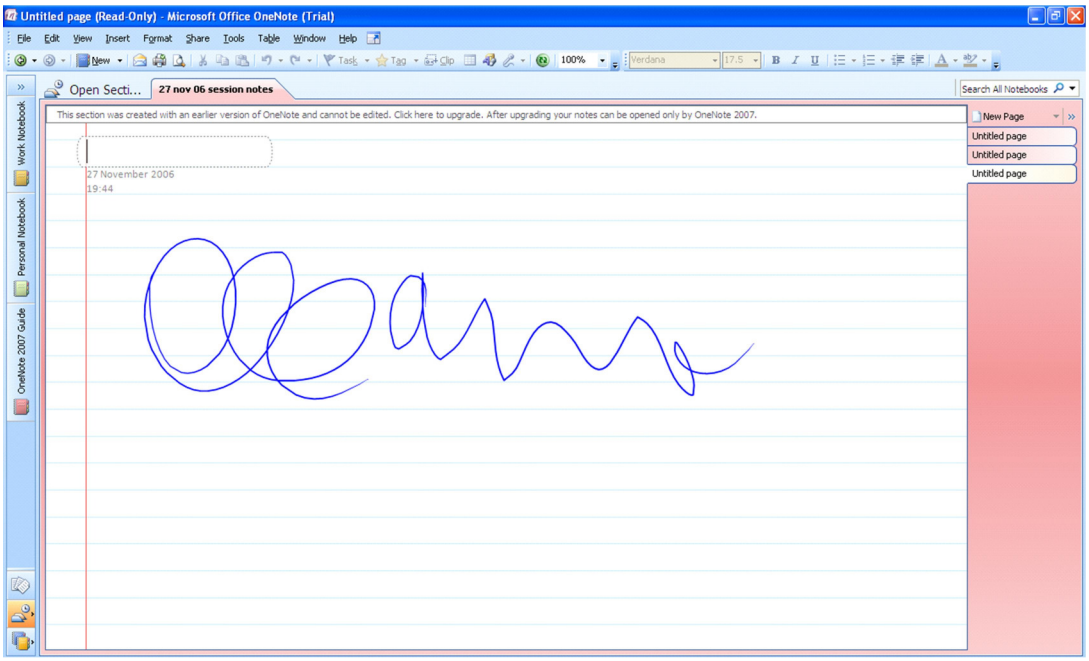


Figure 5.1: Microsoft Office OneNote interface

Impacts of technical failure within the studies

In both Set-Up A and B, technical failures occurred with the PC tablets that required me to intervene. This is not too dissimilar to how a technical failure with equipment would be resolved within Westbourne Rehearsal Studios. The person working at the studio would usually be called into the room to resolve the issue if the bands could not do it themselves. In the periods where technical failures were being resolved, the participants in the study either took a break or continued to work.

Whilst the technical failures in Set-Up B were minor and occurred two times in three sessions, Set-Up A suffered a more significant problem that required me to withdraw the tablets for about 45 minutes (00:43:30 to 01:28:48 of video) in session two. Whilst the tablets were withdrawn, the group in Set-Up A continued to work, even though it disrupted their flow of work. For the purpose of this study, this disruption actually had great benefits because it inadvertently highlighted the extent to which participants in Set-Up A had become reliant on the tool. For example, one participant had to copy information from the withdrawn tablets on to paper when he failed to remember what he played; he actually could not continue to work without getting the information off the tablets. This was interesting because it appeared that he relied more heavily on the compositional information recorded on the tablets than his own internal memory.

Recruiting musicians for participation

As in chapter four, I targeted musicians who were proficient at playing their instruments. Their composition expertise, and experience in playing in groups was a secondary consideration. My selection process was not influenced by the genres of music that musicians had experience in. In addition, I did not discriminate on the grounds of the sex or age of the musicians.

I advertised in several places including the Queen Mary university campus and London community social networking sites used by musicians (i.e., www.gumtree.co.uk, www.musofinder.co.uk). Out of the six musicians used in Set-Up A and B, four were recruited on the Queen Mary university campus, and two were recruited on-line through www.gumtree.co.uk.

A task information sheet was sent out electronically to potential participants. This gave details of the study including how many questionnaires they would fill, the remuneration package, location of the study and my contact details. Musicians were asked to bring their own instruments, but they were informed that supporting equipment such as amplification would be provided. The musicians were told that they would be paid GBP 7.50 for each session they attended. The total sum was paid at the end of the final session.

Instructions to selected participants

Participants who were selected for the study were forwarded a second task information sheet. It was a briefing on what to expect within the study and the sessions. They were told that they would meet their group in the first session. They were informed that their task was to create a composition in three weekly sessions, each lasting two hours. They were asked to bring anything they needed to help them create a composition, or otherwise inform me so that I could provide it for them. They were told that they were welcome to bring ideas to the group and that the group could decide how to use the ideas. They were told that in the final session they would have to make an audio recording of the composition for someone outside of the group; this was to create an end objective and time frame.

The information sheet explained that the seating arrangement may be determined by me and that some groups “may be asked to work in the same room but with barriers that inhibit visual contact between each member”. Participants were also informed that additional artefacts such as a PC tablet may be provided in their set up. The information sheet explained that if the

participants had a problem with the altered setting, they should contact me before the study commenced.

Dissemination of recorded session material

There was at least one member within each study group who expressed a desire to receive materials recorded within the sessions. Therefore, after every session, I emailed each participant audio recordings and written information that the group created using the IAs in the room. I was involved in this process because the information was recorded on University property, which meant that participants did not have access to it once the sessions ended.

5.1.2 Data capture

There were three methods for data capture within this study: video recordings of all sessions, my observation notes, and questionnaires that participants were asked to fill out before and after sessions.

Video

Two videos were recorded covering different angles of the rehearsal space capturing all musicians for the whole session. Each video lasted two hours and captured the sessions in full.

Observation notes

I sat in on all sessions and took hand written notes of the sessions, which focussed on key work episodes similar to what was suggested in 4.2. I noted down some of the misunderstandings or problems that occurred within the episodes of work as well as new ways in which I thought musicians were communicating and representing knowledge about the composition.

Questionnaires

For each session, participants filled out a pre-task questionnaire at the beginning of the session (see appendix G and H) and a post task questionnaire at the end of the session (see appendices I and J). In the end of the final session, the participants also filled out a post study questionnaire (see appendices K and L). These questionnaires were issued before and after each session, and were collected when participants indicated they had finished. I used the questionnaires to learn more about what participants themselves said about issues that

mattered to this research (e.g., did they have more or less difficulty than normal in obtaining and remembering musical information?). The questionnaires also informed me about activities that may have taken place in between sessions that account for certain behaviours within the session observations. I also asked to obtain copies of written information that was brought and used during the sessions once the study was completed.

E-mails

The participants in the group asked for their e-mail addresses to be shared in order to have the ability to contact each other. I asked the group to involve me in their e-mail exchanges so that I was aware of activities outside of the session. Some participants used e-mails to inform others that they were working on the compositions; however, composition information was never exchanged. E-mails were also used to request changes in the session days or times. I used the mailing list to distribute the recorded material but I never discussed anything about the sessions or the compositions with the participants.

5.2 Analytical Framework

The analytical framework used in this chapter was the same as the one described in 4.2. The analysis focussed mainly on the way information flowed across the system based on key episodes of work. As in chapter four, I focussed on episodes of work that involved transferring knowledge of musical properties and composition structure from one musician to another, developing the composition beyond its current state, and re-constructing knowledge distributed across the group and across time.

5.2.1 Stages of analysis

As described in previous chapters, videos were first reviewed and key episodes were time stamped. The observation notes were also referenced to determine areas of interest. The transcription of actions and communication was conducted within and between performances in much the same way as described in chapters three and four.

Describing the propagation and transformation of representational states in key work episodes helped to outline some of the changes that had taken places as a result of the introduction of the PC tablets. To get a more complete understanding of the impact of tablets, I also tracked the use of the PC tablets outside of key episodes I had marked out. This involved tracking

usage through the three sessions, including periods where people may have looked towards them during conversation, not just when they actually manipulated them or referred to them in communication. In addition, I used the answers to the questionnaires to get an insight into what the participants themselves were saying about their use of the IAs and the conditions under which they were asked to compose music. It must be noted that whilst the participants' use of IAs was of great interest, I did not solely focus on this. As in previous chapters, I analysed the way representational states propagated across the system in a number of key episodes. Within this chapter I mainly present findings that relate to the use of IAs because I want to illustrate the changes that take place within JMC. However, my conclusions take on board all findings relating to the way representatonal states propagated across the system. It was important not to skew the findings by focussing solely on the information represented in one particular medium. It was also important to show the different means by which information flow could have occurred and rationalise why the IAs were used at certain points. The findings from the analysis were used to form a judgement on how the IAs supported the distributed nature of problem solving in JMC.

5.3 Set-Up A

Set-Up A was a face-to-face environment that included the PC tablets and OneNote application. In addition, a portable digital audio recorder was made available to one of the participants. This enabled him to record and playback the audio as and when he decided or when he was told to by others. In the Westbourne Rehearsal Studios studies, one person was also required to operate the device for audio recording and playback, either on their own accord or when they were asked to do so by others.

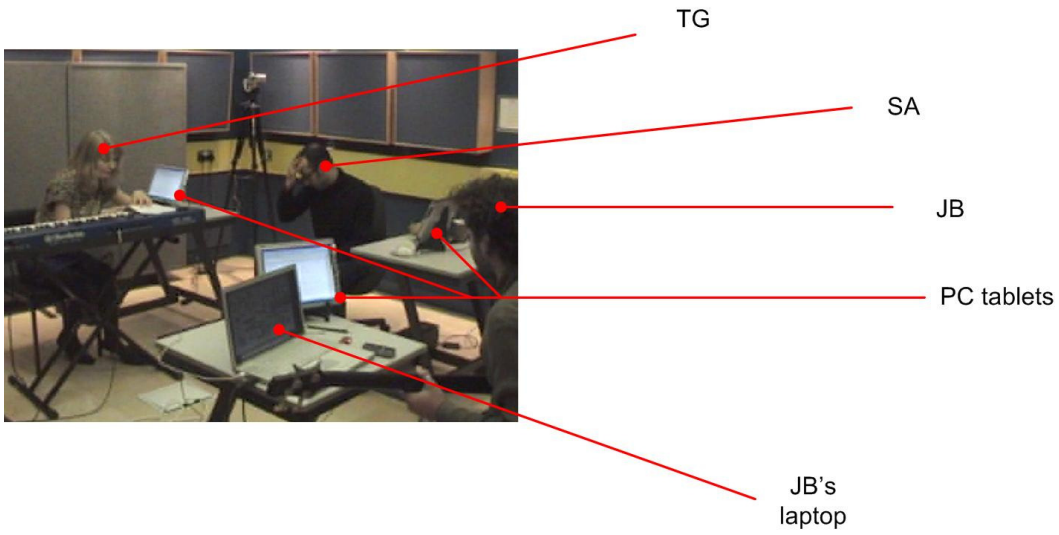


Figure 5.2: Set-Up A camera one angle

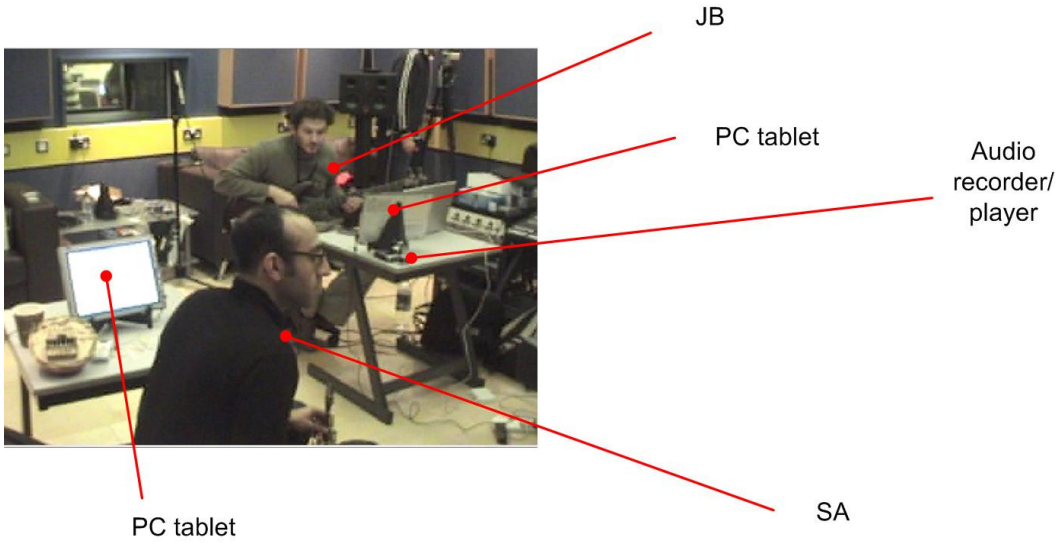


Figure 5.3: Set-Up A camera two angle

5.3.1 Participants

The participants in this study were JB (bass), SA (saxophone) and TG (keyboard and vocalist). Full details about the background of the participants can be found in appendix O. All members of the group in Set-Up A stated they liked to play Jazz. Based on my understanding of Jazz music, I suggest a bass player, keyboard player and saxophonist are able to create a Jazz composition. The bass and keyboard can provide rhythm whilst the saxophone can act as a solo instrument. Putting together a group of participants who play a common genre of music is important as it is likely to help them compose together, even though they have not worked together before in a set up that is not typical to how Western Contemporary compositions are created.

5.3.2 Layout

In chapter three, the ethnographic studies suggested that musicians in their natural rehearsal setting often positioned themselves in relation to where others were situated, and in relation to the position of the equipment they were going to use. They also usually maintained a position that enabled them to see others in the group. These findings are reflected in the layout of Set-Up A; see Figure 5.4. The new IAs introduced into the room required extra equipment, such as tables, to also be placed in the set up.

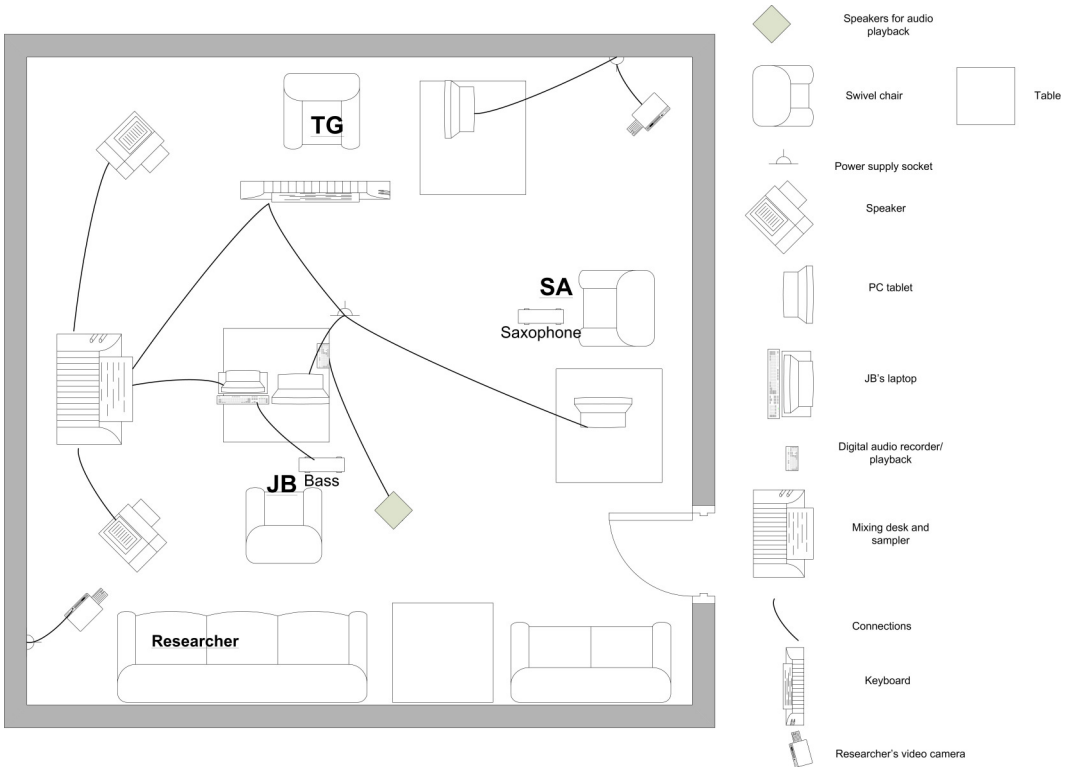


Figure 5.4: Set-Up A layout

The open layout allowed the participants to move around. On numerous occasions SA walked to TG's work space to look at pieces of paper she had laid out, and sometimes to highlight areas of the TG's keyboard he was making references to in his communication.

5.4 Set-Up A Findings

In this section I will present findings that help to illustrate what the group was able to do with the new information trajectory and how it impacted the way knowledge was created and shared across the group. In particular, I will illustrate how the new resource supported the way the musicians handled the issues raised in chapter three and four (e.g., managing the cognitive burden associated with compositions that are in development and supporting the distributed nature of problem solving).

5.4.1 Use of sketches to support shared understanding

The examples illustrated in this section demonstrate new ways in which a group involved in JMC were able to support shared understanding. The group in Set-Up A started the first session

with high level ideas about the types of musical scales they want to play and how they wanted the composition to develop. They explored their ideas through discussions and musical demonstrations. This exploration was reflected in the written language that developed through the use of the PC tablets. Drawings were used to describe potential elements of the composition as it progressed. These sketches were often referenced in communication within the system, and as a result verbal language initially associated to aspects of the sketches became commonly used even when the communication did not refer directly to the sketches themselves.

Session one:

00:42:22	SA:	erm and then I think from there <looks at tablet> we basically do essentially that kind of thing but ramp it up that much more quickly
00:42:31	TG:	ok?
00:42:32	SA:	erm in terms of just overall intensity
00:42:34	TG:	are you thinking about the middle section now?
00:42:35	SA:	no I am think actually about <looks at screen> the
00:42:38	TG:	the first section
	SA:	well I mean I mean <picks up stylus> ok if you want to take this metaphor <looks to TG and JB> to ridiculous <laughs> sort of <looks at tablet> literal extremes then
	TG:	yeah
00:42:46	SA:	I'm I'm actually thinking erm <stylus on tablet> th th well really the take off erm the take off and landing and then and then wid and then weird stuff in the nother place <writing on tablet as he speaks> and then another take off and landing <looks to TG> to come home
00:43:00	TG:	ok? Alright?
	SA:	<stylus on tablet> so this so the bit we just did felt like this bit <looks to TG>
	TG:	<looking at SA's tablet> ooh mmm

This excerpt is taken at a point when the composition structure was emerging. When the group failed to agree on the locality of the reference in relation to the structure of the composition (i.e., TG asking questions at 00:42:34 and 00:42:38), SA used the tablet to reference a sketch that he had made earlier in the session, which mapped an idea about the structure. The tablets provided the opportunity to not only write culturally defined information that act as pre-computations (i.e., musical scale information), but also non-cultural forms of information, for example a sketch.

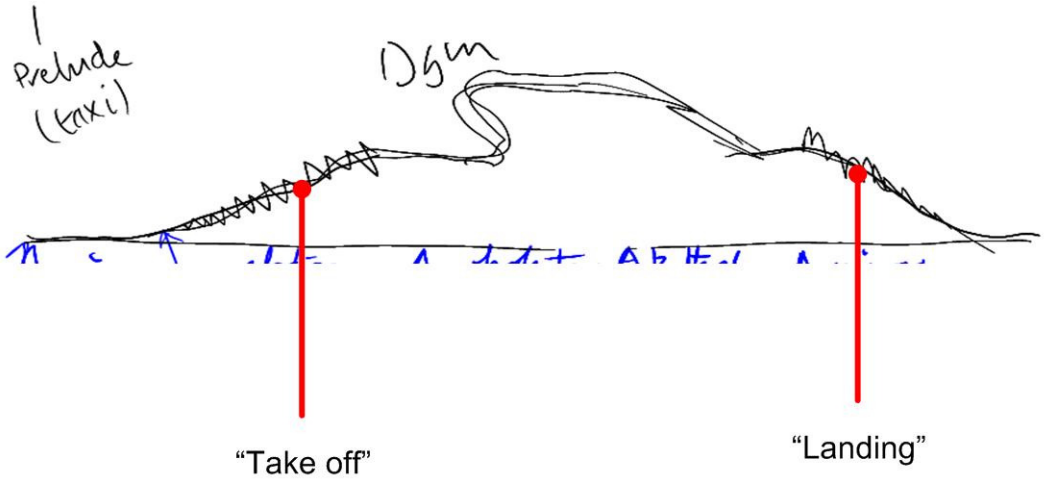


Figure 5.5: Verbal reference to a written sketch

In figure 5.5, I have marked where the words "take off" and "landing" refer to on the sketch. The participants did not label the sections permanently, but did refer to the words "take off" and "landing" through the three sessions.

Session one:

01:10:12	TG:	I mean do you want chords or?
01:10:14	SA:	I don't know <looking to JB> eee <looking to TG> I was talking more in terms of the texture....it is more open at that point <to JB>wha wha
	TG:	emm
01:10:24	SA:	what do you want to do?
01:10:25	JB:	what follows eh you mean
01:10:28	SA:	yeah yea the bit that follows after that yeah
01:10:31	TG:	Oh are you talking about the <pointing to screen> the **exotic bit** then
	SA:	<looks to screen>
01:10:36	SA:	I am talking about the the basically the **take off**

The words "take off" and "exotic bit" were not actually written on the screen but were used in relation to the sketch that SA had made along with his verbal explanation. SA often refers to "take off", "landing" and "exotic bit" as musical events. Though, TG and JB often ask SA how these musical events can be transformed in reality, they too use SA's terminology during the communication. For example, TG uses "lift off" at (session one 1:22:11) when she is unsure about the section of that SA is talking about. Even though SA does not mention lift off, TG makes this association: "wait a minute are you talking about <looking at the screen> the lift off or are you talking about a different section". TG also uses the sketch to discuss an idea with SA. For example, she points to a section on her screen and states "if we are in this upward slope ...

I thought that would be the bit where...oh yeah looking forward to the holiday" (session one 1:22:37). The lyrical idea relating to "looking forward to the holiday" is identified to be suitable for a section of the composition using the visual sketch as a reference. This demonstrates that the participants mapped information represented visually on the screen with information that they remembered internally. It is possible that the visual information may have provided a visual cue to the verbal references that were made, and vice versa.

The use of sketches to support the distribution of knowledge was different in the function it served to representations I described in previous chapters. The sketches allowed for more abstract and high level ideas to be shared and developed. The visual representations were later associated with the verbal language used as part of the communication to describe aspects of the composition long after the actual sketch ceased to be used. This in part appeared to support the convergence on certain elements of the composition at certain times, especially as references were visually available to all during communication.

