THE COGNITION OF MUSICAL IMPROVISATION:
THE VALUE AND EXPERIMENTAL IMPLEMENTATION OF A NEW SCIENTIFIC APPROACH

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THIS DISSERTATION IS SUBMITTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.
DECLARATION

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except as specified in the text. This work is not substantially similar to any other work I have submitted for a qualification at the University of Cambridge or any other university. It does not exceed the word limit prescribed by the Music Faculty.

Andrew Goldman
March 2015
As musicology takes a turn towards considering music in terms of performance rather than as discrete pieces or works, musical improvisation has come more into focus. Historical, ethnomusicological, and critical literatures are emerging exploring the ubiquity of different improvisatory traditions in the West and around the world, and reconsidering the cultural meanings and situations of such practices. A cognitive-scientific understanding of improvisation can contribute a framework in which to meaningfully compare practices from different improvisatory traditions as well as different kinds of non-musical creative practices. Furthermore, a cognitive approach is able to properly characterise improvisation—a way of making music—as a process. Previous literature (including some of the cognitive literature) has based its discussions of improvisation on criteria such as frameworks, rules, constraints, novelty, and ‘real time performance’, notions that all can best be interpreted as deriving from product-based reasoning about music. Given that the same musical product can be produced via different processes, these criteria become problematic in defining what improvisation is and how it is done when the goal is to distinguish it as a process.

Cognitive-scientific approaches are well-equipped to distinguish between different performance processes. In this dissertation, rehearsed/memorised performance and the plurality of processes that constitute ‘improvisation’ are all recast as different ‘modes of performance’. It is hypothesised that performers learn to play through different pedagogies and practice methods, leading to the employment of different modes in their musical productions and perceptions. Based on theories of perception-action links, two kinds of experiments are conducted to differentiate between these modes and types of perception. The first are between-group experiments comparing differences in the perception of musical structures in groups of non-improvising and improvising pianists. The second is a within-group study that compares improvisers playing in different modes of performance, with and without delayed auditory feedback, allowing for a comparison of motor processes employed for each mode.

The findings help to consolidate a secure basis for defining and explaining improvisation cognitive-scientifically. Future experiments can build on this foundation by examining other musical styles, employing other cognitive-scientific theories, utilising neuroscientific methods, and by situating the general theoretical approach into the broader discourses of human interaction and the psychology of creativity, all of which are in part predicated on the approaches outlined in this dissertation.
First, I am grateful to the Cambridge Trusts for financially supporting this project and my time in Cambridge more generally. Thanks also to Wolfson College, the Faculty of Music, and the Music & Letters award for their financial support which has helped me to travel around the world and present this work at conferences.

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While the content of this dissertation is my own work, the process of developing ideas is by no means a solitary endeavour. I am grateful to my colleagues in the Centre for Music and Science for several years of lively debates and discussions, and to my colleagues in the Music Faculty more generally for thoroughly challenging me to question my most fundamental assumptions.

While the final product resulting from these years in Cambridge has been this dissertation, it is, of course, not the only way I have developed or the only way I have spent my time. Deep thanks are due to Wolfson College and its community for not only providing a stable, peaceful, and comfortable home away from home, but for affording me the opportunity to further discover myself in the college’s cosmopolitan environment.

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The topic of improvisation raises many exciting questions. How do improvisers ‘make it up’? Is the music they create really \textit{new}? If not, is any music truly improvisatory? If so, is all performance improvisatory? How is improvisation different from or similar to composition? What role does prior training and knowledge play in improvisation? What kinds of knowledge could be employed in improvisation? Why are many musicians unable to improvise? Are they really unable to improvise, or is it more a matter of which practices are traditionally called ‘improvisatory’? What political and social reasons might motivate designating only certain practices as ‘improvisation’? How does the practice of improvisation express values of freedom? How do improvisers communicate? How could theories of musical improvisation be used to understand other kinds of human creativity? These questions and more arise when improvisation is discussed. They inspire passionate discussion from a wide range of perspectives in that they raise some fundamental issues about what music is and invoke somewhat mysterious ideas like novelty and creativity.

In order to provide a stable platform from which to make some sense of the concept of ‘improvisation’, this dissertation establishes a cognitive-scientific research programme. It argues that a cognitive-scientific approach can provide some clarity and unity to many of the questions arising from the discourses surrounding improvisation. In order to accomplish this, it engages with these various literatures, proposes a new scientific approach that is sensitive to them, and conducts and reports on a set of experiments on musical improvisation conducted within the proposed cognitive framework. It suggests and describes future empirical research, aiming to gradually refine a definition and understanding of what improvisation is and how people do it.

Needless to say, establishing a scientific research programme for something like improvisation is complicated. Not only is this a difficult problem in practice due to the complexity of the behaviour, it also is problematic in principle in that improvisation is often meant to embody ideals of freedom and creativity, perhaps in contradiction with the systematising aims of science. In order to situate and justify such a project, this dissertation reviews and critiques a variety of literatures on improvisation in order to arrive at a reasonable conception of the phenomenon. It links that conception with current theories in cognitive science that could make it accessible to experimentation. The specific goals of the
dissertation are elaborated below, but first it is important to consider the general state of research in musicology today, the current musicological scholarship on improvisation in particular, cognitive science generally, and the creativity literature to show how a study of improvisation is topical and meaningful, and how it is supported by current attitudes in these fields.

**Improvisation in musicology today**

In the recent history of Western Art Music, the practice of improvisation has largely left the mainstream performance tradition (Moore, 1992). Whereas once the practice of improvisatory preluding (Goertzen, 1996), Renaissance polyphony improvisation (Cumming 2013), cadenza extemporisation, figured bass realisation, and other skills may have been common in the repertoire of a musician in the Western art tradition, in more recent history there has been a much more impermeable partition between work-based performances that recite set pieces of music, and improvisation, which is either thought to exist only in the interpretative and expressive parameters of performance (see Clarke (2005) for a discussion of different kinds of creativity in performance) or, in the West, reserved for describing jazz and other musical practices outside of the classical art tradition. It is often considered by musicians in the art tradition to be a somewhat exotic skill with many art-music practitioners claiming that they are unable to do it.

In today’s scholarship, however, this attitude is being strongly challenged in a number of musicological research areas. These challenges promote the place of improvisation in academic discourse. First, the ontology of music has been called into question. Music could be thought of as notes on the page such that the same notes and markings will constitute the same ‘piece’ of music, or ‘musical work’. However, many scholars now centralise the role of the performer. The nature of a performer’s interpretation has expanded from merely adding subtle details to a more substantial and varied contribution (see Rink, 2005, for an exploration of various contributions made by performers’ ‘interpretations’). Not only are performers creative and expressive with what they do with those notes, but music can be defined as being fundamentally constituted through performers’ (and audiences’) actions and behaviours, with the notes on the page playing only a dependent part of the process (see Cook, 2001; 2013). Entire research institutions, such as the Centre for Music Performance as Creative Practice, have been devoted to investigating the nature of performance process in music and developing music-analytical, sociological, psychological, and other ways to study it. And
nowadays, musical *performance* is not the only aspect of music that is considered as performative! Listening has been considered as a kind of performance in that the listener plays an active role in shaping his or her own perception and construction of the music’s organisation and meaning (Born, 2010; Cross, 2010). For similar reasons, music analysis, that is, interpreting the meaning of music or considering how its structures work together, could similarly be considered as an active, performative practice in that how one parses music would depend on their theoretical understanding (although Rink (2002) reminds us that performance can transcend analysis).

With this shift towards centralising performance in music studies and with the development of theories and methodologies to understand performance, a range of questions about performers, performances, and audiences are invited. In this way, such shifting attitudes about music’s ontology help promote questions about improvisation. Improvisation would seem to be a clear example of the performer taking control of music rather than having it exist outside of performance as notes on a page. Improvisers would seem to perform and compose at the same time, clearly embodying the idea that performance constitutes music’s existence. That is, it would not exist without the performance! With researchers comparing performance processes, improvisation as a process (or set of processes) could be compared to other ways of performing. This is reflected in a variety of literatures discussed throughout this dissertation, and this comparative enterprise plays a substantial role in the cognitive approach introduced in this dissertation.

A second aspect of today’s musicology that promotes scholarship on improvisation is a move towards interdisciplinarity in musicology and academia more generally. The advent and aftermath of the so-called “New Musicology” that developed in the 1980s following Kerman’s (1985) criticism of the field at the time helped inspire a diversification of methodologies employed in the discipline. Kerman’s seminal text motivated musicologists to change course from the historical archiving of works to a rekindling of hermeneutical and critical inquiry. Since then, musicology has embraced a diverse range of methodologies to construct and answer questions about a broader conception of music’s meaning and context within society. It has adapted methods from literature studies to find new ways to investigate and interpret musical texts, it has renewed its interest in considering material artefacts in music, in comparing musical traditions around the world, through investigating the sociology of music, and in harnessing advances in the sciences to incorporate musical discourses into various scientific frameworks (acoustics, psychoacoustics, psychology, computer science,
cognitive neuroscience, etc.). This methodological diversity in contemporary musicology, and perhaps in contemporary academia more generally, places particular problems in the centre of inquiry (e.g., how does music transmit meaning) allowing multiple perspectives to converge on a shared answer. In this way, interdisciplinarity is embraced and an attitude of the-more-the-merrier often prevails. For instance, the call for papers of a London conference in 2012 on Music and Shape sought “as many perspectives as possible”. It is a familiar sentiment.

Interdisciplinarity provides a foundation for a study of improvisation. A musicology focussed on the historical documentation of great musical works or one limited to analysing notes on the written page would not have much to say about improvisation, a practice that is, at least on first reflection, fundamentally performative. The diversification of musicological methodologies and the increasing desire to synthesise them provides a tempered platform to ask questions about a phenomenon as complex as improvisation.

A wide range of literature has been developed along the lines of these two trends in musicology, moving the study of improvisation towards a more central place in music scholarship. Indeed, the topic of improvisation is a convenient hub of topical questions. How is improvisation created through performance? How can the act of improvisation be used to express political ideals (e.g., freedom)? How is improvisation similar to language through its interactive nature? Ethnomusicologists, critical theorists, music theorists, cognitive scientists, psychologists, sociologists, and historians all contribute to this research (which will be reviewed and discussed throughout this dissertation).

It is against this background that the present research on improvisation is contextualised. This background has to some extent made this research possible and has helped to legitimise it as a topic of inquiry. The tools to study improvisation and the appreciation of the value of such a pursuit are in place.

Despite this increased interest in improvisation, however, there is still a need for more coherence between ways of understanding improvisation. Many questions are still hotly debated and different methodological approaches are not always able to effectively share their insights through the formation of a comparative enterprise. The diverse perspectives arising from an interdisciplinary musicology lead to many different conceptions of improvisation and focus on different aspects of the practice. On the one hand, such diversity would seem necessary, especially for such a seemingly ineffable practice. What could
definitively be said about a practice that is, in many ways, defined by its freedom? On the other hand, having a stable conception of the phenomenon could help link different kinds of understanding in the literature to unlock the value of interdisciplinarity by increasing the ability of scholars with different perspectives to communicate. It is argued throughout this dissertation that a cognitive-scientific approach can provide such a stable foundation to reason about improvisation and ask questions that can connect the multiple discourses surrounding it.

**Cognitive science today**

Meanwhile, cognitive science has been increasing the scope of behaviours it seeks to explain, tackling more and more abstract and complex human capacities. Researchers are not only examining low-level aspects of perception, but are forming theories of neuroaesthetics to explain the perception of beauty (see Cinzia & Vittorio, 2009 for a review). Not only are they examining how the motor system functions in movement planning and execution or how the sensory systems in the brain function in the generation of images, but they are constructing neuroscientific theories of creativity to show how people can mentally form and act on new ideas (Dietrich, 2004a). They are no longer only examining brain lesions associated with aphasia, but are attempting to document how people improvise rap lyrics (Liu et al., 2012). Many scientists are examining the neural foundations of such all-encompassing features of the human mind as consciousness (e.g., Damasio, 2000; Koch, 2004).

Cognitive scientific methods have also been applied to music. Music cognition seeks to explain how people are able to accomplish the necessary psychoacoustic processing to hear pitches, how people are able to abstract a sense of tonality from an acoustic signal, how people are able to embody rhythm and metre, as well as other lower level processing questions. It takes on more complicated and perhaps culturally relative questions as well such as how those pitches and rhythms are able to induce emotions and why they induce the emotions that they do, how they promote and induce movement, how music relates to visual images as in film scores, whether and in what ways music is a human universal, how music is used to communicate, how our capacity for music has evolved and how it may be related to other human capacities like language, and many other questions (see Hallam, Cross, & Thaut, 2009).

Some cognitive-scientific research on musical improvisation in particular has already been done (and will be reviewed later in the dissertation), although a broader scientific theory
has not been developed to guide the experimental questions that are asked by researchers. In fact, although there are a small handful of experiments on improvisation, a larger project to construct a coherent cognitive-scientific theory that can guide questions about the cognition of improvisation has not been completed since Pressing’s (1988) cognitive model which, while ambitious, orientating, and groundbreaking, is not without problems and is certainly not the only approach (see chapter 4).

In addition to the broader musicological context, this dissertation’s ambition to put improvisation into a cognitive-scientific context is situated within these trends in cognitive science. Similar to the musicological methodologies and attitudes of today that support this project, cognitive science offers a set of methodologies and theories that can be applied to improvisation as well as a general acceptance and valuing of bringing such a project into a scientific domain.

But of course, cognitive scientists’ ambitions to describe complex behaviours scientifically are not without well-justified resistance and controversy. Musicology today is seeing an increasing convergence between scientific methods and ethnomusicological, sociological, critical, and music-analytical methods. There is scepticism of scientific methods in their attempt to describe and explain objects of inquiry typically reserved for the humanities. Ethnomusicological studies put science’s generalising aims in check by observing and documenting important differences between musical traditions around the world. Sociological studies similarly challenge science to respect the diversity of traditions within a society and also challenge science’s often physical and mechanistic explanations to respect the role of social objects and forces (concepts like society and culture) in determining the structure, function, and meaning of music. Critical studies challenge science (and all other theoretical frameworks, for that matter) by urging theorists to question their terms as fundamentally as possible, making operational definitions necessary for experimentation difficult to develop. In particular, as science aims to develop explicit theories and operational definitions, it is particularly susceptible to forgetting the ultimately temporary and culturally-contingent nature of the concepts at play in its experimental frameworks. In order for a scientific method to succeed, therefore, it must be sensitive to the challenges coming from these other theoretical perspectives. These challenges can be raised in many areas of music cognition research, but it is a particular issue for improvisation. The concept of improvisation is often championed as a hallmark of freedom. It is that which is unsystematic, unpredictable, new, novel, and free. This carries political implications; improvisation can be
an expression of and a tool to exercise freedom. Given that science aims to systematise phenomena, it would seem to directly contradict the nature of improvisation. A scientific foray into such a concept, therefore, must respect these challenges and spend the necessary effort to adequately address the criticisms in order to build a stronger research paradigm, or, indeed, to make it possible to build one at all.

A brief word should be offered about studying creativity scientifically. Creativity has entered the scientific domain through psychological, computational, and cognitive studies of human creative behaviours. Boden (1995) argues that creativity, while perhaps always being partially unpredictable, can still be studied scientifically, and has contributed computational approaches (Boden, 1999). Finke, Ward, & Smith (1992) have proposed a cognitive model of creativity called the ‘Geneplore’ model to explain how creative insight can arise through mental reflection. Sternberg’s edited volume assesses various kinds of psychological research on creativity (Sternberg, 1999). Csíkszentmihályi’s (1996) oft-cited theory of flow has been applied to many creative behaviours in an attempt to explain creative states of mind. Recently, flow has been taken into the neuroscientific realm by Dietrich (2004b) to explain how such states of mind have physiological correlates. There are many other studies on the psychology of creativity; this research is mentioned here only to demonstrate that a precedent has been set—scientists are attempting to understand creativity with cognitive and computational models and experimental approaches. Improvisation is typically regarded as a creative behaviour, so even the very notion that such a thing could be understood scientifically is in part based on this precedent, and requires a stance to be taken on whether creativity is within the purview of scientific understanding. This scientific research characterises creativity as something worldly, not completely ineffable inspiration; as such, creativity is thought to occur through documentable processes, or at least aspects of the creative process are documentable. This dissertation does not base its cognitive-scientific theories on any particular existing cognitive model of creativity, but it shares the attitude that it is at least partially explainable through experimentation, and it describes how its findings could relate to future research on creativity (see chapter 8).

**Goals of the dissertation**

There are three main goals of this dissertation. The first is to address how improvisation, a supposedly unpredictable act of creativity and freedom, can be investigated and understood scientifically. This is the main question asked in this dissertation, and its
primary goal is the establishment of a reasonable scientific research programme with theories and hypotheses sensitive to and respectful of the concept’s elusive nature. Doing so requires situating the scientific approach within several complex discourses of improvisation: the ethnomusicological literature which examines improvisatory music practices around the world, the critical and historical literatures which interrogate the meaning and political nature of the concept along with the origin and appropriations of those meanings, the music-theoretical literature which attempts its own definitions of improvisation often based on formal musical structures (notes, chords, etc.) and analysis, and previous cognitive-scientific literature which attempts to bring these questions into the realm of the science of the mind. In this way, to investigate improvisation scientifically is not simply about trying to answer an existing question about how improvisation works and how people do it, but rather about constructing a new strategy for asking questions about improvisation that can gradually refine a definition and understanding through experimentation. This new approach provides a way to reason about the kinds of initial questions that inspired this research.

Second, it is argued that the cognitive-scientific approach is a good one for bringing some clarity to many apparently paradoxical and problematic questions raised in trying to define improvisation. Questions about improvisation are motivated by questions of process. What an improviser plays may be interesting in the same way that what a composer composes is of interest, but as it pertains to the nature of improvisation, what is important is how the music was produced. Cognitive science, it is argued, is particularly good at making distinctions between such processes. Through focussing questions of improvisation on differences between mental processes rather than basing inquiry on music-theoretical analysis (analysing structures like chords, notes, scales, etc. after the improvisation has been played), many of the apparent difficulties in defining and understanding improvisation in relation to composition and rehearsed performance dissolve into a more parsimonious research approach. In this way, the theories and conclusions developed by this research can engage with discourses from other disciplinary approaches.

The third and final goal is to actually implement this research strategy by designing and running scientific experiments that can help refine a definition of improvisation through behavioural observation and measurement. This requires using current theories in cognitive science to construct a set of experimentally tractable questions to investigate improvisation in the laboratory. This is mainly done through applying common-coding theories which can describe differences between different musicians’ representations of musical structures and
differences between motor processes that underlie different kinds of musical performance. Three experiments are conducted in this dissertation to begin actualising this research programme. Other experimental tracks based on other cognitive-scientific theories would be possible within the general research strategy developed according to the first and second goal of this dissertation, but the specific track followed here is argued to underlie other related questions. In other words, although there are many questions this dissertation does not explore (see below), it still offers a paradigm in which to develop research for those other questions, and further, the research it does complete is argued to relate to those other potential tracks. The conclusion of this dissertation explores these possible further research directions which could augment and develop this strategy mainly through proposing neuroscientific experiments, and ways to apply its experimental methodologies to multiple improvisatory traditions around the world rather than to relatively limited groups of participants recruited for these experiments (i.e., jazz and classical pianists).

**What this dissertation is not**

Setting out to describe the cognition of musical improvisation is a rather large topic and there are bound to be some areas that are not emphasised as much as they should. This dissertation introduces a coherent cognitive-scientific research programme for studying improvisation, but it does not in itself address every aspect of the practice. Rather, it could be most directly said to offer a strategy to research the cognition of improvisation and an interdisciplinary justification for and contextualisation of the approach. I discuss three main omissions here.

The first has to do with the specifics of its experimental programme. After introducing a general strategy to research the cognition of improvisation, the dissertation focuses largely on motor planning and sensory-motor associations. Needless to say, there are certainly other possible aspects of improvisatory performance processes. There is an explicitly justified reason to examine differences in sensory-motor associations and motor planning provided in this dissertation, but there may be unforeseen ways to hypothesise about, for instance, the cognition of rhythm and meter that underlies improvisation and musical interaction (see, e.g., Iyer’s (2004) discussion of the role of temporality). Further development of such other research questions would not immediately follow from this work, although the general structure of the approach advocated in the following chapters—that is, comparing improvisers with non-improvisers, and comparing improvisers playing under
different performance circumstances—could be adapted analogically to investigate rhythm and meter, or other aspects of improvisatory performance that could contribute to a definition and understanding of improvisation.

The second omission is one that is more systemically methodological. While looking for differences in the cognition of rhythm and metre could be justified by and understood within the theoretical approach outlined in this thesis, a consideration of how people improvise in groups does not follow as clearly. Obviously, the way people interact whilst improvising is a very important area of inquiry given that many of the practices which are typically called improvisatory are done in groups, and in some ways is central to the practices that define improvisation. Of course, this does not mean that understanding the processes in individual improvisers is not also important, especially given the general paucity of explanations of any kind. Any insight would be helpful here. The way the theories are formulated in this dissertation are thought to be compatible with an examination of group improvisation in an overall research strategy towards defining and understanding improvisation, but again, similar to the consideration of rhythm and metre, significant further work would need to be done to make this connection. Still, this dissertation could serve as theoretical support for such a project.

A third area that could be elaborated in this thesis is the application of the experimental methods to improvisatory traditions besides jazz. The thesis argues that the cognitive-scientific principles used to understand improvisation are both motivated by and can serve to explain certain aspects of improvisatory traditions around the world, but it is not pellucid how its experimental paradigms could be adapted to test its effectiveness. It should be possible in principle to accomplish this, but again, significant additional work would need to be done in order to actually carry out these research projects. This would involve adapting the experiments to make them compatible with other traditions. The cognitive-scientific theories would be similar, but their implementation in experiments would need to be adapted to fit with the specific music theories and practices of these different traditions.

In all of these cases, it is argued in this dissertation that the research strategy it constructs could be applied to future research on these topics. Further, the specific conclusions it draws from its specific work on sensory-motor associations and motor processes are hypothesised to underlie other aspects of the cognition of improvisation. I offer further comments on how such future research could be formulated in chapter 8 after the rest of the dissertation clarifies how this could work.
Chapter outline

The general structure of the dissertation involves a theoretical exploration of the concept of improvisation through reviewing ethnomusicological, critical, historical, music-analytical, and cognitive literature. It then presents a general cognitive-scientific research strategy and specific theories about the cognition of improvisation which can inform some of the problems that arise from these literatures. Specific predictions from these theories are then tested with a series of experiments. It concludes by developing ideas for further research.

Chapter 2 examines the treatment of the concept of improvisation in the ethnomusicological, historical, and critical literatures in order to justify and situate the cognitive-scientific approach. Because the concept of improvisation is so variable from musical tradition to musical tradition, and because it may in principle be indefinable, this general interrogation of the concept is necessary to formulate a reasonable scientific approach.

Chapter 3 explores how improvisation is typically defined in terms of products instead of process. Given that improvisation is primarily a question of process, of how music is created rather than what is created, typical definitions fail to adequately distinguish it from rehearsed performance and composition, or between different kinds of improvisation. It is argued that many perspectives of improvisation, despite drawing more complex social claims about the practice or otherwise seeking to define performers’ processes, still rely on product-based definitions of improvisation. Another approach is needed that can define and distinguish between processes. This shift in perspective allows for the phenomena to be better formulated and operationalised for scientific experimentation.

Chapter 4 reviews the existing cognitive-scientific literature on musical improvisation including the few complete models that do exist (computational and cognitive), neuroscientific literature, behavioural experiments, and corpora analyses. It shows how this research, too, is often based on the product-based conception of improvisation described in chapter 3. The literature is shown to be lacking a coherent theoretical approach, but several important methodological considerations are preserved in order to construct a more coherent research programme.

Chapter 5 proposes a new way to consider what improvisation is through observing differences in the perception and cognition of different groups of musicians, and the same
musicians under different performance circumstances. Instead of distinguishing between improvisation and memorised performance, it suggests considering a plurality of modes of performance, each with particular cognitive characteristics arising from differences in musicians’ pedagogies and practices. It constructs a set of questions that can examine these different modes based on common-coding theories and motor theories of perception and proposes two main lines of experimental that can begin to characterise these different modes of performance.

Chapter 6 reports on the between-group experiments conducted within this theoretical framework. These experiments test differences in music perception between improvisers and non-improvisers based on differences arising from their practices and pedagogical methods by which they learned to play music. The first experiment has adapted an experimental paradigm from the common-coding cognitive literature to test differences in the sensory-motor associations of a group of improvising pianists and a group of classically trained pianists with little to no improvisatory experience. This experiment tests the hypothesis that improvising pianists have motor representations of particular musical structures (here, seventh chords) that are more strongly primed by sensory stimuli than their non-improvising pianist counterparts. Given that this first experiment had several methodological problems, a second experiment was designed with a similar motivation that is more able to detect such differences. How these differences in perception could underlie differences between modes of performance is explored.

Chapter 7 presents a within-group study. This study compares improvisers playing under different performance conditions (from memory, and two kinds of improvisation). Delayed auditory feedback (DAF) is used to investigate differences in the motor processes underlying different modes of performance. The findings are similarly explained in the context of common-coding theories, and explores why different modes of performance might differ in this regard.

Chapter 8 concludes the dissertation with a discussion of how the theoretical approach has been largely supported by these experiments, and how they advance an understanding of improvisation. It provides specific examples of how future research could elaborate on some of its goals, including addressing the omissions raised above. Further possible research projects pertaining to the cognition of metre in improvisation, cognitive projects concerning group improvisation, and specific neuroscientific hypotheses are articulated to demonstrate how this research approach could serve as a foundation for future improvisation research.
also contextualises the findings within a broader consideration of the importance of examining differences in music perception and cognition between groups of musicians both within Western music and between world music traditions, thus emphasising the importance of a greater sensitivity to such differences in music cognition research more generally.
CHAPTER 2: SITUATING AND JUSTIFYING THE COGNITIVE-SCIENTIFIC APPROACH

How can improvisation be studied scientifically? Should it be? Scientific research approaches aim to generalise beyond particular observations, however qualified such a generalising claim may be. How can such a pursuit be successful while still being sensitive to the variation between conceptions of improvisation in musical cultures around the world? The concept of improvisation might not even exist in certain musical traditions that do not distinguish it from rehearsed or memorised performance as is done in the West. Further, how could such a scientific approach ever determine a suitable operational definition for experimentation when improvisation might otherwise be conceived as the very embodiment of freedom and creativity, fundamentally antithetical to the systematising aims of science?

This chapter will elaborate upon these challenges and explain why the cognitive-scientific approach is rightfully controversial. Determining appropriate theoretical premises upon which to design cognitive-scientific experiments presents its own in practice hurdles which are discussed in chapter 5; this chapter aims to situate and justify the cognitive-scientific approach in principle by reviewing ethnomusicological, historical, and critical perspectives on improvisation and considering potential objections that might be raised by them.

From the ethnomusicological and historical literature, in addition to describing the diversity of improvisatory musical traditions, it will search for commonalities amongst them in order to provide a foundation for a set of reasonable cognitive-scientific questions. Finding these commonalities will help in designing cognitive-scientific theories that can be similarly general. It will also show what the cognitive-scientific approach can offer to an ethnomusicological one—that is, theories capable of making meaningful comparisons between traditions by not wholly relying on the emic music theories of those traditions. From the critical literature, it will examine the aims of critical theorists in their work on elaborating and interrogating discourses of improvisation—in other words, their goals of determining what the concept means (implies, connotes), how it has come to mean what it means (through historical and social analysis), and constructing new meaning through connecting the concept
with other social concepts such as freedom or political liberty. It will show how differences between these critical theorists’ research aims and those of cognitive science are in some ways incommensurate. However, it will also demonstrate a fundamental commonality with the critical literature in that cognitive science is also trying to interrogate the meaning and definition of improvisation and construct a discourse based on that interrogation, albeit through different means.