5.4.2 Creating reusable representations

As discussed in chapter four, problem solving was often led by one person and the knowledge distributed to others. The difference in the study of Set-Up A was that the PC tablets became a shared space for knowledge to be distributed in a permanent form, which enabled some information to be recorded and reused by more than one person. Whilst SA was the creator of the initial sketches, other members built information around them to add to the representation. For example, when the composition started to form, TG used the space below SA's sketch to record information that had been generated about the chords of the composition. SA's initial sketch along with TG's written information acted as an ad-hoc representation of the chords and structure of the composition at that point.

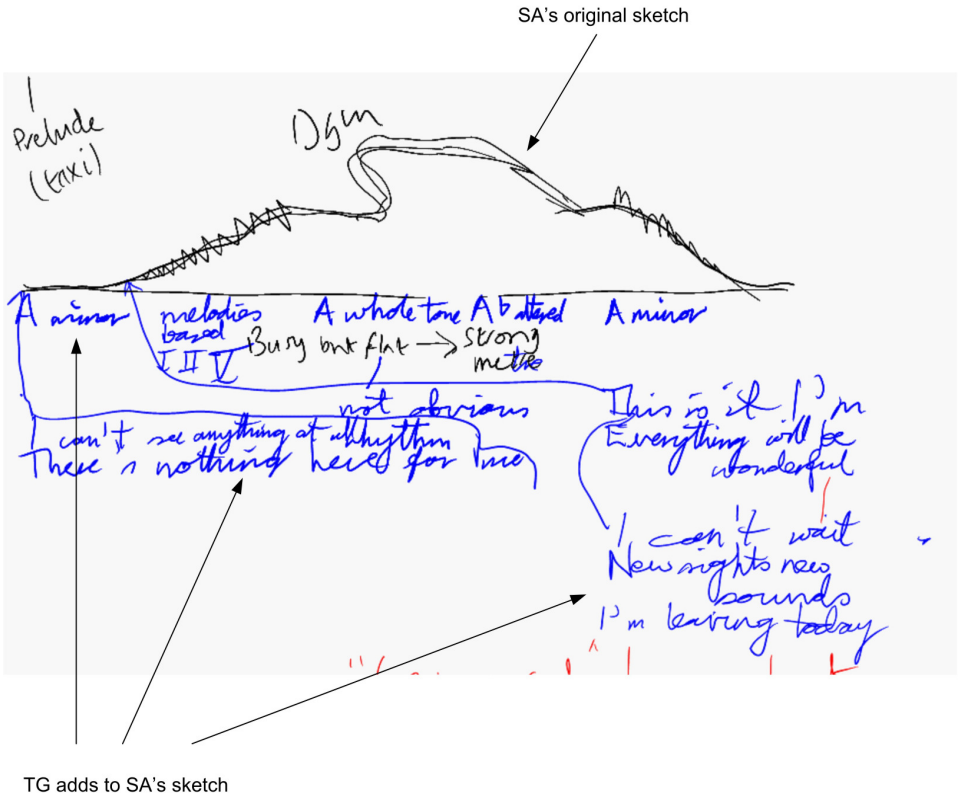


Figure 5.6: Composition development using written language

Figure 5.6 is a form of composition development using written information. Such an implementation of composition development is not possible without the tools such as those provided in the set up. However, I do not believe that such sketches resulted solely because of the availability of the PC tablets and the OneNote application. It was the availability of the PC tablets and the experience and method of work of the three participants that is likely to have contributed to the sketches. I cannot say whether three different musicians placed in Set-Up A would also produce the same types of markings. However, it can be said with some certainty that the visual nature of the information in a shared space enabled this particular group to build on the use of written language during the development of the composition.

5.4.3 Visualising the changing states of knowledge

The properties of compositions frequently change when in development. The group in Set-Up A illustrates how knowledge in the beginning of the development of a composition looks very different to when it has significantly developed, especially when using the PC tablets as a means to represent ideas. The group in Set-Up A illustrated that the PC tablets can be used to represent both high level abstract ideas and more worked out information about the

composition. However, not everything that was recorded was useful all the time; the information was seen to evolve as the composition evolved. This was particularly evident when a technical failure occurred in session two. As a result, the group effectively lost the information that they had created on the PC tablets. Once the tablets were reintroduced, the group did not try to recreate the information from the first session. Instead, they wrote down information about the properties of the composition that were most appropriate to represent at that point. Given that the reintroduction of the tablets occurred near the end of session two, the composition had significantly developed from session one when the sketches were made. In the first session, the group produced a plethora of information on the tablets. Most inscriptions were created in context of the communication of the group and therefore reflected certain language used in the conversations; they did not always represent information that directly mapped onto something that could be played on musical instruments. I suggest that the information was used to help the JMC functional system to bring together high level abstract ideas.

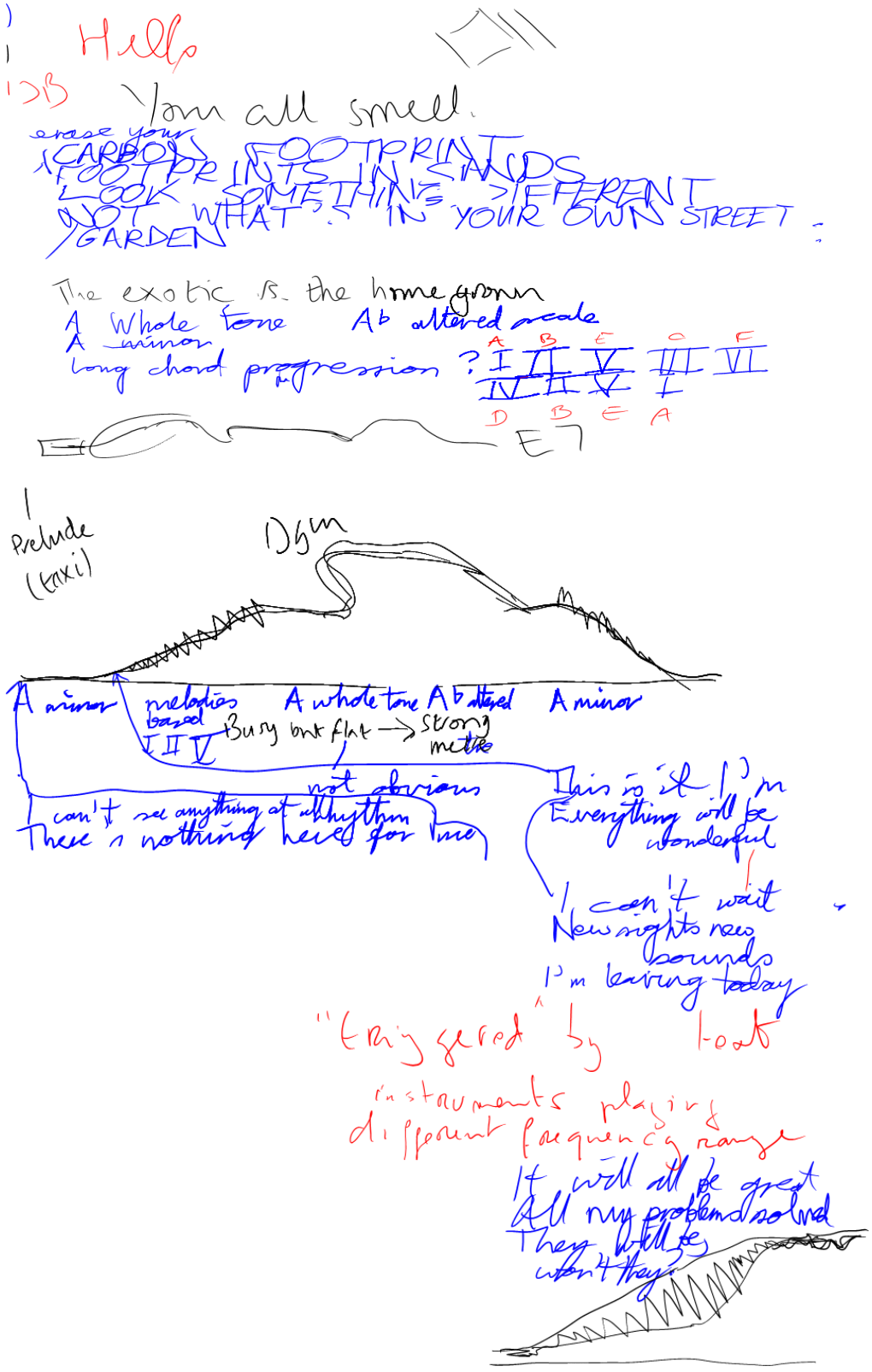


Figure 5.7: Set-Up A's PC tablet wrtten notes in session one

By the end of session two the composition had developed beyond the state that it was represented in figure 5.7. Each functional system had possibly formed an understanding of what they had to perform and were able to notate compositional information using musical scale information in written form. As stated in chapter two, musical scale information can be used as pre-computations because they can essentially be regarded as pre-determined representations of how to physically play a sequence on an instrument. Figure 5.8 shows the written information created after the PC tablets were reintroduced following the technical problem in session two.

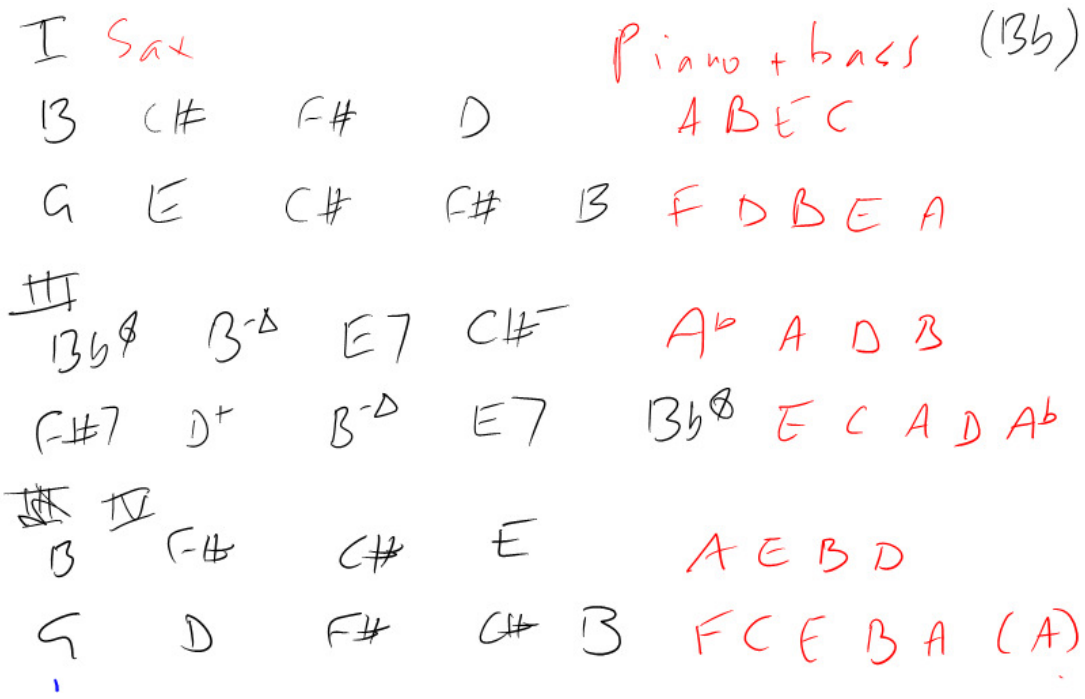


Figure 5.8: Set-Up A's PC tablet written notes after technical failure in session two

In the figure 5.8 SA and JB wrote out the different sets of information relevant to the instruments. SA, in black, had written out musical information relevant to what he had to play. Similarly, JB had written out information relevant to the bass and keyboards. Whereas in session one, the composition was described in more high level written language as seen in figure 5.7, the information illustrated in figure 5.8 is geared towards defining specific actions to be performed in the composition. Whilst the technical failure can be seen as the trigger for a new sheet being used to enter information in figure 5.8, I suggest that the new information reflects the difference in the cognition of the system at two different points in time (i.e., going from high level and abstract sketches to more specific details of performance information in later sessions). Information in figure 5.7 might be regarded as a rough work sheet of sketches and

ideas that helped the group to develop the composition beyond an initial starting point. Information in figure 5.8 becomes a more worked out version of the compositional information which eases the burden of the musicians because it visually displays the sequence in a clear manner.

5.4.4 Computational offloading using PC tablets

In chapter three, I presented an excerpt of work that illustrated how participant G of *Young Band* faced the challenge of interpreting long streams of compositional information quickly in conversation, and remembering the interpretation for the next time he performed a jam. The PC tablets, in part, supported the participants in Set-Up A to overcome this challenge by helping them represent information in a visual and more permanent form in a shared space. The output produced on the screen eased the cognitive burden of remembering transient information in real time, which the participants in Set-Up A became accustomed to in their sessions.

Session one:

00:40:04	TG:	erm <looking to her left at paper> I I did a chord progression there I think I did something like <reads off paper> one two five three six four two five one <looks to SA> something like that
	SA:	mmm yeah yeah
00:40:15	TG:	erm and I did them over sort of two bars each sort of two bars per each chord
	SA:	uhum
00:40:22	TG:	erm does that sound
	JB:	ca ca could you sa say that again or write it in the <picks up stylus>

At 00:40:22 JB picks up the stylus and asks TG to repeat or write what she called out on the tablets. In Set-Up A participants often explicitly asked for information to be written down in the shared space, even though it was available through other media including paper.

The advantage of writing the information on to the tablet was that it eased the JB's cognitive burden because he had several challenges: 1) to interpret the information at the speed it is being called out, 2) to transform it into playing the bass, and 3) to remember this interpretation and transformation for future performances. When TG wrote out information on the tablet, JB did not need to internalise the verbal information given by TG; he could also reference the information by reading it on the tablet. His task became reading information off the tablet and transforming it to playing the bass rather than listening to TG's verbal reference, remembering it long enough to transform it, and finally remembering it whilst continuing to work on other sections of the composition.

5.4.5 Re-constructing knowledge that is distributed across the system and across time

The PC tablets supported the resumption of work in Set-Up A by helping participant TG to introduce new ideas that she created outside of the session directly alongside the representation of the composition that was recorded on screen. TG had the opportunity to use information that was recorded in the previous session in order to create new ideas between the sessions on paper. When the second session resumed she used a mixture of information from the previous session as well as information developed between the sessions, to communicate new ideas to JB and SA.

Session two:

00:01:36 TG: shall I say what I did in the week?
00:01:38 JB: sure
SA: ok yeah
00:01:41 TG: I was going to e-mail you with it but erm my computer at home isn't working very well so erm (inaudible) but erm the thing is I worked out the same chords progression as I was using for the introduction bit
SA: <nods> mm
00:01:56 TG: erm in the altered scale <glancing between paper and SA>
00:01:57 SA: <nods> uhum
00:01:56 TG: erm and I hope I have done that correctly
SA: uhum

00:02:02 TG: I can <picks up stylus> write the altered scale notes
JB: ok <picks up stylus>
00:02:06 TG: on to this <points to tablet> erm
SA: <nods turns to own tablet> ok yeah
00:02:09 TG: space here <stylus on tablet>
00:02:12 SA: <picks up stylus and puts on tablet>
00:02:17 TG: so
00:02:18 TG: dot
(SA inaudible)
00:02:20 TG: and <turns to SA and JB> this is for the middle section
SA: <looking at tablet> uhum
00:02:22 TG: you know the bit more exotic section
SA: uhum
00:02:25 TG: <looking at paper and then writing on tablet> so it is the same chord progression exactly erm but instead of er the notes that
SA: uhum
00:02:33 TG: we had before erm we got A flat er
00:02:39 JB: I am not sure where you are
SA: yeah where you are writing it? Is it near the top?
00:02:42 TG: no I am writing it near the bottom actually
SA: ah ok
00:02:47 TG: so <resumes writing on tablet> A flat
00:02:49 SA: ah there it is
00:02:51 TG: B D (not paying attention to others)
JB: oh ok
00:02:52 TG: and then erm I've got A C E (inaudible) … sorry
00:03:07 JB: sorry is that a one above the A?
SA: <plays saxophone>
00:03:10 TG: yes that's a one sorry I'll write it a bit more I can't get the erasure on here
00:03:17 SA: er
00:03:18 TG: oh here we go
00:03:29 TG: erm and I that the erm altered scale would work better than the whole tone scale
SA: <nodding> yeah the
00:03:38 TG: erm because I thought that we could include th ee in the melody the top part of the harmonic minor scale
SA: ok
00:03:46 TG: because that really does sound exotic
00:03:48 SA: yeah <looks to tablet
TG: <writes on tablet>

As the transcription continued, there were no noticeable points where participants raised concerns about forgetting something that was played previously. For example, JB and SA seemed to understand TG's reference for "exotic section" (00:02:22), and subsequently the group seemed to have maintained enough understanding to continue to work from the previous session. Part of this can be attributed to the way information was able to flow across the system. This is because the tablets provided a new information trajectory to support JMC. Figure 5.9, Information flow in Set-Up A, illustrates how information flows across the system based on the excerpt above.

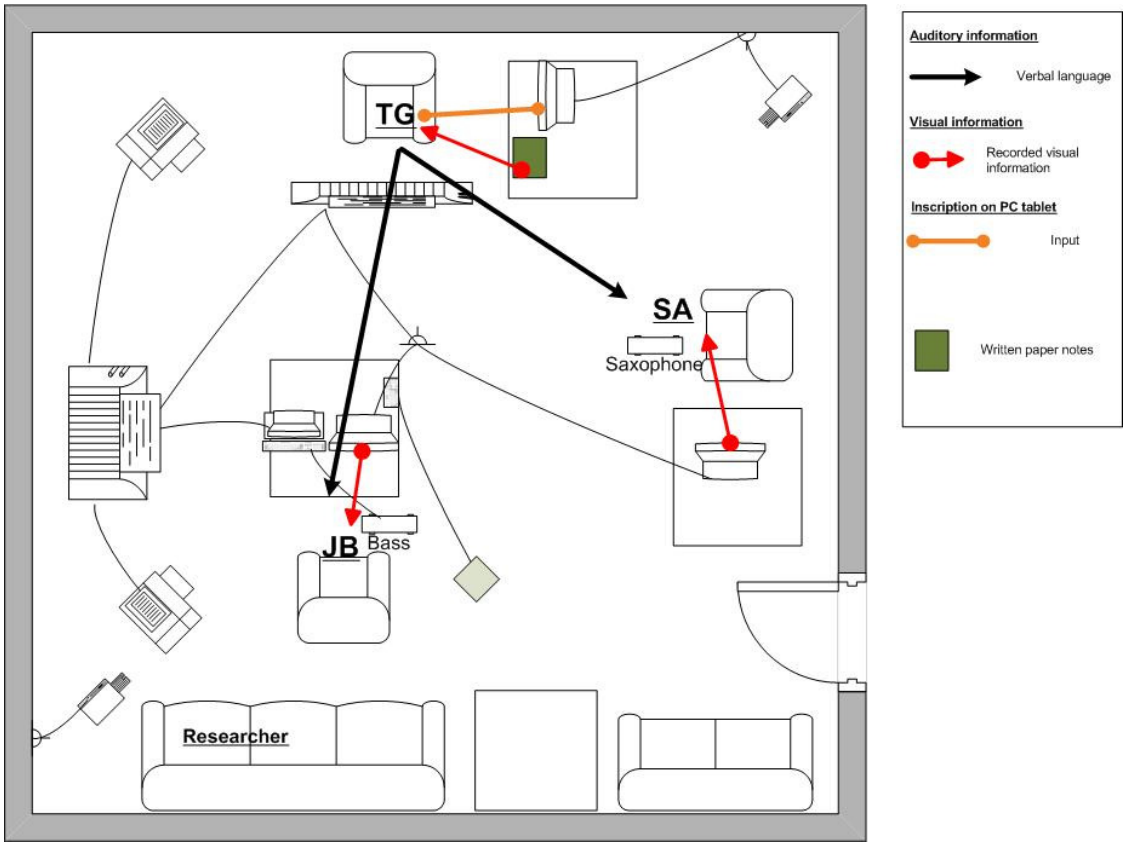


Figure 5.9: Information flow in Set-Up A

In chapter four, information on written notes was shared by reading it out loud or passing paper around. Figure 5.9, Information flow in Set-Up A, illustrates how information is shared across the system simultaneously, making it easier for TG to disseminate information she created outside of the session and aligning the representations to existing references created in the previous session. This is not to say that the reconstruction of knowledge about the composition was flawless. Whilst the group in Set-Up A did not appear to have forgotten many aspects of what they had created in the previous sessions, their session two post-task questionnaire

demonstrated that members were aware that sections of music were not played from the previous week, even though they felt it was good:

(TG): “The beautiful saxophone melody from last session – we had some of it but not as much”

JB felt there was something missing from last week but he was not specific: “don’t remember exactly – it was more improvised”.

Whilst the group reconstructed enough knowledge to continue to work, they did not recreate a performance of many elements of the composition from a previous session, even though they may have wanted to. Therefore, the PC tablets were useful in supporting the reconstruction of certain elements of the composition, but as with the written notes in chapter four they were not used to bring about an exact performance of a jam from the previous session.

5.4.6 Summary of how IAs supported JMC in Set-Up A

The findings of the Set-Up A study suggest that the new resource supported musicians to manage certain cognitive burdens associated with compositions that are in development and supported the distributed nature of problem solving in a number of ways. Firstly, musicians were able to share information simultaneously across the system in written form and in real time. The participants in Set-Up A used this to create representations that were often reused by different participants across time. This ability also meant that information relevant to different members could be built on representations created on the tablets. This made it possible to represent some of the transient information in a rehearsal session in a more permanent form that can be used to distribute knowledge and develop ideas. The shared space helped the group converge on certain elements of the composition at certain times, especially as references were visually available to all participants during communication. The visual reference to elements of the composition relieved the cognitive burden associated to remembering composition information that was rapidly changing and transient in nature. There was less pressure on participants to translate and memories into real time information that was verbally described.

This study encourages the idea of incorporating shared IAs that support musicians to record information locally and be able to distribute it across the group. It must be noted that the Set-Up A group were not typical to the types of bands I observed in Westbourne Rehearsal Studios. It is likely that participant TG would have used paper to make written notes regardless of the availability of the PC tablets. Nevertheless, the manner in which the whole group used the PC tablets to progress JMC showed that representing information in a visual and shared resource

appeared to be intuitive to participants when a system was available. Participant JB stated in the beginning of session one that he normally experiments with music before committing to compositional ideas especially in written form or sketches. Yet JB became an active user of the system because it provided a means for the group to represent knowledge about the composition. A similar observation was made with the group in Set-Up B, which I describe in the next section. Even though there were many differences between the two study set ups in terms of the physical setting and the study participants, the PC tablets were used as means to represent knowledge within the system.

5.5 Set-Up B

In this set up, physical barriers were placed in between the three musicians to inhibit their ability to see other members and their physical spaces. Figures 5.10 and 5.11 illustrate the study set up.

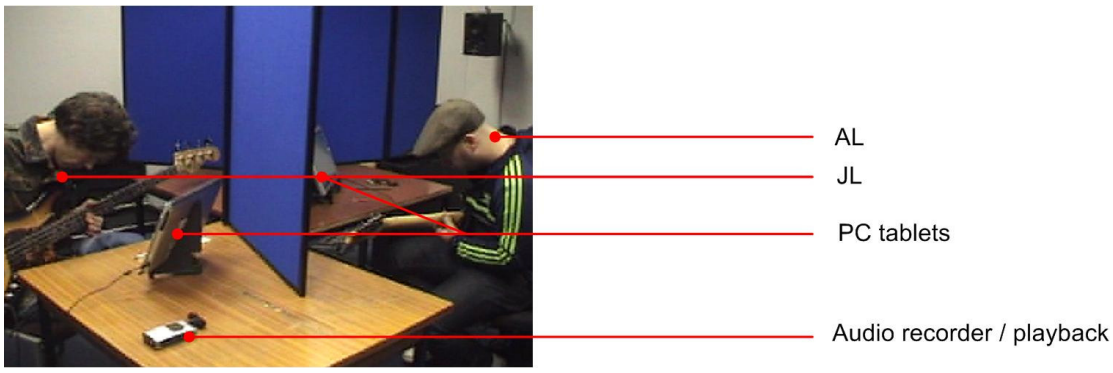


Figure 5.10: Set-Up B camera one angle

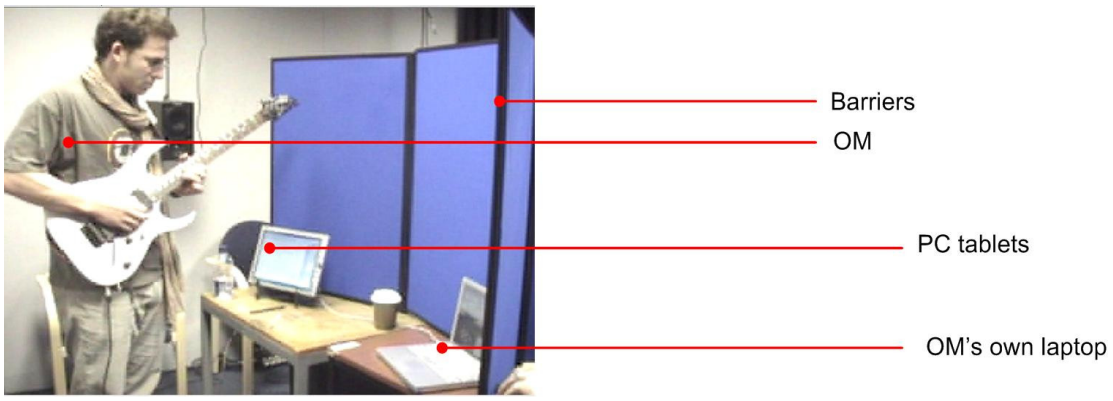


Figure 5.11: Set-Up B camera two angle

I attempted to create a work cubicle for each participant, which contained a PC tablet. Participants were asked to remain within their allocated cubicle but they could stand and sit as they wished, so long as they did not attempt to see other participants.

5.5.1 Participants

The participants in this study were AL (guitar), JL (bass) and OM (guitar mainly as soloist).The three participants were selected based on the answers they had given in their pre-study selection questionnaire (see appendix M). All members of the group in Set-Up B stated they liked to play Rock music. In a typical Rock set up, the bass guitar, rhythm guitar and guitar soloist have specific roles; the former two work as a rhythm section, the latter can act as a soloist. It is, therefore, not unusual to have these three musicians work together to develop a composition. Details about the background of the participants can be found in appendix N.

5.5.2 Layout

For Set-Up B, I kept the musicians in the same formation throughout the study. This was done mainly to create the boundaries necessary to keep the musicians separate from each other. We placed the amplification within reach of the participant who was using it.

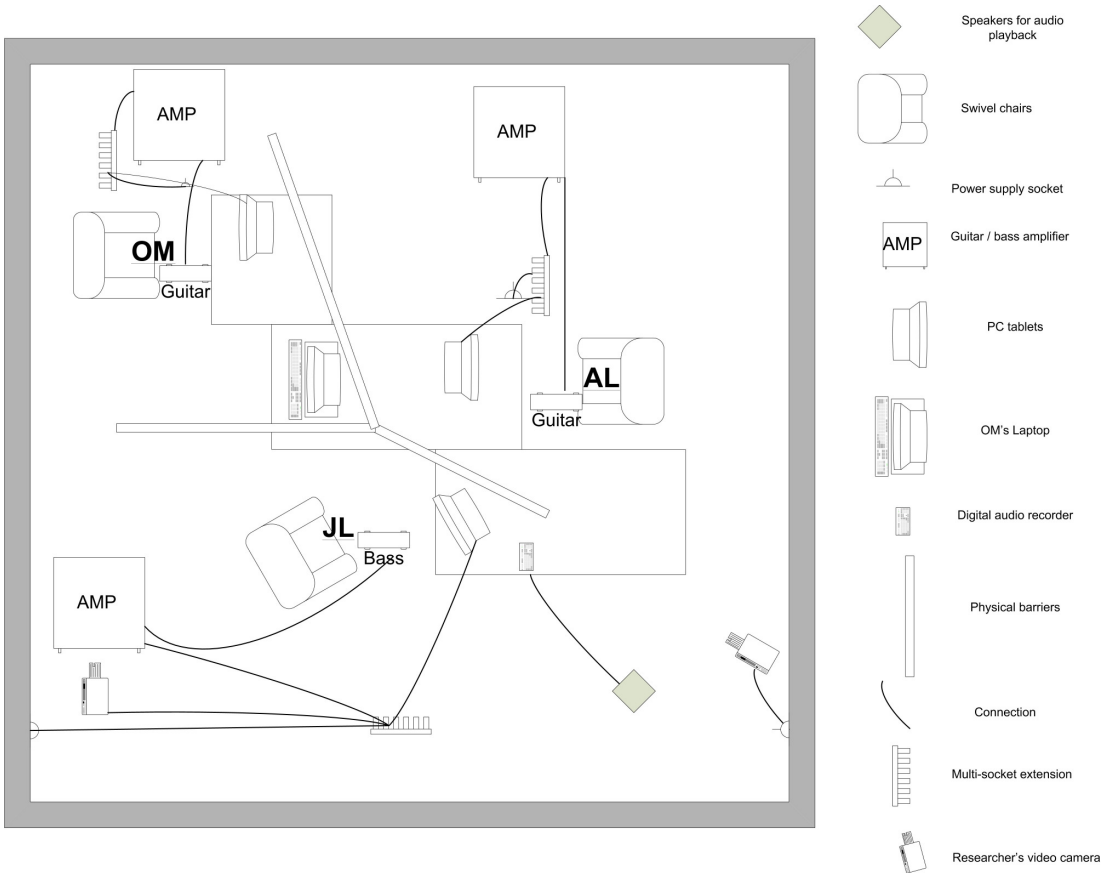


Figure 5.12: Set-Up B layout

As figure 5.12 illustrates, the boundaries for each individual workspace are defined using physical barriers. This meant that the participants only had access to physical artefacts within their work space. For example, JL only had access to his PC tablet, the bass, the bass amp behind him, the digital audio recorder and the connectors. He did not have visual access to the other participants' work space, but was able to communicate verbally with others. OM brought his own laptop into the room and used it to record the audio of the session on to it.

5.6 Set-Up B Findings

The group in Set-Up B were more similar to the types of bands that I had observed in Westbourne Studios, especially as they were all interested in Rock music. This group started generating ideas through jams, unlike the group in Set-Up A who played around musical scales and sketched ideas out on PC tablets. The participants in Set-Up B stated in their post-task questionnaires that the main issue the visual barriers caused was that they felt isolated from each other. Participant OM also stated he was not able to look at AL's guitar to see what was

being played. Participant AL and JL stated that the PC tablets partly helped the group to connect, as they found new ways of “seeing each other”. Despite the presence of the visual barriers, by the end of the three sessions, the group recorded two compositions that they had worked on throughout the three sessions. I will present a number of examples that illustrate the way the PC tablets and audio recorder supported the group when developing compositions. In particular, I will present findings that show some correlation with the findings of Set-Up A.

5.6.1 Creating reusable representations

One of the difficulties music groups typically face is managing the transfer of knowledge when there is a lack of global composition structures whilst the composition is in development. As in Set-Up A, one of the contributions of the PC tablets was that it enabled representations to be created which were reusable at a later point in time. This meant that the group in Set-Up B were able to create temporary composition structures by building on existing recorded references. Figure 5.13 illustrates an example of how this was achieved.

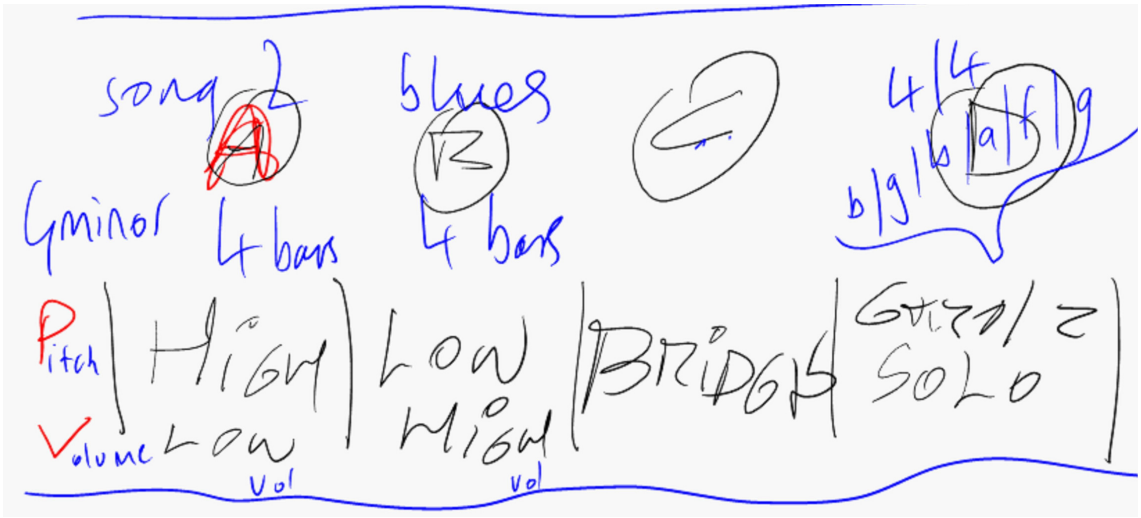


Figure 5.13: Temporary composition structures created in PC tablets

The letters A, B, C and D represent the sections of music below them. To overcome the lack of a global structure, AL suggested someone should call out each section. There were no section names such as verse or chorus, nor were there chord names. Instead information such as “High low”, “Low High”, “Bridge” and “Solo” acted as reminders of a set of information that each participant had to transform. On many occasions, the visual information on the screen was called out by either JL or AL during performance to fill the void that existed whilst global cues were in development.

Figure 5.14 demonstrates how the written information enabled the group to not only create structures, but also to change their order. The arrows in the diagram demonstrate the group's decision to swap sections three and four. Figure 5.14 supports the notion that composition structures often evolve out of musical ideas (i.e., jams) and not the other way round; there are no musical placeholders (Rosenbrock, 2003) such as verses and choruses that musicians fill. Therefore, the musicians appeared to benefit from having a visual form of support in order to initiate changes in ideas, which would normally have to be described solely using transient information. When the composition is in development, musicians not only have to keep track of what output to produce for each section but also track changes to the order of the sections. Writing it out produced a form of computational offloading (Scaife & Rogers, 1996) which eased one set of computations that musicians had to perform (i.e., calculations of the sequence of each section).

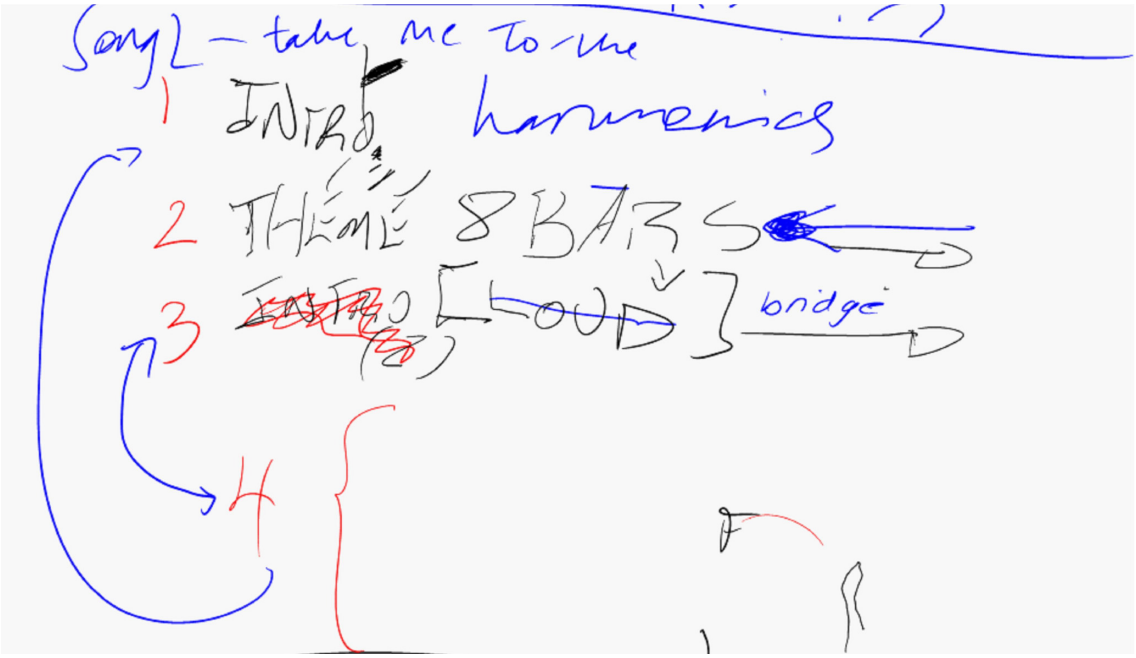


Figure 5.14: Visually illustrating changes in composition structures

5.6.2 Computational offloading using PC tablets

In previous chapters, representing information about sections of music that were not created often occurred using verbal communication accompanied by the outputs from musical instruments. In Set-Up A, the participants used sketches to outline ideas before playing them. In the following excerpt, AL uses information on the screen to help convey an idea he proposed for a section of music that had not been created.

Session one:

00:40:09	AL:	and then from there <looking at tablet> where do you think we should go? Shall we go down or up? And then go er may be I can do a guitar solo you can do another guitar solo (pointing to OM even though no one can see him)
00:40:20	OM:	er...against what?
00:40:22	AL:	<writing on tablet> right here
00:40:23	OM:	after the bridge thing?
00:40:25	AL:	yeah...shall we may be say <plays guitar> ...
00:40:46	AL:	so if I play that you can play a guitar solo on that <playing guitar throughout>
00:40:51	OM:	right?
	AL:	< picks up stylus and writes on tablet > ok we'll say guitar solo 1 and 2 < writes on tablet>

I interpret the above excerpt to involve AL instructing OM to play a section of guitar that had not been created (i.e., a solo after the bridge), which contained the musical components that AL outlined. OM appeared to understand the concept of the solo, but not *when* he had to play one. AL answered OM's question ("against what?") in two steps: 1) AL used the information on the tablet to help OM find the location of the proposed section in relation to the written information about the current state of the composition 2) AL played the music that accompanies the "solo" after OM confirmed he had found the location of the solo. This is a different implementation to what I had seen in my previous experience because I had not observed musicians making markings on a shared written space in real time as a way to localise information. The burden of formulating the "bridge thing" may be made easier for OM who may have one less calculation to perform because he can visually recognise the sequence of the composition instead of formulating it in his head when AL described it verbally and/or musically.

The following excerpt demonstrates how ideas can be written down before the sequence is played, which meant the group were not reliant on internalising all the information in real time.

Session two:

00:17:22	**JL:**	**<looking at screen> well why don't we try doing just repeat the first two bits...**
00:17:26	**JL:**	**so we do loud bit for four bars**
00:17:28	**AL**	**<plays guitar>**
00:17:29	**JL:**	**and then a quiet bit for four bars...and then a loud bit for four bars? And then when we have a hang of that we could try going to the bridge**
	AL:	**<looks at tablet>**
00:17:38	**JL:**	**and the solos? Whadchya reckon?**
00:17:40	**AL:**	**Yeah..yeah I think that's cool like because if we if we just loop like different sections forever it just gona you know…be boring after a while**
	JL:	**Yeah**
00:17:47	**JL:**	**coz we never really got the dynamics thing last time actually (laugh) ... so**
00:17:53	**AL:**	**<stylus in hand> do you want to write this what you just suggested?**
00:17:57	**JL:**	**Ok <writes on tablet> so I just mmm**

The information that JL starts to write out represents the group's agreement on what path to take, and provides a visual representation of a sequence that would otherwise have to be memorised by participants. In this case, the generation of ideas represented in a visual form was used to coordinate cues for change at a local level (i.e., individual looking and screen) or at a global level (i.e., someone calling out changes).

5.6.3 Re-constructing knowledge that is distributed across the system and across time

The role of the PC tablets was marginal to the group's attempt to reconstruct knowledge about the composition from session two. The information contained in the PC tablets was referenced more than the audio that was recorded on the audio recorder within sessions one and two. However, the audio recordings played a more prominent role in how the group remembered and created a shared understanding of the properties of the composition in the beginning of session three. The information in this section focuses on how the audio recordings helped to bring about a performance of the composition closer than what the group had achieved before listening to the recordings, even when looking at the PC tablets. This will help highlight the different roles that information on PC tablets and audio recorders can play in JMC. Using the tablets appeared to be a means for the group to represent knowledge about the composition as it progressed, whilst listening to, and playing along with, the audio recordings of jams were a means for participants to align ideas with each other as well as the previous session.

In session three, the group started work by tuning their instruments and warming up, which was also how they resumed the previous session. The warm up jam of this session was based on the introduction section of one of the compositions from session two. However, OM and JL appeared not to remember that this was something that they played previously. The re-construction of knowledge about the composition started when the jam ended.

Session three:

00:05:47	AL	<stops playing guitar and picks up stylus and goes to tablet>
00:05:53	AL:	that was the intro
00:05:54	JL	<laughs>
00:05:56	AL:	and then
	OM:	was it?
00:05:59	AL:	it was something like that wasn't it?
00:06:05	OM:	you can play it again
00:06:08	JL	<picks up stylus> so you know last week you were gona write it all down weren't you?
00:06:12	AL:	was I?

This discussion continued, but AL is interrupted in his attempt to write the notes out neatly, by OM who asks AL to “jam it first” (00:06:35). I assume OM wanted to recall the introduction through playing rather than written form.

Session three:

00:06:40	OM:	you know the intro was it this thing that were just playing now?
	AL:	<puts stylus down>
00:06:45	AL:	it was something like that <plays guitar>
00:06:55	AL:	and then something like <plays guitar>
00:06:59	OM	<plays guitar>
00:07:01	JL	<plays bass>
		(a period of jamming)
00:07:18	AL:	oh no I think we don't we not playing this any more (Al is not referring to the introduction but a section later in the composition)
00:07:22	OM:	oh yes something tells me we got rid of that
00:07:26	AL:	I think we...was this ok <plays guitar>
00:07:30	OM:	yeah I think so <plays guitar>
		(JL has been looking at the screen and playing intermittently)
00:07:41	AL:	does anybody remember the structure?
		(JL and OM playing instruments)
00:07:51	AL:	<picks up stylus>
00:07:53	JL:	<looks at tablet> and then there was a <plays bass> <looks at tablet>
00:07:58	AL:	<plays guitar>
00:08:02	JL:	<plays bass>
	OM:	<plays guitar>
		(a period of jamming)
00:08:18	AL:	something like that?
00:08:20	OM:	yeah
00:08:25	JL:	do you want to listen to what we got? <picks up Audio recorder/playback> (referring to the audio of previous week)
00:08:27	AL:	oh yeah that's a good idea

By 00:08:20, the communication indicated that there is some form of consensus that the group has recalled enough of the composition from the previous session in order to continue working on it. The following segment illustrates that a number of ideas from the previous week were forgotten, even though AL and OM appear to be in agreement that what was played in the previous week “was something like” the jam they just conducted (00:08:18 to 00:08:20). This is highlighted by the presence of the audio playback of the composition from a previous session.

Session three:

00:12:40	(Audio playback of file plays through speakers)	
	JL:	yeah see that's the bit that you were just playing wasn't it? (referring to introduction section AL was referring to earlier in the session)
00:12:41	AL:	<plays guitar along with audio playback)
00:12:48	JL:	yeah this is from last week
00:12:52	AL:	oh yeah it was...(referring to something he had not remembered to play in this session)
00:13:02	AL:	<plays guitar>
00:13:09	AL:	oh yeah I was doing <plays guitar>
00:13:24	OM:	I was doing something like <plays guitar>
00:13:36	AL:	<picks up stylus>
00:13:39	OM:	oh JL you were doing some slides weren't you?
00:13:40	JL:	oh yeah that's right <plays bass>
00:13:44	OM:	oh yeah that's the one
00:13:50	OM:	I wasn't supposed to be doing that (referring to something he heard on the playback)
00:13:57	AL:	it doesn't sound bad

The jam performed by the group before audio playback is likely to have outlined the core chord changes, and possibly the rhythm and phrasing. However, it is clear the audio playback provided many details that the group had forgotten. This situation is comparable to the findings in chapter four where there was a conflict in what people remembered. Without referencing the audio playback, the group in chapter four relied on fragments of ideas that were generated in the present session with what they could remember and agree of the properties of the composition from the previous session. Therefore, it was not a direct continuation of where they left off in the previous session. This might be inherent to many groups that may not always realise that ideas from the previous session have been temporarily or permanently forgotten. This does not result in a failure to progress. However, the progress may mean losing certain elements created in the previous session, some of which they may prefer to remember.

I suggest that the group in Set-Up B was better placed to have more of a direct continuation of work from the previous session because they referred to audio recordings. Essentially, by 00:08:20 the group arrives at a point where an agreement of the ideas about the previous session has been reached. The playback of audio at 00:12:40 onwards took this process further by allowing the group to not only listen back and work out what they played, but also allow them to play together with the audio playback.