**Challenges to cognitive science**

Given the variation in the usage of the term ‘cognitive’, it will be helpful to explicitly state what is meant here by the term for the purposes of this dissertation. Cognitive-scientific research postulates the existence of mental processes and aims to describe them either with abstract models based on behavioural observations, through computational modelling and simulation of human and animal perceptual and motor capacities, and through anatomical and physiological observation as in neuroscientific and other biological methods. Such theories often aim to generalise beyond a particular cultural framework, reasoning that the biological constraints on thinking are relatively similar for all humans; despite human cultural diversity, evolutionarily speaking, humans share almost all of their biological heritage and thus most of the biological basis for thought as well. This, of course, is not to discount the effect of development on how such cognitive systems may change for individuals or groups. Different environments (culturally, socially, and otherwise) can lead to differences in the development of these cognitive systems in such a way that people can come to have quite different cognitive characteristics. Just how ‘plastic’ the mind is, just how much it is able to change, is an open question, but many current researchers in cognitive science are interested in examining this flexibility (e.g., see Huttenlocher, 2002). Indeed, this dissertation embraces such developmental differences. They will be central to the specific cognitive claims made about improvisation in the coming chapters. However, despite such plasticity, there can still be a common basis for comparison in that the differences that arise through plasticity are principled and theories can link them to differences in the environment and upbringing. In other words, plastic material still has properties to be studied, and it cannot be infinitely plastic. Lastly, by explaining behaviour with biological, computational, and neuroscientific theories, cognitive science can make an understanding of behaviour commensurable with other scientific theories of the natural world, thus allowing for the possibility of a convergent understanding of these phenomena. If an understanding of how people think can be linked to
the physiology of the brain, it can also be linked to evolutionary theories about its phylogenetic development, ideas about the chemistry of the brain, and perhaps even the physics that might govern various evolutionary constraints (e.g., brains can only be so big before overheating).

This science can explain low-level aspects of perception and cognition such as processing in the visual system (e.g., see Marr’s (1982) computational account of vision). Explanations of these kinds of cognitive capacities may extend across cultural lines; while there may be certain differences in something like colour perception (see Lakoff, 1987), much of the visual system may still function very similarly for most humans. However, cognitive scientists today are not just trying to explain vision. As noted in the previous chapter, current researchers are increasing the scope of behaviours they seek to explain to include aesthetics, creativity, consciousness, and other abstract and complex capacities. The notion of pursuing a cognitive science of improvisation at all is testament to this trend. Can there be a cognitive science of improvisation that extends across cultural lines in the same way there is a cognitive science of vision?

There are a few major and oft-discussed problems with this scientific expansion into topics typically reserved for the humanities. The first is that such ambitious studies risk extending their conclusions beyond their subject groups. Any experiment to support such cognitive scientific theories must work with a limited number of participants and extrapolate more general theories from those findings. This is not a problem in principle—scientists can use statistics to be reasonably sure an effect is present in more than just a relatively small group of participants. Further, if the nature of the theory relies on commonalities in the structure of the brain, and many brains have been scanned and observed, scientists can reasonably argue about the generalisability of certain claims based on shared biological characteristics. Of course they should always remain sceptical and be willing to consider new and unforeseen differences! In the meantime, one of the ways such a process could go wrong, and as Henrich, Heine, & Norenzayan (2010) have argued, has gone wrong, is that many theories are not based on an adequately diverse participant pool. Henrich, Heine, & Norenzayan argue that the majority of psychological theories are based on WEIRD participants—that is, they are Western, Educated, Industrialised, Rich, and Democratic. These WEIRD participants are outliers in many domains of psychological inquiry and abstracting human universals from observations of them is dubious.
It is possible in principle to have a psychology completely confined to WEIRD participants. Its theories could be consistent within the population. It would be better, however, to expose such theories to a wider range of human behaviour in order to strengthen them. This would allow for broader claims about human behaviour, allowing scientists to more parsimoniously connect theories of cognition with biological, evolutionary, and environmental commonalities around the world. This is ideal and ambitious, but also in many ways necessary, lest a scientific theory be led astray by WEIRD participants or remain vulnerable to the slightest behavioural anomaly. Admittedly, this dissertation will go on to present experimental work conducted on WEIRD participants, but it provides specific ways in which its theories could be tested on non-WEIRD participants by adapting the experimental procedures. In order to accomplish this, one must be familiar with improvisatory traditions outside of the West. Is there something more universal to be described at all than could be gleaned from studying Western musicians? If so, how could the same theory be experimentally tested in different traditions? In order to respond to these concerns, it is necessary to consider the ethnomusicological literature on improvisation to bolster a cognitive approach.

Another problem arises in trying to identify instances of improvisation at all. One may wish to set out to find them in different cultures in order to compare them, but this is a problematic enterprise in principle. The risk here is that a concept of a particular phenomenon in question—like aesthetics, consciousness, or improvisation—may only exist in a particular cultural framework of understanding. The concept ‘improvisation’ may not be a fixed natural kind, like the chemical element gold, ‘out there’ to be studied in different places regardless of the context. Hacking’s (1999) philosophical distinction between ‘interactive’ and ‘indifferent’ kinds is useful here. What improvisation is, to some extent, depends on what people say it is—that is, it is interactive with the people engaging in it and studying it. It is a moving target. Improvisation’s existence as such may be confined to a particular cultural framework. Western music makes a distinction between improvisation and rehearsed performance, but not all musical traditions would make such a distinction, or may make different kinds of distinctions between types of performance. In this way, calling some music ‘improvisatory’ requires a particular cultural situation and risks taking one cultural perspective into another cultural environment and misapplying the term, or forcing another tradition into the confines of the term when it really does not fit, or where another emic term may be much more suitable. Incidentally, the same problem exists for venturing into the
world looking for instances of ‘music’ more generally and developing cognitive theories of it. As it pertains to developing a cognitive-scientific theory, if one could reliably identify instances of a particular practice in any culture, one could then search for cognitive correlates of it and reliably associate such correlates with that behaviour. However, given that instances of improvisation identified as such may only exist within that particular cultural framework, so too would those cognitive correlates only be meaningful within that framework. It is seemingly antithetical to the generalising aims of the scientific enterprise and paralyses it with contingency.

Again, similar to the WEIRD problem, this might not necessarily be a problem either—one could accept the cultural specificity of the concept and endeavour to create a cognitive-scientific theory in order to exclusively serve an understanding of the concept of improvisation in Western culture. However, this attitude is a slippery slope. ‘Western culture’ is not one entity, either. One could argue that there are many different improvisatory traditions within Western culture that do not necessarily share common thought processes. With this attitude, the cognitive-scientific theory would grow more and more confined until it described a single musician or small group of musicians and would lose its scientific characteristic of generalisability.

These problems exist for many phenomena that cognitive science tries to explain, but improvisation presents additional challenges specific to its nature. Some sort of categorisation of behaviour is required for these pursuits; one must be able to have a preliminary operational definition of improvisation in order to study it scientifically which requires forging some kind of principle to identify and categorise the phenomenon. Whether multiple instances of improvisation could be reasonably cast as the same or of the same type presents another challenge—if improvisation is an inherently different practice every time it is done, there is nothing that can be categorised, and its cognitive correlates could similarly not be described as a regular or typical feature. What could be the same about multiple instances of improvisation?

In order to comment on these problems, it will be helpful to consider the critical literature on improvisation. This literature is motivated to examine the term ‘improvisation’ as a discursive tool and its historical and socially situated meanings (e.g., whose music is ‘improvisatory’ and what does that mean about its position in social discourses?). In focussing on the social basis of meaning of the term, this literature is somewhat at odds with a scientific approach, and indeed might consider the scientific approach to be an aggressive
political act of forcing many different kinds of music (and free music at that) into one framework. Through examining this literature, concerns about grouping together different musical practices can be reconciled with a scientific approach. In a very important way, as will be discussed, these approaches share a motivation. That is, both are actually constructing an understanding of the term.

In short, the objections and objectives discussed in this chapter are thus:

- What might be in common between improvisatory musical traditions around the world? What might be different? With a firm account of this, one could then search for cognitive correlates of whatever it is that is in common and construct a theory that extends beyond one culture’s use of the term.

- How could a scientific understanding of musical improvisation that would purport to explain it in general and universal terms ever accomplish its goals if improvisation changes throughout different instances and social situations? A firm account of this will help contextualise and justify the cognitive-scientific approach.

The first point is a question for the ethnomusicological literature. A review of this literature will show what is in common and what is different in improvisatory musical practices around the world. It will show how the cognitive-scientific approach can be built on commonalities observed between these traditions and will also show how while both kinds of scholarship are concerned with performers’ processes, the two differ in regard to how they attempt to describe that process and thus in their ability to create a successful comparative theory. The second point is a question for the critical literature. There is a tension between the systematising aims of science, and the resistance to making essential and prescriptive definitions of mutable cultural concepts. By reviewing the critical literature, this tension can be addressed. Further, a review of this literature also shows a fundamental similarity between these approaches in that both thoroughly interrogate the concept of improvisation and aim to iteratively construct and reconstruct its meaning through careful observations.

**What is a ‘process’?**

Throughout this dissertation, it is argued that typical definitions of improvisation cannot adequately distinguish the phenomenon from rehearsed performance and composition. Cognitive science, it is argued, can offer a characterisation of improvisation that can meaningfully distinguish it from other kinds of music making, as well as provide a platform upon which to compare different improvisatory musical traditions and different non-musical
creative behaviours. This is done, it is argued, through a characterisation of process. (as well as considering differences in cognitive representations—see Chapter 5).

Ethnomusicology and music-analytical approaches offer an account of improvisation based on process, and through a discussion of these literatures, the advantages of a cognitive account of process are made clear. This comparison is introduced in this chapter and developed in the following chapters. However, before making this comparison, it would be helpful to describe just what is meant by ‘process’ as the word could be used in many different senses, even within cognitive-scientific approaches.

When a musician makes a movement at an instrument, one could describe ‘what’ was played in structural terms (e.g., a loud chord) or one could look at all of the interneural and neuromuscular signals that preceded the production of the structure. The various steps that lead to the production of that chord comprise the process. A process, in the sense used in this dissertation, thus takes time, and has a specifiable sequence and quantity of ordered steps.

Depending on the kind of theory one applies, this timescale and these steps could vary significantly (learning to play an instrument is a ‘process’ that takes many years). For the purpose of the arguments developed in this chapter and the following chapters, the process is considered on a short time scale (how movements are planned and executed).

Of course, in order to understanding how a process works, one would also need to understand how each of the steps functions. Some understanding of the structure of these mechanisms would thus be necessary (invoking the biological idea that structure and function are related). To this end, chapter 5 discusses how it is important to understand the nature of representations that are involved in musical performance processes after introducing the specifics of the cognitive approach.

The concept of process should also be distinguished from what could be called a ‘dynamic’, which would be a continuous interaction (without discretely ordered steps) perhaps between one musician and another, or between sensory-motor processes carried out within an individual musician.

Towards a more effective comparative enterprise

There are two main aims in reviewing the ethnomusicological literature on improvisation. The first is to find commonalities and differences between the diverse improvisatory traditions around the world upon which to base a less ethnocentric cognitive-scientific inquiry, and indeed to establish that it is possible at all. As Nettl (1974, 2013) has cautioned, improvisation is not a single phenomenon. He argues that ethnomusicologists
should focus on not only documenting the diversity of traditions, but also in questioning the meaning of the term through comparative study:

The customary picture of improvisation, then, would and should be greatly expanded by an understanding of non-Western cultures. Unfortunately, the recent ethnomusicological literature contributes to this end in only a piecemeal fashion, providing specialized studies of systems and subsystems without giving much attention to the nature of the concept, and certainly making little attempt to be comparative. (Nettl 1974, p. 4)

This is what a cognitive-scientific approach would aim to accomplish and contribute. It could provide a theoretical framework within which to make a comparison, and in so doing would challenge and help construct an operational concept to be tested with experiments that could provide data supporting and advancing such theories. The existing ethnomusicological literature documents traditions and attempts to explain performers’ thought processes. However, as will be seen in the review below, this literature often relies on music analysis in terms of the music theories of the people making the music. This kind of explanation is not easily translatable across traditions leaving ethnomusicological approaches less able to make comparisons. Cognitive science has something to offer here in helping to accomplish a more effective comparison.

On this point, a useful distinction can be made here between ‘music theory’ and ‘theories of music’. Different musical traditions may have different explicit ways of describing their music, and the function of that music within a cultural context. Describing an F major chord only has meaning within a particular organisation and function of musical structures. A Hindustani rāga has meaning only within its own music-theoretical context. With music theory, one would be right to be cautious of trying to use one system to describe a different one. Hindustani rāgas can tell you little about Iranian dastgāhs, at least on the surface. In fact, one could expand music theory to the more abstract aims of critical studies which theorise about the meaning of terms like ‘improvisation’. The meaning of the term itself is different in different cultures, defined by different sets of principles perhaps based on the music theory of formal structures, and perhaps on social contexts. In order to be comparative and to find commonalities beneath the surface of emic descriptions of practice, or particular cultural situations of them, one could develop ‘theories of music’. Such theories would attempt to answer broader questions, and importantly, would not be in terms that describe particular musical practices. For instance, Cross (2003) has developed evolutionary theories to explain why humans might be musical at all and the selective advantages that musical capacities might endow. Sociologists might develop theories of music to explain...
how music is able to have political or social meaning regardless of the particular style and location of the practice such as Turino’s (2008) distinction between ‘participatory’ and ‘presentational’ musics—a term which can describe and compare musical traditions across cultural boundaries.

Cognitive science can offer another such theory of music. If one wishes to accomplish the comparative enterprise for which Nettl calls, one would need such a comparative framework. Cognitive science (amongst other types of theories of music) could fill this role. In order to form such scientific theories of music, one would need to observe different instances of music-making around the world, and propose a link between them in the cognitive-scientific theoretical framework. This is necessarily limited; one cannot observe every musician in the world. Whatever theory is formed from a set of observations could be challenged by a future observation of another practice that might contradict the theory; in fact, the possibility of this occurrence, that is, the possibility of falsificationism, is a strength of this approach (see Lakatos, 1970).

It should be noted here that for the same reasons a cognitive approach can draw comparisons between different musical traditions, it can also draw comparisons outside of musical practices. If the creative processes underlying improvisation are described in terms not specific to music theory, they could also be used to describe other creative practices like speech, dance, theatre, and otherwise. This dissertation does not attempt to accomplish this, but it would be possible in principle. Following the presentation of the cognitive theory and several experiments in its later chapters, some possibilities for beginning this kind of comparative enterprise are explored based on the framework this dissertation constructs.

The second main reason to review the ethnomusicological literature thus follows from the first. It is to more definitely situate the cognitive approach and demonstrate what it has to offer. For improvisation, the question of process is central. Questions about improvisation arise from a desire to understand how music is being produced, not just what notes are played. Ethnomusicological literature on improvisation claims to help describe performers’ thought processes. Cognitive science also seeks to identify performers’ processes. By comparing its methods with those found in the ethnomusicological literature, the value of the cognitive-scientific approach will be highlighted. Generally speaking, the ethnomusicological approach describes performers’ processes through naturalistic observations and music-analytical descriptions of the musical product rather than through comparing performance under experimentally controlled conditions and explaining it in terms
that are not exclusively musical, as a cognitive-scientific approach could do. The limits of music analysis as a way to understand improvisational process are discussed in detail in chapter 3. This chapter focuses on the issue that such forms of analysis cannot as effectively engage in a comparative enterprise because the music-analytic terms of music differ between cultures. The cognitive-scientific approach by contrast can build on naturalistic observation by using experimentally controlled conditions to describe musical performance process in such a way that it is translatable between traditions.

**Caveats to the ethnomusicological approach**

A few more words of caution must be offered before reviewing the ethnomusicological literature. Monson (1994), citing trends in post-structuralist theory, has cautioned against characterising any culture (self or other) as homogenous. The people described in various cultural traditions are *people*, and as such they borrow, mix, and synthesise ideas from ‘other’ cultures. They should not be stereo-typed as having a single compositional/improvisational process or style. Documentation of traditions, therefore, should be multivocal to emphasise the blurs between purported cultural boundaries. Similarly, Slobin (1992) has demonstrated the complexity of delineating cultural practices. Each culture does not have a typical kind of music or set of musical practices—the intersection of several planes of inquiry (supercultural, subcultural, and intercultural in Slobin’s terminology) might help better attribute particular musical practices to particular people and ways of life. It is not as simple as identifying a particular culture’s particular music.

In response to this, the cognitive-scientific approach described in the following chapters does not pretend to be universal. However, it is formulated in such a way so as to be able to expand to accommodate such subtleties that might arise through the diversity Monson and Slobin describe. Whether boundaries are drawn around cultures, subcultures, groups, individuals, or other social structures, the same principle applies. Cognitive science can propose a way to categorise behaviours based on its own theoretical frameworks, and through such categorisation construct common explanatory principles. Behaviours that contradict such an organisation can force the theory to adapt to accommodate the anomaly, or start from scratch. It is an empirical question.

Another problem with assessing the ethnomusicological literature is that an ethnography of another culture’s improvisatory musical practices must presuppose a category
of improvisational music-making that is in opposition to some other mode of music making, such as rehearsed performance. To use the term at all requires some kind of delineation from other musical practices. Not all musical traditions may call their own music ‘improvisatory’ even if it seems to have improvisatory characteristics as imposed by a Western theoretical definition. As such, an ethnomusicological review for the purpose of this dissertation would seem to need to explore how other cultures make music, not how they ‘improvise’. For this reason, an ethnomusicological survey would seem to need to extend not just to musical traditions with clear similarities to Western notions of improvisation, but to every musical practice that might have a hint of such improvisatory characteristics.

Needless to say, this would be an impossibly immense task. One can never observe all possible musical behaviours, but one has to start somewhere. By first identifying musical practices that in some way seem similar, the foundation for a theory can be laid. Future observations may help redraw the lines of that theory and may ultimately end up discarding the original terms (i.e., perhaps improvisation just does not work as a comparative term). A cognitive-scientific conception of improvisation could be constructed through various ethnomusicological observations. Future observations might refine that theory, or completely falsify it. Again, this is not a problem, but a strength of the scientific method.

What follows is a review of several musical traditions around the world which seem to have improvisatory characteristics, at least in the Western conception of the term. The review will show similarities between the observations made by the authors as well as similarities in their evaluative methods which will later be used to form the foundation of the cognitive scientific theory proposed in this dissertation in chapter 5. It substantiates the motivations described above and will be followed by further critique of these methods along with further contextualisation and promotion of the cognitive-scientific method.

A review of improvisatory traditions

In recent years, scholars are beginning to fulfil Nettl’s call for comparative study, or at least lay its foundations, by offering documentation and analysis of a diverse range of musical traditions that might be understood as being improvisatory. The work of these ethnomusicologists has made comparison possible by providing something to be compared, even if the actual work of comparing them is less common. This section reviews literature on several improvisatory traditions from around the world. It also includes documentation of historical traditions from the West as they function as an additional ‘other’ and can thus
enrich this comparative enterprise. It does not include a separate mention of jazz although it is mentioned alongside some of the other traditions, and jazz practices will be considered in later chapters. Throughout the review of this literature, I will highlight similarities and differences between these traditions and begin to demonstrate where cognitive science can contribute to a more effective comparative enterprise.

**Iranian improvisation**

Nooshin (1998) documents *dastgāh Segāh* (Iranian classical music) in order to examine and describe its performers’ creative processes. Nooshin describes the traditional invocation of the nightingale, a bird that is said to never repeat itself in song, as a metaphor in her description of this improvisatory tradition. Students learn collections of short musical passages called *gushehs* from masters which together comprise the *radif*. By transcribing and analyzing musical excerpts, Nooshin shows how some *gushehs* are musically flexible in ways that other *gushehs* are not. *Gushehs* are considered by Nooshin to be a framework for improvisation, some of which impose more determination on the improvisation than others due to their differences in this flexibility. She describes this difference as follows:

Whilst it has only been possible to present complete transcriptions of two *gushehs* here, the wider range of material analysed in the original study...suggested a continuum of *gushehs* in Segāh, ranging from the most ‘pre-defined’ to those with the greatest scope for improvisation. (p. 92)

Nooshin meticulously catalogued the way *gushehs* are used, and how they are varied in performance. She goes on to characterise the *radif* as a ‘pool’ of ideas which includes not only material to be modified, but also generative and combinatorial principles. Nooshin also notes the importance of informal listening experiences which help shape the ‘ear’ of musicians and non-musicians.

This ethnomusicological study has identified a musical tradition, considered its pedagogies, compared different modes of performance varying in the degree of pre-determination, and has offered musical analytical techniques to describe such performance processes. Despite a difference between the organisation of this music and, for instance, Western jazz, the language describing the creative processes sounds quite familiar. There is a discussion of combinatorial rules, pools of ideas, and the employment of the ‘continuum’ concept of flexibility. These are familiar ideas and notions.

Nooshin’s goal was to describe the creative processes of the musicians. It is also important to note here that her way of arriving at an explanation of these processes is based
upon music analysis. Indeed the resultant characterisation of the process is inextricable from music-analytical terms—flexibility and the lack of pre-determination are defined in terms of divergence from music-theoretical patterns.

Such an inquiry potentially could have much in common with an explanation of the processes used in other improvisatory traditions. Some of the similarities are more immediately apparent: degrees of pre-determination that describe various gushehs could be like the degrees of pre-determination imposed by different kinds of chord progressions or melodic restrictions as in Western jazz, and similar to learning gushehs, jazz musicians might be said to learn ‘licks’ and associated generative principles to get from one to another (even if licks are not explicitly emphasised or claimed to be important, there are recurrent melodic patterns in many jazz improvisations). Much of the conceptual understanding is shared here and could potentially be applied to other traditions, although certainly aspects of this Iranian study are specific to dastgāh Segāh in terms of the ways the modes constrict some gushehs in different ways than others. There cannot be a direct transfer of understanding if the terms are kept within the different music theories (jazz harmony could not describe gusheh properties). A comparison, however, in the principles by which a performer might learn and manipulate their musical knowledge could be possible.

In fact, elsewhere, Nooshin & Widdess (2006) have written a short comparative study of Iranian and Indian improvisatory traditions. They address issues such as the applicability of the term ‘improvisation’ given an ambiguity between what is rehearsed and what is created in performance, various concepts within these traditions which make such distinctions, and how while there are terms which roughly correlate, the introduction of the term may be seen as a device by which Westerners could ‘other’ this music and distinguish it from the concept of composition championed in the Western art tradition. They also highlight similarities in the pedagogy: “In general, Indian music resembles Iranian music in the extent to which imitation and memorisation are the fundamental learning processes, even though it does not have a universally recognised, memorised and notated repertoire like the radif” (p. 109).

Their comparison also invokes Berliner’s (1994) ethnography of jazz as being somewhat similar in this regard. These kinds of comparisons describe different traditions in similar terms. It is not clear whether the observations of the traditions give rise to the comparative terms, or whether the comparative terms already existed and certain aspects of these traditions were simply fit into them. Regardless, a comparison can still be made.
The particular terms of the comparison, however, as will be discussed in detail in the following chapter, are based on music-analytical claims. Even though it would seem that a meaningful comparison is possible, the notion that musical processes can be understood through concepts based on music analysis (such as frameworks, continua, musical rules, etc.) may be mistaken, and as such the comparison has less meaning as well. A cognitive approach could offer another kind of comparison that is not susceptible to such problems, but this matter is discussed in later chapters. For now, suffice it to say that comparisons are possible through framing aspects of traditions in certain ways.

Another kind of comparison could be within a cultural practice such as comparing memorised performances with improvised ones and assessing differences. It is important to note here that it would be difficult to make such a comparison in Iranian music, at least from Nooshin’s account. It would seem that these different kinds of performance exist as they do in the Western classical tradition, but not necessarily in Iranian music. Nevertheless, as is apparent from her study, different processes may be at play depending on the musical material that is being used and how much it suggests definite continuations or in how much it allows freedom. As such, there could be different kinds of performance (e.g., constrained and free), but they may not align well with distinctions between modes of performance in other traditions (e.g., memorised and improvised). This does not mean it is impossible to compare processes—it just means that one cannot wholly rely on culturally specific emic descriptions of practice to do so. Some other kind of theory (such as cognitive-science) would need to propose a common framework in which to compare differences.

**Hindustani and Karṇāṭak music**

Classical Indian music is an improvisatory musical tradition relatively well-known to Western musicians. Despite being identified as improvisatory, many authors have set out to show, though, how such musical performance is neither mysterious in the processes of its inspiration nor completely unstructured and spontaneous. Indeed, to perform such music, though ‘improvisatory’, takes years of training and the acquisition of various types of musical knowledge.

Similar to Nooshin’s account of musical practices in the Iranian tradition, Widdess (2011) suggests that improvisatory performances of Hindustani classical music involves recalling previously learned material as well as compositional principles, and requires an educated audience to comprehend and support such a performance (p. 188). He seeks to
identify and describe performance processes in the improvisation of the ālāp section of a track from a CD recording of the sitārist Budhaditya Mukherjee. Through showing how two different rāgas are combined, and keeping in mind how such a combination would be meaningful to an educated audience, Widdess seeks to describe regularities and principles of improvisatory performance processes. Why are particular notes chosen and what would they mean in the music-theoretical context that an educated listener would know?

Again, notably, the description of process here is accomplished through music analysis in music-theoretical terms. The explanation is couched in those terms—a note might acquire meaning because of its relation to different regularities during performance in different rāgas. The process is thus also described in such terms—explicit terms—that the musician himself or herself would be likely to be able to consciously describe. Nevertheless, improvisatory ability in this tradition would seem to require the long-term exposure to and acquisition of regularities in different musical contexts both in terms of pre-specified series of notes and perhaps also regularities in how new series of notes can be generated and combined.

Viswanathan & Cormack (1998) describe regularities in Karṇāṭak improvisation. Again, by employing musical analysis, they show the various kinds of regularity that exist in gamaka (ornamentation), saṅcāra (phrase), and svara (pitch). Musicians acquire these regularities when they train so that while to an uneducated listener the improvisation may seem miraculous, “[f]or them, there is no mystery involved—this is a skill that is learned over many years. A broad system of rules has been absorbed and used like a blueprint for molding the edifice of each improvisatory form.” (p. 231). Again, ideas of a system of rules arise that acts as a kind of blueprint. What differs in the accounts of these traditions of improvisatory music is the names of the parts of music and the specific ways they change, but there is consistently the idea of acquiring knowledge of musical regularities and frameworks, and the idea of interacting with educated audiences by making changes or emphasising parts of those frameworks.

Arabic improvisation

Racy (1998) provides an account of improvisation in Arabic music. Similar to Nooshin’s study, Racy identifies features of creativity in improvisation of the tarab tradition in Arabic music as relying on a learned set of compositional devices shared by other musicians—both in terms of a stock of ideas, but also in terms of compositional processes.
Racy goes on to emphasise ecstatic states which resonate between the performer and the audience. The audience must be educated in the music as well in order to understand and appreciate what the performer does, but also to render the appropriate environment for performance:

In effect, the full shape of a ṭarab performance depends on three interrelated factors: first, an emotionally meaningful stock of compositional devices shared by participants in the ṭarab process; second, the skill of the ṭarab artist who possesses ‘soul’ and may be able to render his performance in an appropriate ecstatic state; and third, the listener’s musical disposition and sensitivity communicated through direct emotional-musical input. (p. 103)

It would seem that the analysis of Arabic music and Iranian music also share a common feature of the need to learn compositional devices and a stock of musical ideas, at least as the authors have suggested. However, to what extent can we say that the necessary training is similar to that in other traditions? Or that the creative processes are similar? They are situated in different cultural contexts, so can we make a claim that a similar performance process is at play in both traditions? What would that mean considering the specifics of the style differ (which instruments are used, for instance, or the names and organisation of musical structures)? Again, as discussed below, the cognitive approach has something to offer here in solidifying this similarity.

**Gamelan music**

Gray (2010) has described creative practices in Gendér Wayang, a type of Balinese gamelan music used to accompany shadow puppet plays. Referring to Nettl’s notion of a continuum of improvisation, Gray suggests instead that the different kinds of Gendér Wayang are more like “an interrelated web of connected actions and concepts” (p. 231). Gray reviews different musical practices that have different types of improvisatory practices ranging from those with more pre-determined elements and those that are more free to vary. He emphasises that improvisatory practices can arise from the interaction between musicians, not just in solo performance. In the conclusion of his article, he ties in notions of predetermination and freedom to larger cultural values of political and personal freedom.