Session three:

00:14:06		(In audio playback JL is heard counting out the introduction of a composition)
	OM:	<plays guitar along with audio playback>
00:14:08		(AL and JL both smile. OM is jamming a new guitar part with the audio playback. He then stops)
00:14:28	AL:	<plays guitar along to audio playback>
	JL:	<plays bass to audio playback and AL>
	OM:	<plays guitar to audio playback, AL and JL>

I suggest playing along with a recording of a composition provided the JMC functional system the ability to not only align their ideas with each other, but with the previous session. The following segment illustrates another example where a direct continuation of work is made more likely because of the use of the audio playback. Group members listen to some problems with the previous week's performance.

Session three:

		(listening to previous week's audio)
00:16:30	JL:	we definitely were struggling a bit with that last week weren't we?
00:16:34	OM:	which bit?
00:16:35	JL:	trying to go from the yeah
	OM:	intro to the

The group appear to be in agreement that they have reached an understanding of what they each have to perform. I propose that this marks the beginning of the continuation of work on a composition from a previous session.

Session three:

00:18:00	OM:	em does everyone remember what they were doing?
	AL:	and JL <looking at tablet>
00:18:05	JL:	I think yeah
00:18:06	JL:	its just the way it fitted together is still slightly problematic

The examples in this section illustrate how information is distributed across many components (i.e., musicians, tablets and audio recorder). Most notably the use of the audio playback highlights the fact that details of a composition may be forgotten and therefore the musicians can have lapses in memory about how compositions are remembered from one session to the next.

The excerpts within this section illustrate that many forms of information were presented through a number of different media in the system. Figure 5.15 is an illustration of the possible flow of information to participant JL. The playback of audio through speakers was recorded audio; output of instruments was live audio through amplification; information on screen was static recorded visual data; information from hand position on an instrument (i.e., JL looking at bass guitar) was live visual data. This combination of live, recorded, transient, static and visual representations provided the system with an array of opportunities to reconstruct knowledge about the composition from a previous session. During the reconstruction of knowledge, there were no references to musical scale information. Instead, a shared understanding was created through mutual awareness of recorded sounds coming through the speakers. The participants played over the recording using their musical instruments and often made verbal references to the audio playback. This language helped to highlight musical properties of the composition by creating references in context of the recorded information. The recorded audio of the jam sessions contained a representation closer to what the group was looking to transform and hence did not require extra translation. The references to the composition were based less on the written information and verbal information, and more on the recorded audio from the playback. Verbal language was still critical to coordinating action, but it was required less in describing the properties of the composition.

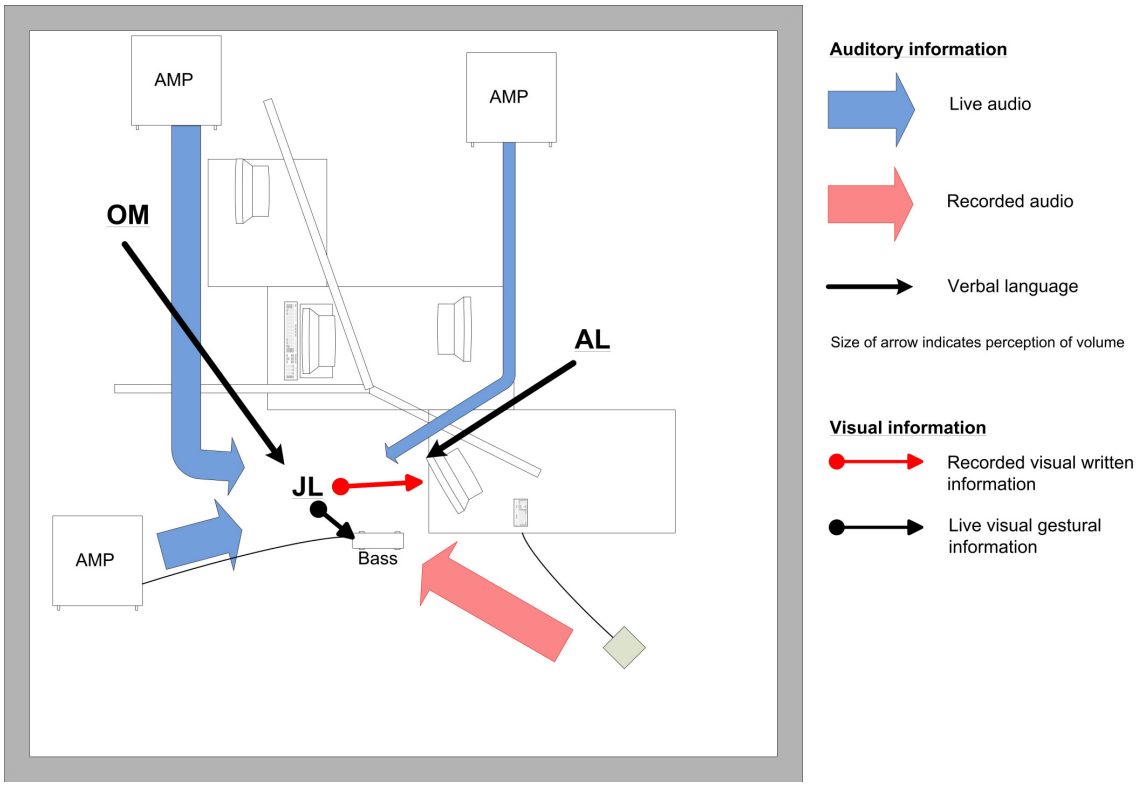


Figure 5.15: Information flow to participant JL

The participants seemed to take the recorded audio as the true representation of the state of composition. For example, JL laughed when AL stated that their jam was the introduction of the composition (00:05:54). However, when he heard the audio recording he states “yeah see that's the bit that you were just playing wasn't it?” (00:12:40). The recorded information was used to reinforce a direction or path, for example, OM made references to the recorded audio in order to inform JL to play something he performed previously.

00:13:39	OM:	oh JL you were doing some slides weren't you?
00:13:40	JL:	oh yeah that's right <plays bass>
00:13:44	OM:	oh yeah that's the one

Without the audio recording, OM’s verbal language may not have been adequate to help convince JL that he played *slides*, because they may not have been able to create a shared understanding of the term *slides*. The output of the audio playback provides the evidence that helps to create the shared understanding within the group, without solely relying on transforming verbal or written information.

5.6.4 Summary of how IAs supported JMC in Set-Up B

The PC tablets were used to support the group in Set-Up B in a similar way to what was reported in the findings of Set-Up A. In particular, the ability to create and build on representations in a visual and more permanent form allowed participants in Set-Up B to manage the cognitive burden associated to the changing nature of a composition in development. For example, the group created temporary composition structures by building on existing recorded references and were able to change their order by using arrows. To overcome the lack of a global structure, the group called out information from the screen during performance. They also used information on the screen to help convey an idea for sections of music that had not been created. In the main, the PC tablets augmented the group’s ability to distribute and build on existing knowledge.

Whilst it is likely that the group in Set-Up B would have managed to record compositions without using IAs, the fact that IAs were used for significant amounts of time to help progress JMC is interesting. The group’s usage of the PC tablets and audio recorder at different stages of JMC may reflect the types of support they require as their knowledge of the composition evolves over time. The written information created in a shared context may be useful when more coordination

is required to manage the burden associated to interpreting information when the composition does not exist or is frequently changing. However, audio recordings provided more details about what was being played within different jams, and were therefore useful to participants when attempting to remember the finer details of the performance.

5.7 Summary

In this chapter I have illustrated that access to shared IAs such as PC tablets can have an impact on the way knowledge is distributed across a number of rehearsal sessions. One obvious consequence is seen in the way musicians shared information simultaneously across the system in written /sketch form and in real time. Whilst there were many variations between the two study set ups in terms of the people, their skills, their experience, genres of music they composed, compositions, the instruments they played, the group dynamics, and the room set up, there were key similarities in how JMC progressed. Both studies showed that converging on a shared understanding of the compositional properties at certain points in JMC was integral to how the two groups in the studies went from initial explorations of ideas to more specific knowledge about how to bring about a performance of the composition. The participants in Set-ups A and B used the PC tablets to augment their abilities to share knowledge and develop ideas by creating, recording and referencing visual information. This made it possible to represent some of the transient information in a rehearsal session in a more permanent form that they were able to use to develop and communicate ideas.

The combination of live, recorded, transient, static and visual representations provided the groups an array of opportunities to shape language use and subsequently help bridge knowledge within, and between, functional systems. Findings from Set-Up B also suggest that audio recordings were useful to participants when recalling the finer details of the performance, whilst written information developed in a shared context was useful when information about the composition did not exist or was frequently changing. In both set ups, shared references created in inscriptions gave the groups the opportunity to negotiate an understanding of ideas and updates made to the composition. For example, the studies described in this chapter demonstrated that composition ideas could be proposed and shared without musical references being created first, and temporary composition structures could be visualised as they developed. In Set-Up A, written language in the form of sketches was used to create high level abstract concepts of proposed compositional ideas.

It is likely that groups in both studies would have had the ability to create compositions whether they had the IAs at hand or not. However, the compositions may not have progressed in the same way and consequently they may have sounded different or had different structures. I do not propose that the IAs helped the musicians to make better compositions, only that the musicians had more opportunities to create and share knowledge which may have changed the way they made music together. The extent to which the IAs were used within the session suggests that recording and reusing information across time can aid the propagation of knowledge across the system to support the progress in JMC.

Chapter Six: Discussion and Conclusion

6.0 Overview

In chapter two I stated that there are no tools that have been commercially or academically designed to support JMC in a co-present environment. The reasons were attributed in part to the general lack of understanding that existed about what occurs in JMC. In particular, questions were raised regarding how knowledge about compositions is developed and shared across time, especially as IAs did not appear to be employed in JMC. My research has started to address this issue through outlining the means by which compositions are created across multiple sessions of work.

I used the theoretical framework of DC to help analyse work from a cognitive, social and organisational perspective, taking into account the role of structures and resources within the environment where work takes place. The outcome of my analysis has helped to account for the way knowledge was shared across a JMC system that consisted of people and artefacts. My study findings illustrate that the main outputs of a session of work are the changes that take place within the musicians themselves in terms of their knowledge and how they perform compositions. Audio recordings and written information created as part of the process of JMC are not considered to be the main output of the session. These outputs are by-products of collaborative work, which support how knowledge about the composition propagates across the system and across time.

My study findings highlight that problem solving in JMC can sometimes be achieved by one person working on their own; however, the solution must be presented in a shared context. The ability to distribute knowledge from the local level to the rest of the group impacts how an idea is brought to realisation. Therefore, JMC progresses when the outputs of local actions are brought into coordination within the functional system to support the distributed nature of problem solving. Many challenges exist in this process, none more so than the use of transient representations. My research highlights that there are many forms of transient representations that have to be processed within JMC, which can place a cognitive burden on musicians when compositions are in development. My studies show that musicians do not remember compositions fully by themselves all of the time; they are reliant on other musicians as well as the IAs available to them. In particular, I illustrate how IAs support musicians to remember more details about a composition in development, as well as how they help musicians to reuse existing representations to further their ability to share and create ideas. IAs also support

collaboration by providing new opportunities to create agreement on the definition of compositional components presented in recorded form.

The findings from my research have a number of theoretical and design implications that I will discuss in this chapter. The theoretical implications relate mainly to my findings about the process of JMC and my use of DC as a framework to guide the analysis. The design implications of my findings outline four considerations that help channel design rationale in *what* to support in JMC. These considerations are a starting point for further research to be undertaken from a design perspective.

6.1 Summary of key findings

The summary of key findings is split into three sections: a review of how compositions emerged out of improvisations, the key challenges in distributing knowledge within JMC, and how the introduction of shared IAs supported the distribution of knowledge.

6.1.1 How compositions emerge out of improvisations

In chapter two I stated that the overarching question that JMC poses to designers relates to how ideas created in improvisation develop to become a composition over time. Music composition affords the opportunity to take ideas expressed in improvisation and develop them into a specific pattern of musical sequences which outlines what a group has to play. One way to view this process is to look at the way knowledge is distributed across the group and across time.

Convergence on certain compositional information: Whether an idea is based on a group or individual performance, or expressed verbally, it has to propagate across all members in order for a composition to emerge out of improvisation. In addition, at some point groups have to decide to take one particular path. Therefore, convergence on the definition of compositional information at certain points of a rehearsal session is an important feature of how JMC progresses compositions to become more structured and how new ideas are introduced.

Local actions supporting progress in JMC: My study findings in chapters three to five illustrated that often a single person may play a more active role in helping to distribute knowledge about the composition. Therefore, the distribution of knowledge from the local level to the rest of the group is a key feature of how groups are able to bring an idea to realisation in JMC. This is one of the key processes that helps transform improvisations into structured compositions over time.

Ways to distribute knowledge: A simplistic view of how knowledge is shared focuses on how musicians come to know where to place their hands during different sequences of a composition. There were a number of different implementations of how this happened in the studies:

1) Musical scale information presented in verbal language or written form helped musicians to constrain the choices about where to place their fingers on different instruments. However, knowledge about how to transform musical scale information into the implementation of playing depended on the individual musician's experience.

2) Mimicking was often a collaborative process whereby the musician being mimicked waited and repeated what s/he played a number of times until the person mimicking ended up playing the sequence appropriately. In this process verbal and gestural communication was often important, in addition to the ability to see the musical instruments being played.

3) Playing by ear describes a musician's ability to transform information into the action of playing solely by hearing something played on another instrument. This is perhaps the most efficient way that representational states propagate because it dispenses with the need to describe compositional information or go through an elaborate mimicking process. However, the biggest problem with playing by ear is that it is neither easy nor possible to always determine the compositional information created in performance.

4) Written notes on paper helped recorded representations to be passed around the group, and were used in different sessions as a way to support knowledge transfer.

6.1.2 Key challenges in distributing knowledge in JMC

My findings from chapters three and four helped to highlight a number of challenges faced by musicians in distributing knowledge when they are in the process of developing compositions. The focus of many of the findings that I have presented in the studies relate to the way representations are used within JMC. The key challenges in the distribution of knowledge that I outline here relate mainly to the impacts of transient representations.

The use of transient representations

The key mechanisms that help develop the composition are based on how language is used in communication and in coordination with artefacts like musical instruments. The majority of representations created and shared in JMC are, therefore, based on the outputs of verbal and gestural communication as well as musical output generated from musical instruments and supporting artefacts such as amplifiers. Consequently, the outputs of most interactions are transient in nature. This means musicians are often tasked with translating information as it is being represented. In addition, in order for the composition to progress, some knowledge must be maintained about the compositional properties (e.g., the notes, rhymes, structures and so forth) as it develops over time. This means that at least one member of the group has to have some internal notion of the compositional properties. Dealing with transient representations provides challenges to musicians, some of which are highlighted below.

Reconstructing knowledge across multiple sessions: I illustrated in chapter four that, whilst a number of external resources were available, the key resources used when reconstructing knowledge across time were the internal memories of the musicians themselves. The musical instruments and written notes only became useful when there was some agreement with what one of the musicians could remember about the composition. Problems did occur in scenarios where there was a disagreement between musicians' memory of what was played previously. The situation could only be resolved by reconstructing what compositional information the group knew and agreed on through cycles of performance and evaluation. The analysis shows that groups did not have a direct continuation of where they left off in the previous session, but instead fragments of ideas that were generated in the present session along with what could be remembered and agreed of the properties of the composition from the previous session.

Promoting shared understanding: In **c**hapter two I highlighted the importance of intersubjectivity in collaborative work. This is not about how people come to share identical representations, but how a coherent interaction can proceed. My studies highlighted that whilst language based on musical scales has relatively fixed meanings, the meanings musicians come to share about non-musical scale information is created in the process of work; non-musical scale information by itself does not always support the distribution of knowledge. Ascribing meaning to transient representations in a group requires the capacity for all participants to have access to the process and the representations being used. Convergence on the definition of compositional information at certain points of a rehearsal session is one way groups attempt to create a shared understanding of representations. Whether this involves a discussion or a musical performance, awareness of the outputs and activities that help to create shared understanding is essential, because transient representations cannot be revisited without being reproduced. To reuse representations, some internal notion must exist in order for it to be recreated. This means that musicians have to internalise many elements of the rehearsal session outputs (e.g., knowledge about the different takes of a performance or cues to change) if they want to refer to or reuse representations to support the promotion of a shared understanding of new ideas or a reformulation of existing ones.

Developing composition structures: One of the key challenges in JMC is developing composition structures using transient information. When compositions are in development, structures are usually changing frequently. In order to coordinate the performance of a composition, groups often formulate cues to change from one sequence to another. Since the composition structure is in development, so are the references to the cues to change. Therefore, composition structures and language associated to them are both emerging and not pre-planned. Consequently, the language associated to the emerging composition structure is

often expressed more in terms of what the speaker can formulate at the time of speaking. This is challenging for others because they have to interpret the speaker's terminology about the composition in real time, and they have to remember and execute this interpretation when the group next performs the composition. The findings from the studies illustrated that instruction for composition structures were often long and convoluted. To overcome this, musicians often used global cues as the main way to initiate changes during performance. However, this strategy was sometimes problematic in the long run. This was especially the case when the group could not use the external cues to propagate knowledge of potential points to change. This can occur in situations where musicians cannot communicate with each other during performance. In chapter three I illustrated that many sessions can pass without knowledge about the structure of the composition being fully attained at the local level (i.e., by the individual musicians). Therefore, reliance on external and global cues can be a barrier to how a composition is remembered in the long run at the local level.

The distributed nature of problem solving: The distributed nature of problem solving in JMC poses challenges to groups. Whilst problem solving can sometimes be achieved in isolation, the solution must be presented in a shared context. The ability to distribute knowledge from the local level to the rest of the group impacts how an idea is brought to realisation in JMC. In particular, being able to define compositional properties during problem solving, and creating a context for meaning to be attributed to it across the whole group at the same time can be complicated at times. In chapter four I illustrated that the distribution of knowledge is not always structured in a particular sequence where an individual’s task or need is addressed before knowledge reaches another individual. More often than not, a number of activities overlap across a number of individuals and artefacts in order for knowledge to be distributed. The means by which representational states propagate and transform across the system impacts how knowledge is reconstructed across time, how shared understanding about new and existing ideas is achieved, and how compositional structures are developed. In chapter three, the group was solely reliant on transient representations, whilst in chapter four some information was also recorded on paper. In both situations there were no artefacts used in the room to help externalise information in a shared context in order to offload the burden of what the musicians had to remember and learn together.

6.1.3 How shared IAs support the distribution of knowledge

Despite the challenges that are faced in JMC, my findings in chapter three and four illustrated that there was no central resource that helped musicians visualise and externalise information in a more permanent form within a shared context. In chapter four I posed the question about whether an information trajectory that enabled recorded information to flow across the system at the same time would be helpful to support the distributed nature of problem solving in JMC. In this section I will summaries the key findings relating to how a shared IA[1] that supported the creation of inscriptions in a shared digital notepad appeared to support the distribution of knowledge in two lab based studies that I conducted in chapter five.

New form of information flow: The most observable consequence was seen in the way musicians shared information simultaneously across the system in written /sketch form and in real time. This supported the distribution of information from the local level in a different way than previously observed. Whilst there were many variations between the two study set-ups, both groups used PC tablets to augment their abilities to share knowledge and develop ideas by creating, recording and referencing visual information. This made it possible to represent some of the transient information in a rehearsal session in a more permanent form that could be used to develop and communicate ideas. The manner in which the whole group used the PC tablets to progress JMC showed that representing information in a visual and shared resource appeared to be intuitive to participants when a system was at hand; the IA became a means for the group to represent knowledge about the composition.

The use of reusable representations: The shared IA became a shared space for knowledge to be distributed in a permanent form, which enabled some information to be recorded and reused by more than one person. This ability meant that information relevant to different members could be built on representations created on the IAs. For example, in Set-Up A musical scale information was associated to initial abstract sketches as the session progressed. This meant that a shared understanding of certain ideas created in early exploration was, in some respects, maintained and developed whilst composition development progressed. In Set-Up B, the group was able to develop composition structures in a visual form around existing inscriptions recorded on the tablets. This in part dispensed with the need to formulate

[1] As I detailed in chapter five, I used three PC tablets that were connected together via a wireless network, with Microsoft OneNote software which supported written inscriptions to be created and shared in real time.

compositional structures using transient representations. The ability to create representations of the structure made it possible for groups to visually change the order of sections by making inscriptions rather than describing it in words.

The use of written sketches: The findings illustrated that the shared IAs were used to represent both high level abstract ideas and more fully-formed information about the composition. High level abstract ideas expressed in sketches supported intersubjectivity within JMC because it enabled musicians to form a basis for ideas to be described without needing to fully define exact meanings from the outset. The visual representations were later associated with the verbal language used as part of the communication to describe aspects of the composition long after the actual sketch ceased to be used. This showed that initial idea exploration in visual sketch form can become the foundation to how coordination is achieved on a more long term basis. This appeared to support the convergence on certain elements of the composition at certain times, especially as references were visually available to everyone during communication.

The ability to ease cognitive burden: Writing out information produced a form of computational offloading (Scaife & Rogers, 1996) which partly changed the amount of information musicians had to process in one go. The IAs supported the ability for musicians to record composition information and ideas, which provided the opportunity for musicians to partly overcome the challenge of interpreting long streams of compositional information presented in conversation. This potentially supported the musicians' ability to chunk information (Chase & Simon, 1973), making it more manageable to process.

The reconstruction of knowledge across multiple sessions: The shared IAs were used in different ways within the studies to support how knowledge was reconstructed across multiple sessions in order to resume work on a composition. In Set-Up A, participants introduced new ideas that were created outside of the session directly alongside the representation of the composition that was recorded on screen. Being able to refer to existing representations made it more possible for new information to be used in the same context. Participants used the opportunity to take information that was recorded in the previous session to create new ideas on paper between rehearsals. The participants appeared to maintain enough understanding of the inscriptions to allow for new ideas to be proposed in the same shared space when sessions resumed. The ability to record and share compositional information across the group and across time provided a new way for representational states to propagate in the functional system and across time.