These musical practices have considerations specific to the style—how can an improvisation fit over the particular kinds of melody and accompaniment, where is there freedom to vary melodic and rhythmic structures, how can players communicate within these constraints, etc. There is much to be said of Balinese gamelan music in this sense. As far as
it concerns whether the music is improvisatory, however, there are very similar considerations. Gray reflects:

Besides definite pitch and rhythm changes, the overall ‘feeling’ of the improvised version is one of letting go and allowing the music to flow. It seems to echo Buda’s [a musician Gray is discussing] comment above about ‘playing using just feeling’. However, as with much improvisation, it is hard to ascertain how much, if any, material is genuinely ‘new’ in the sense of never having been played before. (p. 235)

Gray begins to critically examine the term improvisation here by challenging whether this music is genuinely new, with novelty often being a key feature of definitions of improvisation. Similarly, Sutton (1998) asks whether Javanese gamelan players are actually improvising. Sutton is more careful to set aside a preconception of what improvisation is and instead focuses on what it is that Javanese gamelan players are doing, leaving the assignment of a term for later. This is more akin to returning to a study of music making in other cultures rather than needing to specify that it is improvisation outright. In this way, even though he also uses music analysis to make his claims which potentially confines his theories to this particular tradition, he focuses more on the performance process without couching his observations in a preconceived notion of the concept of improvisation. This attitude is more akin to the cognitive approach I will outline in the following chapters. A musical tradition is examined in light of its seemingly improvisatory characteristics, but observations should be able to change the use of terms and definitions. After examining various musical practices, there may be better ways to differentiate between types of performance.

Sometimes ethnomusicological approaches are not as careful to call into question the stability of the term, although most are aware of its shortcomings. In the end, it is of secondary relevance whether the term fits properly so long as the musical traditions are critically documented. How to develop broader theories that could unite aspects of these traditions, that is, the comparative study, can proceed whether or not the individual studies are critical of the term so long as the study comparing them is not distracted by any false unity that ‘improvisation’ might suggest.

**Historical practices**

Historical literature on past musical practices in the West provides another set of improvisatory traditions to add to a comparative enterprise. Because the examination of historical practices can also help to make more general observations about improvisatory practices generally, they are included in this ethnomusicological review.
There are a handful of studies concerning improvisatory practices in the history of Western art music. These studies are necessarily based on written records (treatises, scores), introducing tension between the illusory stability of the written text and the ephemeral and extemporaneous nature of improvisatory practices. With ethnomusicological studies, additional research resources are available such as interviewing and interacting with practitioners of living traditions and sound and video recordings. As for the historical studies, scholars have sought to understand improvisatory practices of the past despite relying on making inferences through potentially misleading written texts (did people actually do what they say they did?). Of course, this is not only a problem for improvisation—the so-called Historically Informed Performance debate has struggled to understand performance practices of the past more generally (see Butt, 2002). Much of that debate concerns whether such practices should be preserved on aesthetic grounds. One could study the improvisatory literature with the aim of recreating these practices, but for the present purposes, they are reviewed solely for comparative purposes. Several examples of this literature are described here, showing how scholars have approached the topic of historical improvisatory practices in Western music.

Generally speaking, the historical literature offers case studies of particular improvisatory practices (such as ornamentation or preluding) that demonstrate the relationship between the performer and the score—that is, raising issues of performance practice in how much agency a performer had in realising written music. Like the ethnomusicological literature, a definition of improvisation is assumed in the background to allow for a discussion of these practices. The precise nature of notation and the role of the performer are questioned, but the definition and meaning of improvisation is not always directly critically interrogated.

Prior to the solidification of a canon of musical works, musicians are known to have incorporated more kinds of improvisatory practices into their performances. Cumming (2013) documents improvisatory practices in Renaissance music and notes that, rather than being esoteric, these skills were commonly practiced by trained musicians. In singing a canon, a strict set of rules governed which pitches and intervals would lead to an appropriate harmonious sound. Musicians could study these rules and learn to improvise contrapuntal music. Schubert (2014) has a set of YouTube videos explaining how this can be learned relatively quickly by following the rules of Renaissance modal counterpoint.
Toliver (1992) has hypothesised about improvisatory practices in two-voice madrigals from the 14th century Rossi Codex. Due to discrepancies between the multiple extant copies, Toliver considers room for improvisation within these performances. Specifically, he points to simultaneous pauses in both parts and certain short-range functioning tonal features as possible points of communication between the performers whilst improvising.

Goertzen (1996, 1998) has documented the practice of preluding in 18th and early 19th century pianists. She writes about the structural characteristics of the preludes, their function, when they would be appropriate to play, how they could introduce a new work, and how they might be used for pianists to test the piano before a performance. With specific reference to Clara Schumann, Goertzen refers to pedagogical methods of learning cadences and figures in all keys as a precedent for improvisatory abilities.

In his cognitive study, Berkowitz (2010), whose research will be discussed more in developing the cognitive-scientific approach in later chapters, reviewed several improvisatory treatises (mostly about preluding) from the 18th and 19th century by C.P.E. Bach, Kollmann, Vierling, Türk, Grétry, and Hewitt. He reviews the principles of variation and combination from these treatises to inform an understanding of how improvisation was taught and learned. In order to learn to improvise cadenzas, for instance, musicians would learn stock figures in many different keys in order to combine them in an improvisatory performance.

These historical studies potentially provide further fodder to develop a stronger comparative enterprise. Many of the claims about improvisatory processes are also based on music analysis (asking questions about how notes are chosen, for instance) and document how performers acquire rules and vocabularies. Similar terms are used to describe these practices as ethnomusicologically documented traditions.

**General critique of ethnomusicological approaches**

Many of these studies describe what performers know in terms of acquired repertoires of musical structures and/or in terms of generative principles as understood to be acquired by performers through looking at the structures produced by those principles. Such structures and principles are learned through listening, interacting with audiences, or by direct instruction from a master. There are rules (or at least tendencies) that describe when they are likely to occur in performance, and violation of those rules can be a deliberate expression of musical meaning, particularly for audiences who are in-the-know. On the surface, there are thus many ways to begin comparing these traditions.
Of course there are many differences between these traditions as well. The instruments are different—not just the musical instruments, but the instruments of meaning. The language, music theory, and performance contexts are different. These differences are important to understand, but they do not necessarily contradict a theory that otherwise unites these traditions according to their similarities. To take a simple example, a theory of improvisation could be formulated to account for a saxophonist improvising as well as a clarinettist even though their instruments are different. It could be formulated for a saxophonist playing for a group of friends versus an audience of strangers. There may be similar principles that could be used to describe the improvisatory process regardless of the instrument or performance context. It may be that something about the instrument or performance actually contradicts the basis upon which a theory claims similarity, and in that case the difference would challenge the theory, but some kinds of difference do not necessarily preclude the possibility of a common theory.

Many of these studies cited above claim to describe performance process. A cognitive-scientific approach would also claim to describe process. What is the difference between these approaches? There are two ways ethnomusicological approaches can benefit from a cognitive-scientific approach. The first arises from a certain reliance on phenomenology. Ethnomusicologists sometimes ask musicians how they are doing what they are doing. The musicians may be able to give very insightful answers, but even so it would be difficult to forge a comparison from this kind of self-observation, at least without the assistance of some other kind of theory. For example, if musicians from different traditions consistently reported ‘losing themselves’, one could postulate a psychological theory that extends beyond a particular tradition and begin to describe various correlates of that experience, such as which contexts are most likely to induce it, or its cognitive-scientific correlates (for instance, something like Csíkszentmihályi’s (1996) theory of flow). A self-report, however, could also rely on the specific terminology of that tradition such as when a performer describes his or her own process in terms of their own music theory. It may be an internally coherent explanation, but it is not clear from this how one would accomplish a comparison between traditions when the music theoretical terms are incompatible. Further, it risks a kind of self-fulfilling prophecy or folk psychology. Musicians learn through particular traditions with their own music theories, and then when asked how they do what they do, they describe it in those same theories. In this way, the act of explanation is more like an aspect of the practice than it is a theory of how it is done. This, of course, is not to say that musicians
cannot have insights beyond the terminology of their music theories. These insights are very important and valuable, but taken alone would only serve as a first step. They could then be compared with observations from other traditions, or examined empirically. In other words, additional work beyond such insights would need to be done to forge an explanation.

The second main issue, as has been raised alongside the above discussion of different musical traditions, is the general reliance on music analysis to describe creative process. Perhaps an ethnomusicologist considers which notes are produced and where, or from making multiple observations, abstracts generative processes that could describe which notes will be produced. The problem here is that multiple different processes of movement planning (as would underlie improvisation) could have led to the production of the same notes. In this way, music analysis could potentially confound what might otherwise be characterised as different modes of performance. One of cognitive-science’s strengths is its ability to characterise the different ways one can know how to do something. For example, upon first listening to a new style of music, it would be very difficult to know whether it was ‘improvised’ without such extensive analytical work beforehand. If, however, there are characteristic cognitive processes, differences in modes of performance could be more immediately characterised. Cognitive-scientific approaches can try to characterise such modes of performance in terms of brains and biology, not just in terms of notes or other music-theoretic constructs. To be sure, this relies on its own form of analysis—but it is analysis in the framework of a theory of music, not music theory. Such cognitive processes would be described in terms outside of a particular music theory and thus could provide a framework for comparison.

In short, the comparisons that do exist and the ones that seem most imminent are based on observations arising from music analysis. As will be explored in the following chapter, ideas like ‘real time’, ‘frameworks’, ‘rules’, and other ideas typically associated with improvisation do not successful distinguish it as a kind of performance. Thus, comparisons based on such ideas can be successful in showing similarities between traditions of music making, but they are less successful in characterising improvisation as a kind of performance.

**Generalisations and universals**

The comparative enterprise does not follow from individual ethnomusicological studies without additional contributions from ‘theories of music’ (in the sense described above). There is plenty of content to be compared, but the actual act of comparison is still
relatively rare. This may be because such a comparison might imply a kind of false unity; there may be no motivation to claim similarity across traditions because it would obscure relevant differences.

Can a cognitive theory fulfil this role and describe improvisation across multiple cultures without devaluing the differences? Yes and no. No because what improvisation is in different cultures is different—it refers to a different set of musical practices with a different tradition, pedagogy, cultural situation, and meaning. Improvisation is not the same thing to different people. However, yes because a cognitive approach can construct its own typology of modes of performance that is commensurable across cultures. Various musical traditions may share cognitive mechanisms outside of the terminology of the varying music theories. When ethnomusicologists point out that some music is more rehearsed than other music, or some musical structures introduce more constraints than others, there may be commonalities in how that musical knowledge is represented in and produced by the mind. Below the surface of varying musical terminology, a common set of cognitive principles may help describe types of musical practices around the world.

One could also check whether music theoretical claims are possible, cognitively speaking. If an ethnomusicologist claims that a musician is never meant to repeat themselves in a performance, one could reasonably ask whether people have a sufficient capacity for remembering everything they have played as would be necessary to accomplish such a feat. Or, if a musician claims to use a particular principle to generate music, cognitive theories could help describe the mechanism by which the principle functions or deny the possibility of such a mechanism on neurophysiological grounds. Cognitive perspectives, through comparing what people say about performance and what people actually do in performance and their actual perceptual capacities, can provide another perspective on how such musical discourses are constructed.

That being said, this dissertation is not based on ethnomusicological fieldwork. Its empirical contribution is through behavioural experiments conducted with Western musicians. It is important to discuss this issue in principle, however, because there is a similar problem in generalising across musicians even from a similar tradition. Not all musicians in Western society are the same—not all jazz musicians are the same. This point may be obvious to ethnomusicologists, but cognitive-scientists need to temporarily suspend this perspective in order to compare groups experimentally according to a limited number of factors. Even though musicians may vary in how they have learned to play music, in their
The goal is not to completely characterise every instance of improvisation. Of course there is individual variation between performers and between performances. But such variation does not preclude trends and principles. The goal is not to say improvisation is one type of thing, cognitively—there may be a suite of improvisational modes of performance. But, there may be differences between such modes of performance that could be used to enrich a discourse of what ‘improvisation’ means.

**Critical studies of musical improvisation**

The discussion now turns to critical studies of musical improvisation. By critical studies, I mean three things. First are those studies that explore the historical origins of the meaning of the term. How has the term come to be used in modern discourses and how can examining its history inform our modern understanding? Second are those studies that comment on the cultural implications of such a term. The fact that a term like improvisation exists implies certain things about cultural conceptions of musical ontology and musical practice. How and why is it used in musical discourses? Examining its use can also reveal political forces, such as by considering which music is called improvisatory, why it is called that, and what that connotes. Lastly are those studies that expand the meaning of the term improvisation through applying it as a metaphor for various other cultural and political activities. For instance, one could ask how improvisation could be understood as a metaphor for rebellion. Much of the current scholarship on improvisation follows these research questions, including an entire online peer-reviewed journal devoted to “Critical Studies in Improvisation”.

As for examining the history and cultural implications of the term, in a seminal article, Lewis (1996) describes how concepts like “improvisation” and “aleatory” have been differently mapped onto what he calls Afrological and Eurological traditions of music. John Cage’s music is considered ‘aleatoric’ whereas Charlie Parker’s is ‘improvisatory’, a symptom of an underlying political distinction. In this way of thinking, what makes something ‘improvisatory’ is as much a political question as it is an ontological one or a question of internal process. How, then, can performers engage with improvisatory music making in order to open a dialogue with these political issues? A critical theorist may ask whose music gets to be called ‘improvisatory’ and why.
In a discussion of perceptual agency (that is, listening as a form of active construction), Monson (2009) links music perception to the larger perception of cultural meaning: “[People]…relate these aural signs and markers to a web of ideas and discourses they may have encountered—with respect to Coltrane, spirituality, genius, freedom, originality, African American consciousness—as well as to their understanding of history” (p. 26). The idea of freedom is ‘heard’ and linked to larger discourses and social situations. To understand improvisation in this regard is in large part to understand this connection. Through this kind of connection, improvisation could acquire a metaphorical meaning as standing for such social situations.

Here, a tension arises between scientific and critical approaches to improvisation. On the one hand, if the concept of improvisation is elaborated to extend into networks of meaning, the scientific approach would seem politically aggressive. If a scientific approach were to ‘explain’ how improvisation works, they would in some sense be taking away the scope of such elaborations employed by its practitioners and by critical theories. On the other hand, if improvisation is an opaque concept that means more about the people that use the term than the term means itself, then the scientific enterprise would seem illogical because no such concept exists solidly enough to even try to be systematic about it.

Tensions between cognitive science and critical theorists are not just confined to the issue of improvisation. Improvisation is a particularly provocative example because of its aesthetic of freedom—science could risk prescribing the value of improvisation—but more generally scientific theories have long encountered resistance when they start to tread on aesthetic grounds. Hui (2013) recounts the emergence of the field of psychophysics and its descendent, experimental psychology, in 19th century Germany and Austria. She focuses on the role of music aesthetics in this early research on linking the physical world with its psychical counterpart. With aesthetic tensions permeating the musical discourse of the time, such as the need to reconcile having a correct way to listen (following from Hanslick’s theory of ‘aesthetic listening’) with an increasing acceptance of the historicism of beauty, scientists sought to justify aesthetic positions by appealing to the steadfast yet elusive foundation of the ‘natural’. Their programme, as Hui writes, was not always successful—theorists and scientists like Hugo Riemann with his theory of undertones and Ernst Mach with his goal to explain the accommodation mechanism of the ear (how someone could hear out different parts of the same sound signal) were not able to find physical evidence for the aesthetic philosophy they were trying to explain. Even at the outset of music psychology, the
intersection of scientific explanations with aesthetic questions has been problematic. Sound and its perception may be a process that can be described by scientifically measuring and examining the inner ear and brain, but at what point does ‘music’ as a social object become compatible with scientific theoretical frameworks?

To this day, this is an uncomfortable tension. Music is difficult to define outside of the context of its value to a particular society—it would seem to play a different role in different cultures or subcultures, have different value to different people. Because its definition is circumscribed by aesthetic considerations, trying to explain it scientifically risks becoming prescriptive—this is what music should be to people, this is the role that it is ‘natural’ to play in society. Monson (2008) confronts this tension. She comments on a modern instantiation of this kind of debate between postmodern theorists and cognitive neuroscientists, focussing on the example of music perception, characterising it as an active process. Monson expresses that she has been

...pleasantly surprised to discover that much in the recent wet mind cognitive neuroscience literature resonates with themes that have dominated debates in social and cultural theory in the last twenty years, including poststructural understandings of the subject, ideas of social construction, contingency, and processes of emergence (p. S47).

This comment reminds scientists that trends in the ways questions are asked could be influenced by larger trends in humanities scholarship (although one wonders what would be said of this relationship had cognitive-neuroscience produced claims contrary to theories from the humanities, as they sometimes did in Hui’s history). In any case, it is a characterisation of a strong contingency of science. That aside, this comment nevertheless highlights the political nature of such attempts of conciliation. Monson goes on to suggest “not that we replace the interpretive paradigms that have shaped interdisciplinary dialogue across the humanities and social sciences with discourses of cognitive neuroscience but that we allow them to mingle and see what happens” (p. S50). Although the motivation to synthesise scientific and critical perspectives resonates with an underlying theme of this dissertation, it highlights the political tension that still exists: who is the ‘we’ Monson mentions? Who has the authority to ‘allow’ them to mingle? The perspectives are not really fully cooperating yet.

From this kind of position, the challenge to a cognitive science of improvisation is that it may be missing the point—improvisation is about freedom and functions in society as such. It may or may not be about systematisation, but either way it does nothing to explain
its place in society. Further, scientific research may not have the authority to make such claims anyway because it may simply fail to see its own contingency on theories from the humanities.

**Response to the critical literature**

How then could a cognitive-scientific approach proceed that seeks a theory of improvisation that could extend to multiple traditions? A scientific approach that seeks generalisability of any sort would seem to be insensitive to the relevant political issues and could risk being terribly biased and imperial with its claims, eliminating the scope for opposing interpretations of the concept.

In response, similar to much of the critical literature, the scientific approach is *also* a constructive one; that is, it starts with some implicit definition of the phenomenon and makes observations (usually through experiments) in order to develop the meaning of the term. It should not claim or aim to specify the phenomenon completely—that is impossible and illogical. Again, something like improvisation is not a natural kind. The boundaries of the concept can change. That is what it means to be critical! But, they can change with purpose. In developing a theory, one can argue for conceiving of the concept differently in order to accommodate more phenomena, or to offer tools to make meaningful comparisons. One of the ways to do this is through cognitive science as I will demonstrate in the following chapters.

Certain aspects of these different approaches are incommensurate. There will always be material to inspire cultural criticism, thankfully. A well-developed scientific approach should not tell musicians how they should play or what their music should mean—it may help explain how things work or why they have certain features, but it should not tell people what to do with that understanding. This is profitable for both critical and scientific enterprises. There will be new behaviours to understand scientifically, and new meaning to construct critically. These approaches are not at odds with each other.

Is the scientific enterprise politically neutral? Does it have to commit to a particular conception of improvisation thus sidelining certain other practices or forcing them into an unwanted mould? Because the scientific approach is also constructive, going in one direction does not mean invalidating or excluding another. The cognitive approach that follows in this dissertation does not claim that improvisation is a single phenomenon—there are many ways people can perform music and each of them is assumed to have some cognitive correlates to
be described. Finding commonalities between certain of these modes of performance does not mean the others are invalid or unimportant.

Somewhat frustratingly, in order to explore these kinds of questions in the critical literature, a sort of seed definition of improvisation is used; that is, improvisation is treated as something like real-time music making with parameters that are unspecified before performance. Around this seed definition, complex insights are made and amassed to form an instructive picture of music in society. It is not so important at the outset to fully determine what improvisation is because the meaning of improvisation is gradually accrued through these inquiries. Nevertheless, this implicit seed definition is still in the background, but this is secondary in importance to the elaboration built around it. In this way, the critical literature is similar to the ethnomusicological literature. For instance, one might argue that a group of musicians is not really improvising even when they call their own music improvisation, and then discuss what that means about their engagement with the aesthetics of freedom and who gets to use the word. But, this would rely to some extent on some implicit definition. How is it known that the music is ‘not really improvisatory’ if there is not some implicit sense of what that means? The meaning of the term is elaborated through discursive inquiry, but the definition is not necessarily directly confronted.

There is something paradoxical about this logic—the critical studies of improvisation are about improvisation. At least, many of them are in a journal called ‘Critical Studies in Improvisation’. They must have at least something in common or are at least trying to focus around a set of related issues. Unless the whole concept is jettisoned and authors again return to simply describing music making in culture (similar to challenges faced by ethnomusicologists describing improvisation in other cultures), some search for commonalities, by whatever methodology, seems justified. It should be noted that many scholars do want to throw away the term. Labaree (2014) advocates describing a more multifaceted musicianship that is sensitive to differences in practices in order to avoid stereotyping different musical practices under the use of one term. In fact, chapter 5 of this dissertation advocates a similar kind of stepping back to a broader set of terms in order to avoid mischaracterising and equivocating different musical practices.

This tension with the cognitive approach may arise from a misunderstanding of how cognitive science could treat improvisation. As for the issue of taking away freedom through explaining underlying cognitive processes, this is simply a case of incommensurability. Explaining underlying cognitive processes should not intersect with a judgment about
freedom and indeed should actively avoid any aesthetic proclivity. Whatever improvisers are doing and whatever they say they are doing, there are underlying cognitive processes that can be described in conjunction with their behaviours. Describing these processes does not change whether or not they are truly free in whatever sense of the term. As for other aesthetic and political biases, it should actively avoid any particular position and try to be neutral. If it has an ulterior, more insidious side that is actually implicitly politically charged, then it should actively seek out these biases as urged by Henrich, Heine, & Norenzayan (the study on WEIRD participants discussed above). In any case, these problems are not specific to cognitive scientific methods. All scholars risk having political biases. Cognitive science is not peculiar in this regard and should be held to the same standards of exposing its biases. So, there is no particular in principle problem with the cognitive-scientific approach in this regard.

As for the issue of reifying the concept as would seem to be necessary for a scientific approach, admittedly a cognitive approach would have to provisionally accept a finite definition of the term. This is more similar to critical approaches than it might first appear. Both approaches assume a kind of seed definition—for cognitive science it would be called an operational definition—and both make observations and build theories around this starting point to determine trends and make insights. Cognitive science does so through postulating principles of similarity and conducting experiments to support or reject those theories. It may not conclude that improvisation is a unitary phenomenon. In this way it is similar to critical studies. It starts with an assumed definition and explores ways to make connections between various instances of performance. It does start with a reified definition, but it is only provisional. Both approaches are constructing an understanding. The cognitive approach is developed here to profit from its particular advantages as described above (i.e., its potential to draw meaningful comparisons between musical traditions and creative practices, and its commensurability with other sciences).

Chapter conclusion

This chapter has reviewed literature and ideas from the ethnomusicological and critical literatures on improvisation in order to justify the cognitive-scientific approach in principle. It has shown how a cognitive approach could benefit from ethnomusicological literature in its aims to generalise beyond small groups of experimental participants, which aspects of the ethnomusicological literature might serve as at least an initial basis for
cognitive comparison, and how cognitive science can contribute to a comparative study between such musical traditions. It has shown how certain aspects of the critical literature are simply incommensurate with the scientific approach, and that this is not a problem but a strength. It has shown that in other ways the enterprises are quite similar in that both work to construct theories that can add meaning to the term through observation.

This chapter has also claimed that these approaches rely on a sometimes implicit definition but it has not outlined exactly what that is. There is a common sense of the term, sometimes criticised by this literature, that nevertheless unifies much of the discourse. Improvisation has something to do with ‘making it up’ in ‘real time’ with certain constraints or along a continuum of constraints. These ideas are in the background and need to be brought forward for examination. The following chapter will explore commonly used definitional features of improvisation in order to offer its own criticism of them. This is necessary to build a cognitive scientific approach that can move forward in practice.
The previous chapter sought to justify and situate the cognitive approach to understanding improvisation within ethnomusicological, historical, and critical literatures. It argued that cognitive science has potential advantages in its ability to draw comparisons between different improvisatory traditions as well as between different kinds of creative practices because it does not rely on tradition-specific music theories. Why do such music-theoretical methods fail to adequately draw comparisons and characterise what improvisation is? How can the cognitive approach reframe the question to contribute to the comparative enterprise and help characterise the nature of improvisation?

In order to accomplish these aims and address these problems, a very important question must first be asked: what is improvisation? The reason this needs to be asked is not so that improvisation as it is already understood can be examined scientifically. Rather, it is so that a cognitive-scientific definition can eventually be presented as an alternative to the current understanding. Further, the cognitive approach is not aiming for an ultimate and complete definition of the term; rather, it aims to gradually refine its own definition through experimentation and observation. However, despite this gradual process, the approach still needs to establish an appropriate frame in which to work. In order to establish this framework, other approaches to defining improvisation must be reviewed to show what can be challenged and added. Where does one begin?

The first step would be to locate some kind of prototypical definition of ‘improvisation’ through examining multiple applications of the term, and extracting common features. People refer to many different practices as being instances of ‘improvisation’. What do they have in common? However, it could be that different groups use the term in different ways, adapting and refining it to suit their own purposes for the term in describing different kinds of practices. For this reason, comparing uses of the term between practices might seem like an illogical apples-to-oranges endeavour. While it is true that different traditions and practices appropriate the term with different motivations, there is still some prototypical meaning that makes the term ‘improvisation’ appealing to use in the first place (as opposed to using another term). A prototype does exist.
It is just that the prototype is messy! Maybe a purportedly prototypical definition has nothing to do with certain uses of the term. Maybe some uses of the term really are misapplied. The most precise reason to identify why this process is messy is to point to the frameworks that are used to draw comparisons. Some kind of framework must be used to say that two practices are similar. If one challenges the way similarities are drawn—i.e., change which framework is used—a different set of practices can be considered to be similar, perhaps omitting some of the old ones and incorporating some new ones. This is what is being proposed here. Some typical prototypical features used to identify ‘improvisatory’ practices are identified from existing literature and descriptions, and the applicability and usefulness of those terms are questioned. A cognitive approach provides another way to draw comparisons between musical practices. In that this cognitive approach is working with a largely similar group of practices, it is still an approach to describe ‘improvisation’, although at the conclusion of this chapter, it is suggested that the more general term, ‘modes of performance’, may be more useful for its purposes.

Why does this new categorisation need to be done? A new categorisation represents a new way of thinking about the problem; it is not drawing lines for its own sake. It is argued in this chapter that the typical way of defining improvisation is internally contradictory in that it fails to adequately distinguish improvisation as a process, a way of making music, even though that is the main aim that a distinction of improvisation from composition or rehearsed performance would need to accomplish. Generally speaking, this is due to a reliance on product-oriented thinking and music-analytical methods. A cognitive-scientific approach is better able to define improvisation as a process. Secondly, in-so-doing, it is also better able make comparisons of processes and to find commonalities between different musical traditions, and potentially between other non-musical improvisatory behaviours.

This chapter will identify several common qualities of improvisation invoked in various literatures and argue that these typical definitions fail to adequately distinguish it from other processes of musical performance and are not very good at comparing improvisatory processes across traditions or at comparing different kinds of creative practices. It is then proposed that it is not impossible to construct a reasonable delineation between improvisation and other kinds of creative musical practices, and that a cognitive-scientific approach is able to construct a definition that sufficiently distinguishes improvisation as a process of music-making along with its other advantages in being able to make comparisons across musical traditions and other creative behaviours.
As opposed to what?

Before delving into various features of definitions of improvisation, it should be asked why a term like ‘improvisation’ is needed at all, regardless of the framework used to define it. Why do we even have the term? Why do we need a separate category of musical practice? The introduction and second chapter discussed the resurfacing of interest in the term and its use in different societal and critical contexts. Another perspective of this issue discussed here is an ontological one. It would be conceivable simply to have a theory of musical practices without the specific labels of improvisation, composition, and memorised performance. That a distinction is often made reflects a particular culturally-specific ontology of music; as it is today, improvisation is commonly defined by distinguishing it from composition and memorised performance.

As for delineating improvisation from the act of composition, Wegman, writing in Nettl et al.’s (2014) Grove dictionary entry on improvisation, notes the relationship between the concept of improvisation and the musical work:

The concept of improvisation has been current in the West since the late 15th century to designate any type, or aspect, of musical performance that is not expressive of the concept of the fixed musical work. Its precise definition depends on the stability and perceived identity of the ‘fixed musical work’ [...]. He goes on to note that in musical traditions without such a strong concept of the musical work, the concept of improvisation is not invoked. Wegman (1996) has elsewhere described the historical relationship between an emerging emphasis on the concept of ‘composer’ and the bifurcation of the perception of ‘improvisation’ and ‘composition’ as separate activities. Having an ontology of fixed works allows for a separate concept of improvisation. Improvisation would seem to lack the (perceived) solidity of the written work. Thus, scholars may ask questions about how music could be produced without it and define the remainder of those processes as ‘improvisation’. Similarly, Brown (1996) argues that ontological questions about improvisation in part arise from the fact that improvisations are recorded: “The problem is that, as recorded, the music may have an entirely different phenomenology from that of the living thing. Indeed, it may have a different ontology” (p. 366). Recorded improvisations become a kind of musical work and are then considered in a similar light as a composition. One can then compare these processes of musical production. In a world without any recordings (including the written score as a recording), there would be less motivation to consider improvisation as separate from composition (although one might still be able to
distinguish improvisation from a rehearsed performance). In this way, a separate ontology of improvisation in part relies on recordings.

As for delineating improvisation from rehearsed performance or other forms of performance, Gould & Keaton’s (2000) philosophical approach would dissolve the need for a strong distinction in that they argue that all performance is improvisatory:

...

Their reference to ‘the extent’ of improvisation should be noted briefly as the idea of continua of improvisation will be discussed below. For here, suffice it to say that their argument suggests that due to the discrepancy between intention and action, all performance requires a kind of real-time compensatory mechanism, the use of which renders all performance as improvisatory.

All of this is to say that through various ways of reasoning, it is conceivable that no such distinction would be necessary at all, or that the distinction is entirely contingent upon how a culture conceives the ontology of its own music. One could instead ask how people make music rather than how they improvise or how they play from memory. All of the relevant questions about stylistic features, cultural discourses, and even psychological processes (such as types of memory, motor processes, etc.) would remain, but understanding this would not be in service of delineating ‘improvisation’ as a concept in particular from other kinds of performance.

So, do we need a term like ‘improvisation’? What is fundamentally desired is a way to describe differences in performance process, and interrogating the concept of improvisation is a good way to raise questions about such differences. What a musician playing from memory is doing is intuitively different from what an improviser does, and what a composer does at a desk is intuitively different from what an improviser does at an instrument. But are these activities actually different? How can differences (and similarities) be understood? What other kinds of performance might be used to distinguish improvisation, or different kinds of improvisation? It is conceivable that no term would be needed, or that different terms could be constructed, but either way what is at the heart of this issue is a desire to describe and delineate different types of musical processes. It is argued below that it is possible to reasonably make such distinctions between modes of musical creation (and some of them could keep the name
‘improvisation’)—it is just that the typical ways this is done in the scholarship do not work well. A cognitive-scientific approach, as fully outlined in chapter 5, has something to offer here.

**Product thinking dies hard**

As mentioned above, the main reason typical ways of defining improvisation do not work well is that they rely on music-analytical methods and product-oriented thinking. Because of this, they fail to make a successful delineation between improvisation and other musical processes and are unable to provide an adequate framework for comparison with other musical traditions and creative practices. By music-analytical methods, I mean that they rely on various parameters of formal musical structures (notes, chords, etc.) to describe the performance process. To claim, for example, that improvisers choose the notes or that improvisers can leave the harmony free to vary relies on musical structures to define improvisation. By product-oriented thinking, I mean that improvisation is defined by setting it against the musical performance or composition of ontologically distinct ‘pieces’ of music (see Goehr, 1992; Ingarden, 1986) in such a way that without work-based musicology, improvisation as a separate phenomenon would be much less distinct as described above.

The reason this fails is because what is needed is a characterisation of process, not product. The specific structures produced by improvisers are not in question *per se*—they could have been produced by many different processes. What is at issue is the way structures are produced in improvisatory performance contexts as compared with non-improvisatory ones. Products are important for other musicological reasons. One may wish to analyse the structures created in an improvisation in order to make inferences about style, references a performer may be making, or otherwise socially significant aspects of the music. Of course these are important and meaningful questions—it is just that they do not necessarily help define improvisation (as opposed to music making more generally). Rather, they look at the content of the thing-improvised just as one could look at the content of a thing-composed. Even if the product carries its meaning by virtue of the fact that it was improvised, the question remains to characterise what that means and how the process differs from perhaps similar music that could have been produced through composition, or a rehearsed performance. There are also other questions about communities of improvisers—the cultural situation of their music, the ethical implications of it—but if one wishes to characterise what they do as *improvisatory* and understand those cultural and ethical positions in terms of things that are improvisatory, the
basic implicit understanding of the term ‘improvisation’ still needs to be defined, and it is still one of process, a question of how music is made or done.

It is somewhat ironic that a resurfacing of interest in performance process in current musicology is in line with a renewed interest in improvisation, yet the definitions of improvisation are still tied to product-oriented thinking. A definition of improvisation motivated by music analysis and work-based musicology is vulnerable to criticisms put in focus by these current trends that blur the boundary between creative roles (performer, improviser, composer). Rink’s (2005) edited volume collects several perspectives on these roles of the performer and the interaction between musical structure and interpretation. Generally speaking, because the creative roles are blurred and shared between a more traditional delineation between composer and performer, so too are typical definitions of improvisation blurred with these other practices. This attitude—that many forms of musical performance are creative—will underlie many of the following criticisms of definitions of improvisation.

Having made these comments about the need for the term, and the general reason previous definitions fail to fulfil these needs, I will now discuss specific aspects of definitions of improvisation often invoked in various literatures and show how and why they do not successfully delineate improvisation from other modes of performance and musical generation. I will then sketch the cognitive-scientific approach and show how it can successfully delineate types of musical processes as well as more successfully compare processes across different musical practices and creative behaviours. That is, I will present a way of constructing a cognitive-scientific definition of improvisation that will be developed theoretically and experimentally in the following chapters.

**Challenging a typical definition**

A useful place to begin is the Grove Dictionary definition of improvisation. Nettl et al. (2014) have produced a definition that, as perhaps a dictionary definition should, reflects conceptions of improvisation in a variety of literatures:

The creation of a musical work, or the final form of a musical work, as it is being performed. It may involve the work’s immediate composition by its performers, or the elaboration or adjustment of an existing framework, or anything in between. To some extent every performance involves elements of improvisation, although its degree varies according to period and place, and to some extent every improvisation rests on a series of conventions or implicit rules. The term ‘extemporization’ is used more or less
interchangeably with ‘improvisation’. By its very nature—in that improvisation is essentially evanescent—it is one of the subjects least amenable to historical research. I wish to discuss several aspects of this definition and show how these aspects weave through different literatures, and thus serve as an initial prototypical definition to challenge. I demonstrate how the features of the definition are influenced by work-centric and music-analytical ways of thinking about improvisation and discuss why that is ultimately not able to adequately define the phenomenon. The goal here is not to respond specifically to this definition—surely many researchers would have some objection to this particular definition for various reasons—but rather to respond to themes that it raises that appear in a wider variety of literatures. For each of the features mentioned in this definition, I will discuss its inability to help differentiate improvisation as a process. In addition to these features, a few other others that are commonly raised (i.e., novelty, and composition versus improvisation) are similarly discussed below even though they are not explicitly mentioned in this definition.

“The creation of a musical work”

The opening phrase of Nettl’s definition would seem to characterise improvisation as being primarily an issue of the creation of an end product rather than a process. One could interpret “the creation of a musical work” as “the process of creating a musical work”, and in this sense, the definition could be read as concerning both process and product. But, why is a musical work mentioned at all?

Nettl is probably not using the term ‘work’ in any technical sense (e.g., referring to the Werktreue) but rather as a placeholder in order to find a word to refer to the content of what is improvised. In this way of thinking, a composer creates a work as well through some other generational process.

Alperson (1984) raises a useful distinction between two senses of the term ‘improvisation’. One sense is improvisation as the act of improvising and the other is improvisation as the thing-improvised. An improvisation, of course, is a piece of music that has been created through the act of improvising. In either of Alperson’s senses, the characteristics of improvisatory music and its distinguishing features revolve around its nature as a process, as a way of performing/composing music, not as a characteristic of the product. A thing-improvised is of interest as such in order to characterise the process of its production. The term ‘improvisation’ primarily exists to distinguish between processes, between ways of creating music.
To refer to a thing-improvised as a composition or work, as Nettl et al. do, is to define what is produced in structural terms, whatever kinds of structures those may be. Those structures might be described in a tonal theory (e.g., Järvinen, 1995), a Schenkerian theory (e.g., Larson, 1998), or otherwise, but calling it a ‘work’ calls it out as some sort of structural object. This conception of an improvisation as a work might lead to questions about what structures there are in the improvisation and how they work together, as one would ask in an analysis of a composition. There is no problem with this in itself—the process of improvisation does produce something, however that something may be defined, and the product of improvisation could thus be understood in terms of structures. In this case, however, one is simply describing pieces, works, etc., with music theory regardless of the process of its creation. The major problem with this, then, is that different processes could lead to the same structures, depending on how you analyse them. In other words, it ceases to be a question of process.

It is possible to make inferences about performance process based on analysing structures. One might compare improvisations with compositions (or rehearsed performances) and ask what is structurally different in order to make an inference about the different processes. One just needs to be careful in choosing an appropriate theoretical approach and associated technique of analysis. In other words, which structures does one examine and how do those structures help differentiate improvisation as a process? The analytical technique chosen would need to support a theory aimed at understanding the improviser’s performance process and not just to understand structural relationships in themselves. A cognitive approach could provide such a theory and set of analytical techniques.

Improvisation may be “the creation of a musical work”, but the focus should be on the “creation” and not the “work.” So, keeping the product in the centre, as this definition does, does not seem to contribute to an understanding of improvisation as a process, nor does it hint at an analytical approach to make such a distinction. So, until such an approach is established, why mention a ‘work’ at all? It distracts from the relevant questions of process.

“*Its degree varies*”

Another commonly considered feature of improvisation is that it can vary in degree. If music is theorised to exist along so many dimensions (pitch, rhythm, harmony, metre, timbre, tempo, etc.), each one of these dimensions could be free while the others could be fixed. For instance, an improviser might play over a chord progression with a fixed harmonic structure
while the specific pitches or rhythms might be free to vary. Such a concept was also invoked by various ethnomusicological accounts cited in the previous chapter (such as Nooshin’s suggestion that some Iranian gushehs are more flexible than others, or Widdess’ suggestion that different modes in Indian classical music provide different kinds of freedoms). Sometimes these dimensions are sorted into structural and expressive characteristics in such a way that harmony and pitch classes might be structural whereas tempo fluctuation, local fluctuations in rhythm (e.g., rubato), or articulation might be expressive improvisation that could emphasise structural features (Clarke, 1988) or perhaps be considered as *sui generis* content (Merker, 2006). This might suggest that Western classical music is improvisatory in the sense that the expression is free to vary. The reasoning goes that the more dimensions that are free to vary, the more improvisatory something is. In this sense, the degree can vary. Gould & Keaton’s discussion of improvisation mentioned above also invokes this idea of ‘extents’ of improvisation. The concept of a ‘continuum’ is sometimes also employed (e.g., Larson, 2005), suggesting that music is not either improvised or predetermined, but somewhere along a continuum. Benson (2003) identifies 11 types of improvisation according to different “types and degrees” ranging from adding ornaments to adding measures, arranging music for other instruments, changing the melody/harmony, etc. (p. 26-29). Benson’s types of improvisation are also discussed as a way of dividing between types of improvisation in the conclusion of this chapter.

In this conception, what is ‘improvisatory’ depends on how one parses music into these theoretical dimensions. Admittedly, it seems natural to divide music into dimensions like rhythm, harmony, and melody, but this would not be the only way to separate dimensions of music. Changing this dimensional analysis post-hoc would make the same performance more or less improvisatory or improvisatory in a different way. Of course this is paradoxical because the process of creation is not changed by the post-hoc analysis. In this way, saying that music is more or less improvisatory along a continuum is merely a matter of the perspective of the analyst and not necessarily a matter of the process of the performer.

Further, dividing music into dimensions to measure relative improvisatory-ness is wholly dependent on a work-based conception of music. Consider a jazz pianist playing over a very well-rehearsed chord progression utilising stock phrases and familiar patterns. From one performance like this to the next, there would be many similarities in certain structural characteristics. Yet, because no one of them is written down with the notes and rhythms in a precise order, it would be considered improvisatory (according to the ‘degrees’ perspective).
with harmonies fixed, and rhythms and melodies left to vary. Another jazz pianist might play over the same chord progression with a much more adventurous and varying repertoire of ideas, relying less on stock phrases and never seeming to repeat an idea. This, too, would be the same ‘amount’ improvisatory according to this degree/continuum notion. Of course, the processes at play are probably quite different. That such an equivalence could be drawn is only because neither is written down as one would write down a musical work.

A further objection to the notion of degrees of improvisation is that there is no guarantee that the musicians are thinking in these dimensions in any explicit way whilst performing. Such a continuum of improvisatory-ness may be invoked by a music analyst after the performance, even if that analyst is the performer him- or herself providing a phenomenological report (e.g., Kingscott & Durrant, 2010; Norgaard, 2011), but during the performance, there is no guarantee that such explicit dimensions align with a performer’s internal process. This is a problem that recurs through many of the definitional criteria described below, as well, such as ‘frameworks’ and ‘rules’. Clarke (1989) neatly points out that music theory and music psychology do not necessarily align; how an analyst describes the way music works (in terms of musical structures functioning together) may not align with how a performer makes it work. In other words, performers may not be thinking in discrete harmonic, melodic, and rhythmic terms—these music-theoretical categories could be all mixed up and mentally represented together, or simply divided in different ways.

Lastly, for those accounts that invoke the idea of a continuum, a continuum implies that there are infinite possible points between these categories. However, any time an instance is identified, it is described according to a limited number of music theoretical categories. So, it is really more like an ordinal scale. But, more importantly, calling something a continuum (not just in the present context of these concepts, but more generally) relies on the security of the endpoints. If the endpoints are not well-defined, all of the points in between will be incomprehensible. Calling something a ‘grey area’ adds no new understanding without a firm understanding of the endpoints. Since the endpoints of the supposed continuum in this case are ‘improvisation’ and ‘pre-determined performance’, the reasoning is patently circular.

“Immediate composition”

Immediacy is a concept often associated with improvisation. This could be construed in two ways: improvisation as ‘real time’ composition and improvisation as being unmediated. Nettl et al. probably do not mean the latter as their own definition later raises issues of
constraints and rules (which function as a kind of mediation—see below). Thus, immediacy is discussed here as meaning ‘real time’ musical creation (also known by similar concepts such as extemporisation and spontaneity).

Real time creation could be compared with both rehearsed or memorised performance and composition. As for a comparison with rehearsed or memorised performance, every kind of performance is in real time in that it happens as time progresses. In rehearsed performance, notes are also determined in real time in that they do not exist until they are produced, yet this is not intuitively similar to improvisation because the product they are producing is thought to already exist. But, improvisers are not creating all of their knowledge of music in real time; they are employing years of experience with their instruments and previous knowledge of music—just in a different way. The reason improvisation is thought to be in real time arises from thinking about works—the specific arrangement of structures may not have existed exactly as such. Without thinking of the product of improvisation as such, it becomes clear that non-improvisatory and improvisatory performances alike are employing previous knowledge of music in real time.

In this way, the notion of ‘real time’ distinguishes improvisation only when focussing on the musical product. Otherwise, both are processes of real time creation. What is ‘created’, that is, the nature of the ‘work’ that an improver produces, depends on how the music is analysed. Again, since the nature of the product changes depending on the nature of the analysis, and changing the analysis does not change the nature of the process, it is unclear how citing real time distinguishes improvisation from the process of rehearsed performance.

This comparison with other forms of rehearsed performance needs to be mentioned, but the real time criterion is usually used to differentiate improvisation from composition. This is an attempt to distinguish between compositional processes; improvisation is composition in ‘real time’ whereas composition is a wider set of processes that may or may not be in real time.

Two aspects of real time could distinguish improvisation from composition. One is that an improviser must have a one-to-one temporal correspondence between thought and action. Whereas a composer could take an hour to compose two seconds of music, an improviser must do it in those two seconds as it is being performed. The other is the idea that an improviser cannot go back and change what has been played. Whatever comes out on the first go has to be used. There is no editing in the beginning to make the end more sensible.
Notice, of course, that this kind of reasoning relies on the assumption that the improviser is composing a work, a product, with a beginning, middle, and end. Being able to ‘go back’ implies that the performer is spinning out a work rather than just performing (in a general sense). If that notion is abandoned, what is left is the realisation that both improviser and composer are performing behaviours in real time. Of course, what the composer is ‘doing’ (for now, moving a pencil over paper or pressing keys at a computer) is different than what the improviser does at an instrument. Both are employing prior knowledge, but the knowledge directs different kinds of movement. For the improviser, knowledge must be linked with musical movements (a movement is necessarily connected with a sound) whereas the composer’s movements do not. How this difference in interface modulates the employment of prior knowledge is an important question because it is one of distinguishing between processes. The relevant difference is actually one of mediation. How are composition and improvisation differently mediated (neither is immediate), and how is the nature of the knowledge employed necessarily different to accommodate such differences in process? This could serve as a basis for a comparison of processes.

One important observation does come from retaining a notion of ‘real time’. An improviser must play only things that are playable at the moment of performance, and can already compose within his or her working memory capacity (or other cognitive limitation)— e.g., it might be hard to improvise the retrograde inversion of a tone row playing 12 notes per second while composing this would be a much easier matter. Of course, an improviser might play something by accident or make a mistake and this kind of an occurrence would not exactly be the employment of a ‘playable thing’, although the way the improviser might respond to it would need to be. This kind of comparison most likely represents the spirit of claiming that improvisation is in real time, and so the criticism above may seem to nit-pick. However, the observation made here—that improvising consists only of playable things—emphasises a true process distinction and focuses the question on distinctions in process between types of knowledge that are employed. Merely claiming that improvisation happens in real time is a shallower claim.

In short, focussing on ‘real time’ can be helpful but only with the right perspective on it. One needs to show how the supposed constraint of real time can truly differentiate improvisation as a performance process given that all human behaviours are in ‘real time’. By claiming that an improviser must draw upon playable things, for instance, helps to locate the nature of the knowledge employed during improvisation. This idea is developed in the
presentation of the cognitive theory in chapter 5 in which sources of improvisatory knowledge are discussed.

“Elaboration or adjustment of an existing framework”

The notion of a framework is another familiar idea associated with improvisation and is related to the ideas of varying degrees of improvisation (see above) as well as to the idea of rules and constraints (see below). Some examples of a framework could include a jazz pianist playing over a particular chord progression (where the harmonies are established and provide a framework), a Baroque opera diva ornamenting a *da capo* opera melody (where the melody is already determined and provides a framework), or a Hindustani sitar player playing within a particular mode (where the mode helps to define the typical musical gestures one might perform). One might also include cultural context as a kind of framework—when, for whom, where, and in what context would someone improvise and how does understanding these questions help describe the performance process?

One reason to include frameworks in a definition of improvisation is to show how improvisation is not actually a completely novel behaviour. Performers are not creating music *ex nihilo*. The framework already exists and can guide musical performance. The other reason is to support explanations of improvisatory process; an improviser or theorist might claim that the *way* someone improvises is by employing such frameworks.

In most improvisatory traditions and in practice, this is often true. There are music-theoretical structures that players learn to follow. When you ask them about their own performance process, they may well cite these and say that they are using some kind of pre-determined structure (be it a melody, harmonic progression, or otherwise) to guide their musical choices (see the phenomenological studies cited above). Further, Berliner (1994) examines how improvisers describe their own processes of playing on existing structures (frameworks) whilst improvising (p. 222). The ethnomusicological studies from the previous chapter document such frameworks in a variety of musical traditions including Iranian, Indian, Arabic, Indonesian, and historical Western practices.

A framework-oriented explanation of process would go something like this: first a performer learns a chord progression and then they improvise using that chord progression keeping the harmony constant but varying the melody. The choices that are made in the melody are tied to the harmonic framework. Thus, *how* they are playing is thought to be
described through identifying such harmonic regularities. Knowing about the harmonic regularities could explain how the melody notes are chosen, and thus explain process.

Music-analytically defined frameworks can describe process in this way, but there are several questions that arise about how accurate and meaningful this description is. The first issue, similar to that raised in relation to ‘varying degrees’ of improvisation, is that there is no guarantee that identifying frameworks through music analysis will align with what the performer is thinking. One might think that it would be possible to simply ask the performer, but what they say should not be taken as the only interpretation. Performers learn to understand music to be parsed into similar music-theoretical categories as third-party analysers. In this way they function as observers of their own behaviours. They may say, for instance, that they keep the harmony constant and vary the melody, but cognitively speaking, those categories may be merged or divided differently. That would not necessarily be evident to a performer—being able is not the same as knowing how. Of course they have special insight into their performances that could guide and advance a theory of process, but their word should not be taken as a final explanation. Because of this potential disconnect, it is disputable how much a framework (defined in music-analytical terms) could actually describe a performer’s internal thought processes.

Another aspect of this problem is the role of the listener in establishing frameworks. What the framework is could be argued to change depending on who is listening. Whose ears are constructing these regularities? For instance, consider Ayari & McAdams (2003) study which demonstrated different structural observations made by listeners of European versus Arabic cultural origin when listening to Arabic music. The different groups made different structural delineations, and within the Arabic group there was not always agreement on the modal structure of the music. Cultural differences in listening and perception as active construction of music are increasingly evident and emphasised (see Born, 2010; Cross, 2010). Understanding how listeners/observers make sense out of a performance (including by dividing it into music-theoretical structural categories) is an important question, but does not explain the process employed by the performer. The potential disagreement between listeners is testament to the limitations of this method. The truth of the process relies on the truth of the music-theoretically defined structure, and if the structure is in the ear of the observer, the purported performance process would change depending on who is listening. This is paradoxical—the performer is only producing one performance at a time. From the listeners’ points of view, there may be multiple performances since there are multiple listeners. That is fine for
explaining processes of perception, but this does not help advance an explanation of the processes of performance.

Turino (2009) distinguishes between ‘formulaic variation’ and ‘improvisation’. Whereas formulaic improvisation would be to employ “melodic, rhythmic, or harmonic paradigmatic substitutions [...] made before in relation to the basic model [...]” (p. 104), Turino defines improvisation as “instances in performance where [he] surprise[s] [him]self with purposeful alterations, extensions, or flights away from the model and habitual formulas” (p. 104-105, italics in original). Turino goes on to note that unless someone is intimately familiar with a specific performer’s playing, a listener would be unable to distinguish formulaic variation from improvisation. In this slightly different take on frameworks (the regularity that allows for such melodic, rhythmic, and harmonic substitutions), Turino notes that a listener would be unable to discern whether something was improvised because to do so would rely on familiarity with structural regularities (in this case, on the part of the individual performer). So, analysing structures would not seem to connect with an explanation of process, at least not without extensive experience looking over an individual’s music-making. One could go down this road and analyse large corpuses of improvisations to try to distinguish between the more adventurous, ‘surprising’ moments, but this would run into the problems cited above in more traditional forms of analysis that such methods are still reliant on music-theoretical categories and may not align with the performer’s perspective. Besides, a more parsimonious approach that could characterise process in the moment would be preferable, and is something which the cognitive approach could offer.

A second problem is that understanding process through frameworks would not be easily translatable across musical traditions aside from the mere fact that they exist. It is not surprising that some kind of framework could be found in different traditions; would one expect to find a tradition with absolutely no stylistic regularity, where even the instruments themselves and cultural contexts of performance have absolutely nothing in common between instances of improvisation? The specific analytical categories in one tradition probably would not exist in another (there are no Iranian *gushehs* in Hindustani music), so an explanation of process based on analytical terms would not be easily translated between traditions either—at least not without some additional theory that could describe how performers acquire frameworks and employ them, explained in non-music-analytic terms. Similarly, bringing explanations of musical-improvisatory processes outside of music into discussions of other
creative behaviours would not be possible without a theory that provides some other kind of explanation.

The third and most important problem with an explanation of process based on frameworks is that they again risk equivocating different kinds of performance process. If a performer follows a chord progression, in what sense does that truly describe his or her process? A performance from memory might also follow the same chord progression while a different process governs the way notes were generated or recalled. A classical performer might also describe their memorised performance of a sonata as following a harmonic progression, or as using the melody as a framework for ornamentation in the recapitulation of a da capo aria. Surely performers playing from memory (at least the experienced ones) are aware of the frameworks that underlie the structure of compositions, and could describe the music they play in terms of these categories. A violinist playing a chaconne, for instance, may very well be aware of the harmonic framework and use that knowledge of frameworks to aid memorisation and execution of the piece. Composers also use frameworks—surely a songwriter uses stock chord progressions upon which to compose melodies, and a classical composer has been acculturated with musical styles and structural tendencies. Frameworks underlie many modes of performance, not just improvisation. They are a kind of knowledge held by musicians, not exclusive to improvisers. In this way, frameworks are more a description of style than they are a characterisation of process. The important question about such knowledge of frameworks as a means of explaining process is not merely that they exist in the music. That is putting the cart before the horse. What is important is the way the performers know and are able to use the frameworks. Merely identifying that frameworks exist does not show how one could describe such differences in how one knows the frameworks.

“Conventions or implicit rules”

Theorists of improvisation are quick to point out the various kinds of rules that are both acquired from musical training or otherwise set by structural features of the mind, instruments, and other aspects of the musical environment. These concerns overlap with those of frameworks to some extent, and ‘rules’ could be interpreted as including issues of ‘constraints’. Similar to the idea of frameworks, such rules/constraints remind us that improvised music is not created \textit{ex nihilo}. Ashley (2009) summarises comments on three kinds of rules: constraints of the body, constraints of real time, and constraints on what an improviser knows.
The body has particular structural characteristics which could be seen to constrain improvisatory performance. A pianist can only play so quickly, or reach certain chords. This of course depends on what instrument one is playing, and musicians can design instruments to get around such physical constraints. Memorised performance has constraints of the body as well, as would composers who are writing music to be performed by humans with constrained bodies. It is important to understand how the body influences musical regularities, but it is unclear how it describes improvisation specifically.

Real time has been discussed above. Ashley invokes the concept to suggest that only certain kinds of thinking can be done due to the cognitive constraints of playing in real time. For instance, one can only plan ahead so far, or recall what one has already played with limited accuracy. This treatment of real time is closer to a description of process, but again only insofar as it relates to assuming that an improviser is spinning out a complete work (thinking ahead, looking behind, etc.). In this way, real time still does not distinguish improvisation as all performance would have similar constraints of real time.

Knowledge, Ashley’s final category, is more abstract and could be interpreted as a bit of a catchall depending on how inclusive one wishes to be with the idea of ‘knowledge’. Hogg (2011), for instance, would include the cultural meaning of the instrument as a kind of social knowledge that informs improvisation, whereas one might consider knowledge in the sense of how a performer acquires stylistic regularities from a particular musical tradition through his or her musical development. For instance, an Iranian improviser might be constrained by knowledge of the radif. One might also include constraints on thinking in this category; the human mind works in a particular way, and its structure has some bearing on what is possible to play.

Constraints do not seem to be able to describe improvisation specifically, but there is another problem with the desire to identify such rules. The desire to do so arises from conceptions of music as music-theoretically defined structures. Without such a structural perspective, the body, time, and knowledge would be seen as enabling, not constraining. As for constraints of the body, perhaps it is better to invoke Gibson’s (1977) notion of affordances than to focus on the form of the body alone. The body has a certain form, and instruments have a certain form, and the interaction between them creates a kind of dynamic that enables certain kinds of movements and sounds. How does one identify something that cannot be done at an instrument (as postulating constraints would require)? One would have to conjure one from music theory! But those abstract alternatives are not a part of a performer’s process; they
are not thinking of things they cannot do. Rather, they work with what they are able to do. In this way, constraints can describe products within music-theoretical systems, but do not inform performance process. Better is to consider knowledge as enabling.

Time is also a kind of affordance. One can work with time. At slower tempos, certain things are possible, and faster tempos afford a different set of opportunities for an improviser. It is true that an improviser cannot do the slow tempo things at fast tempos, but would they ever try that? They might, and perhaps would fail to accomplish their goal, but they would end up doing something (even if it ended up being aesthetically undesirable). That something, whatever it is, would be possible at the faster tempo. Improvisers are always working in the realm of the possible. Impossibility is an abstraction of music-theory. Constraints are an afterthought.

As for real-time in the sense that a performer cannot create a structurally coherent work as a composer could (because they may not remember everything they have played), what they cannot do is again defined by music-theoretical structures and work-based ontologies of music. This does not explain what they are doing.

As for constraints of knowledge, similar principles apply although it is difficult to describe this in general because ‘knowledge’ could mean many different things. As it would pertain to knowledge of music theory, a constraint is only a constraint by virtue of the existence of alternatives (e.g., C major is only a constraint if Eb major also exists). But, the alternatives are music-theoretical objects—definitely part of post-hoc analysis, but not necessarily part of the process of production. Again, the same performance could be seen in the light of a different set of constraints depending on the type of analysis, but since the analysis does not change the process of the performance (as it has already happened), it is unclear how identifying constraints in the product would explain the process.