One of the most important findings in the studies was the context in which different IAs were used across time. Along with the shared IA that supported the creation of inscriptions, the groups were also given audio recorders. Findings from both studies revealed that the shared IAs were useful to support the reconstruction of certain elements of the composition, but as with the written notes in chapter four they were not used to bring about an exact performance of a jam from the previous session. The group in Set-Up B demonstrated that using audio recordings was potentially a better means of reconstructing knowledge about the composition in a more exact manner. The audio recordings represented the output of several instruments in one go. This meant that more details of the performances were available when the composition was represented in recorded sound. This potentially highlights two different needs that are reflected in music composition research. Abrams et. al, (2002) state that the music composition process involves macro-level (or structural) conceptualisation versus micro-level (e.g., note level) editing. Within the studies, the written information created in a shared context was useful to support coordination when the composition structures and ideas were emerging and changing frequently; this supported the macro level conceptualisation. Audio recordings provided more details about what was being played within different performances, which potentially supported the micro-level knowledge required to remember the finer details of the performance.

6.2 Theoretical implications

DC helps describe the co-ordination among people, and between people and artefacts (both high and low tech), as a *functional system*. In describing the way the representational states propagate and transform across the functional system, insights are gained into how the cognitive system is able to achieve a successful outcome in a problem solving activity. Within my analysis, the focus on how the representational states propagated and transformed was helpful in providing a number of insights relating to how knowledge is distributed across the JMC functional system. For example, the construction of the activity chart in chapter four was a way to bring together several different sources of information into one snap shot of the system, which helped to illustrate the fragmented nature of how knowledge was reconstructed across time. This type of analysis is unique to the way DC can be used to provide insight in a domain of study. DC provided a more flexible way to create a unit of analysis than attempting to define tasks, as in Task Analysis, or to delineate activities, as in Activity Theory (Gruen, 1996).

My findings support the DC view that human behaviour cannot be explained simply by focusing on what occurs in an individual's head. The analysis of the episodes of work relating to the reconstruction of knowledge about a composition across time is testimony to how intelligent

human behaviour is best explained in context of the interactions among a number of human actors and technological devices for a given activity. Findings from my analyses illustrate that the power of the unaided individual mind is limited because there is only so much that can be remembered and learnt without external aids (Fischer, 1999). Illustrations of the flow of information within rehearsal sessions highlight that there are many transient representations that have to be processed, which can place a cognitive burden on musicians to know what to play when the composition is in development. My studies show that musicians do not remember compositions fully by themselves all of the time: they are reliant on other musicians and the IAs available to them. Whilst musicians often believed that they had remembered all that they needed to, evidence suggests that many details of what they produced previously was forgotten; details which were later desirable to reproduce. Perhaps this is one of the key arguments to encourage the idea of designing support for an area that currently relies mainly on using transient information across multiple sessions of work. In short, my studies have illustrated that IAs supported musicians to remember more details. In addition, IAs helped musicians reuse existing representations to further their ability to share and create ideas, and to create agreement on the definition of compositional components.

My findings suggest that creation of knowledge about a composition can be influenced by what can be created, remembered, and brought to realisation through mutual understanding. Therefore, resources such as language and artefacts play an important role in how different elements of the functional system coordinate actions and exchange information. Language in particular, has an important function because it acts as a mechanism that distributes the cognitive load of a problem across the system (Hutchins, 1995a). In any given rehearsal room set up, a JMC functional system will need to create a shared understanding of the emerging properties of the composition. In the field studies, the shared understanding was achieved predominantly through the use of verbal, gestural and musical information. In the studies I described in chapter four, written notes were also used as a way to achieve shared understand between different functional systems, even if this was not the reason musicians made the notes in the first place. Appendix E[2] demonstrates how my own band sometimes looked at the laptop to cue changes to each other, even though the laptop was mainly supposed to be used to record and playback audio. In all these cases placement and availability of resources influenced how people coordinated their activities, which meant that the implementation of work was greatly influenced by the availability of, and access to, resources.

My approach to analysing studies of JMC was significantly influenced by previous DC research

[2] Appendix E is an excerpt from my own diary.

including Hutchins (1995a & 1995b), Halverson (1994a), Rogers (1992), Furniss & Blandford (2006), Perry (2003), Holder (1999), Flor & Maglio (1997), and Gruen (1996), to name but a few. I believe I have managed to apply the knowledge that I gained from the literature by studying how information moves through the JMC functional system based on the analysis of cognitive ethnography in a number of work episodes within each study. This was particularly apt to my research because it helped me go beyond describing what people know and focus on how people go about knowing what they know (Hollan, Hutchins & Kirsh, 2000). This is one of the principle reasons to use DC over other methodologies I described in chapter two. For example, analysing the interaction and conversations within the study was critical to determining how people came to share an understanding when they communicated with each other. However, analysing a series of conversations did not help to illustrate the complex nature of how knowledge is organised across time unless the conversations and interactions were tracked throughout the process.

I relied on different forms of analysis, such as tracking the use of artefacts (Furniss & Blandford, 2006), to gain a number of insights in the analysis. The role of artefacts was not obvious by solely looking at conversations, because they were also used outside of group interaction. Therefore, using existing DC research such as Furniss & Blandford (2006) helped me to structure my analysis to consider how the environment supports access to resources and how the resources shape the cognition of the people working together in a problem solving activity. My method of analysis was not particularly different to what existing DC research has outlined. What can be considered as a deviation is my use of lab based studies to study a functional system. Whilst the lab based studies were not completely realistic set ups compared to what I observed in the field studies, they nonetheless provided useful insight into how JMC functional systems develop compositions. The lab studies provided me with an opportunity to track how knowledge was being shared within and between sessions, as well as be able to observe the different ways knowledge appears to be distributed when new IAs were made available.

One of the questions that I outlined in chapter two was whether Marr's (1982) three levels of description of a cognitive system would be useful to apply to JMC. After all, Hutchins's (1995a) use of the computational description of navigation is one of the few times that DC research actually accounts for Marr's levels of description. In addition, navigation on board a military naval ship has far more defined structures that can be used to describe in computational terms. Whilst JMC may also have regular activities that require representational states to propagate to achieve a certain goal (i.e., transfer of knowledge about musical properties), the problem solving structures are not as fixed as something like the fix cycle. Regardless, I was able to create a computational description of a JMC cognitive system. The process of attempting to

describe JMC in computational terms was useful for the early stages of my analysis when I was conceptualising what the JMC functional system was actually achieving in each session of work. I believe the main constraint that needs to be satisfied for a successful operation to take place in the JMC functional system is the emergence of a composition that preserves a structure which is remembered and performed over many sessions. In order for this to occur, knowledge about the composition must be distributed across the functional system in every session that the composition is being performed. The concept that compositions are not physical products is important. The output of a session of work in JMC is the shaping of knowledge about a composition. The implementation of how this occurs is impacted by the availability of different resources within the functional system.

The DC perspective that the availability of different resources can influence how information is shared or remembered is particularly important to JMC and potentially other forms of multi-session creative collaborative work. JMC is different to domains that produce relatively fixed or predetermined end products as a consequence of a session of work. In JMC the final state of the composition is unknown and more prone to be shaped by the process. For example, if details of the composition are forgotten between sessions, the outcome of the composition is likely to change. This is different to systems such as an emergency medical dispatch team that Furniss & Blandford (2006) studied because the process of work is unlikely to create a new form of medical dispatch. For example, the process will either produce a successful output or not (i.e., either an ambulance is dispatched to the appropriate address with the relevant details or not). Similarly, Johnson and Hyde's (2003) study of collaboration in a jigsaw puzzle task highlighted that mechanisms for collaboration such as communication and coordination greatly influenced the process of how the puzzle was put together. Regardless of the process, a successful outcome to the task was the creation of the puzzle which can be said to have a pre-determined final state; a completed puzzle will always look the same. The output of creative work may not have such fixed or predetermined structures; they are an emergent property of the group activity. Associating this perspective to composition is different to Sawyer's (2003) assertion that the process of improvisation is the product of improvisation. My findings suggest that the process of JMC supports the transformation of improvisations into compositions. The product of composition is not the process, unlike in improvisation, but the knowledge that is maintained about the composition that help bring about a performance across time.

6.3 Implications for design

My research has started to address how knowledge about compositions is developed and shared across time. I have outlined some of the methods that help knowledge propagate between musicians and how knowledge about compositions is reconstructed in different sessions. I have looked at the resources that are used within rehearsal sessions and constructed a view of how compositions emerge out of improvisations. I have also identified challenges that currently exist in JMC and taken the precedent-setting step of investigating how a form of Information Technology support can potentially change the way people conduct JMC. As it stands, the design implications of my work lie mainly in the themes that have been developed through my findings. I will outline four high level design considerations which have emerged from the findings of my thesis. These considerations are not meant to be standalone statements or guidelines to be given to designers. They can only be considered within the context of the findings of this thesis in order to help channel design rationale in *what* to support in JMC. Designers looking to support JMC using Information Technology still have major challenges in translating the findings of my research into an actual implementation of a functioning system. The issue of *how* to support JMC requires more thinking. Therefore, each consideration in itself requires further research from a design perspective to determine the most suitable implementation that is possible to achieve.

Extend the notion of reusable representations

The findings of my studies in chapter five suggest that when representations are recorded in a shared context, musicians often reuse them to enhance their ability to share and create ideas. Therefore, the system should provide a facility that allows different users to reuse the representations recorded in the context of a rehearsal session. Whether information is recorded in auditory or written form, the system should support users to take representations, as a whole or in part, and reuse it in different workspaces. Information Technology provides the opportunity to represent information in a number of different ways. Where possible, representations should be in formats that support flexibility in how they are used. For example, visually representing audio provides new opportunities for users to associate inscriptions with recorded sound. Alternatively, allowing users to link audio files to inscriptions present new ways in which representations can be used within JMC. Overall, designers should consider how Information Technology can be used to expand the potential of reusable representations within JMC.

Support the distributed nature of problem solving in JMC

One of my key conclusions in chapter four was that the distributed nature of problem solving in rehearsal sessions requires the outputs of local activities to be disseminated across the group in

order for progress to be made in JMC. The system, therefore, should support the ability of individual users to disseminate information across the group at the same time within a rehearsal room. The system should provide a shared space to allow different users to contribute to this process and support problem solving and this process should be visible to all. However, the system should also consider a private space for users to maintain representations that support them to work with information relevant to what they need to know for themselves. This will support the reconstruction of knowledge which occurs across the group at different points in time. The system should also support the ability to share information with all members or specific ones. At certain times it may be useful to share information with everyone whilst at other times it may only be relevant to specific users.

Support the use of portable recorded information

My studies highlight that work on compositions can continue outside of the rehearsal session. In chapter five, I illustrated how the ability of participants to use recorded information both inside and outside of the session supported how they developed the composition individually and as a group. Therefore, considerations should be made for a system to allow information to be easily taken away and developed outside of a rehearsal session. In addition, the system should support information being brought back into a work space where there is potential to work with existing representations for a composition. Therefore, information should be easily portable. The concept of portable recorded information can be important to how knowledge propagates both within and between sessions. Considerations can be made about incorporating systems based on mobile technologies, including *smartphones,* because these are potentially available to a wide range of users across a physical space. In addition, they can support the ability to carry information both inside and outside of a rehearsal session.

Look beyond existing artefacts

My findings from the field work illustrated that a cassette recorder was the only artefact that could be used to record information. No resources were available to help visualise and externalise information in a more permanent form within a shared context. Indeed, the key motivation to use PC tablets in my studies was that there was no existing IAs available to help study the distributed nature of problem solving in JMC. My suggestion is that designers should also consider looking beyond the artefacts that are traditionally used in a rehearsal room. Artefacts traditionally used in JMC have little or no capabilities to support the use of portable recorded information, or to allow for representations to be recorded, manipulated and reused over time. In short, very few artefacts exist in a rehearsal room that support the ability of musicians to share knowledge in JMC.

Looking beyond existing artefacts can mean looking at fairly primitive technologies like whiteboards mounted on the wall, right through to groundbreaking ideas such as incorporating blue-tooth technology within musical instruments to directly transfer certain information to be displayed or played on other instruments. Whilst this may appear to be unconventional, design has to consider that JMC is not only about the moments improvisations occur, but also how those improvisations are worked out to become compositions. Such a process requires deliberate definition and dissemination of information across a number of people and sessions. Within this process, availability of different artefacts can impact how compositions take shape.

6.4 Critical reflection on field and lab studies

Within this thesis, I have described a two month study conducted in a rehearsal studio (i.e., the field), and two studies conducted in a setting I helped to organise (i.e., the lab). Traditional DC research has mainly focussed on real world settings to explain the structures and resources available to practitioners of work in their actual work settings. The idea of a lab based study was inspired by Hollan, Hutchins and Kirsh (2000) who stated that “the richness of real-world settings places limits on the power of observational methods”. Their proposition to make “well motivated experiments” is something that had not been done before. My approach can be described, in part, to be unique to other DC studies because I incorporated lab studies in my research even through they were exploratory rather than experimental in nature.

Field and lab studies

Lab based studies helped to monitor the way knowledge was shared within and between rehearsal sessions. In addition, the lab studies helped to capture data from the inception of a group and a composition. I was able to study how ideas about compositions were developed from the outset. The field-work did not always help to illustrate how compositions had developed. Whilst I was able to observe the performance and development of compositions, I could not determine how knowledge was maintained and shared across time in the field study. It was especially difficult to determine whether interaction outside of the session or listening to recorded audio shaped the way musicians were able to think within sessions. However, the field work *was* extremely valuable because it helped to illustrate how groups naturally organise their session, their physical setting, and their communication. The field work was also a means for me to validate whether findings in the lab based studies bore any relevance to how JMC works in the field. In addition, it provided ideas about how to position participants and artefacts in the lab.

My participation in the first lab study

Another difference to typical DC studies was my participation in the first lab based study. My participation was useful because it enabled me to keep a record of some of the experiences of being part of the compositional process from a participant's point of view. It also helped to map high level structures of the sessions and consider whether interaction outside of the sessions appeared to impact how knowledge was developed and maintained. My participation was a means of accounting for all visible mechanisms that supported the distribution of knowledge across time.

Introduction of shared IAs in second lab study

The DC view that human behaviour is shaped by the resources and environment it is situated in was partly the inspiration for the set ups in the chapter five lab studies. Bodker, Nielsen, and Petersen's (2000) study of a physical environment that supported members of interdisciplinary groups to 'wonder' round IAs also highlighted that an artificial environment can be used to study the way cognition is supported in a certain context.

Providing a shared IA in the studies I described in chapter five was intended to help me determine the different ways in which knowledge was distributed across people and across time using recorded information. In addition, one of the set ups directly disrupted the visual access of the participants in order to determine whether there were differences to how the IAs were used. These types of intervention are highly unique to traditional DC research because they can be regarded as an artificial condition which bears little relevance to the way work is conducted in the field. My assertion is that the lab studies were not designed to recreate a completely realistic situation; no lab study can really maintain this. However, the lab studies were an attempt to understand how musicians develop and share knowledge about the composition without solely relying on transient information. It is a starting point for research in determining how new forms of support can be envisaged for a domain that currently does not use computer systems as part of the process of work. At some point, a form of intervention will occur in order to test how a new system or tool can be used.

Other issues concerning studies

I am mindful that the JMC functional systems described in my lab studies consisted of people who had not worked together. I have to consider how a JMC functional system would function within my altered set ups if the participants had a history of working together. Would they

become as reliant on creating a written language using the tablets? How would they incorporate existing knowledge to the new set ups? In addition, in my studies, the musicians were in a relatively constrained space, which meant that they were naturally close to the IAs. Consequently it required little effort to look at or use the IAs during interaction. This may be different to how musicians in Westbourne Rehearsal Studios work because they can move around and position themselves in different ways. This will no doubt affect how a tool is used because it may not be as available as in my set up.

Another area to highlight is that I did not fully outline the downsides of the technologies within the analysis. Essentially, I was focusing on how the IAs changed the nature of work within the set ups. I did not discuss the physical and cognitive labour associated with setting up the types of technologies. Design would require an understanding of the potential overheads and the types of problems a technical tool would cause because it will impact whether there is uptake or not. Essentially, my findings cannot be the justification for designers to start prototyping, but one that guides them into areas that they should consider supporting.

I must also take into account a number of issues that my DC study did not capture. For example, in creative collaborative work compatibility (i.e., how people feel about working together), motivation and creative abilities are essential factors to how the human components of the system work together. A participant (JB) in the chapter five lab study states in his post study questionnaire that he usually made music with people he was friends with first, therefore working with people who he did not know well was very “artificial” for him. Does being more or less compatible with someone affect how shared understanding is achieved? Does motivation to work on a composition impact how resources are used? For example, a number of people in the studies did not review information between sessions. Some stated that they did not have time. If this was the musicians’ own working project, rather than a lab study, would they have been more motivated to review this information? Was it the case that they were not motivated to work with information out of session or that they were not responsive to the types of media that were presented to them? Finally, the creative abilities of the group potentially have an impact on the quality of the ideas that are produced. Yet, the type of study that I conducted did not specifically search this out. DC is not designed to form judgement on the quality of ideas. Therefore, certain concerns that may be important to the musicians involved in JMC have not been taken into account.

6.5 Future direction

One of the most obvious next steps in research would be to examine each element of the design consideration in more detail, before considering developing computer applications. As

stated earlier, the considerations direct designers towards *what* to support in JMC. The most direct continuation of research would be to look at *how* to bring each consideration to realisation. This can involve researching existing design literature about the issues relative to each concept, right through to prototyping and testing. Whilst the design considerations share a relationship with each other, it is advisable that each be researched separately. For example, looking at how to create support for the creation of reusable representations for JMC is, in itself, a considerable challenge. There are many unanswered questions about how a system might work. Potentially one of the successes of the tablets was that they were not very complicated to use and only provided the ability to make inscriptions. A more complex system may disrupt the flow of the activity. In addition, a number of concepts have been introduced as part of the design consideration that need to be tested. For example, the implementation of associating or linking representations in different formats (i.e., written inscriptions and a visual representation of audio) can be done in a number of ways. It is likely that user testing of a number of prototypes must take place before settling on one form of support. In addition, features of the user interface, including understanding how to deal with the concept of private vs. public space, are just some of the issues that relate to one of the considerations.

Another future research direction could focus on conducting more in depth research about how the findings of this thesis can be applied to rehearsal rooms in the field. In reality, Westbourne Rehearsal Studios mainly looks to provide musicians with facilities that are to be used within a single session of work. I would also like to consider how supporting the distribution of knowledge within a single session can be considered, using the findings of my current research. This will not discount the reuse of representations created across time. Indeed effort should be made to make it easy for musicians to reuse material they have recorded. However, the unit of analysis would solely focus on the rehearsal space, and would therefore have a different research perspective to my current work. The proposed research would consider the way IAs are employed to support a single rehearsal session rather than how IAs support the development of compositions across multiple sessions. This scenario is more realistic to implement and research in the field because it does not attempt to track how knowledge is distributed outside of the session. The set up may not require complex technologies to be provided in the initial stages. For example, providing digital whiteboards or the ability to initiate audio recordings and playback from different areas of the room can be simple ways to create opportunities for bands to manage the creation and distribution of knowledge. The findings of this research will help to inform design about the realistic role of new systems within physical environments in which JMC currently takes place naturally.

6.6 Final remarks

As a musician who has been actively involved in JMC throughout this research, I would say that the moments of creativity that occur within improvisations are possibly the most enjoyable; it is almost why I am in a band. The process of how improvisations become compositions is often the least enjoyable part; there is a challenge to it. One key challenge is managing social relationships. Whose idea should be taken forward? What happens when there is a clash between opinions? Other challenges relate to the aesthetics of what is created, for example, what happens when exciting improvisations become drab compositions? These are very important issues to bands, but are not addressed within my research.

It is difficult to imagine how a computer system can support these issues. My work has managed to identify other challenges that exist within JMC, ones that perhaps are not always obvious even to the musicians themselves: the challenge of dealing with transient representations and the distributed nature of problem solving in a rehearsal session. The rationale to support musicians with artefacts that offer new ways to share knowledge is perhaps best summed up by the notion that “human beings have a bounded rationality: there is only so much we can remember and there is only so much we can learn” on our own (Fischer, 1999). JMC is not immune to this notion, even though it does not currently use many recorded representations within the process of work. My research has provided justification into the *why* and *what* of support for JMC. My work is a small contribution towards understanding the ways researchers and designers can look to support multi-session creative collaborative work. This is not directly about making people more creative, but is about looking at different ways to support and augment their “bounded rationality”.

Bibliography

Abrams, S., Bellofatto, R., Fuhrer, R., Oppenheim, D., Wright, J., Boulanger, R., Leonard, N., Mash, D., Rendish, M., Smith, J. (2002) Qsketcher: An environment for composing music for film, *Creativity and Creativity*, ACM Press, p.157-164

Amitani, S., Hori, K., (2002) Supporting Musical Composition by Externalising the Composer's Mental Space, *Proceedings of the 4th conference on Creativity & cognition*, ACM Press, p.165-172

Annett, J., Cunningham,D. (2000) Analyzing command team skills. In J. M. Schraagen, S. F. Chipman, and V. L. Shalin, (Eds.), *Cognitive Task Analysis*, Mahwah N.J.: Lawrence Erlbaum and Associates, p. 401–415.

Baecker, R. M., Grudin, J., Buxton, W., Greenberg, S. (1995) *Readings in human-computer interaction: toward the year 2000*, Morgan Kaufmann Publishers

Bannon, J. L., Bødker, S. (1991) Beyond the interface: encountering artifacts in use. In Carroll (Eds.), *Designing Interaction*. Cambridge: CUP, p. 227-253.

Barendregt, W., Bekker, M. M., Bouwhuis, D., Baauw, E., (2006) Identifying usability and fun problems in a computer game during first use and after some practice, *International Journal of Human-Computer Studies*, 64, 9, p. 830–846.

Bastien, D., T., Hostager, T., J. (1988) Jazz as a Process of Organizational Innovation, *Communication Research*, 13, 5, p. 582-602

Bayton, M. (1998) *Frock Rock: Women Performing Popular Music*, Oxford University Press

Becker, H. (2000) The etiquette of improvisation. *Mind, Culture, and Activity*, 7, 3, p.171-176

Bennett, A. (2001) *Cultures of Popular Music,* Open University Press

Berger, M, H. (1999) *Metal, Rock and Jazz: Perception and the phenomenology of musical experience,* University Press of New England: Hanover

Beyer, H., Holtzblatt, K. (1998) *Contextual Design: Defining Customer-Centred Systems.* San Francisco: Morgan Kauffman

Blackwell, A. F., Green, T. R. G. (2000) A Cognitive Dimensions questionnaire optimised for users. In A.F. Blackwell & E. Bilotta (Eds.) *Proceedings of the Twelth Annual Meeting of the Psychology of Programming Interest Group*, p.137-152

Blaine, T., Perkis, T. (2000) The Jam-O-Drum interactive music system: A study in interaction design, *Designing Interactive Systems*, ACM Press, p.165-173

Blickensderfer, E., Cannon-Bowers, J. A., Salas, E., Baker, D. P. (2000) Analyzing knowledge requirements in team tasks. In J. M. Schraagen, S. F. Chipman, and V. L. Shalin, (Eds.), *Cognitive Task Analysis*, Mahwah N.J.: Lawrence Erlbaum and Associates, p. 431–447.