At this point it will be helpful to mention the idea of the improviser as the pseudorandom note-chooser because this will become important for the consideration of empirical studies on improvisation reviewed in the following chapter. One way to think of what improvisers do is that they choose notes one, or several at a time pseudorandomly, with the ‘pseudo’ part constituting various kinds of constraints and rules as discussed above. Apart from these constraints and rules, the rest of what improvisers do is a kind of free generation, a choice of multiple alternatives. This section and the previous one have raised questions about considering improvisation this way both through questioning the ideas of
constraints, rules, and how ‘alternatives’ are defined by music theory and not necessarily by
the performer’s own process. Many of the experiments described in the next chapter (which
reviews past empirical work) characterise improvisers as pseudorandom note-choosers; the
critiques I offer of this formulation are mainly based on the criticisms described in this
section and the previous one. Similarly, the alternative type of performer pitted in contrast to
the pseudorandom note-chooser could be thought performers who engage in naive recitation.
Musicians playing from memory, by virtue of exposure and education in similar musical
styles and regularities, also have some knowledge of constraints and rules that govern their
playing (if they make a mistake, for instance, they will make mistakes that reveal their
structural understanding of music, showing that they are not naively reproducing notes one at
a time). This concept is also challenged in the following chapters.

“Essentially evanescent”

In what sense is improvisation evanescent? Perhaps something is fleeting about
improvisation in that it can never fully be captured through writing or another recording
technology, but in what sense is it any more evanescent than any other practice of the
immediate or distant past? Other historical practices such as those documented by the
Historically Informed Performance movement bear just as much ambiguity over how music
used to be performed, and this literature reminds us about the evanescence (or at least context
dependence) of all performance practice (e.g., see Butt, 2002). The implication is that because
improvisation is not written and because the musical content is not otherwise captured or
recorded, its nature is more elusive. Again, the lack of specific information about musical
structures is used to set improvisation apart. Other kinds of music making are arguably equally
evanescent given their precise musical inflections or performance rituals cannot be fully
reconstructed. Whatever historical sources might help modern researchers reconstruct such
traditions could also help reconstruct improvisatory traditions. It is difficult to suggest that one
practice is more evanescent than another.

The term evanescent may be referring to a more specific sense of not being able to be
fully described or defined. This attitude is seen in writers like Bailey (1992) who claim that
improvisation, by its very nature, is not definable: “[…] any attempt to describe improvisation
must be, in some respects, a misrepresentation, for there is something central to the spirit of
voluntary improvisation which is opposed to the aims and contradicts the idea of
documentation” (p. ix). According to this kind of a view, because the idea of improvisation
refers to that which is new and departing from norms, it would be a contradiction in terms to fully define what improvisation is. Improvisation refers to what might possibly be. Freedom is part of the discourse of some improvisatory practices, but it is also at least partially describable. Conversely, determination is part of the discourse of work-based performances, but there is also freedom in its performance. Both have evanescent aspects and both have recordable and describable aspects.

Freedom and evanescence may be more emphasised in improvisatory discourses, but this is in some sense a different question than the ultimate aims of this dissertation. This sort of issue is more a question for critical approaches of improvisation in constructing the meaning and cultural context of the practice. These aims are incommensurate with the present objective to describe improvisatory process (see chapter 2). For now, it is enough to say that evanescence is not specific to improvisation, but the reason it is invoked in discourses surrounding improvisation are a separate question that do not have much bearing on this goal of characterising improvisatory process.

Novelty

Another concept commonly invoked in discourses of improvisation (although not directly mentioned in Nettl et al.’s definition) is that of novelty. Improvisers might be thought to create new music in the course of performance—to ‘make it up’. These ideas implicitly weave through some of the other definitional criteria; for instance, trying to use frameworks to characterise improvisation requires assuming that a recited performance that employs frameworks is not novel, even though recited performances are not completely pre-determined and thus could have novelty by the same criteria.

Few would argue that improvisers are creating music ex nihilo; novelty is thought to be based somehow on prior knowledge and is constrained by musical, cultural, physiological, instrumental, and other parameters as discussed above. Despite the acknowledgment of these constraints, and despite problems with the conception of these constraints, novelty is still part of discourses of improvisation and often times a ‘good’ improviser is one who is thought to be novel. Someone who is perceived as playing the same ideas repeatedly may be thought to be either a bad improviser or simply not really improvising (Turino might call this formulaic variation).
Since novelty is present in many forms of performance, not just improvisation, one could claim that in order for something to be truly improvisatory, it must have those novel characteristics whether or not it is in a typical improvisatory setting. In other words, between rehearsed performances and improvisatory ones, one could collect all of the novel bits and say improvisation is a subset of those (only a subset since there may be additional criteria).

Then one would need to determine what counts as novel. What counts as new is as much a question for the listener as it is for the performer. One could examine the same performance with many different listeners or examine it from different perspectives (such as considering the notes, the context, or other features of the performance) and find different ways to characterise the novelty. Given that this analysis would occur after the performance, it is unclear how this would help characterise improvisatory process or help distinguish improvisation from other modes of music making.

It is important to understand novelty discursively—what are improvisers trying to express, how do they talk about their music, and how can these concepts be woven into a wider discourse of musical politics? But as far as identifying novelty (or what people call novel) advances an understanding of process or of distinguishing improvisation from other kinds of musical generation, it is less clear. This is an instance of the incommensurability described in chapter 2 between cognitive and critical approaches to understanding improvisation.

Studying novelty systematically might step on some toes in that to do so is to recharacterise novelty as not-novelty because it would be based on prior knowledge (Napier (2006) discusses this tension in the context of North Indian music). Perhaps some novelty is systematic and some truly is not. For the parts that are systematic, there is something to be said about that systematic process, and whether or not it is called ‘novel’ is a separate question to how that process can be understood and described. For the parts that genuinely are novel, while it would be important to describe what happens after such novel occurrences (e.g., how performers and audiences respond), nothing can be said about the process underlying them (otherwise they would be more like the systematic novelty). Also keeping in mind that if such truly novel occurrences do actually happen, there is no reason why they could not happen in any type of performance. This moves away from a desire to characterise improvisation as a process from other kinds of performance and into an area of the social reasons some music is termed ‘novel’. While this is an instructive question, it falls outside the goals of this dissertation.
Composition versus improvisation

Definitions of improvisation often aim to distinguish it from composition rather than rehearsed or memorised performance. This is based on the notion that both improvisation and composition are thought to be forms of creation and the implicit bias that rehearsed performance is not. Of course, memorised performance is still an act of creation, but improvisation and composition are considered to be in a separate category because they are thought to be more creative through creating novel arrangements of musical structures or developing new rules altogether for compositional systems.

There is intractable arguing about the difference between improvisation and composition in the literature as modes of creative music making. People want to know whether music is composed before the moment of its performative instantiation. Terms like ‘comprovisation’ are sometimes used and challenged to describe a performance that is somehow a bit of both (Bhagwati, 2014; Dudas, 2010; Stewart, 2013). Scholars want to know if music was pre-composed or improvised (e.g., Sutton, 1998), or where along a supposed continuum a particular performance falls.

All of the discussions of the difference between improvisation and composition inevitably fail because the terms of the definition of improvisation also fail, as I have discussed in this chapter thus far. Ideas like frameworks, continua, real time, etc. do not make meaningful distinctions in themselves and cannot be used to compare modes of creation.

Another reason this distinction fails is because ‘composition’ (verb) is not itself a process. More accurately, composition should be understood as a set of processes which all contribute to the composition (noun), perhaps including pencil-and-paper processes, playing an instrument, constructing mathematical systems, or many possible others. If one wishes to continue to view music as compositions (arising from product-based ontologies of music), then the relevant part of the argument is to characterise these different processes that contribute to a composition, a ‘work’. Improvisation could potentially be a stable category for one of them (a category which itself could be further divided into subtypes), but it does not make sense to compare improvisation with composition. Improvisation is a kind of process, or perhaps a set of related processes. Composition is a term referring to all processes that could create a work. In other words, one can compose through improvising in various ways, compose through constructing mathematical systems, or compose through many other possible processes, but one cannot compose through composition. Composition is not itself a process.
Given the interest in comparing improvisation with composition, the relative lack of comparison with rehearsed performance should be noted. Probably the reason this comparison is not usually made are for the same reasons that rehearsed performance is not typically regarded as creative (i.e., creating something new). If rehearsed performance were regarded as a more creative enterprise, it might make more sense to compare that kind of creation with improvisatory creation since both are modes of musical performance. Although they are not usually compared in this way, it is relevant to mention here that musicians who typically perform from memory or from the score are trained in the same frameworks and musical rules as improvisers in that they acquire stylistic regularities. A pianist playing the Alberti bass line of a Mozart sonata understands the schema and the framework the harmonic progression would impose. They, too, would have expectations of what notes would fit above an Alberti bass—they are not completely blind to such rules, regularities, and frameworks. In other words, they are not using the *naive recitation* mentioned above. Thus, comparing improvisation with rehearsed performance is also quite difficult in the sense that musicians have knowledge of similar stylistic regularities and structures. At least, it is difficult to make the comparison when focussing on these music-analytically defined structures. Intuitively, the way a performer playing from memory understands and uses the Alberti bass is different than the way an improviser would understand and use it. But that is just the point—it is not about the structure, it is about the way it is understood and used—the question is one of process, and one which cognitive-science is well-equipped to explore.

**Towards an alternative way of defining improvisation**

This chapter has reviewed definitional features commonly invoked in discussions of improvisation and has argued that despite their employment in discussions of process, and the need for a definition that can distinguish between processes, they are unable to accomplish a meaningful distinction due to being tied to music analysis and product-oriented ways of thinking. The typical ways of talking about improvisation can also be used to describe memorised and rehearsed performance as well as processes involved in composition. In this way, multiple musical processes are confounded when looking at the product of the process. This ambiguity is well noted as is evidenced by arguments about the definition of improvisation, but there is not a clear alternative. There is also no clear way forward in constructing a comparative enterprise both across musical traditions, and across different types of creative behaviours.
This whole argument may seem counter-intuitive because at each stage, one could argue that the difference between an improvisation and a rehearsed performance is that improvisers are ‘making it up’, or that the difference between an improvisation and composition is that it is ‘made up’ in ‘real time’, but each of the criteria fails in itself to distinguish improvisation from other kinds of musical generation as discussed above. Since all of the criteria are dubious in themselves, despite the intuition, the distinction is not justified—at least in this formulation.

Whether it is a third-party music-analyst’s explanation or a first-person phenomenological one, describing process in terms of musical products cannot distinguish improvisation without the aid of some other kind of theory. A performer or analyst can describe how they put structures together to form a performance, how they manipulate structures in performance, and various other aspects of the process, but the concepts that are often invoked do not distinguish improvisation from other kinds of musical behaviours.

This is where the cognitive approach can help. It can bring in a ‘theory of music’ (rather than using ‘music theory’—see chapter 2 for an explanation of this distinction) to help explain what is different about these criteria whilst improvising as compared with other modes of performance. It can help explain the how questions raised above such as how improvisers use frameworks differently, or how the constraints of real time are different for improvisers than they are for performers playing from memory. Because of the way it structures its theories (that is, based on brains, bodies, biology, and physiology) it is more readily translatable across musical traditions and potentially other creative practices. This approach is developed below and in the remainder of the dissertation.

Can structure inform process?

Despite the complaints made in this chapter about how structures are used to characterise process, the cognitive theory presented in the following chapters still relies on a kind of structural analysis. To explain this, it will be useful here to distinguish between two perspectives on musical structure. The first thing that is important to point out is that a structure is only a structure by virtue of a theory. Music theory forms chords and notes out of an acoustic signal. Without a theory, without some way to think about those chords and notes, they would not be structures—they would be some kind of movement or sound, but not a meaningful structure. With a different music theory, the same movement or sound could be considered to be a different structure, meaningful within a different theory.
Such theories that define structures are typically music theories with structures like chords and notes. However, it should be noted that other kinds of theories that are not music theories could similarly identify structures in musical performance that would be better equipped to describe and compare processes of performance. The cognitive-scientific theory and experiments described in the following chapters analyse structures. In those cases, the structures are data. Data, similar to structures, are only data when defined by a theory. There may be many dead leaves strewn across an autumn meadow scene, but those leaves will only become data if one wishes to compare how many there are as compared with previous years, or to compare relative shades of red and yellow. A theory is like a frame in this sense that turns a phenomenon into data with the purpose of making a comparison or testing a hypothesis. Returning to music, a cognitive-scientific theory could examine a musical performance and identify different sorts of structures within a different sort of theory and cast those as data for the purpose of a different kind of analysis and hypothesis testing.

In other words, the cognitive-scientific approach does not abandon music analysis in the sense that it still analyses structures present in musical performance. But, it brings a different frame, a different theoretical approach that is better able to infer process from structure. This approach is akin to a study like Spiro, Rink, & Gold’s (2008), which analysed tempo fluctuation profiles in performances of Chopin. These tempo fluctuations are a kind of structure, but they are not present in the score and their specific profiles are not typically identified by music theory. Such theories may eventually influence music theory to include considerations of structure, but it is this contribution that we are after.

As for a cognitive approach, experiments could be set up to compare differences in certain kinds of structures present in musical performance based on specific hypotheses arising from cognitive-scientific theories. Such data could include comparing tempo fluctuations in improvised performance, or perhaps neural activity, or differences in neuroanatomy. The experiments that follow will choose specific structures to analyse—the point of mentioning it here is to explain how cognitive-science will still rely on structural analysis, but the structures are defined by theories that are better able to link them to an explanation of process, and better able to identify similarities and differences in process across traditions and creative practices because it does not rely on music theories.
Chapter 3: What is improvisation?

**Alternative scheme: modes of performance**

Throughout this chapter I have claimed that a cognitive approach could contribute to a definition of improvisation that is better able to accomplish the necessary goal of distinguishing it as a process. I will briefly sketch here what the cognitive approach will look like before fully presenting it in the following chapters.

First, crucially, there are many ways to create music, not just improvisation, composition, and rehearsed performance. These categories themselves include many different possible processes. Improvisation itself could include many different processes. Hargreaves (2012), for instance, distinguishes between strategy-generated, audiation-generated, and motor-generated ideas used in improvisation. Composition could include applying new mathematical systems or working out a standard chord progression. Rehearsed performance could be from memory or read off of sheet music. Further, rehearsed performance would vary in process between an expert and a novice in the sense that the expert may be applying their knowledge of musical organisation in ways that a novice cannot. The point is that many different kinds of processes may be equivocated by these broad terms. Having overarching terms is not a bad thing in itself; such terms can be useful in describing general trends and types of performance. However, what is at issue is that the definitions as they are fail to distinguish between the relevant differences between all of these kinds of constituent processes. What is needed is a new set of categories based on theories that are able to adequately distinguish between types of process. This is where the cognitive approach can help.

Basically, the approach, as will be fully outlined in chapter 5, is to temporarily abandon the distinctions between improvisation and rehearsed-performance and zoom out to consider different ‘modes of performance’ as different ways of moving and perceiving music.

While the music-theoretical structures that are being produced in performance might be similar, the process that leads to their production could differ. Modes of performance refer to the different cognitive processes that could produce these structures. Different performers may have acquired different modes of performance through differences in their pedagogies and experiences, and the same performer might engage different modes of performance at different times. It is very likely that there are individual differences in these modes, but it is also likely that there are commonalities based on similarities in pedagogies and experiences as well as similarities in the brain and body. For this reason, the goal is to construct a taxonomy of modes of performance based on features of these different modes.
What, exactly, would define these modes is intentionally left ambiguous. While a more specific theory of how different modes might be categorized is presented in chapter 5 (one that is argued to be a strong approach and a reasonable place to start this kind of inquiry), the broader theoretical approach adopted in this dissertation would allow alternative ways of characterizing such modes.

The cognitive approach provides a method to use structural features created under different modes of performance to make inferences about the process of that particular mode. The kinds of structures it would use would not be in service to music theory, but would be chosen according to a cognitive-scientific theory of music. This is what leads to its scientific advantages of being able to make comparisons outside of particular improvisatory traditions. Such observations about structures would be in service of a cognitive theory of musical process, not one explained in music-theoretical terms. The explanations are thus not specific to a particular music theory, so they could explain process in different styles and traditions as well as potentially draw parallels with other creative practices that might be explained in similar terms. These ideas are developed in the presentation of the cognitive theory and its experiments in the coming chapters.

Note that such descriptions of process differ from something like Benson’s (2003) taxonomy of 11 kinds of improvisation cited above. Benson identifies different kinds of improvisation based on varying degrees of structural change (which was argued not really to be able to distinguish between processes of music making) whereas something like Hargreaves (2012) sources of ideas, which is also a taxonomy of different improvisatory processes, is distinguishing between processes in a way that does not rely on formal structural analysis. The latter is akin to what the cognitive approach presented in chapter 5 is trying to accomplish. It may well be that the different kinds of improvisation Benson describes do require using different processes, but the process is not defined by which formal structures are manipulated. That describes the result of the process.

Eventually, the term ‘improvisation’ may still be useful to classify a group of such modes of performance. A group of such modes of performance may fit nicely into a category that is somewhat similar to common conceptions of improvisation. In other words, several modes of performance may share cognitive characteristics, and those modes might be the ones typically found when looking at practices otherwise called ‘improvisation’.
How to characterise such modes of performance is the next stage of the explanation of the cognitive approach. It is the aim of the remainder of the dissertation. The first step along the path from here is to review previous cognitive approaches that provide further foundation for the more specific theories that are necessary to accomplish these goals. The following chapter examines these.
CHAPTER 4: PAST COGNITIVE-SCIENTIFIC WORK ON MUSICAL IMPROVISATION

In the preceding chapters, a cognitive-scientific approach has been contextualised and compared with other examinations of performers’ processes from the ethnomusicological and critical literatures on improvisation. The influence of music-analytical thinking on questions about improvisation has been demonstrated in multiple literatures on improvisation and argued against on the grounds that it mischaracterises improvisers and has trouble distinguishing improvisation from other modes of performance. What, then, could constitute a cognitive-scientific theory of improvisation apart from ethnomusicological, critical, and music-analytical approaches? What experimental paradigms could be employed to characterise and explain improvisation?

In this chapter, existing cognitive-scientific empirical approaches are reviewed in order to help establish a new cognitive approach presented in the following chapter. The strengths and weaknesses of the existing cognitive literature are highlighted. I argue that this literature, like the literature discussed in the previous chapter, is also largely influenced by music-analytical questions about improvisation—that is, questions trying to answer how improvisers are able to generate musical structures like notes and chords—in that their theoretical bases rely upon the kinds of definitions presented in the previous chapter. This chapter further serves to highlight the prevalence in this way of asking questions about improvisation but also to demonstrate nonetheless what can be gleaned from it to help establish a new paradigm. The next chapter presents a new approach building on and responding to this existing work.

The existing body of cognitive-scientific work specifically concerning improvisation is relatively small. Much of it is empirical in the sense that it seeks to draw conclusions about improvisation through observing and analysing existing music. Some of it is experimental in the sense of trying to observe differences between performance processes under laboratory-controlled performance conditions.

There is not a unified approach in this literature or a coherent set of paradigms. Because of this, the goal of reviewing the existing cognitive literature is not to expand on any
specific existing research agenda, but rather to extract and analyse the various motivations of the studies that do exist. By considering these approaches in this more abstract way, their value can be retained even when moving in a new and different research direction.

Much of the experimental work that has informed the cognitive approach presented in the next chapter is drawn from other cognitive-scientific studies on music and other behaviours that are not themselves directly applied to an understanding of improvisation. The research described here is directly about improvisation. The other work will be integrated into the discussion in the next chapter as well as in the experimental work presented thereafter.

Six kinds of existing cognitive literature are discussed here: models of improvisation, neuroscientific experiments, music analysis of improvisation motivated by cognitive scientific theories, studies of listening to improvisations, phenomenological studies of improvisers, and developmental psychological studies involving improvisation. Each will be discussed in turn.

Models of improvisation

A model of improvisation attempts to outline in abstract terms what would need to happen for someone (or something) to improvise. It sets out a series of steps in the process and summarises the necessary capacities, leaving further details of particular mechanisms to be determined through future empirical work. In order to create a model of some task, that task needs to be operationalised quite definitively. The more definitively the task can be described, the more accurate a model could be at describing how it could be carried out.

One approach common to cognitive science is to create a computational model. The question here is how to program a computer to accomplish a task that a human is able to do. As for musical improvisation tasks, this model could either be explicit in the sense of outlining steps that manipulate symbolic representations of musical structure, but could also be an implicit connectionist model that can learn to mimic improvisatory behaviour through exposure to a corpus of examples without such explicit steps. The basic question here is what would a computer need to compute in order to improvise?

The cognitive music-analytical literature reviewed below can aid computer scientists in this pursuit by abstracting rules and patterns from recorded or transcribed improvisations that could then be replicated by programming a computer to generate sequences of notes.
according to those rules. Johnson-Laird (1991) addresses this question directly by writing about the theory of a computational model of improvisation as well as creating two implementations, the first involving a program that manipulates explicit symbols and the second using a connectionist approach that can ‘train up’ but does not manipulate explicit symbols. Other computational approaches have applied similar principles to create improvising computers. François, Schankler, & Chew (2013) have created a machine that recombines and outputs musical material input by a human improviser in order to interact with that performer. Norgaard, Spencer, & Montiel (2013) have worked with mathematicians and computer scientists to extract patterns from corpora of improvisations in order to create a program that could generate them in a similar style.

Johnson-Laird’s approach is to consider improvisation in terms of the style of “modern jazz—the idiom that was developed in the 1940s by Charlie Parker, Dizzy Gillespie, and their colleagues, and that has continued to be the dominant style to this day” (p. 291). He argues that improvisers do not just memorise collections of replicable patterns (‘licks’), but rather learn sets of generative principles. Johnson-Laird’s strategy to describe improvisation in this way is characterised by the question he asks: “How does a bass player choose which note to play next?” (p. 313). Some set of stylistic restrictions is somehow acquired by an improviser such that some principle could describe the generation of notes or other musical structures. Similar questions are asked of harmonic progressions, rhythmic structures, and melodies. In fact, Johnson-Laird defines a note as consisting of five dimensions: pitch, onset time, duration, intensity, and articulation. The constraints on improvisatory note-choosing are framed in terms of working memory capacities under time pressures, and Chomskian grammatical principles.

The influence of music-analytical approaches to understanding improvisation could not be clearer here. Johnson-Laird conceives of the product of improvisation in terms of rigidly defined musical structures (notes, rhythms, etc.). A computational theory would have to formalise music in some way, at least for the explicit symbol approach. It needs a strict operationalisation of the task.

The practice of creating such models follows in the tradition of David Marr’s computational models of vision (see Marr, 1982). The idea is that if one wishes to understand how the mind can accomplish a task, what the task at hand actually is needs to be understood. What is it that the mind has to accomplish, exactly? Computational modelling is one way to describe this. By getting a computer to successfully accomplish a task, something
about what the mind would have to accomplish can be inferred even if knowledge of the specific neurobiological mechanism is left for later research. This approach works quite well for modelling perceptual capacities like vision. In order for the brain to allow humans to recognise objects and interact with them, it would need to be able to do things like detect light contrast, detect edges, etc. Considering how a computer would have to manipulate such data is thought to help guide the search for some analogue in the biological hardware of the human visual system—that is, how the brain does it.

Crucially, and as Johnson-Laird is well aware, what a mind has to accomplish does not necessarily imply how it is accomplished: “[t]he theory concerns what the mind has to compute in order to produce an acceptable improvisation. A theory of what is computed is not, of course, a theory of how the computation is carried out” (p. 291). Such models work well for perceptual processes, but this what/how distinction raises concern for a model of improvisation, which for these purposes is considered as a motor process that generates actions. As emphasised in previous chapters, looking at the notes alone could equivocate multiple possible processes that led to those notes. Thus, what improvisation is must be understood in terms of the ‘how’, not the ‘what’. The ‘what’ may be very similar for musical composition, memorised performance, and multiple different kinds of improvisation. These other practices may very well follow the same (or very similar) music theoretical rules that would be used to create the computational model. One could apply similar formal descriptions of patterns to the output of a memorised performance. If you did not already know that a performer was improvising, describing the process in such terms would not distinguish between the two.

Do improvisers have to choose notes according to restrictions and rules? One could describe it that way, but it is not necessarily what they are ‘doing’. Johnson-Laird further notes that “one cannot show that the ‘grammatical’ account of performance is wrong” (p. 319) on the basis that it is able to reproduce a product similar to what an improviser produces and that “there are many other possibilities”. This is exactly the problem. A computer could be programmed to imitate the product, but it is not clear how it can help us understand the human process. This is not to say that a computer that can accomplish such a feat is not valuable in other domains, but as a springboard to a psychological theory, it is not as useful because it is highly disputable that it at all resembles what a human player is doing. In this way, a computational model does not help define what improvisation is. It can learn
to mimic style (similar patterns of notes, chords, structures), but it does not mimic or explain the relevant concern: process.

In response to this pitfall, Johnson-Laird also writes that one could describe improvisatory music production in terms of a connectionist acquisition of regularities. Human improvisers may acquire many of the rules and regularities through exposure without an explicit formalisation of rules. So too might a computer learn in this way by being ‘trained up’ with transcribed solos, implicitly learning their regularities in order to mimic them. Similarly, Toiviainen (1995) has produced such a programme with similar reasoning.

Even a connectionist alternative, however, has to take some analytical structure as the relevant input. It is carrying out a process of producing notes (or, as Johnson-Laird suggests for further research, higher level musical structures). The same process could be carried out on compositions—a computer could implicitly learn to create compositions in a similar style. It is a description of the online process that is being sought, though, and it is unclear how such a connectionist model could do better in theorising about such a psychological process beyond suggesting that neurons are doing something like the nodes in the connectionist model. This would simply seem to suggest that improvisers gradually acquire musical regularities implicitly. This does not seem to go much further than simply observing that young musicians acquire stylistic characteristics that change the way they hear and play. So do musicians in the classical tradition who supposedly do not improvise. They, too, become enculturated into particular musical styles. That being said, discovering differences in the regularities whilst playing in different modes of performance could potentially serve as part of the foundation of a psychological theory if an appropriate reason for such a difference could be described. This perspective approach can lead to the establishment of an experimental paradigm.

Murray-Rust & Smaill (2011) have proposed a computational model of musical interaction based on a consideration of jazz improvisation. In contrast to Johnson-Laird’s model, and Pressing’s cognitive model (discussed below), Murray-Rust & Smaill focus on questions about interaction rather than a single player’s ability to generate musical material. To accomplish this, musical structures are reconsidered as musical acts, which have the intention to change the state of interaction between musicians. Such a pursuit required explaining issues such as conventional meaning of certain acts and issues of common knowledge between performers. The authors pilot a computer programme based on these principles to interact with human performers. While questions of interaction fall outside the
scope of this dissertation, this model should be noted for providing a way to explain improvisatory process that is not wholly reliant on musical structures. Such questions about communication would be more easily linked with cognitive questions, and as such could potentially build on the approach introduced in the following chapter. If parsing and interpreting musical acts requires embodiment and prior knowledge, one might ask how those tasks are accomplished cognitively, and why some musicians would be more readily able to do so than others (i.e., why cannot some musicians improvise as fluently?).

Another approach to modelling in cognitive science is to create a cognitive model. This kind of model is not formulated to be simulated with a computer, but instead suggests the capacities and steps that exist in the mind that facilitate certain behaviours. Pressing’s (1988, 1998) work on the cognitive modelling of musical improvisation is the only cognitive model about the behaviour that attempts to be comprehensive. It is often cited as such and thus is important to understand for the purposes here.

Pressing’s model begins by dividing improvisations into discrete, non-overlapping structures called ‘event clusters’. These clusters have sonic, musical, and perceptual-motor properties, he argues. What an improviser knows in order to produce these successive events is a ‘knowledge base’ consisting of objects (particular structures), features (qualities shared by sets of objects), as well as processes (which can manipulate objects and features). Event clusters are produced and arranged in temporal sequence using feedback and planning, thus creating an improvisation. Pressing goes on to argue that these different kinds of knowledge each have sensory-motor representations in the brain. Improvisations are constrained by the available knowledge and the available time in which to recall and execute it. He describes how feedback can be used to guide the production of events.