Boden, M. A. (1992) *The Creative Mind.* London: Abacus

Boden, M. A. (1994) *Dimensions of Creativity.* London: MIT Press

Bødker, S. (1991) *Through the interface: a human activity approach to user interface design*, Lawrence Erlbaum Associates: New Jersey Hove and London

Bodker, S., Nielsen, C., Petersen, M, G., (2000) Creativity, Cooperation and Interactive Design, *In Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques*, ACM Press, p. 252-261

Bovey, S. (2006) Don't tred on me: The ethos of '60s Garage Punk, *Popular Music and Society*, 29, 4, p.451-459

Bryan-Kinns, N. (2004a) Daisyphone: Support for Remote Music Collaborations, In *Proceedings of the 2004 conference on New interfaces for musical expression*, New Interfaces For Musical Expression, National University of Singapore, Shizuoka, Japan, p. 27 - 30

Bryan-Kinns, N. (2004b) Daisyphone: Design and impact of a novel environment for remote group music improvisation. *In proceedings of Designing Interactive Systems*, ACM Press, p.135-144

Bryan-Kinns, N., Healey, P. G. T. (2006) Decay in Collaborative Music Making, In *Proceedings of the 2006 International Conference on New Interfaces for Musical Expression,* New Interfaces For Musical Expression, IRCAM, p.114-117

Burkholder, J. P., Grout, J. D., Palisca, V. C. (2006) *A history of western music (7th Edition)*, WWNorton: New York, London

Campbell, P., S. (1995) Of garage bands and song-getting: The musical development of young rock musicians, *Research Studies in Music Education*, 4, p. 12-22

Candy, L., Edmonds, E., Mamykina, L., (2002) Collaborative Creativity, *Communications of the ACM*, 45, 10, ACM Press, p. 96-99

Cauty, J., Drummond, B. (1999) *The Manual: How to have a number one hit the easy way 2nd Revised edition*, Ellipsis London Ltd

Chase, W., Simon, H. (1973) The mind's eye in chess, In W. Chase (Eds.), *Visual Information Processing*. New York: Academic Press

Clark, H. H. (1996) *Using language*, Cambridge University Press

Clark, H. H., Wilkes-Gibbs, D. (1986) Referring as a collaborative process. *Cognition*, 22, p.1-39

Clarke, P. (1983) A Magic Science: Rock Music as a Recording Art. *Popular Music*, 3, Producers and Markets, p.195-213

Cohen, S. (1993) Ethnography and popular music studies. *Popular Music*, 19, 2, p. 123-128

Cole, M., Engeström, Y. (1993) A cultural-historical approach to distributed cognition, In G.Salomon (Eds.), *Distributed cognitions: Psychological and educational considerations*, Cambridge University Press, p.1-46

Cook, N. (1998) *Music, A very short introduction*, New York: University Press

Coovert, M. D., Thompson, L. F., Forster, L. L. (2000) *Computer Supported Cooperative Work: Issues And Implications For Workers, Organizations, And Human Resource Management (advanced Topics In Organizational Behavior Series).* California: Sage Publications

Couger, D. (1996) *Creativity and Innovation in Information Systems Organisations*. Massachusetts: Boyd and Fraser Publishing Co.

Csikszentmihalyi, M. (1997) *Creativity: Flow and the Psychology of Discovery and Invention*. Harper Perennial

Dalton, D. (1980) *Rolling Stones in their own words*. London: Omnibus

Dennis, A. R., Nunamaker, J. F., Vogel, D. R. (1990) A Comparison of Laboratory and Field Research in the Study of Electronic Meeting Systems, *Journal of Management Information Systems*, 7, 2, ACM Press, p. 107-135

Devris, P. (2005) The rise and fall of a songwriting partnership, *The Qualitative Report,* 10, 1, p.39-54

Digidesign. (2009) About Pro-Tools page, viewed 05 May 2009, <http://www.digidesign.com/index.cfm?langid=100&navid=507&itemid=35911&ref=pt8-hpb>

Engeström, Y. (1987) *Learning by expanding: An activity-theoretical approach to developmental Research,* Helsinki Orienta-Konsultit

Engestrom, Y. (1999). Activity theory as individual and social transformation. In Engestrom, Y., Miettinen, R., Punamaki, R.L. (Eds.), *Perspectives on activity theory*, Cambridge University Press. p. 19-38.

eJamming Audiio. (2009) *Come explore eJamming Audiio*, ejamming Audiio homepage, viewed 05 May 2009, < http://www.ejamming.com/>

Fischer, G. (2004) Social Creativity: Turning Barriers into Opportunities for Collaborative Design, *Proceedings of the eighth conference on Participatory design*, ACM Press, p.152-161

Fischer, G., Arias, E., Carmien, S., Eden, H., Gorman, A., Konomi, S., Sullivan, J. (2004) Supporting collaboration and distributed cognition in context-aware pervasive computing environments, *Proceedings of the Human Computer Interaction Consortium Winter Workshop*

Fischer, G. (2005) Distances and Diversity: Sources for Social Creativity, *Proceedings of the 5th conference on Creativity & cognition*, ACM Press, p. 128-136

Fjermestad, J., Hiltz, S., R. (2000) Group Support Systems: A Descriptive Evaluation of Case and Field Studies, *Journal of Management Information Systems*, 17, 3, ACM Press, p. 113-157.

Flor, N. V., Holder, B. (1996) Hearing with the eyes: Towards a theory of improvisation. *Eighteenth Annual Proceedings of the Cognitive Science Society*, Lawrence Erlbaum Associates, Mahwah, NJ. Publication, p.147-153

Flor, N. V., Maglio, P. P. (1997). Emergent Global Cueing of Local Activity: Covering in Music, *The Second International Conference on Computer Support for Collaborative Learning*, University of Toronto, p.45 – 52

Forsberg, A., Dieterich, M., Zeleznik, R. (1998) The music notepad. *Proceedings of the 11th annual ACM symposium on User interface software and technology*, ACM Press, p. 203-210

Frith, S. (1981) *Sound Effects: Youth, Leisure, and the Politics of Rock 'n' Roll.* New York: Pantheon Books

Furniss, D., Blandford, A. (2006) Understanding Emergency Medical Dispatch in terms of Distributed Cognition: a case study, *Ergonomics Journal*, 49, 12/13, p.1174-1203

Garageband. (2009), *Garageband '09*, Garageband '09 homepage, viewed 05 May 2009, http://www.apple.com/ilife/garageband/

Gardner, H. (1994) *Creating Minds: An Anatomy of Creativity Seen Through the Lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham, and Ghandi*. New York: Basic Books, Inc.

Garfinkel, H. (2002) *Ethnomethodology's Program*. New York: Rowman and Littlefield

Gioia, T. (1988) *The imperfect art: Reflections in Jazz and modern culture*, New York: Oxford University Press

Green, D. W. (1996) *Cognitive science: an introduction*, Wiley-Blackwell

Green, T. R. G., Blackwell, A., F. (1998) Design for usability using Cognitive Dimensions. Tutorial session at British Computer Society conference on Human Computer Interaction, Sheffield

Green, T. R. G. (1990) Cognitive dimensions of notations, *Proceedings of the fifth conference of the British Computer Society*, Human-Computer Interaction Specialist Group on People and computers V, Cambridge University Press, p.443-460

Green, T. R. G. (2000) Instructions and descriptions: some cognitive aspects of programming and similar activities, *Proceedings of the working conference on Advanced visual interfaces*, AVI, ACM Press, p. 21-28

Green, L. (2001) *How popular musicians learn: A way ahead for music education*, London: Ashgate

Grief, I., (1988) *Computer-supported cooperative work: a book of readings*. San Francisco: Morgan Kauffman

Gruen, D. M. (1996) The Role of External Resources in the Management of Multiple Activities, PhD Thesis, University of San Diego, USA

Gurevich, M. (2006) JamSpace: Designing a collaborative networked music space for novices, *Proceedings of International Conference on New Interfaces for Musical Expression,* New Interfaces For Musical Expression, IRCAM, p.119-123

Hall, G. (2002) Bands Without Borders, *Electronic Musician Magazine*, October 2002, p. 72-86

Halverson, C. (1994a) Traffic Management in Air Traffic Control - Collaborative management in Real time. *SIGOIS: Bulletin for the Special Interest Group on Organizational Information Systems*, ACM Press, 15, 2, p. 7-11

Halverson, C. (1994b) Distributed cognition as a theoretical framework for HCI: don't throw the baby out with the bathwater - the importance of the cursor in air traffic control. Report 94-03, Department of Cognitive Science, University of California, USA

Halverson, C. (2002) Activity Theory and Distributed Cognition: Or What Does CSCW Need to DO with Theories?, *Computer Supported Cooperative Work*, 11, 1-2, p. 243-267

Heath, C., Luff, P. (1991) Collaborative Activity and Technological Design: Task Coordination in London Underground Control Rooms. *In Proceedings of the Second European Conference on Computer-Supported Cooperative Work*, ECSCW, Kluwer Academic Publishers, p.65-80

Healey, P.G.T., Peters, C. (2007) The Conversational Organisation of Drawing, P*roceedings of the First International Workshop on Pen-Based Learning Technologies*, PLT, IEEE Computer Societym, p. 1470--1475

Holder, B. (1999) Cognition in flight: Understanding Cockpits as Cognitive Systems, PhD thesis, University of San Diego, USA

Hollan, J., Hutchins, E., Kirsh, D. (2000) Distributed cognition: Toward a new foundation for Human-Computer Interaction research, *ACM transactions on Computer-Human Interaction*, 7, 2, ACM Press, p.174-196

Holtgraves, T. (2002) *Language as social action: social psychology and language use*, Taylor & Francis

Hornecker, E., Marshall, P., Rogers, Y. (2007) From entry to access – How shareability comes about. In *Proceedings of the 2007 conference on Designing pleasurable products and interfaces,* Designing Pleasurable Products And Interfaces, ACM Press, p. 328-342.

Hutchins, E. (1990) The technology of team navigation, In J. Galegher, R. Karuat, C. Edigo (Eds.), *Intellectual teamwork: social and technological foundations of cooperative work*, Lawrence Erlbaum Associates, p.191-220

Hutchins, E. (1995a) *Cognition in the Wild,* Bradford: MIT press

Hutchins, E. (1995b) How a cockpit remembers its speeds, *Cognitive Science*, 19, p. 265-288

Hutchins, E., Klausen, T. (1996) Distributed Cognition in an Airline Cockpit. In Middleton, D. and Engeström, Y. (eds.), *Communication and Cognition at Work*. Cambridge University Press, p. 15-54

Indaba Music. (2009) *Indaba Music home page*, viewed 05 May 2009, <http://www.indabamusic.com/>

Johnson, H., Hyde, J. (2003) Towards modeling individual and collaborative construction of jigsaws using task knowledge structures (TKS), *ACM Transactions on Computer-Human Interaction (TOCHI)*, 4, ACM Press, p.339-387

Johnson-Laird, P. N. (1988) Freedom and constraint in creativity, In Sternberg R. J. (Ed.), *The nature of creativity*, New York: Cambridge University Press, p. 202-219

Jordà, S. (2001) New Musical Interfaces and New Music making Paradigms, *Proceedings of the 2001 conference on New interfaces for musical expression,* New Instruments for Musical Expression Workshop*,* National University of Singapore, p. 1-5

Kauppila., P. (2005) The Sound of the Suburbs: A case study of three Garage Bands in San Jose California during the 1960s, *Popular Music and Society*, 28, 3, p. 391-405

Kennedy, M., (2006) *The Concise Oxford Dictionary of Music*. Oxford: Oxford University press

Kent, J, C. (1976) Edward Elgar: A composer at work: A study of his creative processes as seen through his sketches and proof corrections, PhD Thesis, Kings College University of London, UK

Kirwan, B., Ainsworth, L. (1992) *A guide to task analysis*, Taylor and Francis

Kivy, P. (2001) *New Essays in Musical Understanding*, Oxford University Press

Klein, G. (2000) Cognitive task analysis of teams. In J. M. Schraagen, S. F. Chipman, and V. L. Shalin, (Eds.), *Cognitive Task Analysis*, Mahwah N.J.: Lawrence Erlbaum and Associates, p. 417–429

Knakkergaard, M. (2000) Virtually no reality, *Popular Music Online*, 3, viewed 05 May 2009, < http://www.popular-musicology-online.com/issues/03/knakkergaard.html>

Kuutti, K. (1996) Activity Theory as a potential framework for human-computer interaction, In Nardi, B. (Eds.), *Context and consciousness: activity theory and human-computer interaction*, MIT Press, p.17-44.

Latour, B. (1990) Drawing Things Together, In Lynch, M. and Woolgar, S. (Eds.) *Representations in Scientific Practice*, MIT press. p. 19-68

Lave, J. (1988) *Cognition in Practice*, Cambridge University Press

Leach, J. (2001) MetaTone: Shared Music Environments for musical collaboration, MSc Thesis, Queen Mary University of London, UK

Lefford, N. (2000) Recording Studios Without Walls: Geographically Unrestricted Music Collaboration, MSc. Thesis, MIT, USA

Levin, G. (1994) Painterly Interfaces for Audiovisual Performance, MSc. Thesis, MIT, USA

Lilliestram, L. (1996) On playing by ear, *Popular Music*, 15, 2, p. 195-216

Malmkjær, K., Williams, J. (1998) *Context in language learning and language understanding*, Cambridge University Press

Marr, D. (1982) *Vision: A computational investigation into the human representation and processing of visual information*, New York: Freeman

Matusov, E. (1996) Intersubjectivity without agreement, *Mind, Culture, and Activity*, 3, 1, p. 25-45

Mayer, R. E. (1992) *Thinking, Problem Solving*. New York: W. H. Freeman and Co.

Mayer, R. E. (1999). Fifty Years of Creativity Research. In Sternberg R. J. (Ed.), *Handbook of Creativity*. Cambridge: Cambridge University Press

Mayes, R. T., Draper, S. W., McGregor, A. M., Oatley, K. (1988) Information flow in a user interface: The effect of experience of and context on the recall of MacWrite screens, In Jones D. M. & Winder R. (Eds.), *People and computers IV,* Cambridge University Press, p.257-289

McGillen, W. C. (2004) In conversation with Sarah and Matt: perspectives on creating and performing original music, *British Journal of Music Education*, 21, p. 279-293

Nabavian, S. (2002) The emergence of composition from improvisation, MSc Thesis, Queen Mary University of London, UK

Nabavian, S., Bryan-Kinns, N. (2006) Analysing Group Creativity: A Distributed Cognitive Study of Joint Music Composition, In *proceeding of 28th Annual Conference of the Cognitive Science Society*, p. 1856-1861

Nardi, B. A. (1996) *Context and Consciousness: Activity Theory and Human-computer Interaction,* MIT Press

Nemeth, C. R., Cook, P., O' Connor, M., Allan, P. (2004) Using Cognitive Artifacts to Understand Distributed Cognition, *IEEE Transactions on Systems, Man and Cybernetics,* 34, 6, p. 726- 735

Ninjam. (2007) Ninjam homepage, viewed 05 May 2009, <http://www.ninjam.com/>

Norman, D. A. (1995) *Things that Make Us Smart*, Addison Wesley

Norman, D. A. (1998) *The design of everyday things*, MIT Press

Olson, J, S., Olson, G. M., Storrosten, M., Carter, M. (1993) Groupwork Close Up: A comparison of the group design process with and without a simple group editor, *ACM Transactions on Information Systems*, 11, 4, ACM Press, p. 321-348

Osborn, A. (1953) *Applied Imagination: Principles and Procedures of Creative Problem Solving*, New York: Charles Scribner's Sons

Paperback Oxford English Dictionary (2006) Oxford University Press

Pepperell, R. (2002) Computer Aided Creativity: Practical Experiences and Theoretical Concerns, *Computer & Creativity*, ACM Press, p.50-56

Perry, M. J., Macredie, R. *Distributed cognition: investigating collaboration in open organisational systems*, Technical Paper, Brunel University, UK

Perry, M. J. (1997) Distributed Cognition and Computer Supported Collaborative Design: The organisation of work in construction engineering, PhD Thesis, Brunel University, UK

Perry, M. J. (1999) The application of individually and socially distributed cognition in workplace studies: two peas in a pod? In *Proceedings of European Conference on Cognitive Science*, p. 87-92

Perry, M. J. (2003) Distributed Cognition, In Carroll M. J. (Eds.), *HCI models, theories, and frameworks: toward a multidisciplinary science*, Morgan Kaufmann, p. 193-223

Pinelle, D., Gutwin, C. (2001) Group task analysis for groupware usability evaluations. In *proceedings of the 10th IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises*, WETICE, IEEE Computer Society, Washington DC, USA

Preece, J., Rogers, Y., Sharp, H. (2002) *Interaction Design: beyond human computer interaction*, John Wiley & Son Inc

Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S., Carey, T. (1994) *Human-Computer Interaction*, Addison-Wesley

Porcello., T. (1996) Sonic Artistry: Music, Discourse, and Ethnology in the Sound recording Studio. PhD Thesis, University of Texas, USA

Powell, S. (1995) *Hit Me with Music: How To Start, Manage, Record, and Perform with Your Own Rock Band*, Millbrook Press

Reddy, M. J. (1979) The conduit metaphor -- a case of frame conflict in our language about language. In Ortony A. (Ed.), *Metaphor and thought.* Cambridge: Cambridge University Press, p. 284-297

Richardson, L. (2000). Evaluating ethnography, *Qualitative Inquiry*, 6, 2, p. 253-255

Rogers, Y., Ellis, J. (1994) Distributed Cognition: an alternative framework for analysing and explaining collaborative working, *Journal of Information Technology*, 9, 2, p. 119-128

Rogers, Y., Brignull, H., Scaife, M. (2002) Designing Dynamic Interactive Visualisations to Support Collaboration and Cognition. In *First International Symposium on Collaborative Information Visualization Environments IV 2002,* IEEE, London, UK, p.39-50

Rogers, Y., Rodden, T. (2003) Configuring spaces and surfaces to support collaborative interactions, In O' Hara, K., Perry, M., Churchill, E. and Russell, D. (Eds.) *Public and Situated Displays*, Kluwer Publishers, Norwell MA, USA, p.45-79

Rogers, Y. (2006) Distributed Cognition and Communication. In Brown K. (Eds.), *The Encyclopedia of Language and Linguistics 2nd Edition*, Elsevier Ltd, p. 181-202

Rosen, P. (1997) “It was easy, it was cheap, go and do it!" Technology and Anarchy in the UK Music Industry, In Purkis, J & Bowen, J. (Eds.), *Twenty-First Century Anarchism: Unorthodox ideas for a new Millennium*, Cassell Press

Rosenbrock, A. (2002a) The composition process in pop and rock: Musical creativity in groups, In *proceedings of the international ESCOM conference 2001*, La créativité musicals - musical Creativity, Lieg, Belgium

Rosenbrock, A. (2002b) “I think I've never had a good idea in the practice room.” *In and out of the studio*, Organised Sound, 8, 1, p.89-96

Rosenbrock, A. (2003) Creativity with a large `C' - Creativity with A Small `C', *Proceedings of 5th Triennial Conference of the European Society for the Cognitive Sciences in Music*, Hanover University of Music and Drama, Hanover, Germany, p.34-37

Sacks, H., Schegloff, E. A., Jefferson, G. (1974) A Simplest Systematics for the Organization of Turn-Taking for Conversation, *Language*, 50, p. 696–735

Sasso, J. (1980) The Stages of the Creative Process, *Proceedings of the American Philosophical Society*, 124, 2, p. 119-132

Sawyer, K., R. (2003) *Group Creativity: Music, Theatre, Collaboration*, Lawrence Erlbaum Associates

Scaife, M., Rogers, Y. (1996) External cognition: how do graphical representations work? *International Journal Human Computer Studies*, 45, p. 185-213

Schegloff, E. A. (1992) Repair After Next Turn: The Last Structurally Provided Defense of Intersubjectivity in Conversation, *American Journal of Sociology*, 98, p. 1295–345

Schiphorst, T., Calvert, T., Lee, C., Welman, C., Gauder, S. (1990) Tools for interaction with the creative process of composition, *Proceedings of the SIGCHI conference on Human factors in computing systems: Empowering people*, Conference on Human Factors in Computing Systems, ACM Press, p.167-174

Shank, B. (1994) *Dissonant identities: The rock'n'roll scene in Austin, Texas,* Wesleyan University Press

Shneiderman, B. (2000) Creating Creativity User Interfaces for Supporting Innovation, *ACM Transactions on Computer-Human Interaction*, 7, 1, ACM Press, p.114-138

Shuker, R. (2002) *Popular music: Key concepts*, Routledge

Simon, H., A. (1996) *The Sciences of the Artificial (Third edition)*, MIT Press

Sloboda, J. (1985) *Generative processes in music,* New York: Cambridge University Press

Solso, R. L., MacLin, K. M. (2001) *Experimental Psychology: A Case Approach*, Allyn & Bacon

Star S., L., Griesemer J., R. (1989) Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science*, 19, 4, p. 387–420

Stefik, M., Foster, G., Bobrow, D., G., Kahn, K., Lanning, S., Suchman, L. (1987) Beyond the chalkboard: computer support for collaboration and problem solving in meetings. *Communications of the ACM archive,* 30, 1, ACM Press, p. 32-47

Steinberg. (2009) *CuBase 5*, Details of CuBase 5 product, viewed 05 May 2009, http://www.steinberg.net/en/products/musicproduction/cubase5_product/cubase5_details.html

Sternberg, R. J. (1999) *Handbook of Creativity*. Cambridge: Cambridge University Press

Suchman, L. (1987) *Plans and Situated Actions*, Cambridge: CUP

Suchman, L. and Trigg, R. (1991) Understanding practice: video as a medium for reflection and design. In Greenbaum, J. & Kyng, M. (Eds.), *Design at Work*, Lawrence Erlbaum Associates, p. 65-90

Tanaka, A., Tokui, N., Momeni, A. (2005) Facilitating collective musical creativity. In *Proceedings of the 13th annual ACM international conference on Multimedia*, International Multimedia Conference, ACM Press, p. 191-198

Tillman, J., B. (1987) Towards a model of the development of musical creativity; A study of children aged 3-11, PhD Thesis, University of London Institute of Education, UK

Titon, J. T. (1977) *Early Downhome Blues: A Musical and Cultural Analysis*. Chicago: University of Illinois Press

Townsend, S., A. (2003) Stop! Look! Listen! for Effective Band Rehearsals. *Teaching Music*, 10, 4, p. 22-25

Walker, W. F. (1997) A Computer Participant in Musical Improvisation, In *Proceedings of the SIGCHI conference on Human factors in computing systems*, Conference on Human Factors in Computing Systems, ACM Press, p. 123-130

Wallas, G., (1926) *The Art of Thought*, New York: Harcourt Brace

Warr, A., O'Neil, E. (2007) Tool support for Creativity Using Externalizations, In *Proceedings of the 6th ACM SIGCHI conference on Creativity & Cognition*, Creativity and Cognition, ACM Press, p. 127-136

Westbourne Rehearsal Studios. (2009) Westbourne Rehearsal Studios homepage, viewed 5th May 2009, <http://www.westbournerehearsals.com/index.htm>

Winograd, T., Flores, F. (1986) *Understanding Computers and Cognition: A New Foundation for Design.* New Jersey: Ablex Norwood

Wright, P. C., Fields, R. E., Harrison, M. D. (2000) Analyzing human-computer interaction as distributed cognition: the resources model, *Human Computer Interaction*, 15, 1, p. 1-41

Zachary, W. W., Ryder, J., M., Hicinbothom, J., H. (2000) Building cognitive task analysis and models of decision-making team in a complex real-time environment. In J. M. Schraagen, S. F. Chipman, and V. L. Shalin, (Eds.), *Cognitive Task Analysis*, Mahwah N.J.: Lawrence Erlbaum and Associates, p. 365–383

Zhang, J., (1997) The nature of external representations in problem solving. *Cognitive Science*, 21, p. 179-217

Zhang, J., Norman, D. A. (1994) Representations in distributed cognitive tasks, *Cognitive Science*, 18, p. 87-122

Zhang, J., Patel, V. L. (2006) Distributed Cognition, Representation, and Affordance, *Pragmatics and Cognition*, 14, 2, p. 331-341

Zollo, P. (1997) *Songwriters on songwriting*, DaCapo Press

Appendix A: Young Band physical positions

Young Band session one positions

Video 1 (00:18:20)

Video 1 (00:18:16)

Video 1 (01:39:37)

Young Band session two positions

Video 1 (00:00:03)

Video 1 (00:22:35)

Video 1 (00:46:35)

Young Band session three positions

Video 2 (00:03:51)

Video 2 (00:12:19)

Video 2 (00:31:13)

Young Band session four positions 1

Video 1 (00:05:48)

Video 1 (00:19:54)

Young Band session four positions 2

Video 1 (01:09:44)

Video 1 (01:13:06)

Video 1 (01:16:17)

Appendix B: Young Band interview

In the second session of my observation, I had the opportunity to ask questions of two members of the band (D and G). The other two members of the band (V and B) were late. D had gathered around the me for an informal chat whilst G listened in as he changed a string on his guitar. I will use much of the quotations from the discussion as an illustration of how the musicians themselves think about the way the do things and possibly why they do it. I believe that much of what is described in the interview is a fair reflection of what happens in rehearsals and how bands like *Young Band* approach song writing. In the session before this interview, the group were heard referring to “songs”. I asked questions that related to how they make songs.

Me: How do you make songs?

D states that G and B both play guitar and come up with a “chord sequence for a riff and they play it when we are all together”.

D: “and everyone has different input about where where it should change to into different parts and when it should be quiet and when it should be loud”.

G: “It all stems from ideas rather than...it's not often B or I'll come up and say we got a whole tune...that's more difficult.....it's like I got this idea which is the best way to write as a band....I'll have an idea for a guitar part and B would put his bass to it and he'll write something else and I'll play along with that”.

D: “As long as it is just an idea it never really gets set in stone until until we all play together”.

G states that he has songs that are complete but “they don't seem to work with the band...they might do with time but it's not just...you know what I mean it's better to have band music..and we write together”.

Me: Do songs finish in a session or do they go into more than a session?

D: “It's never completely finished it it it can be a full song so it can be like three and half minutes it's got everything there but after wards we go back and we make little changes ... no song is ever complete because you can always you can always change it round”.

Me: Do you meet outside of the session to make and develop songs?

G stated that they did not meet to discuss anything outside of the rehearsal room because “a lot of stuff happens when we actually play it”. He goes on to say that when they play they select aspects that they want to keep: “it is more like yeah put that in”.

G: “it seems to be on an individual basis as well.....like people look after their own their own parts and everyone else goes yeah”. By this I assume he means that an individual would create an aspect of the song on their instrument and others would give feedback..

Me: Do you guys make notes or remember stuff in your head?

D: “we don't really make notes ... V makes notes for the lyrics ... other than that we all..I guess we all have an idea of what it is may be it is a good idea to make notes.....sometimes you come back and say that bit shouldn't be like that”.

G: “well no we have a clear idea well no I know it's weird...problem is we all have our own language as coz we don't write it down (inaudible) we have our own language of where it should be it's like we'll have two (hand gestures) and then a change and then one and we're like what the fuck I'm thinking about it as fours”.

D: “Four bars”.

G: “Well I don't think of it as bars I think of it as little sequence or something”.

D: “No I think of it as bars just because of the fact that I play drums means I can get everything (inaudible) structured”.

G: (nodding) “mine's an abstract structure”.

Me: So how do you overcome it? Does it cause problems?

G: “I feel we are all developing a unique language .....it's like we all speak a different language and then we just put it in the middle and we'll come up with a new one and we're all like ah I get it”.

D: “Every song has a change (laugh).....every song has one bit called the change and 'yea that's just before we do the change' ”.

G: (simulating a conversation between two people) “and then it goes 'the small change' 'oh the small change' then the big change then the other change on the mic like 'other change' .... on stage we're like 'other change' and we're like what the fuck is that? It's all part of the fun I suppose”.

Me: but it works

G: “that's the thing it's em it's not about the specific words we say we get it we get the point across and erm we understand each other.....I'd like to think (smiles)”.

Me: What is the tape for?

G: (the tape) “is for reflection .... to see how good we really are what we really sound like because you know you can't listen properly when you are playing”.

Me: is it because of the volume you can't listen to yourself?

D: “when you are playing you are focussing on what your are playing you are not really hearing everyone else's parts as you would when you are playing back and that's one of the best thing's about recording the demo thing on Sunday and now we have a good quality recording of us playing so we can really listen to it clearly and pick out what everyone is doing”.

G admits he doesn't pay attention to what V sings about.

D: “especially in places like this where the vocal volume never seems to be loud enough”.

G: “I can't hear myself when I was just singing then.....and eh with the tape is like ah that’s what you’re doing V”.

G: “Because I'll hear the drums I'll hear the bass...not in so much detail as you come when you listen back to it but the vocals it's like ahhh I understand now”.

Conclusions from the interview

- A song starts an idea and by the language used an idea can consist of a guitar riff
- Ideas are not “set in stone” until it played when everyone is together
- Everyone has input into when changes should occur, when it should be quiet and loud
- The song is in continuous development. It can be a “full song” but can can be “changed around” later

- The onus is very much on each individual to create their own lines and for others to say “yeah” as means to approving it

- They state that they do not meet outside of the rehearsal session to discuss or develop songs

- They do not make written notes but D thinks it may be a good idea as “sometimes you come back and say that bit shouldn't be like that”

- They have a different language in describing ideas and song structures, and they develop a common language based on the different languages that are “put in the middle”

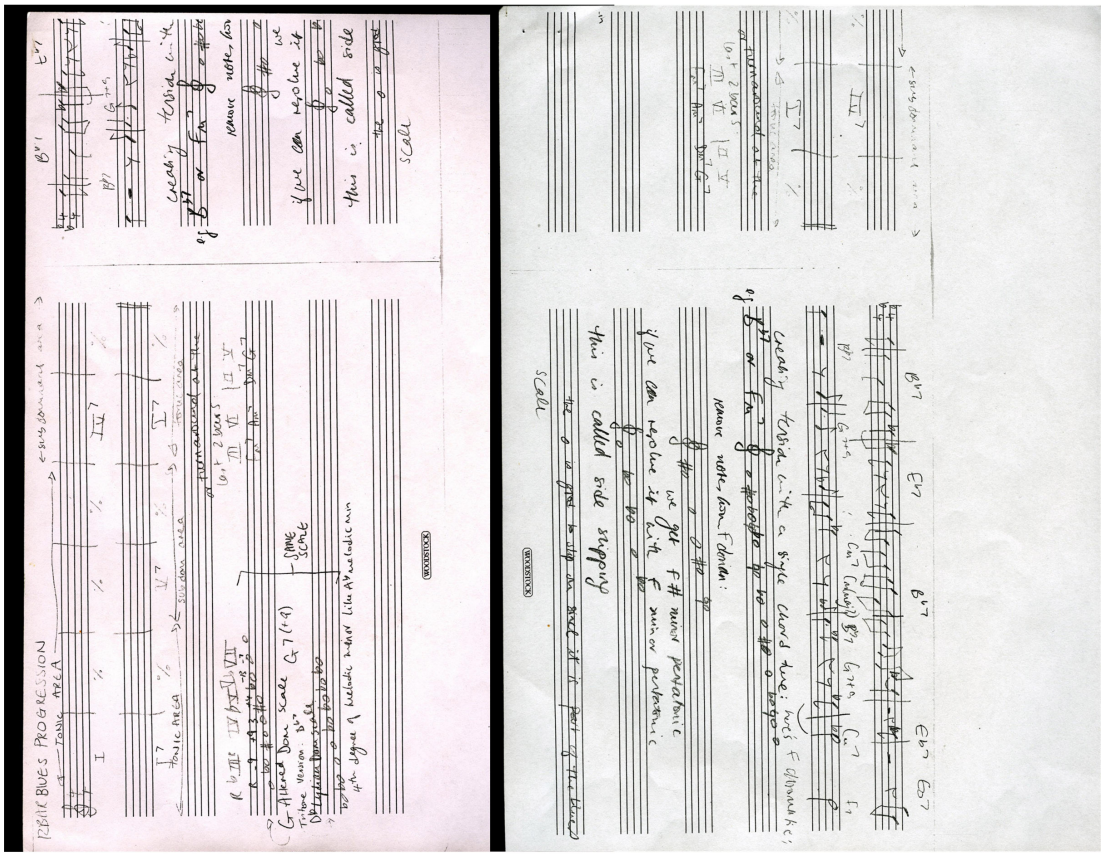
- The details of what others play are heard more clearly on cassette than when the play as a band in the room. One reason could be because they are concentrating on what they are playing and possibly listen less to what others play. The other aspect may be the volume of instruments or vocals are not high enough to be heard clearly

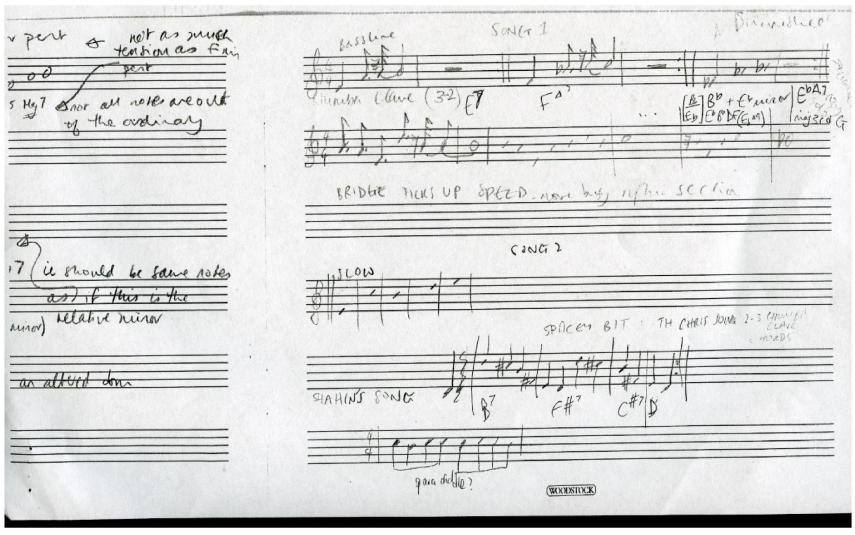
- G's statements about speaking different languages is a good illustration of the way different people express the properties of the song. Whereas D the drummer thinks of song structures in terms of bars, G the guitarist thinks of it in terms of sequences of sounds. This relates to what they need to know when they play their instruments. A drummer is the time keeper of the band and has to play a regulated rhythm for a Rock song, usually at the same tempo, throughout the song. Playing the drums requires more automation than playing the guitar or keyboard which may not be as regulated; they express mood and “colour” in a song. For this reason G may find that counting bars to be more difficult than knowing that a sequence is about to end and the beginning of another is due to be played. Such changes may be infrequent for drummers. People need different knowledge to play different instruments, and this can often mean they express themselves in their way of thinking.

Appendix C: Laboratory study one participants' background

Name	Sex	Age range	Occupation	Musical Background	Music Collaborative Experience	Song Writing Experience
H	Female	20-30	Research Student	Classically trained; Violin	Expert – jammed and performed live with improvisation Jazz ensemble	Beginner (First time)
C	Male	20-30	Research Student	Formal knowledge of music; Bass guitar, Guitar & Keyboard.	Played with original and covers bands and earns side income from it.	Expert. Has written & recorded with bands and is involved in writing a musical.
A	Female	20-30	Animator, Artist	Classically trained; flute, Piano	Beginner – rarely played with other people	Beginner
S	Male	20-30	Research Student	Self taught, Bass guitar	Expert – has played with bands for numerous years	Expert – written and recorded with various bands.

Appendix D: Participant H's written notes





Appendix E: Researcher band diary excerpt

For a period of four weeks, I kept a diary of all the days that I had rehearsal sessions with my own band. My main motivation was to keep a record of all events that related to what I had to do with the band. This included my own thoughts and feelings about the events that occurred. My diaries helped to me to reflect back on session and create some overviews of the goings on in a rehearsal room across time. In total ten entries were recorded. In this appendix I present one of the more detailed entries that I made.

Travel to university

It is Monday and I have several activities. I have to go to university and I also have rehearsal with the band afterwards. Monday's is usually a band rehearsal day and we confirmed our meeting in the last session, on Friday. I travel from home to university via the London underground. It is about 10am and I have beaten the morning rush hour. The journey takes about 45 minutes and I fill the time reading the free newspaper paper Metro, which I picked up from a stand at the station. I am not carrying any bags. In my pocket is an IPod shuffle (a music player) which contains demo tracks of songs that my band has been developing. As usual, in my left back pocket of my jeans is my plectrum (used to play electric guitar and bass), which I usually take on rehearsal days. I have loose change, my mobile phone and my travel card. I have been listening to the demos of songs, or *tracks* as we sometimes call them. There is about seven songs and they are in a continuous loop, which means once the player finishes playing the final track, it loops back to play the first track. I did on occasion replay a track by taking the IPod out of my pocket and clicking the back button before letting the IPod carry on with the play list automatically. I do not recall how many times each song was played during my travel. I know that I heard them at least once and some of them at least twice.

At university

I have been at university from about 11:00 am going through the day researching papers for group creativity and preparing for my supervisory meeting at 5pm. I have my meeting with my supervisor, which went relatively well.

Travel to rehearsal

At about 6:20 pm I travel to rehearsal by tube. I listen to the demos on my IPod as I travel to Whitechapel by London underground. One of the tracks I am listening to, lets call it *track A*, has a complicated structured which I think can be simplified. I feel this track can be commercially

popular and a simpler structure would help it. I walk about 10 minutes to get to our rehearsal room. I turn IPod off as I walk.

In the rehearsal room at Jamestown studios

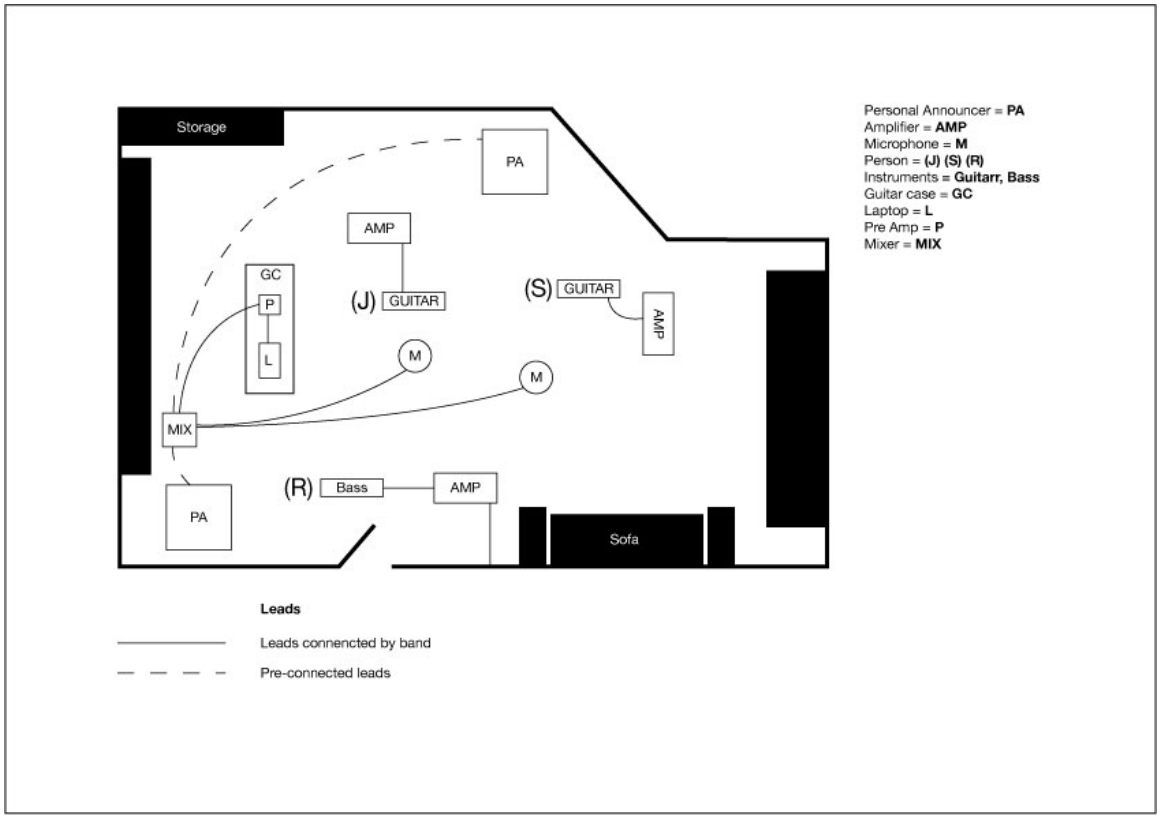
We share our rehearsal room with three other bands and each band has their own equipment. This room is part of *Jamestown studios*. We hire this room on a monthly basis, which is different from rehearsal studios which hire rooms on an hourly basis. We share a number of items in the room, for example a personal announcer (PA) and mixer for the vocalists. All bands usually use their own instruments and their own amplifications, but it not uncommon that people use each other's equipment.

The room is slightly cramped and I think it has too much equipment in it. There are moths in the room and sometimes the rubbish is not cleared, making the room very untidy. My band mates (J) and (S) have already started to set up in our rehearsal room when I arrive. I am about 15 minutes late; I am often late. I greet my band mates and take off my jacket. I am slightly embarrassed to be late once again. I quickly begin to set up for rehearsal. This may be a different task for each musician. I find my bass guitar in the corner of the room in a soft case. I unzip the case and walk over to my bass amp.

One band member asks about my weekend; we had not talked or seen each other since before the weekend. I give him reply as I look for leads, which connect my bass guitar to other equipment like my amplifier and tuner. I find the leads and ask if anyone is using the tuner that is on the floor. This was more for courtesy as I was going to take it anyway. I plug one end of the lead into the bass and the other to the tuner. Meanwhile, I hear sounds of the guitar amps being turned on and some playing. After tuning my bass, I take the lead out and connect it to my amp and turn the amp on. I play some notes on the bass to determine the quality of the sound and the volume. I am satisfied that it is a good sound, and I am now ready to rehearse. Since walking in the room, this has taken about ten minutes. No one actually says that they are ready, but it seems obvious when instruments sound like they are in tune and the person holding it is waiting.

"I thought we could work on *track A*" says the singer songwriter (J). "I think we can play it better and I have a new guitar part for it". I say nothing at this point, even though I want to talk about the structure. I am waiting for the process of work to begin. (J) is holding his guitar and turns to a laptop that he has step near himself. We have been using a laptop to play the backing track of our songs. We have been rehearsing without our drummer because he is away for a month.

The backing track contains a mix of drums and other instrumentation such as keyboards, which the rest of the band cannot play: (J) and (S) play guitar and sing, whilst I play bass. One can think of the backing track much like how a karaoke works: we play what the backing track is missing except we do not have instructions on a screen, which some karaoke systems may have.



(Illustration of rehearsal room described in diary)

Many musicians use backing tracks in their live performances because it enhances the sound of the performance; the effect of playing live music over a backing track makes the sound much more powerful than if a backing track is not used. In our set up, the backing track is played off the laptop and into the PAs via a pre amp and a mixer. The volume can be controlled through the laptop and the mixer. The laptop is mounted on a make shift platform consisting of a keyboard stand with a hard guitar case across the top, allowing the keyboard to be accessible to view and operate whilst (J) is standing up. He asks “shall we run through it?”; I say “yes”. He presses the space bar twice, moves away from the laptop and places his hands on his guitar. The backing starts to come through the PA within a second or two from when (J) presses the space bar.

I listen to the backing track, look at my bass, place my hands around the area where the first notes of the bass line start. At the right time I start to play. I am focussed on listening to the backing track and the sounds of the guitars of my band mates. (J) normally sings but not this time.

Occasionally I see (J) looking at the laptop. I know that he sometimes does this when he is not sure how much of the song is played and when the next section of music within the song is coming up. I also looked at my left hand and the positions that it should be when playing, making sure I am not playing in the wrong key (i.e., playing the correct sequence but not in the right place on the bass); this would usually sound bad. Whilst I play, I recalled that there was a change that (J) asked me to play the last time we rehearsed and the change will be played at a point that I had not yet reached. I make sure I remember to play that part. I notice few notes are occasionally played incorrectly, mainly my finger hitting the wrong notes. The same could be said about the others; we are still at the warming up stage. It is more excusable to make mistakes in the early takes because we are warming up but may become a concern if it persists because it would not sound professional.

After the run through (J) turns to the laptop and presses the space bar. He looks towards (S) and says “you were meant to change with me on the chorus…remember?”. There is silence, whilst I look on. (J) goes on to say in a slightly irritable voice “we went through this on Friday”. (S) replies “ok ok”. (J) turns to the laptop and presses the space bar twice and the backing track begins. We run through the song once more. Once finished (S) states “I am still having problems with the second chorus…I think I am playing over your part”. There is silence. He continues “I think it is messy”. (J) replies slightly lazily “well shall we just loop that section and just play along with it?”; (S) and I nod. (J) turns to the laptop and starts to do something with it. (S) and I wait.