By reframing a body of ‘licks’ that an improviser knows as a ‘knowledge base’ of ‘objects’ along with other kinds of bodies of knowledge like principles to manipulate and combine these objects, and by describing how such knowledge could be represented cognitively, Pressing sets a bit of distance away from a hard-and-fast analytical approach. He translates the questions about improvisatory processes into cognitive-scientific terminology thus helping to make such questions accessible to experimentation.

Or so it would seem. The model is still, at its heart, motivated by a music-analytical conception of improvisation. Despite using cognitive-scientific terminology, Pressing is still asking how musicians choose the notes (choose the structures, choose the ‘event clusters’),
although he describes it as an intersection of multiple kinds of structural constraints. It is true that he shows how such objects might have sensory-motor associations, but that is just displacing the question by replacing music-analytical structures with cognitive representations of them. It is the same underlying reasoning. Any structure you could identify through music analysis would have to have some cognitive representation if someone is to carry it out. Everything humans do has to have some cognitive correlate if we are using our brains and bodies to do it. In other words, it would be difficult for Pressing to be wrong—music can be described structurally, and thus musical structures could also be said to have some sort of cognitive correlate. The difficult part is how to conceptualise improvisation as a process that differs from other modes of performance given that other modes of performance would still produce structures with cognitive representations. That part of Pressing’s reasoning is similar to the music-analytic pseudorandom note-choosing perspective, which I argued against in the previous chapter.

Pressing’s model does not stand to be supported or falsified by empirical findings in the way it is framed, but it does raise some important questions and thus still has great value. Do musicians use feedback differently whilst improvising (as compared with whilst playing from memory)? Do they plan ahead differently? Are perceptual-motor representations somehow different for improvisers as compared with those more experienced with rehearsed performance, or are they employed differently for a given musician whilst improvising as compared with when playing from memory? These are experimentally tractable questions that are raised by Pressing’s discussion. They could help characterise improvisatory performance and refine a definition of what it is in comparison to other modes of performance.

**Music-analytical cognitive approaches**

Another important kind of empirical work on improvisation is that which uses music analysis as a method of inferring cognitive process. The previous chapter discussed two kinds of musical structure to be analysed—those more like music-theoretical structures, and structures in the sense of data to be analysed within the frameworks of a cognitive-scientific theory. The studies discussed here are using the music-theoretical kind in their music analysis. These studies aim to make inferences about cognitive processes from particular observations of these structures. They make inferences about the information processing demands that would be necessary to produce such structures as those in the improvisations
they analyse, and from that draw some conclusion about constraints and principles that govern how the human mind must generate them. Something about the patterns of notes in the transcriptions is thought to be able to reveal something about the process that created them.

For instance, Järvinen (1995) and Järvinen & Toiviainen (2000) analysed transcriptions of Charlie Parker improvisations and determined that the pitch class distributions conformed neatly to Krumhansl’s (1990) and others’ empirical findings on tonal hierarchies—these improvisations followed similar distributions of pitch classes as tonal music in general, and metrical placement in the improvisations was used to emphasise tones important to these hierarchies. The point of these studies was not only to show that bebop style improvisations follow similar tonal principles as Western art music, but to provide some foundation for asking about how improvisers use a sense of tonality:

As far as the study of cognition is concerned, the findings suggest that, in bebop style, improvisers use meter and certain points of the chord structure as aids that help them to create coherent improvisations. This means that the notion of cognitive reference points is also useful in explaining the way jazz musicians approach improvisation in bebop style. (p. 435)

Of course, not all improvisation around the world conforms to Western tonal principles, although it may conform to other tonal systems and conceivably some similar notion of ‘reference points’ could be adapted to describe other styles and improvisatory traditions. This kind of research would seem to allow researchers to begin understanding ‘where’ in the musical structure performers are thinking and attending. At attention hot-spots, like places of strong metrical placement, if performers use more tonal pitch classes, it could help a researcher understand how musical structures are planned. Of course this is not the only way improvisers could plan what to play, but similar empirical techniques could be used to determine planning through structural observations.

For instance, Pfleiderer & Frieler (2010) share a similar premise in their research and take it many steps further. Using a database of transcribed jazz improvisations, their project is continuing to develop sophisticated analytical methods to advance multiple research objectives including discriminating between styles, comparing structural features of jazz improvisation with other styles, and as far as cognition is concerned, “to explore the cognitive foundations of improvisation while testing theories about the cognition of creative processes, e.g., by determining recurring melodic and rhythmic patterns and their underlying melodic-rhythmic prototypes” (p. 2). These improvisations are analysed with respect to their pitch
classes, melodic contours, inter-onset intervals, and other formalised structural features. Various probabilistic and statistical techniques are employed, including Markov Chain Analysis. Schütz (2012) adopts a similar approach searching for a typology of musical structures employed in musical improvisation.

For a cognitive approach, it would be relevant to know if improvisers relied on certain patterns for similar reasons as Järvinen & Toiviainen’s work. Asking which structural units are being produced can lead to questions of how those structures are represented and processed, and what about those structures in particular makes them improvise-able, or improvisatory in character. The drawback with this approach perhaps comes when one actually tries to make that leap into theorising what makes certain structures improvise-able. The specific cognitive mechanisms that would execute these patterns are left a bit vague, which is not necessarily a problem or within the purview of the projects, but would it be possible if one tried? It is true that regularities can be observed in the formal output, but on what basis can one claim that it is then part of the performer’s process and not just a completely external and explicit description of style? Or, perhaps these features are necessary to meaningfully structure music, but cannot describe the specific process by which it was produced (composers at a desk might also have to rely on the same structural regularities). It is similar to the problem raised by Johnson-Laird and Marr described above—it is all too easy to equivocate multiple ‘hows’ for a single ‘what’. One could ask the improviser if that is part of their process which would help, but that too could be misleading (see phenomenological studies discussed below).

Of course, even a cognitive-scientific research programme that did not rely on the kind of music analysis characterised here (searching for patterns of notes with an aim to formalising their underlying generative principles), there would have to be some kind of music analysis in other behavioural experimental paradigms of improvisation. That is, if something different in music produced under different performance conditions is to be detected, those differences must be observed through some form of analysis. The key difference is that the theory motivating this analysis is not asking how the performer chooses the notes, but rather, what are the consequences of choosing the notes in the way, the manner, that the performer does (e.g., is it more sensitive to disruption of various kinds leading to timing fluctuation). In the following chapter, there is a discussion of such an approach with a specific example of such an analytical study I previously conducted (Goldman, 2013).
It is worth discussing generative models more thoroughly here. Since Lerdahl & Jackendoff’s (1983) introduction of a generative theory for music, many music psychologists have understood performance to be governed by such grammatical and generative principles. Improvisers could be thought of as lick-learners and rule-acquirers who amass a body of discrete patterns (on the note-to-note level or at a higher structure level) as well as combinatorial rules, and through these two capacities are able to string together complete improvisations. Indeed, such approaches are sometimes explicitly emphasised in improvisatory pedagogies as seen in ethnomusicological accounts (in which, for instances, Iranian musicians learn sets of *gushehs*, or Indian musicians learn structures specific to different modes) as well as historical accounts (how musicians learn to improvise cadenzas) both discussed in chapter 2. In the jazz tradition, Haerle’s (1978) method suggests learning stock phrases in all keys. Gjerdingen (2007) documents schemata involved in music in the Galant style. Learning such collections might also be done implicitly through long-term exposure to a particular style without deliberately practicing individual units (licks, riffs, *gushehs*, etc.). Knowing large numbers of such structures could allow a musician to string them together to produce an improvisation with an organisational structure beyond the immediate future. Mackenzie (2000) argues from a linguistic perspective that speech uses a huge corpus of larger pre-fabricated, socially-contextualised phrases (e.g., ‘need a hand’, ‘in my opinion’, ‘I see what you mean, but I think that X’). There are generative components, but they would rely on the knowledge of these larger structures. The novelty that generativity would afford relies on a large corpus of these larger structures, and deviation from them (by substituting certain words), Mackenzie argues, is analogous to what an improvising musician does.

Or, as Johnson-Laird argues, and as other researchers are considering as discussed above, it might be best to think of an improvisers’ use of structural regularity as part of a generative process that does not employ such prefabricated material, at whatever level of structure. There may appear to be licks or riffs that are strung together, but what an improviser actually *knows* is a set of principles by which to generate new licks. The structural regularity present in their music (that is, finding licks in an improvisation through various means of music analysis) is evidence of these principles, not necessarily evidence that what the improviser knows is the lick itself.

Such accounts rely heavily on music analysis and characterise the improviser as the note-chooser (or here, generator), which was shown to be problematic in the previous
chapter. However, these accounts consider such musical structures from the perspective of a cognitive theory. The principles by which a musician can generate, order, and recombine elements could be transferable across traditions. In fact, a recent paper (unpublished) by Widdess & Rohrmeier presented at the Perspectives on Musical Improvisation conference at Oxford University in 2014 has described Indian classical ālāps as recursive and generative. Such accounts of improvisation could also link musical generation to other kinds of generation (speech, other ordered movements). This is a promising route and one properly about process, though not one that the work in this dissertation adopts.

One cautionary note about this is the question of why some musicians do not acquire the ability to be generative. Western classical musicians are also exposed to structural regularities through studying, practicing, and performing written works. They may be versed in particular styles and able to identify structural abnormalities. They too repeatedly practice chord progressions and recurrent figurations (scales, Alberti bass, arpeggios, etc.). Yet, many are unable to regenerate these elements in an improvisatory manner in the same way that a jazz player can generate improvisations in the idioms and style of the jazz tradition. It might be akin to Chomsky’s distinction between competence and performance (where the classical player is competent by virtue of understanding the grammar of classical music but is unable to perform it), although classical players do perform grammars through playing rehearsed works. They can articulate and emphasise such grammatical features with expressive characteristics (Clarke, 1988).

The question again could be clarified through considering the question as different ways of knowing. Certainly generative grammars can say something about music performance, but how it characterises improvisation specifically is less clear. In this way, this research approach could be complemented by inquiring into why musicians possess different kinds of grammatical/generative skills. The approach presented in the following chapter may contribute to this distinction, although, again, it does not phrase its arguments in terms of generative grammars.

**Functional neuroimaging studies**

The existing neuroscientific literature does not serve to test or validate any particular cognitive or computational model discussed above; rather, it provides its own theoretical justification. In principle, these studies are closely aligned with the cognitive approach proposed in the following chapter. They are based upon the premise that improvising
Chapter 4: Past cognitive-scientific work on musical improvisation

engages different cognitive processes than rehearsed performance despite what would appear to be similar low level motor activity at the instrument, and without explaining the processes in terms of choosing musical structures.

The studies generally operationalise improvisation as a task that involves the creative selection of novel motor processes. Playing from memory and improvising are similar tasks as far as moving the hands is concerned, but the cognitive processes involved in motor planning, or in terms of creatively selecting supposedly novel motor patterns may differ. In this way, these studies are concerned with creative behaviour, but a central premise is that improvisation is a performance process that differs from rehearsed performance according to distinct neural correlates. These studies do not, therefore, aim to describe process through music analysis alone, although some of the claims and premises are still intertwined with such a conception of improvisation.

This ability to see past formal musical correlates of improvisation is one of their major strengths—they seek to identify differences in cognitive processes without appealing to music analysis, with all of its pitfalls, to detect the difference. By replacing formal musical correlates with neural correlates, these studies are also able to link explanations of improvisatory process with other behaviours that might appear unrelated on the surface. In principle, an explanation of musical improvisation based on notes could not be directly compared with an explanation of, say, a dance improvisation based on particular movements or a different musical tradition with different kinds of musical structures. If neural correlates are similar, however, a connection in explanation could be made. For instance, Brown, Martinez, & Parsons (2006), e.g., compare musical improvisation with speech generation, and Donnay, Rankin, Lopez-Gonzalez, Jiradejvong, & Limb (2014) similarly suggest through an fMRI experiment that trading fours in jazz improvisation shares syntactic processes with language.

There are two drawbacks to this research. One is that despite being able to detect differences in cognitive processes, the definitions of improvisation used in the studies are still couched in music-analytical terms (see below). It still influences the questions they ask. It is not as much of a problem with this research as with other research on process because they are able to make other kinds of observations beyond which notes are chosen, but when one goes back to apply these observations to a theory of improvisation, it can be difficult to make the link. As it stands, for these neuroscientific studies, the typical reasoning could be summarised as first characterising improvisation as free, novel, or spontaneous, then finding
brain areas activated with an improvisatory task, next reviewing past explanations for the roles of those areas, and finally linking those explanations with a characterisation of improvisation. This reasoning risks a kind of just-so explanation where an initial definition of improvisation is used to force the purported functional roles of these brain areas into a preconceived and perhaps unsound definition of improvisation, the very behaviour in question.

The other drawback is a general sense in the neuroscientific literature that improvisation is a single phenomenon. Improvisation is treated as a monolithic type of behaviour. Of course one has to start somewhere, and showing differences in neural correlates between any two modes of performance is certainly a step forward. However, a sensitivity to the different ways in which musicians improvise could help articulate more specific neuroscientific hypotheses as are suggested in the following chapter.

The advantages and drawbacks of the neuroscientific approach can be seen in each of the studies. Berkowitz & Ansari (2008), write that “[i]n terms of cognitive processes, improvisation can be defined as the spontaneous generation, selection, and execution of novel auditory-motor sequences” (p. 535). Their experimental task requires participants to improvise series of button presses from a set of options (1, 2, 3, 4, 5) that are each linked with a tone (do, re, mi, fa, sol). They have rhythmic and melodic conditions, as well as a comparison between the execution of pre-determined patterns in order to contrast brain activity during improvisation with that during a pre-determined performance. Even though participants were not playing an instrument with which they had trained for years, the reasoning is that something similar to the free-response generation on a button box is involved in free-response generation in a more ecologically valid musical context.

The premise, that improvisation involves freedom and can be understood as ‘free response’, again, stems from music-analytical thinking and displaces other questions of differences in process. If improvisation is not to be understood as ‘free’ but rather as differences in the ways musicians interact with their instruments, with others, and with sensory feedback, this experimental task cannot access the right questions. Those differences in process would be visible when the musical aspects of improvisation (beyond button box buttons) are added back in—how does one use their knowledge of their instrument, and how is knowledge used differently in different musical contexts? The distilled free-generation aspect of improvisation, despite having neural correlates of some kind, does not help develop a theory that can explain processes involved in musical improvisation because the assumed
definition is underdeveloped and unsound. It is more a test of whether participants can produce random (or pseudorandom) sequences of key presses. Musical improvisation is not random, and if there is an element of randomness, it is outside of the performer’s control and therefore does not help explain the process.

As for the way the activity of particular neural structures are explained, the pitfall outlined above can be seen in Berkowitz & Ansari’s discussion:

Our result is consistent with many of these proposed functions of the [anterior cingulate cortex], since improvising musicians go through a continual process of decision making, selecting among a multitude of unrehearsed, conflicting possible musical phrases to play at any given moment, and then intentionally executing their final choice. (p. 541)

Whether improvisers are selecting from a multitude of unrehearsed musical phrases is a contentious matter and is probably not a good characterisation of improvisation. In any case, it is in question. So, to assume that the matter is settled in order to attribute functions of the ACC to it is an unsound way to draw conclusions. It is forcing an explanation of the brain area into a preconceived definition of improvisation.

Limb & Braun (2008) take a similar approach of contrasting improvisation with rehearsed performance and are more ecologically valid than Berkowitz & Ansari’s study in that participants played on a MIDI piano keyboard whilst being scanned. Their definition mentions musical context, but does not seem to be able to distinguish improvisation as a process with any solidity: “Spontaneous musical performance, whether through singing or playing an instrument, can be defined as the immediate, on-line improvisation of novel melodic, harmonic, and rhythmic musical elements within a relevant musical context” (p. 1). The definition is circular—spontaneity is defined as improvised playing. How would improvisation be defined? In that this lacks a clear theoretical question about improvisation, the findings will similarly be unlikely to be clearly interpretable. Is improvisatory musical performance spontaneous in ways that other musical performance is not? From a music-analytic perspective it may be, although the previous chapter showed how this is difficult to claim. The differences in how musicians employ their knowledge in varying performance situations are not addressed by this operationalisation of spontaneous performance.

Nevertheless, the study is still able to offer a comparison in that they find different neural correlates for improvisation as compared with rehearsed performances. The increased activity in the frontal polar portion of the MPFC and attenuated activity of the LOFC and DLPFC observed during improvisation as compared with rehearsed performance are
explained by referring to previous literature that has characterised the function of these brain areas. After a paragraph listing such functions including that the MPFC has been shown to play a role in “the neural instantiation of self, organising internally motivated, self-generated, and stimulus independent behaviors [sic]” (p. 4), Limb & Braun state that “[a]ll of these functions are necessarily required during the task of improvisation” (p. 4). The implication is that this study provides converging evidence that these brain areas are properly characterised by past studies, and that improvisation is properly characterised because it activates these areas. This again is circular. The evidence from this study does not support that improvisation requires “the neural instantiation of self”—that must somehow be assumed from a prior conception of improvisation, which may well be erroneous or at least contentious. It is this kind of interpretation of brain activity that is difficult without a more properly interrogated definition of improvisation and theoretical premise. If the definition of improvisation can be questioned on theoretical grounds, it follows that the meaning of the findings are less able to support an explanation. The parts of the brain that are active during their improvisation task surely have something to do with improvisation—or that is to say, have something to do with the experimental task—but of course they do! Without a better defined theory of improvisation, it is difficult to interpret what those areas are doing.

Bengtsson, Csíkszentmihályi, & Ullén (2007) situate their discussion of improvisation within theories of creative behaviours invoking concepts like “free generation and selection of alternatives” (p. 830) to describe the kind of behaviour improvisation is. They note that...

...it is simple enough...to allow an experimental design where the neural processes involved in the free generation of musical structures can be separated from those involved in the sequential organization and programming of the movements (i.e., piano playing), and the processing of movement feedback. (p. 831)

They accomplish this by having participants improvise, and then replay the improvisations from memory, thus having similar motor programming and, theoretically, isolating the free-generation part of the task. This is a strong approach to comparing performance process as it can control for particular movements and isolate differences in process at motor planning and other cognitive levels. Again, the only objection is that whatever the results are, whatever neural areas are activated, must still then be explained within this theoretical framework of improvisation as an issue of free-generation. Since the notion of free-generation (that is, note-choosing) is problematic (see chapter 3), so too is the interpretation of the findings.

de Manzano & Ullén (2012) conducted an important additional experiment following from these other studies. They contrasted pseudorandom response generation (PRG) at a
keyboard with musical improvisation. Past studies of PRG found similar areas activated as the improvisation studies cited above (they list the dorsolateral prefrontal cortex, parietal association areas, anterior cingulated cortex, supplementary and pre-supplementary motor areas, and lateral premotor regions), so de Manzano & Ullén wished to dissociate the musicspecific aspects of improvisation from what might be a domain-independent PRG network of brain areas. Unexpectedly, the Improvise-Random contrast did not reveal any significant brain activity specific to improvisation while the reverse contrast revealed significantly more activated brain areas specific to PRG (the temporoparietal junction, extending primarily into the superior and middle temporal gyri and the postcentral gyri, the medial and lateral premotor areas, the DLPFC and the cerebellum). They attribute this to the expertise of their participants: “During musical improvisation...the load on prefrontal networks for superordinate control was lower [than for PRG], presumably since the participants could rely on highly automatised auditory-motor skills relevant for music performance” (p. 778). An important consideration to take away from this finding is the reminder that not all improvisation is the same. Their distinction between pseudorandom generation and improvisation might be equivalent according to music-analytical perspectives, but in this context they have been distinguished from each other as separate kinds of performance. These findings also seem to suggest that despite the initial operationalisation of improvisation as “extemporization of novel and contextually meaningful musical content” (p. 772), improvisation would not seem to be well characterised or generalised as such. In other words, improvisation is not well-characterised as pseudorandom generation of movements.

Finally, a recent study by Pinho et al. (2014) took a slightly different approach. Noting that “musical training can have dramatic effects on the brain” (p. 6156) and that “pseudorandom and musical generation appear to rely on a common set of [brain] regions” (p. 6156), they ask if musicians with experience improvising have different sorts of brain changes than those musicians without improvisatory experience. This is a somewhat different approach in that it is between groups (although, Berkowitz & Ansari (2010) ask a similar question in a follow up study to the one described above by testing the effect of expertise on their experimental task). It recognises that improvisatory experience is somehow different from musical experience with rehearsed performance which could lead to different musical skills with potential anatomical and physiological correlates. Again, this is an admirable design and a good question to ask in order to differentiate the underlying processes and necessary cognitive skills of improvisation from those of rehearsed
performance. The only issue here, again, is how much any conclusion could add to an understanding of improvisation given that it is defined as a kind of pseudorandom generation of novel responses. Characterising improvisation as novel and pseudorandom is misleading, and further, one could equally well say that all music performance has elements of pseudorandomness insofar as performance decisions are not completely predetermined. This is not to say that there is no difference between improvisation and other modes of performance—it does, however, suggest that definitions of improvisation in this and the other neuroscientific studies cannot sufficiently demonstrate it. This problem surfaces in interpretations of differences in brain activity. The findings cannot necessarily be explained as evidence of underlying pseudorandom processes.

In all of these studies, the neural structures that are activated are surely important for improvisation (at least as it is operationalised in the studies), but as suggested, the interpretation risks falling flat. The neural structures somehow underlie this particular type of improvisation, but not necessarily for the reason these researchers propose—that is, something to do with novelty, creation, and free-generation. This rests on the assumption that improvisation is, by definition, free and novel. An alternative theoretical framework could recontextualise these findings, but the findings themselves from this kind of experiment will not necessarily lead to that new framework.

The findings from these neuroscientific studies are not converging on a coherent explanation of improvisation in neural terms. For instance, Limb & Braun found a deactivation in DLPFC during improvisation as compared with rehearsed performance as compared with Bengtsson et al. who found an activation (Limb & Braun explain methodological issues of analytic techniques and subject pools which might explain the difference). Some brain areas implicated in improvisation were found in multiple studies, but some were not. If a brain area is found to be activated, its potential role is described whereas if it is not activated, an explanation is difficult to find. Should the differences in findings be attributed to differences in method? If the findings are susceptible to this kind of variation, it is difficult to know what to make of the existing data.

Because of this, the theoretical approach proposed in the following chapter and the experiments following that are not aiming to build on the findings, but rather to build on the process that motivated these experiments which is innovative and provides some strong approaches that can be tightened with more thorough theoretically inquiry as provided by the previous chapters of this dissertation. Specifically, the motivation to consider different
underlying cognition behind modes of performance both within group (as with the Bengtsson, Csíkszentmihályi, & Ullén, Berkowitz & Ansari, and Limb & Braun studies) and between groups (as with the Pinho et al. study) are retained in the development of the cognitive approach I propose in the following chapter.

**Phenomenological studies**

How else might process be inferred from the observation of musical structures? Another approach is a phenomenological one. This is not exactly experimental considering that controlled conditions are not established in order to compare how performance might differ under them. It is empirical, though, in the sense that it requires gathering data in a methodical way. This usually means interviewing musicians, or otherwise having them report on their own experiences and music-making processes.

Sutton (1998) argues that a first-hand account is necessary to understand improvisatory process:

> How are we to know improvisation when we encounter it? Reference merely to sound structures is inadequate…[H]ow can we know that these differences are the result of spontaneous decision making by the performers? We need to pay heed both to the sound structures and to what musicians who have produced these structures have to say about the process whereby they produced them. One without the other is insufficient in a quest to identify and understand improvisation.” (p. 73-74)

Is a first-hand perspective necessary for an account of improvisatory process? If combined with third-hand music analysis, is it sufficient?

For example, Norgaard (2011) conducted a study in which improvisers would play and record a passage of music, and then immediately afterwards would be interviewed about their choices and thoughts as they performed. Norgaard found recurrent strategies amongst the seven participants such as using certain stock ideas, repetition, and using melodic and harmonic considerations to guide the improvisations and referred back to existing cognitive models such as Johnson-Laird’s and Pressing’s in order to show that there was some commonality between what they said they were doing and what models predict. Similarly, Kingscott & Durrant (2010) informally interview a liturgical organist and jazz pianist in order to better understand how they improvise. They emphasise the importance of prior exposure to styles and the notion that the music is not conceived *ex nihilo*. The higher level judgments of musical success are built upon mastery of such styles.
Does a study like this support the validity of the models and help explain a performer’s process? Cognitive science has a certain tension with phenomenology in general in that one of the theoretical positions cognitive science takes is that people do not necessarily have an accurate sense of how they accomplish the things they accomplish. Being able to do something does not mean knowing how to do it. As such, musicians may not be able to accurately inform researchers as to how they are able to accomplish a task in question. They might not know, or they might be inaccurate. Further, being aware of the same discourses and music theories that gave rise to the models, they may describe their own behaviour in similar ways, acting as a music theorist. It is a kind of self-fulfilling prophecy in this way—these musicians might learn certain ways of talking about improvisation, and then when they repeat this back, it is taken as evidence to support that the theory is correct. In this way, self-report does not necessarily corroborate the models. Besides, the claims that they make are with the same terms and definitional criteria that are shown to be highly problematic in chapter 3, so even if they were ‘correct’ about it (that is, honestly reporting what they think they are doing), their own explanations are also highly problematic.

This all being said, phenomenology still plays an important role in relation to a cognitive-scientific pursuit. Many performers (though not necessarily all performers) have a detailed and nuanced insight into what it is like to perform and what they think they are thinking about whilst performing. They may not necessarily be right about their own processes, but they may not necessarily be wrong either! Phenomenological inquiry is perhaps best considered as a method of generating questions that could then be experimentally tested. Are performers’ observations accurate? How could they inspire experimental questions, or reframe theoretical motivations to ask questions? If an improviser identifies a particular moment as important for whatever reason, it could be investigated further. Such an investigation, though, would need to be couched in some kind of theoretical framework that is different than what the improviser identifies. In other words, identifying why something is important is different than noting that it merely seems to be from phenomenological report.

**Listening to improvisations**

A few studies have examined the perception of improvised music by having participants listen to improvisations and make various kinds of judgments. These studies serve an important purpose. With structural analysis of musical improvisations, as in the
analytical studies cited above, the analysis could only pick up on formalised features in the
notes and rhythms. By asking about perception and what perceptual characteristics (if any)
are present in improvisation that could be used to distinguish it from other modes of
performance, researchers open doors to further kinds of musical characteristics that might be
important for improvisation that more traditional formal analysis would not predict or detect.
If listeners are able to tell the difference between performances different types of
performances, implicitly or explicitly, experimenters could control for variables and
determine what makes something sound improvisatory. From there, one could postulate
different mechanisms that would be more likely to produce music with such features.

Lehmann & Kopiez (2010) conducted a study in which listeners had to judge whether
a piece of music was improvised or composed. The excerpts were selected from different
styles and were not produced for the express purpose of the experiment. Participants were
not able to reliably recognise whether the Romantic and Classical style excerpts were
composed or non-composed, while they had an easier time telling the difference with Free
Jazz style excerpts. The proposed explanation was that certain cues are present in improvised
selections. Importantly, the authors note that “the cues do not reside in the structural features
of the work itself but rather emerge from its performative embodiment” (p. 579). They go on
to cite ‘togetherness’ of different ensemble members as such a feature. By structural features,
they presumably mean structures like chords, notes, scales, rhythms, and other structures
which can be notated. Cues present in ‘performatively embodied’ music would still be
structural in the sense that they could be formally defined (‘togetherness’ could be formalised
and measured in terms of temporal synchrony of events, for instance). Improvisation may
have features present in it by virtue of its means of production.

This point is further explored by Engel & Keller (2011), who compared improvised
piano performances with imitations of those same performances and found greater variance in
MIDI velocity values (corresponding to sound intensity). They then tested how trained jazz
pianists perceive these different performances using fMRI. They found that the more
uncertainty in velocity, the greater the activation in the amygdale and regions involved with
action simulation. The interpretation is that the amygdale is involved in the detection of
behavioural uncertainty and that networks involved in action simulation were more active in
order to be able to generate predictions whilst listening to more uncertain musical passages.
So, again, improvisation is characterised in terms of unpredictability. The findings here do
not necessarily show that the amygdale responds to improvisation more, rather, it shows that
it responds more to performances with greater variance in keystroke velocity. So the most
direct question is, then, why improvisations have greater variance in keystroke velocity than
when pianists try to imitate those same improvisations.

What is important about this study is that the comparison between improvisation and
imitation shows musicians trying to recreate a musical excerpt, but being unable to imitate
certain aspects of it—namely, the key stroke velocities. It could be that they were unable to
detect the subtle variations, and instead focussed on the other, more perceptible aspects like
the pitch classes. An important control would thus be having pianists imitate rehearsed
performances. It may be that imitated performances in general have smaller variance in
keystroke velocity, not that improvisations have greater variance than imitations.

Nevertheless, there is an important idea motivating this study that should persist
through other studies. That is, the cognitive processes underlying improvisatory performance
lead to differences in structural features compared with rehearsed performance by virtue of
differences in the motor processes that underlie them. Couching these differences in terms of
specific neural systems can make them more accessible to experimental manipulation. For
instance, how is improvisation differently susceptible to certain kinds of disruption? This
approach is developed in the following chapters.

Further, an experimental approach could be further developed from this literature by
manipulating performances to test which musical parameters are necessary to be correctly
identified as improvisatory. This could generate more precise hypotheses about processes
underlying the production of improvisatory music. This could help answer questions such as
how one is able to play a rehearsed piece in an improvisatory manner—what features make it
that way, and what cognitive mechanisms would be necessary to execute the production of
those features?

**Developmental psychology**

There is a small set of developmental studies focussing on musical improvisation (see
Ashley (2009) for a review). These studies are concerned with how improvisatory abilities
develop with age. Paananen (2007) analysed improvisations of children of varying ages to
detect changing musical abilities. Brophy (2005) similarly traced the development of certain
musical abilities such as adhering to a pulse and the ability to use recurrent musical motives.
In a study by Guilbault (2004), children improvised with an accompaniment to see if they
were sensitive to its harmonic changes. Kiehn (2003) applied creativity tests including
Vaughan’s (1971) and Torrance’s (1974) to compare creative abilities including improvisation as well as figural drawing.

These studies track musical cognitive mechanisms as they develop and identify at what age they are employed by children whilst improvising. As well as commenting on how the activity of improvisation may use these mechanisms, these studies suggest when and how more general musical capacities develop, such as representations of pitch and rhythm. They are important in demonstrating that improvisation changes with the development of other musical capacities. As musical cognitive capacities develop, improvisations change and can thus be used as a litmus test for the presence of these capacities. Testing rehearsed performance might have more difficulty in identifying online sensitivity to these musical features.

The value of this approach, then, seems to be located more in understanding the development of these other musical capacities and not on how it is that people improvise. The studies are experimental and compare improvisations under different conditions, but the theories are set up in such a way that the findings are not able to comment on what improvisation is as a performance mode distinct from other modes of performance. Instead, they use improvisation to comment on other capacities. As far as improvisation is concerned, children are able to ‘improvise’ with and without these other capacities (with varying coherence and skill, to be sure)—so whether the presence of these other capacities is necessary for improvisation, or somehow characterises it, is a question left to be answered.

Summary of pros and cons

The existing empirical and experimental literature on the cognition of musical improvisation is by no means unified in approach and is not clearly converging on an accurate and stable explanation of the phenomenon. In this way, specific experimental findings do not naturally suggest a coherent theoretical approach that could generate logical choices for further experiments. Instead, what can be taken from this literature are the best parts of each approach. A new theoretical approach can be forged with these and with theoretical motivations in cognitive science from outside the literature on improvisation.

From the cognitive music-analytical studies, we can keep the idea that analysis (of the right sort) can help infer performer’s process. However, these studies could benefit from having experimentally controlled conditions under which musicians perform. By changing various aspects of the performance task, differences observed through music analysis could
be attributed to differences in process. By analysing improvisations produced outside of the laboratory, it is difficult to make definitive statements about process as discussed above. Analytical techniques such as pitch class distributions, Markov models, entropy, and others used in the studies cited above could still be used, but so, too, could more implicit measures that are less to do with score-based analysis and more to do with features present in performance (such as fluctuations in timing)—that is, the second kind of structures identified in the previous chapter. The listening literature carries this motivation—there may be features of improvisation which are not present in the score that could be important for identifying the processes that led to the production of those cues.

From the neuroscience literature can be taken an appreciation of trying to differentiate between process in terms other than formal analytical ones. There are other correlates of process besides what notes are produced. With functional imaging, one can find neural correlates, but more abstract cognitive correlates could also be described through experimentation. However, one must stay sensitive to the multiple possible processes often equivocated as ‘improvisation’ and also be more discerning in an operationalisation that is not circular or overly reliant on the idea of novelty when improvisation clearly requires extensive training, knowledge, and experience.

The phenomenological literature offers insight into more appropriate questions to ask, although self-report methods alone cannot always answer them reliably. Developing an experimentally tractable theory about improvisation is a task served well by such insights and may, indeed, require them.

The following chapter synthesises these approaches and brings in alternative perspectives from other literatures in cognitive science in order to develop an ecologically valid, experimentally tractable set of questions about how improvisation can be defined and distinguished from other modes of performance, and indeed how different modes of improvisation can be distinguished from each other. Experiments within this new paradigm are then presented in the subsequent two chapters.
Chapter 5: A New Cognitive Approach

Chapter 2 justified and situated a cognitive-scientific approach within ethnomusicological, historical, and critical discourses on improvisation and chapter 3 argued to move away from music-analytical conceptions of improvisation and instead focus the question on different processes of music making. The existing cognitive-scientific literature on improvisation reviewed in chapter 4 could benefit from a more coherent theoretical motivation that is sensitive to the issues raised in the second and third chapters in order to form a better operational definition of improvisation. In other words, what questions might be asked to differentiate improvisation as a process, and how might such cognitive-scientific questions be generated? This chapter provides this theoretical context and proposes lines of experimental research that follow from it. It introduces a strategy to study improvisation scientifically with theoretical justifications that are properly sensitive to the tensions highlighted in previous chapters. It provides general hypotheses and suggests specific experimental directions. Experimental work that supports these theories is presented in the following two chapters.

Towards a cognitive-scientific approach

Consider a jazz pianist improvising a solo. The pianist creates an audio recording of the improvisation and later transcribes it and memorises it, learning to recreate the notes and as many aspects of the expression as possible with meticulous detail. The memorised performance is as close as possible to the improvisation and in terms of traditional forms of music analysis that examine the formal structures that constitute the music, it is identical. But, intuitively, despite the ambiguity of the terms ‘improvisation’ and ‘memorised performance’, something about the processes underlying these two performances is different. Some other kind of analysis motivated by a different theory would be needed to distinguish between these processes.

This is a central motivating question for a cognitive theory. How can these different processes be typified and characterised? Importantly, the focus here is truly on the question of process. Looking at notes alone, as demonstrated in chapter 3, and as highlighted by the
thought experiment presented here, can equivocate multiple possible processes of their production.

This thought experiment highlights two kinds of performances (memorised and improvised), but, indeed, improvisation should not in itself be considered as a single kind of performance process (nor should memorised performance for that matter). Many different ways of making music may be grouped into an overarching term like ‘improvisation’, which itself risks equivocating different kinds of processes—processes that are only categorised by virtue of a cultural distinction between music played with and without orthographic (or otherwise recorded) mediation or based on particular music-theoretical distinctions (as those considered in chapter 3). Many kinds of improvisation may have their own characteristic processes.

Individual musicians may have multiple processes that they employ at different times, and different musicians may have generally preferred or emphasised processes resulting from differences in their pedagogies and experiences (i.e., a classical pianist may be more familiar with playing from memory or sight reading whereas a jazz pianist might be more familiar with various kinds of improvisation). Cognitive science could try to recategorise these various kinds of performance processes, but given the variety of process employed by musicians both within and between musical traditions, can it be claimed that there is anything in common between the processes of individual musicians (or, for that matter, between two performances of the same musician)? That is, is there any point in trying to characterise a type of performance process by whatever criteria if every musician is actually doing something different?

Again, this project is a constructive enterprise. This new cognitive-scientific approach is constructing a way to draw similarities; that is what it means to create a theory. Of course it can be challenged with anomalous observations, but the scientific approach would embrace such challenges as opportunities to refine the theory. So, yes, it is possible, but needs to be refined as it goes.

A cognitive-scientific approach would look for trends between performances in whatever ways it could. It could predict certain behavioural differences and neural differences (anatomical or physiological). Within each of these approaches, many different possible research questions could be asked about the differences, but all would serve the same research strategy of distinguishing between different kinds of performance and their
underlying processes. By examining multiple instances of music making, such observations could contribute to delineating trends in performance and help to construct a cognitive typology.

Until these supposed trends are observed, and because traditional distinctions between memorised and improvised performance are being challenged here, it is perhaps better to avoid discussing ‘improvisation’, ‘memorised performance’, or score-based performance and instead use the superordinate term, ‘modes of performance’, to distinguish between different processes. This allows for new distinctions to be made that do not necessarily align with traditional concepts. It could also allow for experimentally contrived modes of performance that could be designed to elucidate differences in perception and cognition even if they are not adopted naturally by performing musicians outside the laboratory. From here on, this term is employed, although occasionally the more traditional terms are used, particularly when describing experimental tasks to participants. Terms like ‘improvised’ and ‘memorised’ have enough meaning to facilitate an experiment; the ultimate goal, however, is to create a new taxonomy of modes of performance based on cognitive scientific principles. That being said, some of these modes of performance may roughly align with previous senses of the term ‘improvisation’ (that is, they point to the many of the behaviours that are now known as improvisatory) and thus one can still reasonably discuss this research agenda as being about the cognition of improvisation.

Considering the question in terms of modes of performance helps the cognitive theory to be comparative across different musical traditions. For Western music it will help clarify differences between rehearsed performance and improvisation, but other musical traditions that do not typically make such a distinction may have different modes of performance as well (e.g., different ways of improvising, of creating music). Such modes may still have commonalities with modes from other cultural contexts in cognitive terms allowing for cross-cultural comparisons to be made. Perhaps the culturally described distinctions between ways of making music are different, but underlying cognitive principles may be similar.

An important consideration is that the motivation for this question is primarily from a desire to characterise process. Improvisation, whatever it is and however it works, exists as a concept in order to make a distinction in process. As noted in previous chapters, there are, of course, auxiliary questions concerning the products which the process of improvisation creates such as the nature of the structural characteristics of music produced in an improvisatory manner—but these questions are inseparable and always concomitant to the
central question of process; they are a means of characterising the process, not an end in themselves. A cognitive theory can still use structures (observed through specific kinds of analysis) to characterise process. In this way, the structures that are observed are of the second type discussed in chapter 3; that is, one of the tasks will be to design a kind of analysis and identify particular structural features that could imply something about the underlying cognitive processes of different performances (using a cognitive ‘theory of music’—see chapter 2).

Cognitive science is well equipped to describe thought processes. At the level of the musical structures being produced, different modes of performance could be equivocated, but cognitive science could examine everything that happened before those structures were produced (moving back through the muscle movements, sensory feedback from the movements, different kinds of motor activity in the brain, etc.). Through experimentation, the mechanics of these processes can be examined. Such mechanics could be different for different modes of performance, and the theoretical and experimental work of this dissertation provides and tests hypotheses to begin to characterise such differences.

It is largely about different ways of moving, but this approach should also take into account differences in the cognitive representations of musical structures that arise through different kinds of musical training and experiences. Musicians with experience in different modes of performance may perceive music differently. The way musical knowledge is recalled and employed in performance would depend in some part on how it is represented in the mind. Both those with experience improvising and those without often know about similar structures if they play in similar styles (e.g., a C major chord), but this knowledge could be represented differently depending on how it is used or how it was learned. If there are differences in the cognitive representations of these structures between musicians who improvise and those who do not, that would be a contribution to a characterisation of different ways of knowing. One could then postulate a theory as to why these different ways of knowing might facilitate certain modes of performance.

Thus, cognitive science is well suited to describe differences in process through considering the related questions of different ways of moving and different ways of representing musical knowledge, and is capable of defining different modes of performance based on these principles. It can base its explanations on models, biological observations, neuroscientific observations, developmental observations, and behavioural observations,
(making it flexible and able to have consilience with other forms of scientific knowledge as discussed in chapter 2).

As discussed in the previous chapter, similar research has been carried out in the neuroscientific domain. Memorised and improvised performances have been compared, and structural differences between the brains of different kinds of musicians have been compared. The main difference here is that the explanations will not be couched in terms of novelty and free generation, concepts which risk the pitfalls outlined in chapter 3 about characterising the improviser as the pseudorandom note generator. Some other kind of theory is necessary to describe how modes of performance and their associated kinds of perception might differ. The task from here is to describe this new theoretical approach. How can distinctions be made? Where would one look for this?

**Different ways of knowing**

Where to begin in this characterisation? What might be different between modes of performance? A first principle is that improvisation requires prior knowledge. Although improvisation is typically considered to be the realm of the new, innovative, and free, it is illogical to claim that improvisers do not employ some kind of prior knowledge. The ethnomusicological, music-analytical, and previous cognitive literatures generally agree on this matter, although they might differ in what is considered to be ‘knowledge’ (mental representations, musical forms, bodily and instrumental structure, cultural understanding, etc.). One perspective on improvisation that would discount the role of prior knowledge would be to limit a definition to only those moments when something truly novel is created in such a way that prior knowledge is not utilised. Incidentally, this would exclude a large part of the behaviours typically called improvisatory, but it is a perspective worth considering on the pursuit towards defining improvisation. There are two possibilities that arise from this conception, neither of which require delving into definitions of ‘novelty’. Either there are true instances of novelty that are free from prior knowledge, or there are instances of novelty but they can be described through performance processes that do employ prior knowledge. If the former is true, nothing can be said about such a discontinuity; such a process could not be described, although the product could be analysed in relation to prior music or actions. If the latter is true, then improvisation can still be understood in terms of some kind of prior knowledge, or at least prior conditions that led to such novel music making. So, in any case, it can reasonably be claimed that improvising requires some kind of
prior knowledge and can at least partly be understood in terms of the condition and state of the performers. If not, it is simply not within the purview of a description of the performer’s process. Since questions about improvisation are questions about process, it would be outside the purview of this kind of inquiry.

Prior knowledge arises through musical training and experience, broadly conceived. It includes music-theoretical knowledge, perceptual changes (that is, musicians learn to perceive music differently than non-musicians), the acquisition of motor programmes, the acquisition of musical expectations, and many other things. Musicians who claim not to improvise and those who do may have very similar exposure to these acquired musical movements and sounds. Both groups might play the same instruments, have similarly shaped bodies (hands, fingers, arms), have minds governed by similar cognitive architectures (most people have motor cortices), and share much of their cultural understanding. Because of this similarity, from certain perspectives, it can be very difficult to differentiate between memorised and improvised performance. Even when playing from memory, musicians may be using a very similar musical understanding. Consider, for instance, a classical pianist playing a piece by Nikolai Kapustin—a fully written-out etude in a bebop style. They might make a mistake whilst playing, but not just any mistake; perhaps they might play a chord in the wrong inversion, but not a random chord. In other words, a performer playing from memory still has some musical expectations in the style. A jazz player may also understand the bebop style, but is also able to improvise in that style. What is different about their understanding of the music that allows only one to improvise?

It could be many things. Perhaps the improviser has stronger expectations of the style. Perhaps it requires a more explicit understanding of the function of each of the harmonies corresponding to a greater ability to transpose readily. The next section will theorise about what might be different and why, but for here, the point is that all trained musicians have prior knowledge of music by virtue of their training, but the way they understand music is different, and something about that way can be used to describe how musicians employ musical knowledge in performance and perceive music. In other words, there is some cognitive difference, and understanding this difference can help characterise improvisation.
Knowing in an improvisatory way

So, specifically, how can these different ways of moving, these different ways of knowing how to move, and these different kinds of representations of musical structures be characterised cognitively and made observable through experimentation? What would be different and how would that explain the ability to utilise different modes of performance? There is not a stable foundation in the music psychology literature to begin exploring this question. There is writing on general principles of how the brain uses auditory-motor interactions to perform music (Zatorre, Chen, & Penhune, 2007), but this literature does not differentiate between ways of playing music. There is research on jazz pedagogy that assesses predictor variables of jazz improvisation success (see Watson, 2010 for a review) but these studies do not provide explicit and well-developed cognitive theories that might explain these effects. There are some phenomenological accounts of jazz pedagogies as will be discussed below. The point of mentioning this sparseness is to emphasise that starting this research programme will necessarily be somewhat speculative, even if it is theoretically rigorous, as there is no coherent research programme with a solid theoretical justification that already exists.

One promising place to begin is to consider pedagogies of improvisation. If there are many different types of musicians with different skill sets, those differences may be attributable to differences in the way they learn to play music. How do jazz players learn to improvise and what kinds of skills do they emphasise in their training? How does this differ from classical players? One recurrent notion that is common in jazz piano pedagogies and also emphasised in some of the ethnomusicological literature reviewed in chapter 2 is imitation. Musicians learn to fluently transduce auditory perceptions into movements to repeat back what they heard. This imitation is not usually mediated by musical notation. Sometimes these practices are referred to as ‘playing by ear’—a skill often ascribed to improvisers, or at least those with improvisatory abilities. One aspect of practicing imitation may be to notate a passage of music (transcription), but the music is not learned through this notation first; rather, it is the other way around and the notation is a means of demonstrating that the music is accurately heard. For jazz pedagogies, this often involves choosing a solo on a recording and learning to reproduce all of the sounds of that solo, including notes and expressive parameters. The goal is to embody the recorded performer as much and in as many ways as possible and to sound as much like the recording as possible. Madura (1996) found that imitative ability is a predictor of achievement as an improviser (amongst other
factors). May (2003) found that aural imitative ability was the second strongest predictor of jazz achievement in her model (although practicing self-evaluation was by far the strongest predictor).

By contrast, Western classical musicians do not commonly learn to play by ear—it would be uncommon for a pianist to learn a Beethoven sonata solely by ear, and only transcribe it for ear-training practice, although some young pianists do start off learning by rote. The score would be a primary mediator of the transmission of the music. Classical musicians may listen to recordings and imitate masters, but they use the written sheet music as well in such a way that they only learn to imitate the expression of the masters, and not imitate their harmonies or melodic lines—that would not make sense as the harmonies and melodies are considered to be determined by a third party (i.e., the composer). Hence, jazz players are imitating in a different and perhaps more complete sense. Of course there are different skills that arise from these different methods. Being able to skillfully transduce a written score into a musical performance requires its own kind of fluency that someone who has developed their ear in a different way may not automatically possess.

Shim (2007) has documented the pedagogical methods of the jazz pianist Lennie Tristano which describe imitative practices from a performance perspective. Shim recalls, “[Tristano] taught students to connect the aural training based on feeling with an ability to play the instrument, so that they could play what they were hearing, and hear what they were playing.” (p. 124). She goes on to describe particular techniques to achieve this aim:

Tristano recommended singing improvised solos along with records, which helped students internalize the feeling involved in them and assimilate the musical language and expression. He also devised exercises to combine students’ ability to hear their melodies with proficiency on the instrument, ensuring an immediate transmission from the musical conception to its physical realization. (p. 124)

For learning solos, for instance, Tristano advocated first learning by ear and then singing along with the record, then singing without the record, and finally playing the solo on an instrument with or without the record. Tristano’s pedagogy makes the explicit connection to imagery. Finally, to sum up this idea, Shim recalls that “Tristano often stressed the connection between the senses, such as hearing, feeling, and seeing, which would enable students to experience the musical process as a whole” (p. 157). This account connects a common pedagogical practice in improvisation with ideas of mental imagery.

Jago (in press) also discusses Tristano’s pedagogy. Her discussion of the skills Tristano advocated suggests that the pedagogue wished for his students to have a kind of
abstract understanding of musical forms rather than one that relied on a specific instrumental implementation. This would allow for a ready transduction into a particular instrumental or musical context given the organization of the knowledge.

In jazz, another common skill is to practice transposition. Musicians will learn standard chord progressions in all keys, and learn to solo over them in all keys. Having an unequal knowledge of the keys would be a kind of weakness—something to be improved through practice. A kind of invariant understanding arises from knowing the chord progression in all keys rather than a small group of keys—it is a different way of knowing a chord progression. One can come to understand a musical idea/relationship rather than a specific implementation of it in one key. A pedagogical method like Haerle (1978) which emphasises learning licks and chord progressions in all keys demonstrates this approach, as does one like Aebersold’s (2009) Play-A-Long series of backing tracks which allow students to play along over standard chord progressions in different keys. By contrast, classical musicians may practice their scales in all keys, and perhaps some elementary chord progressions, but it would certainly be atypical to learn a Beethoven sonata by transposing it to all keys. This is not typically considered to be a necessary aspect of learning the piece. Part of the definition of a piece in the classical tradition is its key—it is a formal structure, part of the work concept. In terms of a performer’s knowledge of the piece, they are usually not concerned with an invariant understanding of the harmony—they are perhaps (though not necessarily or always) interested in being able to identify harmonic structures, but usually only insofar as they might affect technical execution and musical interpretation (e.g., thinking “I ought to emphasise the dominant here”). These kinds of considerations are usually a high-level skill employed by experts or those with a lot of experience. This is a different kind of understanding to a jazz player’s pedagogical harmonic goals. Similar ideas of invariance through transposition can be seen in the historical treatises discussed in chapter 2 which advocate the acquisition of stock figures and cadences in all keys to be able to combine them to form cadenzas or preludes.

Outside of pedagogy, another very valuable source of observations about how modes of performance might be differentiated is a phenomenological, auto-ethnographic account of David Sudnow’s venture to learn to be a jazz pianist entitled “Ways of the Hand”. Sudnow (1978) documents his thought processes and strategies as he gradually acquires the skill to improvise in a jazz idiom. As Sudnow transitions from “beginnings” to “going for the sounds” to ultimately “going for the jazz” (as he titles his book sections), he describes how
his hands gradually acquire the ability to sing, to connect an understanding of the jazz language and idioms with the immediate ability to fluently instantiate those ideas at the instrument. Sudnow subsequently created a pedagogical method for adult beginners which similarly emphasises learning the way chords, scales, and licks feel (Sudnow, 2010). His method uses a pictorial ‘action notation’ (in Cole’s (1974) sense of the term) which Sudnow calls ‘dot notation’. Each image illustrates a keyboard with dots on the keys indicating the notes to play. Students read a particular realisation of a jazz standard with this dot notation with the aim of gradually acquiring knowledge of the feel of the shapes of chords and licks.

A final observation is one arising from a previous experiment I performed (Goldman, 2013). In this experiment, jazz pianists had to improvise over a familiar chord progression in a familiar key (B♭ major) and an unfamiliar key (B major). Sometimes they played with their right hands alone, and sometimes with their left hands. The idea was to get them to use different strategies to improvise and measure the structural correlates of each strategy. In the unfamiliar key, participants stuck more to diatonic pitch-classes and played with less pitch-class variation (as measured by 0\textsuperscript{th} and 1\textsuperscript{st} degree entropy), suggesting with the lack of familiar motor patterns, participants played more ‘safe’ notes and stuck to more explicit rules for their improvisations. As it pertains to this discussion, some of the comments made by the participants about playing in this unfamiliar key are important. One participant recounted the difference:

In the right hand you’re doing things because you can hear the notes and you play them. Whereas in the left hand, it’s almost like you’re trying to follow the rules of how to jazz improvise. Like, these are the chord tones, and this is how I’m going to work around them. Whereas when you’re improvising with the right hand, you’re just thinking, well this is how this, you hear notes, and you play them.

Again, this connection between hearing and playing is emphasised. In this experiment, it was temporarily made unavailable by the task conditions forcing the employment of a different mode of performance.

What do all of these observations have in common? They all emphasise the role of connecting auditory perception with the motor system. Improvisers often learn to connect their ‘ear’ with their effectors (arms, fingers) and their instruments. It is explicitly emphasised and practiced. Jazz players often aim to expand this fluidity to all keys to avoid potential weaknesses and heterogeneity in their harmonic knowledge. These kinds of skills can be examined using cognitive science. Are they present in musicians who learn by traditional Western Art Music pedagogies, for instance? Such cognitive differences may
underlie musicians’ ability to improvise. This kind of understanding of musical structures might be what it means to be able to improvise, or at least it may help characterise certain modes of performance.

This is not to say that those who learn music in the traditional Western Classical Canon style cannot play or learn to play in such a manner that similarly emphasises this connection between sound and movement. Indeed, discourses in this tradition often emphasise playing highly rehearsed music ‘as though it were improvised’. This theory of the connection between sight and sound is a potential explanation for this phenomenon—music that is played as though it is improvised has a motor planning process and audio-motor association similar to that typically found in improvisatory traditions.

This point re-emphasises the notion that the goal of the present study is not simply to define improvisation, but rather to identify characteristics of musical performance typically considered ‘improvisatory’ in order to arrive at a cognitive taxonomy of modes of musical performance. While perhaps less common, a classical performer might learn to play in a similar way to the jazz students as described above. In that case, they would have a particular way of knowing about music that might align with the jazz players’ knowledge, and perhaps their skill sets would be similar as well. Cognitive modes of performance do not necessarily align with traditional boundaries between improvised and memorised performance contexts. Performers can play in different modes at different times, and may have generally preferred modes based on differences in their training and experiences.

Such observations about sensory-motor associations may be an important step in characterising different modes of performance, and can lead to experimentally tractable questions, but it should be emphasised that this is one of potentially many other methods. The strategy of comparing modes of performance based on differences in experiences, pedagogies, and performance contexts with an appeal to cognitive scientific methods as a way of defining what improvisation is (that is, to delineate modes of performance) could be retained even if other ways of drawing distinctions were proposed. Sensory-motor associations seem to be prevalent and important to this process, but it is of course not the only way to proceed.
A few alternative approaches: Types of knowledge, global states, and embodied cognition

Before searching for a scientific basis of such characteristic sensory-motor associations, two other possible ways to establish differences between modes of performance are raised here as alternatives that are not directly taken in this particular project. Some preliminary remarks on their effectiveness are offered, but other research projects could explore their viability within the general research strategy proposed here.

The first is that the question could be framed as one of employing different kinds of memory (procedural, declarative) in different modes. This is a similar question in some regards and different in others. It is similar in that it seeks to differentiate different ways of producing the same musical structures because those structures might be recalled from different kinds of memory, or by using knowledge with different kinds of cognitive representations. It is different, however, because it is less able to draw a meaningful distinction between modes of performance.

Improvisers may learn procedural knowledge when they practice the same movements repeatedly. This is sometimes called ‘muscle memory’ and might result in playing stereotypical licks. Performers might sometimes use something more akin to declarative memory; that is, they may consciously manipulate certain musical structures to generate new ones such as by deciding to try to invert a melodic line or play a passage using only the interval of a fourth (or some other explicit rule). These different kinds of memory would have different cognitive correlates (Cohen & Squire, 1980). In this way, a cognitive theory of modes of performance could focus on the issue from this perspective.

There is a strong similarity between the modes of performance described here and the idea that improvisers employ different kinds of memory during improvisation. These kinds of memory, though, are not particularly well defined in this situation. Declarative memory is not divorced from procedural memory—surely they interact somehow. For instance, Pressing (1998) writes that “[d]eclarative knowledge (facts) about procedures are folded in with direct procedural knowledge, as part of the process of constructing useful generalised motor programs” (p. 53) This language is very ambiguous. What does it mean to be ‘folded’ in? The theoretical motivation is very similar—that is, to differentiate types of knowledge—but these particular terms are too ambiguous. Pressing is right to suggest that different types of memory are intertwined, but they are probably intertwined for all of the kinds of modes of
performance suggested above. Developmentally speaking, all musicians learn procedural and declarative knowledge, and it could be said to be intertwined for all performance. Playing from memory versus improvising, or improvising in different ways, probably could all be said to use these different kinds of memory. In this way, such terms might be used to describe the different modes, but it would have a hard time differentiating them.

A second alternative is to characterise differences in a global brain state. This would be something like Csíkszentmihályi’s (1996) theory of flow and its neural correlates (Dietrich, 2004b). Sometimes flow is invoked to characterise improvisation (Campbell, 2009; Turino, 2009). This would be a description of more general brain and mind states and are not a specific kind of knowledge.

Again, this is a plausible alternative to the sensory-motor differences I will go on to advocate as a method of delineating modes of performance. My only hesitation is that it is likely to be the case that all performers can enter into these states. It still describes a difference in a way of performing, which has a similar overall perspective as what I advocate (i.e., playing with or without flow could constitute a distinction between types of musical performance), but there is nothing in the theoretical formulation of these states that would help describe the kinds of apparent differences between what people call improvisation and what people call memorised performance, or different kinds of improvisation for that matter.