Whilst (S) and I wait, we play some notes on our instruments in between to fill the time. After a couple of minutes, (J) says “ok” and presses the space bar; the backing track starts. It is a loop (a continuous repetition) of a section. We play along for many minutes. I notice a pattern that that (S) plays that I like. I look towards him and start nodding. I hope that others like it too but I cannot say anything whilst we play; it is too loud. Once we stop playing there is silence for a few seconds. I take this opportunity to say “I think that was cool”; (S) nods. (J) states “shall we record it?; I say “yeah”.

We need to set up some room microphones because there is no facility for us to record; we have to create our own facility. I take off my bass and lean towards a shelf behind me where I take a microphone; the shelf contains numerous music related artefacts. I take a microphone stand from the corner of the room and place the microphone on it. (S) has meanwhile set another microphone on another stand. I look for a lead that connects the microphone to the mixer. I walk to a blue box were we store our leads in plastic bag. I look through a few before finding two suitable leads. I give one to (S) and connect the other one to the microphone I set up. I connect the other end to the mixer. (J) has connected a lead from the pre amp to the mixer to connect the new inputs to the laptop.

(J) moves the microphones around to find a place he thinks will best capture the sounds of made by our three amplifiers. He asks us to play along with the backing track to test the level of the recording. He presses the space bar twice and the backing tracks commences. We all start to play along for about a minute of the song. (J) stops playing and moves forward to the laptop and presses the space bar. The backing track stops and so do (S) and I. (J) uses the laptop to play back the recording; it is grainy and not particularly clear but it should be enough of a reference for the future.

(J) says he will set the backing track to start at the same position as the “last time”, inferring the loop that was played when (S) came up with his new guitar line. He presses the space bar twice and moves back. Nothing happens. He looks towards the laptop and uses the mouse pad to and clicks the button. He presses the mouse pad twice and the backing starts to play. We attempt to play what we each played during the period where (S) came up with his new guitar line.

Both (J) and myself have not changed what we play for many weeks. All I have to do is recall something that I have played many times before. (S) on the other hand has to remember something he only played once. Since he played the new part, we have spent at least between ten to fifteen minutes setting up the microphones and conducting a sound check. (S) did not record any anything down as he was involved in setting up one of the microphones. When the backing track start I listen intently to what (S) is playing whilst playing my own instrument. The guitar seems not quite right. We keep playing and it becomes more to what I remembered. In the mean time (J) starts to play a guitar line that he had not done before; he is *playing off* the new guitar line that (S) is now playing. This sounds good and I look towards (J) and smile.

After a few minutes of playing to the loop (J) turns to stop the backing track. We have now come up with a solution to a problem identified by (S). By agreeing to record it, we all seem to think that we have a good solution. However, from experience we know that we need to listen back to it outside of the room to see if it is really any good.

Having played this track for nearly an hour, we decide to take a quick break. I have not had a chance to bring up the issue of the structure. My feeling is that the structure can always change later; it is what's contained in the structured, for example the problem highlighted by (S) that is something that is better resolved inside of the session. In addition, (J) is the person who usually creates the structures and from my previous experience I know that he is unlikely to want to change structures of songs until all the music is satisfactorily worked out between us. He has commented that if everything sounds good, then we can always extend, shorten or remove sections of music after we record it. We achieved this the last time we recorded a song professionally, where we shortened a song to accommodate a radio station's request.

The song that I wanted the structure changed now has new parts added to it that need to be reviewed outside of the session. Therefore, the likelihood of us reworking the structure today is slim. Had the group, especially (J), been happy with the all the music of the song, I may have had a good chance of getting the group to think about the structure within this session. I do however mention the issue of the structure during the break whilst we are outside of the room. I bring it up as a new topic of conversation whilst the others have a cigarette break. My main aim is to put across my thoughts so that at the opportune moment, this may be considered. I am also seeking to see whether others are thinking what I think about the structure. Whilst the guys smoke, (S) and I talk about a film that I saw over the weekend. (J) joins in the conversation. Once the topic of conversation comes to a natural end, I bring the issue of the structure. "You know *song A*…I don't know what you guys think but I think is a great but it could be trimmed down….I think the best part of it is the chorus and though the verse is cool – I think it is us too long". (S) is the first to reply "I agree….it could be more compact". (J) is the last to comment. "Hmm." There is no real response from (J), which indicates to me that he is not certain he agrees with what I say but he may consider it. From previous experience he would give a more definitive answer, especially if he disagreed. I come back "well I think we should think about it when we come to record or mix it properly". (J) "yis yis", which was a more light hearted way of saying yes or may be a "we'll see how it goes" type of response; not a definitive yes.

Once we return to the session we begin to work on another song. We do not return to play or talk about *Song A* for the rest of the session. I did not write or record anything. I did not see (S) record any information either. (J) took the laptop with recordings we made of *song A*. I expect he will distribute these recordings at some point before the next rehearsal. Often he would forget and therefore (S) or myself may send him a reminder about it.

Appendix F: Description of JMC as a cognitive system

In this appendix, I present a more extended description of JMC as a cognitive system. The findings are based on my analysis of *Young Band*'s sessions (see chapter three).

Definition of the functional system

In JMC, the representation carrying and representation-transforming entities are mainly located within a rehearsal room. Therefore, a simple view of the functional system can consist of all resources used within a session and room that work takes place. My findings about Westbourne Rehearsal Studios helped to describe how a band come to be located in the room, what resources are provided by the studio, and what resources are brought into the room from the outside. The musicians and resources internal to them (i.e., their knowledge, memory etc.), as well artefacts such as musical instruments are examples of resources that are brought into the room. Personal announcers, amplifiers, drums kits, electricity, mixers an so on are resources that are existing in the rooms that are booked. The combination of these resources helps the JMC functional system to rehearse and create compositions. However, to examine how knowledge is maintained across multiple sessions, the view of the functional system must be expanded to include more than one session of work.

Goals of the functional system

I expand my view of the JMC functional system by considering the high level goals that the functional system is assembled to achieve across multiple rehearsal sessions. I use the goals of the band (i.e., what musicians themselves think they are looking to achieve) to help define the goals of the JMC functional system. The goals of the band may not be well defined, and therefore require some interpretation based on the verbal communication of the group in order for me to create a distinct system goal.

Band goals: Based on the conversations and activities of the *Young Band*, I suggest the main high level goals of the each session that I observed were:

- Session one: preparing to record three compositions at a recording studio the following day
- Session two: rehearsing and developing compositions
- Session three: rehearsing and developing compositions
- Session four: rehearsing specifically for a concert (referred to as a gig) for the following week and developing compositions

The rehearsal session activities can be partially dictated by the high level goals of the session. I noted that the sessions before *Young Band* had to create a performance to people outside of the band appeared to have more critical evaluations of performance, which meant more cycles of playing, stopping and commenting. There were more instances where concerns were raised about performance. For example, the composition "slows down a lot you know...he's gona tell us tomorrow" (musician B). Whilst the same composition also slowed down in sessions two and three, B's comment reveals that more emphasis may be put on resolving this issue than in other sessions; there is some sense of priority to address the matter. This is important to consider because it helps to create a perspective about why certain activities occur in certain sessions. There is no formal checklist of activities and goals. These are loosely defined, which means that system goals for each session cannot always be fully determined until the session is completed. This is in line with Lave's (1988) assertion that goals as retrospective constructions of actions. *Young Band* were unlikely to have planned out the session in the way it was conducted.

System goals: Presenting the band's high level goals provides some overall sense of objective to a session of work that may involve many activities each with its own goals and outcomes. Each session of work had some carryover of work and information from the previous session and therefore had some relationship with each other. Whilst session one was mainly about practising three compositions for recording the next day, the same three compositions were played in sessions two, three and four. The aim of session one and four were different but there was a relationship in the fact that the compositions that were performed were in essence observed to be played across all sessions. The labour associated with the compositions in session one contributed to how they were performed in subsequent sessions. Based on this notion, I would define key goals of the larger functional system to include creating, developing and performing certain compositions across many sessions. Since this is multi-session work, the system must maintain knowledge about the compositions across sessions (i.e., it must remember it in some way). In order to create, develop and perform a composition, the system needs coordination between the components within the system.

Computational, representational and implementational descriptions

The computational description aims to outline what the JMC functional system is looking to achieve and what constraints need to be satisfied in order for a successful operation to take place (Hutchins, 1995a). Based on the description of system goals I would state the main constraint that needs to be satisfied for a successful operation in the JMC functional system is the emergence of a composition that preserves a structure which is remembered and performed over many sessions. The representational level of description outlines how the system comes to achieve this output. In order for a composition to emerge and maintain a structure the functional

system needs to *generate*, *develop* and *remember* the composition. Whilst this can be achieved through numerous ways that involve a variety of different inputs, processes and outputs the key representational level of description can be based on representations relating to the musical properties of the composition. This can be represented in written, verbal and musical form during the process of work. How these representations initiate change in the system depends mainly on how the musicians interpret them. This may not always be visible to an analyst and therefore it may not always be easy to describe how inputs are transformed into outputs. At best, I can observe changes in the functional system's performance when representational states propagate across the system initiating a certain output, be it musical, verbal or gestural. Descriptions of how the functional system actually creates inputs, processes and outputs are described at the implementational level, which is informed by the ethnographic research.

At the implementational level my findings suggest that the system activities within a session of work may not produce a physical product as an output. For example, in the study of a medical dispatch team in the London ambulance service (Furniss and Blandford, 2006), the input from a call external to the functional system triggers a number of processes within it which produces an observable outcome that is physically manifested in the world (i.e., an ambulance being dispatched from one location to another). JMC as demonstrated through the session of *Young Band,* may have some observable physical consequences (i.e., physical trail of artefacts that were used in the room or a cassette that is recorded), but these may not be the main products of the session. The main products could be the changes that take place within and between the musicians. For example, musicians may become better performers of the compositions, or they better coordinated with each other the playing of the compositions, or that they change the form of the compositions. These changes may impact their knowledge and how they perform compositions as well as how they use the equipment within the room. Other impacts include the social consequence of collaborative work (i.e., relationships may become stronger or weaker as result of the session). To this end, the shaping of knowledge about the composition is one the most important outputs of the JMC functional system. In essence, the operations of the functional system help shape the cognition of the musicians. In theory, a composition can be said to be created if and only if the musicians can remember what they have to play and how.

Appendix G: Pre-task questionnaire one

Session 1 Pre Task Questionnaire

(Lab based observation of altered Joint Music Composition setting)

This questionnaire will be used to gather each participant's assessment of the task. Information filled within this form will remain confidential.

Participant Name:

About your usual joint music composition set up

Where do your sessions take place (i.e., in a rehearsal studio, at home etc.)?

List artefacts that you usually use?

How long are your sessions (in hours)?

How many people in your group/s?

List the types of music that you usual compose with your group/s.

Have you ever composed with anyone remotely (i.e., not in the same place)?

Yes No

If you yes, please describe any differences you can think of between composing face to face and remotely?

Appendix H: Pre-task questionnaire two

Session 2 Pre Task Questionnaire (Lab based observations of altered JMC setting)

Participant Name:

Preparation for this session

Between the end of the last session and the start of this session did you:

Review last sessions work?

Yes No

If yes briefly describe what you did?

Work on the composition?

Yes No

If yes briefly describe what you did?

Contact any group members with regards to the composition?

Yes No

If yes briefly describe what you did?

Appendix I: Post task questionnaire one

Session 1 Post Task Questionnaire (Lab based observations of altered JMC setting)

Participant Name:

Your reflections on the session

Compare this session to the most common joint music composition scenario that you have experienced.

Did you have more or less difficulty in obtaining musical information like chords names, musical notes, tempos, rhythms, timbre etc.?

Much More More No Difference Less Much Less

Comment on why you think this was the case (optional):

Did you have more or less difficulty in experimenting or improvising?

Much More More No Difference Less Much Less

Comment on why you think this was the case (optional):

Did you have more or less difficulty in creating a song structure or remembering a song structure?

Much More More No Difference Less Much Less

Comment on why you think this was the case (optional):

Please state the level of your satisfaction:

Your contribution

Very unhappy Unhappy Indifferent Happy Very Happy

Your group

Very unhappy Unhappy Indifferent Happy Very Happy

The song/s in its present state

Very unhappy Unhappy Indifferent Happy Very Happy

This session as a whole

Very unhappy Unhappy Indifferent Happy Very Happy

Appendix J: Post task questionnaire two

Session 2 Post Task Questionnaire (Lab based observations of altered JMC setting)

Participant Name:

Your reflections on the session

Compare this session to the last session

Did you have more or less improvisation? (Specify song and tick one box per song).

	Song:	***Song:***	***Song:***	***Song:***
Much More				
More				
Same amount				
Less				
Much Less				

Comment on why you think this was the case (optional):

Did the parts that you personally play change or did you keep what you have in the beginning of the session? (Specify song and tick one box per song).

	Song:	***Song:***	***Song:***	***Song:***
Stayed the same				
Changed Slightly				
Changed Significantly				
Completely Changed				

Did the song/s change from what it was in the beginning of the session (i.e., the musical parts, the structure etc.)?

Yes No

If yes what changed? (Tick as many as you feel relevant):

	Song:	***Song:***	***Song:***	***Song:***
Parts played by me				
Parts played by others				
The structure of the song				

	Song:	***Song:***	***Song:***	***Song:***
Others: Please specify				

Was there anything you liked from the last session that you or other members played but was not played in this session? Parts that you now wish were included having finished the session.

Yes No

If yes, please specify what it was (who played it, what song, description if possible) and why was it not played?

Did you have more or less difficulty in obtaining musical information like chords names, musical notes, tempos, rhythms, timbre etc.?

Much More More No Difference Less Much Less

Comment on why you think this was the case (optional):

Did you have more or less difficulty in experimenting or improvising?

Much More More No Difference Less Much Less

Comment on why you think this was the case (optional):

Did you have more or less difficulty in creating a song structure or remembering a song structure?

Much More More No Difference Less Much Less

Comment on why you think this was the case (optional):

Please state the level of your satisfaction:

Your contribution

Very unhappy Unhappy Indifferent Happy Very Happy

Your group

Very unhappy Unhappy Indifferent Happy Very Happy

The song/s in its present state

Very unhappy Unhappy Indifferent Happy Very Happy

The performance of the song

Very unhappy Unhappy Indifferent Happy Very Happy

This session as a whole

Very unhappy Unhappy Indifferent Happy Very Happy

Comment: (Feel free to express anything you wish about the session)

Appendix K: Set Up A post study questionnaire

Post Study Questionnaire (Lab based observations of altered JMC setting)

Participant Name:

Your reflections on this study.

Compared to your usual joint music setting, rate the impact of the following study parameters on the quality of your composition:

The task timetable

Very negative Negative No difference Positive Very positive

Musical equipment (amps and/or musical instruments provided by the study):

Very negative Negative No difference Positive Very positive

The musical ability of your group members

Very negative Negative No difference Positive Very positive

The lack of working history with your group

Very negative Negative No difference Positive Very positive

The seating arrangement

Very negative Negative No difference Positive Very positive

The volume of speech coming from other members

Very negative Negative No difference Positive Very positive

The volume of instruments

Very negative Negative No difference Positive Very positive

The furniture

Very negative Negative No difference Positive Very positive

The lighting

Very negative Negative No difference Positive Very positive

Your own physical space

Very negative Negative No difference Positive Very positive

Do you think that the quality of your composition or creative output suffered as a result of not being able to see your group members?

Yes No

Comment on why you think this was the case (optional):

Did you use the PC tablets in your sessions?

Yes No

If yes, answer the following question:

Did OneNote (software on the PC tablet) support your work activities?

Yes No

If yes, please specify why, when and how it supported the activity. If no, explain why it did not.

Did you use the scanned notes of your sessions that the researcher e-mailed you?

Yes No

If yes, please specify why, when and how you used it. If no, explain why not.

Did you listen to the audio files that the researcher e-mailed you?

Yes No

If yes, please specify why, when and how you used it. If no, explain why not.

Comment: (Feel free to express anything you wish about this study)

Appendix L: Set Up B Post Study questionnaire

Post Study Questionnaire (Lab based observations of altered JMC setting)

Participant Name:

Your reflections on this study

Compared to your usual joint music setting, rate the impact of the following study parameters on the quality of your composition:

The task timetable

Very negative Negative No difference Positive Very positive

Musical equipment (amps and/or musical instruments provided by the study):

Very negative Negative No difference Positive Very positive

The musical ability of your group members

Very negative Negative No difference Positive Very positive

The lack of working history with your group

Very negative Negative No difference Positive Very positive

The seating arrangement

Very negative Negative No difference Positive Very positive

The volume of speech coming from other members

Very negative Negative No difference Positive Very positive

The volume of instruments

Very negative Negative No difference Positive Very positive

The furniture

Very negative Negative No difference Positive Very positive

The lighting

Very negative Negative No difference Positive Very positive

Your own physical space

Very negative Negative No difference Positive Very positive

Did you use the PC tablets in your sessions?

Yes No

If yes, answer the following question:

Did OneNote (software on the PC tablet) support your work activities?

Yes No

If yes, please specify why, when and how it supported the activity.

If no, explain why it did not.

Did you use the scanned notes of your sessions that the researcher e-mailed you?

Yes No

If yes, please specify why, when and how you used it. If no, explain why not.

Did you listen to the audio files that the researcher e-mailed you?

Yes No

If yes, please specify why, when and how you used it. If no, explain why not.

Comment: (Feel free to express anything you wish about this study)

Appendix M: Pre-study questionnaire

Pre Study Questionnaire

(Lab based observations of altered joint music composition settings)

This questionnaire will be used to determine the suitability of potential participants and to gather general background information about participants' musical experience. Information filled within this form will remain confidential.

Name:

Age:

Gender:

Instrument:

How many years have you played the instrument that you will be using in the study?

< 1 year 2-5years 6- 9 years Over 10 years

Have you ever had formal music training?

Yes No

If yes what grade or how long (months or years) did you receive training?

How would you rate your musical proficiency?

Beginner Intermediate Semi-Professional Professional

When was the last time you played with a group of people?

A week ago Within last month Within last 6 months Within last year More than a year ago

How frequently do you play with a group of people?

At least once a week More than once a month At least once a month At least once every 3 months None of the above

Have you improvised whilst working with a group (i.e., have you played along with others without being told what to play)?

Yes No

If yes how often?

Rarely Occasionally Frequently

Have you ever composed, with others, a song that is suppose to retain a structure for a performance?

Yes No

If yes approximately how many?

1 song 2-5 songs 5-10 songs >10 songs

Have you ever composed songs on your own without others? (Songs that are supposed to retain a structure for a future performance)

Yes No

If yes approximately how many?

1 song 2-5 songs 5-10 songs >10 songs

Can you read music?

Yes No

If so, how well?

Average Well Very Well Excellent

Within a session of work do you make any written notation (be it formal scores or scribbles on pieces of paper)?

Yes No

If yes, how regularly do you do this?

Rarely Sometimes Often Always

What do you tend to write down and what is the purpose of these written notation?

What genre of music do you usual play **and** are open to playing?

Pop Rock Jazz Electronic Blues Latin Hip Hop Classical Reggae Ska Punk

Others (please state):

Appendix N: Participants' background – Set-Up B

Questions	JL	OM	AL
Sex	Male	Male	Male
Age	31	24	26
Occupation	Researcher (Goldsmiths University)	Postgraduate student (Queen Mary University)	Musician
Instrument to be used in study	Bass	Electric Guitar	Electric Guitar
How many years have you played the instrument that you will be using in the study?	Over 10 years	6-9 years	Over 10 years
Have you ever had formal music training?	No	No	Yes – higher national diploma
How would you rate your musical proficiency?	Intermediate	Intermediate	Semi-professional
When was the last time you played with a group of people?	Within last 6 months	Within last 6 months	A week ago
How frequently do you play with a group of people?	At least every 3 months	Not frequently	At least once a week
Have you improvised whilst working with a group (i.e., have you played along with others without being told what to play)?	Yes – occasionally	Yes – frequently	Yes – frequently
Have you ever composed, with others, a song that is suppose to retain a structure for a performance?	Yes – 5 to 10 sings	Yes – 5 to 10 songs	Yes – 5 to 10 songs

Have you ever composed songs on your own without others? (Songs that are supposed to retain a structure for a future performance)	Yes – over 10 songs	Yes – 5 to 10 songs	Yes – 5 to 10 songs
Can you read music?	Yes – average	Yes – below average	Yes – average
Within a session of work do you make any written notation (be it formal scores or scribbles on pieces of paper)?	Yes – sometimes. "Scribbles regarding ideas, mainly for new sounds to be added"	Yes – sometimes. "Chords – if in structure which chords form different part of the song Timing – how long each part lasts for Unstructured changes - Any changes in song and where they occur"	Yes – often "Chord Numbers within a scale (It helps when transposing, Memorizing a chord sequence) When records sound different to what is written (amend mistakes)"
What genre of music do you ***usual*** play **and** are open to playing?	Rock and Electronic	Pop, Rock, Jazz, Electronic, Blues, Latin, Heavy Metal	Pop, rock, Jazz, Latin

Appendix O: Participants' background – Set-Up A

Questions	TG	JB	SA
Sex	Female	Male	Male
Age	39		34
Occupation		Postgraduate student (Queen Mary University)	Postgraduate student (Queen Mary University)
Instrument to be used in study	Piano	Bass	Saxaphone
How many years have you played the instrument that you will be using in the study?	2-5 years	6-9 years	Over 10 years
Have you ever had formal music training?	Yes	Yes	No
How would you rate your musical proficiency?	Intermediate	Intermediate	Intermediate
When was the last time you played with a group of people?	Within last 6 months	Within last month	A week ago
How frequently do you play with a group of people?	At least every 3 months	At least every 3 months	At least once a week
Have you improvised whilst working with a group (i.e., have you played along with others without being told what to play)?	Yes - Rarely	Yes - Frequently	Yes - Frequently
Have you ever composed, with others, a song that is suppose to retain a structure for a performance?	Yes – 2 to 5 songs	>10 songs	Yes – 2 to 5 songs
Have you ever composed songs on your own without others? (Songs that are	Yes – over 10 songs	5-10 songs	No

supposed to retain a structure for a future performance)			
Can you read music?	Yes – very well	Yes - average	Yes - average
Within a session of work do you make any written notation (be it formal scores or scribbles on pieces of paper)?	Yes - often	Sometimes	No
What genre of music do you ***usual*** play **and** are open to playing?	Pop, Rock, Jazz, Electronic	Electronic, Jazz	Jazz