A third alternative is to consider the embodied cognition literature. Sensory-motor associations and their cognitive foundations could be interpreted in light of recent research in embodied cognition. There is no objection here to contextualising the ideas presented in this dissertation within such theories, but whether or not they are interpreted as an issue of embodied cognition is a philosophical question that is not meant to be addressed directly. Despite many cognitive scientists turning to embodied cognition theories to guide their research, Shapiro (2011) notes that much of the research that supposedly supports such theories does not necessarily speak to the philosophical claims of embodiment. In other words, it is possible to do this present research on improvisation without immediately taking a philosophical position on whether or not it is necessary for the mind to be embodied.

Cognitive-scientific theoretical foundations

The observations about sensory-motor associations made above from pedagogies, ethnographies, ethnomusicology, and experiments about the role of connecting hearing and movement in improvisation can be brought into cognitive-scientific frameworks. If
improvisation is a process or several different processes (modes of performance), how do these improvisers plan their movements, process their movements, and represent their movements? How do they acquire differences in their representations of musical structures from players who learn by pedagogies that emphasise playing from memory or from the score? How could such representations be characterised? These questions can be brought into the theoretical frameworks of cognitive science by considering them as issues of mental imagery, motor planning, and sensory-motor representations. These cognitive-scientific frameworks are well suited to comment on these observations and are very promising as ways of bringing questions about improvisation into the scientific domain. The following section reviews these theories in general. Then, several hypotheses specific to improvisation are generated from them. Following this and before beginning to test these hypotheses in the following chapters, the lens is broadened again to show how these questions could be expanded from an initial formulation about jazz to a wider consideration of modes of performance in other musical traditions.

**Mental Imagery**

Understanding how mental imagery is approached in cognitive science is an important source of background and first step to translate these observations about improvisation into cognitive-scientific research questions. An account by Schneider & Godøy (2001) traces how the nature of mental imagery has been an important question in psychology since Ancient Greece. Of course, the meaning of the concept of ‘imagery’ has changed along with developments in the philosophy of mind from more general questions of memory and knowledge to more specific phenomenon as it is understood today. Cognitive science has inherited these questions about imagery and its relation to knowledge, perception, and behaviour. Cognitive-scientific theories typically consider sensory imagery to be a sensation that is generated endogenously in the absence of an external stimulus. This could be both in the sense of conscious and deliberate imagination as well as implicit simulation of the perception of external stimuli. Cognitive-scientific theories and experiments try to explain how these internally generated images are represented, encoded, and processed in the brain and body and what role they play in reasoning and planning movements.

A “notoriously irreconcilable” debate, as described by Thomas (2011), played out about the cognitive science of mental imagery. In Thomas’s summary, one side is led by Zenon Pylyshyn and the other by Stephen Kosslyn. Both scientists admit that images have a
phenomenological experience—we can see an apple if we close our eyes and think—but their representational nature is disputed. Pylyshyn (2002) suggests that images are the result of knowledge of propositions, a special kind of implicit mind-language that links together concepts and properties. Images could be generated from these propositions as could verbal utterances. To remember that an apple is red is to have some coded link between the concept apple and the property red. The phenomenological experience of an image is the result of knowing these propositions. The other side, led by Kosslyn (1994), states that images are a primary kind of knowledge that are depictive and quasi-pictorial in nature. To know that an apple is red could result from imagining an apple and ‘seeing’ that it is red. We can inspect mental images to recall information and reason. Alternatively, Paivio (1986) suggests a dual coding approach in which verbal knowledge and pictorial-image type knowledge both have their own coding in the brain that can be translated from one form to another.

With the advent of neuroimaging, Kosslyn declared an end to the debate. Brain areas used for perception are similar to those used for imagery, suggesting the pictorial view is likely to be correct. While there are still alternative explanations for this from the propositional camp, e.g. Pylyshyn (2002), research on auditory, motor, and musical imagery endeavours to support the pictorial view. This research paradigm is framed by several principles of pictorial imagery, summarised by Finke (1989).

This discussion, as many topics have been in cognitive science, is based on reasoning about the visual system. In recent years, however, these questions have expanded to other sensory modalities. Research in music cognition has examined the dynamics of auditory imagery. Auditory imagery studies demonstrate that the experience of imagining melodies or single tones involves similar neural processing as that which results from external stimulus. Halpern (2003) adapted visual imagery paradigms and sought to force subjects to rely on a depictive representation of an auditory image of a song to accomplish the experimental task. According to her study, areas of auditory cortex involved in perception of external stimuli are also involved in imagery. Herholz, Lappe, Knief, & Pantev (2008) conducted an MEG study demonstrating mismatch negativity involved when subjects heard part of a melody, continued it with imagery alone, and then were presented with a note that was either correct or incorrect. If it was incorrect, there was an associated signal showing that imagery alone can produce mismatch negativity effects. Janata (2001) reviews EEG methods used in studying musical imagery. Zatorre, Halpern, & Bouffard (2009), following research on the transformation of visual mental images (e.g., Finke, Pinker, & Farah, 1989), conducted a
study in which subjects were meant to imagine a melody backwards and implicated parts of the parietal cortex involved in classic mental rotation experiments from the visual imagery literature.

While these studies demonstrate some general principles of auditory imagery and provide analogous evidence for pictorial theories of mental imagery, they are unable to comment much on musical imagery. Auditory cognition is certainly part of musical cognition as music involves sound, but music is not just about sound. Music has other sensory correlates such as visualisation, but more importantly, music making requires movement. Music perception also involves movement simulation (Novembre & Keller, 2014). While the ability to generate and manipulate auditory images is key to music making, a theory of musical perception or cognition cannot be complete without a consideration of how various forms of sensory imagery may be related, and how these imagery abilities relate to movement. Imagining music, particularly if you are a musician, may very well involve motor images as well as sensory ones.

In fact, motor imagery research has similarly been developed adapting theoretical conceptions from sensory literature. Jeannerod (1994) and Jeannerod and Decety (1995) reviewed the motor imagery literature and outline its experimental paradigms, helping to establish its centrality in modern considerations of imagery. Drawing an analogy to visual imagery, they suggest that the brain can simulate motor behaviours without executing the resulting action by generating an activation pattern similar to that of an actual movement. They are careful to distinguish between external motor imagery (imaging watching oneself performing an action) and internal motor imagery (imaging actually performing the action). This movement code in the brain is then inhibited so muscles do not actually execute the movement (Lotze, Montoya, Erb, & Hülsmann, 1999) suggests this inhibition involves the cerebellum). They suggest that motor imagery uses the same neural mechanisms as motor preparation, which occurs before all actual skeletal muscle movements are made. Imagery makes this preparation conscious and sustains it. They also show that this motor simulation can affect autonomic functioning as well, increasing heart rate and respiration when participants imagine certain movements. Lotze & Halsband (2006) reviews data from patients with altered body representations due to limb amputation or other injury.

Several other researchers have discussed various methods of measuring motor imagery. McAvinue & Robertson (2008) review methods for assessing motor imagery including questionnaires which determine the vividness of imagery. They also summarise
mental chronometry studies (which measure how long it takes to imagine doing something, as discussed above). Munzert, Lorey, & Zentgraf (2009) discuss different motor areas of the brain implicated in motor imagery.

One question that arises about these different kinds of imagery is how motor and sensory images relate. This is particularly relevant for music cognition. Can a musician imagine a musical sound without imagining the movement that made it? Can a musician think of a movement at an instrument without also imagining the sound? The kind of imagery described in many of these studies is quite slow—it is about sustaining images in one’s mind for relatively long periods of time. Another kind of imagery, or perhaps slightly differently construed as the activation of a representation of a sensory object or motor plan, is much faster. It involves the automatic activation of these representations in the course of making movements or perceiving stimuli. The relationship between these representations is described by common-coding theories and takes the discussion into a question of the automatic generation of sensory images through the act of planning and executing movements, and conversely the activation of motor images through the perception of exogenous sensory stimuli.

**Common-coding theories**

A second major theoretical area in cognitive science that is relevant to this project is work on common-coding theories. These theories are able to make a connection between the motor and sensory imagery issues raised above. These theories come in a few different forms, but emphasise the same core ideas. Prinz’s (1997) seminal paper proposes a common-coding approach to perception and action which contends that “perceived events and planned actions share a common representational domain” (p. 129). The mechanisms that cognitively represent planned actions are commensurate with those that represent perceptual events and do not need a translation mechanism as past models have suggested which advocate separate kinds of coding for perception and action.

This core contention and these conclusions have been elaborated in other theories. Shin, Proctor, & Capaldi (2010) review studies supporting ideomotor theory, which asserts that “actions are represented by their perceivable effects. Thus, any activation of the effect image, either endogenously or exogenously, will trigger the corresponding action” (p. 943). Hommel, Müßeler, Aschersleben, & Prinz (2001) describe a Theory of Event Coding which “proposes as its core contention that codes of perceived events and planned actions share a
common representational domain, to the effect that perceptual codes and action codes may prime each other on the basis of their overlap in this domain” (p. 850). Hesslow (2012) reviews work on simulation theory which is described in three parts: behaviour can be simulated without actual movement execution, perception can be simulated endogenously with brain areas that are also used for the perception of external stimuli, and, importantly, anticipation of perceptual consequences of actions can thus be simulated.

These theories have experimental paradigms which can clearly test its hypotheses. Sensory stimuli can prime or interfere with action planning leading to traceable behavioural characteristics such as reaction times or error rates in a particular experimental task. Experimental support from these theories comes from literature concerning movement in general and motor theories of perception in speech. In this way, much of the research on these effects is quite general in nature, implying that it is a general principle of human cognition. The tasks in the experiments, which often involve measuring reaction times of key presses, do not often require expertise.

Music is one kind of behaviour that has been tested with these theories that goes beyond general observations about movement. Studies on instrumental music have been prominent in this literature as it is a clear kind of sensory-motor association when someone plays an instrument. These musical studies are special in that they allow researchers to test for effects of expertise by comparing action-effect couplings in musicians and ‘non-musicians’. Although many people listen to music, not everyone knows how to play the instruments that make the sounds and therefore may not have the perceptual-motor links that musicians possess. Playing a musical instrument is also a highly skilled behaviour that involves associations between particular movements and particular sounds, an excellent candidate for common-coding studies.

Drost, Rieger, Brass, Gunter, & Prinz (2005) investigated action coupling in pianists and non-musicians. Pianists learn associations between certain key presses at the piano and particular sounds. The experimenters manipulated the feedback and were able to induce significantly more errors for pianists than non-musicians based on disruptions of the acquired ideomotor association between movement and sound. In a further study, Drost, Rieger, & Prinz (2007) tested the effect of timbre on these effects. Pianists and guitarists listened to stimuli of major and minor chords with different timbres and had to judge whether they were congruent with a visual stimulus of a chord. When the timbre of the aural stimulus matched
the instrument the participant played, more errors were induced. Further, pianists were also sensitive to other keyboard instruments (like organ), not just piano.

Keller & Koch (2008) performed an experiment with a similar motivation. They tested and found that the contour of a short melodic fragment could induce similar kinds of errors for musicians more than non-musicians, suggesting that these short gestural units may be coded as single actions that are susceptible to ideomotor interference from the sound of fragments with different contours.

Baker (2001) suggests that, especially for keyboard players, pitch relationships may have motor maps as well according to several features of typical keyboard instruments. For example, moving to the right is moving up in pitch. Repp and Knoblich (2009) examined how pitch may be mapped spatially for pianists such that higher piano pitches allow participants to respond more quickly with their right hands. Trimarchi & Luzzatti (2011) similarly demonstrated pitch-motor mappings in pianists such that stimuli that were high in pitch primed making a judgment about a visual stimulus with the right hand, and low pitch primed the left hand. Bangert et al. (2006) compared sensory-motor integration between musicians and non-musicians with fMRI showing differences in sensory-motor associations that develop through musical experience. Lahav, Saltzman, & Schlaug (2007) found through fMRI that motor areas involved in action observation were activated when non-musician participants listened to melodies they had learned to play for the experiment.

Other evidence for links between perception and action in musicians comes from altered auditory feedback paradigms. These studies motivate the experiments presented in chapter 7, so a thorough discussion of those effects will be presented as background there.

Common-coding theories thus have robust support from experimental evidence. They are able to explain connections between motor and sensory representations and offer a way to test expertise by comparing those with and without musical training. However, these studies do not test differences between types of musicians (although one of them tests between types of instrumentalists). Depending on the way a musician learns to play and depending on their practice methods, such common-coding effects may change. This idea will serve as the main basis for the experimental work described in the subsequent chapters.
Aside on sight reading studies

Before going on to show how ideomotor theories might help accomplish the establishment of a cognitive-scientific research programme for improvisation, a consideration of the sight reading literature contributes an important stepping stone. The sight reading literature aims to explain how musicians are able to efficiently transduce written symbols on a page into movements at an instrument without prior practice of the specific musical excerpt. Sloboda (2005) describes (and argues against) a sceptical view that this process is merely one of visuomotor transduction; rather, some kind of musical cognition is likely to be involved in the process. That is, some kind of musical processing takes place that recognises patterns, perhaps simulates their sounds, or otherwise identifies musical features in an extra-visual way.

Stewart (2005) examines these questions with theoretical approaches similar to those found in ideomotor research. Using a Stroop task, Stewart demonstrated that pianists may be using a spatial map corresponding to a pitch map in order to efficiently accomplish the task of sight reading a visual score. Kopiez & Lee (2008) ran a regression analysis to find the best combination of predictors for musical sight-reading ability. They found that, among other things, the ability to form auditory images (what they call ‘inner hearing’) was one of the most important. Sergent, Zuck, Terriah, & MacDonald (1992) examined neural networks involved in sight reading and implicated the importance of the supramarginal gyrus or integrating visual and auditory information, the superior parietal lobule for integrating sensory and motor information, and the left premotor cortex and the left inferior frontal gyrus for motor sequencing (the task involved using the right hand only). Waters, Townsend, & Underwood (1998) tested the importance of auditory imagery ability in sight-reading with a series of tests for musicians involving making audio-visual associations and found that performance on these tests was predictive of sight reading ability.

What the motor theories of perception and the sight reading research have in common is that they both seek to describe the nature of the cognitive representations and processing of musical structure. How are sensory relationships mapped to motor responses? How are motor plans linked to sensory simulation? What resources (external stimulation, internal imagery) are available to the musician in planning the appropriate movement? Sight reading is thus mentioned here because the questions would seem to be related to observations motivating a scientific pursuit towards understanding how people improvise.
Another reason to discuss sight-reading is that it is a very clear example of researchers searching for a difference between modes of performance. The implication under much of this research is that the mechanisms necessary for sight-reading may not be the same ones employed in other modes of performance (such as playing from memory) or they may differ in how they are employed despite the different behaviours all being musical tasks. People can be excellent musicians while being poor sight readers. Spatial maps, mental imagery, and motor mappings are important for sight-readers and perhaps for improvisers, but they are probably also involved when musicians are playing from memory or reading from a well-rehearsed score. The point is that they are not necessarily the same, and if they are, they may be employed differently. The behaviours still differ so it is worth investigating whether and how the underlying cognitive processes differ. The importance of considering this literature for a cognitive-research programme on improvisation is that it is an example of research on a mode of performance—here, sight reading. Improvisation may also involve spatial maps, mental imagery, and motor mappings, but it too is a task in itself which may differ in the employment of these cognitive mechanisms.

Another point is that not all musicians are good at sight-reading despite having skills in other musical areas. The way musicians perform and perceive music, even within a given tradition, may be quite different. Good sight-readers may learn music differently when they prepare a piece to be played from memory, or to be played after rehearsal. They may memorise music differently. Just because the style and traditions are similar does not mean the cognition is identical. Differences in sight-reading abilities demonstrate that musicians may have different musical cognitions in general, and a given musician engages different modes of performance at different times. This lesson reinforces the desire to distinguish improvisatory abilities reflecting a general difference in how a musician perceives and produces music, and to distinguish improvisation as a mode of performance—as a mode of employing musical cognitive mechanisms.

As for the specific skills associated with sight-reading, they, too, may bear a similarity with those necessary for improvisation. This is not an easy question to answer because it may not be possible to identify those who are ‘good’ at improvisation (as one can measure how good someone is at sight-reading by counting up wrong notes) and then measure various criteria about their abilities as Kopiez and Lee have done for sight reading (see above). However, one could compare the kinds of skills improvisers have with those that performers who play from the score or from memory have, and explain the differences as resulting from
differences in their pedagogies and practice methods. The experiments described in the subsequent chapter attempt to do just this, and the conclusion explores further ways this could be accomplished.

**Experimental directions and hypotheses**

The discussion thus far has identified common-coding and motor planning theories as a possible means of differentiating various modes of performance and characterising improvisation. The current state of the research that applies these theories to music is not very sensitive to such differences between groups of musicians. Such theories can compare musicians and non-musicians, but what about comparing different types of musicians? Are the sensory-motor associations described by common-coding theories the same in all musicians? Do different modes of performance employ them differently? Different kinds of pedagogies and experiences may train these ideomotor associations differently. There are expert classical musicians and expert jazz musicians, but are the dynamics of their musical representations and processes the same? How do their representations of musical structures differ and how does the recall of musical knowledge differ under different performance circumstances?

Such differences could play a key role characterising various types of improvisation and other modes of performance based on cognitive-scientific principles. Different musicians may have different cognition in this regard. The organisation of knowledge in improvisers may be what gives them the ability to improvise. Different kinds of knowledge allow for different kinds of movement and interaction. To have one’s musical knowledge organised in an improvisatory way, as might be described with common-coding theories, allows one to improvise. The question becomes one of understanding how an improviser’s musical knowledge is structured and how that underpins their musical behaviours.

The idea of modes of movement and different kinds of knowledge underlying movement is not new to cognitive science. It is well-known that highly rehearsed behaviours employ different neural circuits than behaviours that are just being learned. There is evidence of this in music, such as studies that show differences in motor areas (and other areas) of the brain depending on expertise (e.g., Haueisen & Knösche, 2001) as well as more general theories about the transference of motor activity for well-rehearsed behaviours from the cortex to subcortical structures (see Starkes & Allard (1993) for a review of motor expertise). The present hypothesis about improvisation is not making a claim of this specific
sort—that is, that improvisation involves over-rehearsed motor activity—but is rather
drawing an analogy between ‘modes of performance’ and different modes of movement
based on different neural circuitries in previous cognitive-scientific work. Improvisation
could be characterised by differences in sensory-motor activity in the brain. The
experimental portion of this dissertation explores these questions behaviourally, and more
specific predictions about the neural correlates of such differences are proposed in the
conclusion.

Two clear hypothetical tracts for experiments arise from this theoretical premise.
First, how do motor planning and the sensory-motor associations differ for improvisers as
compared with musicians who learn through other pedagogical methods? This question can
be explored with between-group comparisons of the nature of sensory-motor associations of
musical structures between musicians who learn to play through different pedagogies and
practice methods. Second, how do musicians engage these mechanisms differently when
performing in different modes of performance? This question can be explored through
within-group comparisons of motor processes between musicians playing under different
performance circumstances (from memory, improvising in different ways, etc.).

**Hypotheses for between-group studies**

Different musicians, even if they are in similar cultural locations and are exposed to
similar musical traditions, may learn to play and perceive music differently. Western
classical musicians compared with classical improvisers would be exposed to similar musical
styles, but one group would learn these styles in such a way so as to be able to improvise with
them. Jazz musicians and classical musicians learn different styles, but have similar
knowledge of certain aspects of music theory such as being able to read, identify, and play
scales and chords (even if the employment of these musical structures in performance is
different). Other such distinctions may be made in other cultures (see below). When
comparing different groups such as these, the first hypothesis is that there are general
differences in their sensory-motor associations underlying their representation of musical
structures. The different pedagogies by which they learn and the musical experiences
associated with them should lead to these differences. There may be other cognitive
differences between these groups as well that arise from this strategy for scientific research
(see conclusion for additional hypotheses), but for now these experiments will focus on
sensory-motor associations as there are clear reasons to suspect differences in this specific regard as outlined above.

More specifically, improvisers should show stronger ideomotor effects for musical stimuli. That is, sensory images should more strongly prime motor plans and vice-versa than when compared to classical canon musicians. This can be assessed by adapting experiments from previous ideomotor literature and will be described in detail in the following chapter describing these experiments.

**Hypotheses for within-group studies**

Not all improvisation is the same; a given improvising musician may engage different modes of performance depending on the performance context. A general hypothesis is that different performance modes will have differences in motor planning processes and differences in their susceptibility to disruption based on presenting sensory information that conflicts with the motor plans. The experiments that follow test improvisation against rehearsed performance as well as test different kinds of improvisation against each other. These different modes of performance should rely differently on sensory feedback due to the degree to which motor planning in each of them generates its own kind of endogenous simulation. As such, by altering the feedback, different modes of performance should be differently disrupted. More specifically, whilst improvising as compared to playing from memory, musicians should have stronger generation of sensory images and thus be more susceptible to disruption by the presentation sensory stimuli that conflict with such motor plans. Improvisation that is free to the musician’s taste should generate more feedback and be more disrupted by conflicted altered feedback than ‘random’ improvisation in which performers are asked to improvise random passages (which would not rely on engaging the kind of predictive true ‘listening’ that Tristano might describe). The experiments in the following chapters will describe these hypotheses more thoroughly and contextualise them within previous research paradigms used for similar questions.

**Improvisation is difficult but not impossible to study in experiment**

Many of the philosophical in principle difficulties of studying improvisation through experimentation have been addressed thus far, but there are also several important practical obstacles in such a task. Experimental tasks necessarily have certain restrictions for the participants in order to control for certain variables. Because improvisation is typically
conceived as something that eschews controls, the idea of implementing restrictions would seem contrary to the nature of what it is. This is the common struggle between trying to fairly operationalise a behaviour for an experiment whilst maintaining a reasonable degree of ecological validity—if what an experimenter wants to understand is something that happens in the natural world, it is the natural behaviour that needs to be studied and not a caricature of it that distorts its features. All experiments on performance must address this problem, although with improvisation it is perhaps more pronounced.

Another issue concerns controls and measurements. With sight-reading or memorised performance, an experimenter can control aspects of performance such as relative technical difficulty, pitch range, rhythmic complexity, and many other factors that may influence various measurements made in an experiment. Different musical passages can be matched for such factors such that experimental variables can be more precisely isolated. Errors can be measured if there is a pre-specified target performance for which that participant aims. With improvisation, much less can be controlled. Different improvisations cannot be matched as easily. ‘Errors’ cannot as easily be measured because not only may they not exist, but they may be an important part of improvisatory playing (such as when a musician perceives an error and changes his or her performance strategy to accommodate it).

These are difficult problems, but they are not insurmountable. As for studies comparing perception, this is not an issue. It may be difficult to characterise what counts as an ‘improviser’ in order to compare their perceptual abilities with ‘non-improvisers’, but it is also difficult to characterise a ‘musician’. Granted, there is less groundwork upon which to base such a comparison, but it should be possible to forge such a distinction for experimental purposes. Of course the distinction can and should be refined with future research, but if an operational distinction is made between jazz conservatoire pianists and classical pianists, as is made in the experiments in chapter 3, and a difference in perception is found that can be attributed to that difference, a distinction can be supported. The distinction can be gradually refined with further experimentation, including pairing the findings with a more in-depth qualitative investigation of improvisation practice methods as is proposed in the conclusion of this dissertation.

As for the experiments involving performance, there is more of an issue. What structural characteristics of a performance could one measure to reveal differences in performance modes? First, it should be noted that structural characteristics of performance have elsewhere been used to make inferences about performance processes. Shaffer (1981) is
a clear example, but most psychological studies that measures performance characteristics like timing, pitch-class content, key stroke velocity could be described as measuring structures in order to inform an understanding of thought process. What makes these studies different is that it compares different performance modes. The fact that some of these modes are called ‘improvisation’ does not change the fact that cognitive processes are being inferred from structural observations. This study is merely comparing such processes between modes of performance. And, those modes of performance can also be operationally defined. Chapter 3 argued that typical definitions do not adequately distinguish between modes of performance, but amongst the communities that practice these modes (improvising, rehearsed performance, etc.), the terms still have meaning. An improviser knows what to do when asked to improvise a walking bass line, and a performer knows what it means to play one from memory. These accepted definitions can act as operational definitions. Of course, again, they will be challenged and refined through the findings.

The performance experiments rely on MIDI data. Participants played on MIDI keyboards. It is extremely convenient to work with MIDI data that allows fast and efficient analysis of various structural parameters. Sometimes such studies with MIDI keyboards, however, are criticised for being unnatural. Of course there are other expressive parameters and other various features that can be considered, but it is difficult to say what playing a real piano would add. One could collect other kinds of data, of course, besides key presses, and one could study other instruments that are not so easily digitised. This is perfectly true, but there is plenty to study here in the meantime.

MIDI data is inherently structural—it is a list of numbers. Much of this dissertation is arguing against characterising improvisation in structural terms, yet the experiments proposed in the following chapters rely on structural characteristics (mostly timing characteristics). In fact, many cognitive behavioural experiments that seek to describe processes rely on formally structured data collected from participants. The difference here is that the structures themselves are only being measured to inform a theory that concerns process. It is different to say that a framework describes an improviser’s process than to say that differences in timing characteristics between performance conditions suggest differences in motor planning processes. Both rely on structural observations, but only one describes the way something is played—that is, the process that underlies it. This heuristic difference between types of structures is described in chapter 3.
Another major issue concerns the between-groups studies. How does one find appropriate groups to compare? If the definition of improvisation remains open, who can be counted as a ‘non-improviser’? This problem is similar to finding ‘non-musicians’ for many other current music cognition studies. It is perhaps somewhat more difficult to define, but it is in principle a similar problem. For the purposes of the studies in the following chapters, non-improvisers are taken to be musicians who claim not to be able to improvise and who have little experience with improvisatory music traditions. They are generally recruited from groups of Western classical musicians. Now, just because a musician says they cannot improvise or does not participate in improvisatory music traditions does not mean that they do not improvise. Gould & Keaton (2000), as discussed in chapter 3, would claim that every musician is an improviser. It depends on how you define it, of course. But, again, this research project is not claiming at the outset to be able to define improvisation fully. Rather, it is working with an operational definition in order to help refine a definition. For these purposes, it is thus acceptable to accept these group delineations, at least initially, until a more precise theory might help find better ways to categorise types of musicians.

How comprehensive is this kind of theory?

This theory about how improviser’s perception and cognition differs is based on several key and recurrent observations about improvisation and links them with modern cognitive-scientific theories. It is a very promising link and it is empirically tractable, but how comprehensive and convincing is it as a theory of improvisation?

One potential weakness is that despite being partially based on ethnomusicological observations, the experiments are largely designed to make distinctions between types of Western musicians (jazz players and those trained in the Western classical canon). The use of jazz musicians in these studies is in part a matter of convenience. In the West, jazz is perhaps the most prominent tradition of improvisatory music and this research is being conducted in the West. There are also improvisers in the classical style, but they are rarer.

Jazz is a worthy tradition to study, but these experiments are not about jazz. They are about improvisation, about modes of performance. The theoretical contexts within which the experiments are set are meant to have explanatory value outside of the specific tradition of jazz improvisation. This is not to say that one could immediately generalise the findings from these experiments to explain features of modes of performance in other musical traditions around the world. The experiments here are structured in such a way that their
implementation is specific to the jazz tradition (e.g., some of the tasks involve playing bass lines, and not all musical traditions have bass lines as such). The important point is that the theory behind the experiments would allow them to be adapted to test modes of performance in other traditions. The theories concern motor theories of perception, so a similar task that was meant to induce a motor representation through the presentation of a sensory stimulus could be formulated within a different musical tradition, and similar kinds of comparisons could be made.

Similarly, other creative behaviours could be studied with similar theoretical justification. One might ask how improvising poets (live, spoken-word poetry) move differently than poets who typically write at a desk like a composer might, or how improvising dancers differ in their perception of moves compared with those more experienced with tightly scripted choreography. Of course these research projects would require considerable adaptation to formulate specific experiments, but the point is that a similar approach could be adopted based on similar cognitive-scientific theory to draw parallels between improvisatory traditions in different domains.

The experiments here test improvised and memorised performance with the idea of eventually trying to redraw the lines between this traditional distinction by formulating cognitive modes of performance. These modes of performance may extend beyond the jazz tradition—modes of performance in other musical traditions may have similar distinctions between them. It may be more difficult to make such comparisons in traditions that do not have memorised performances, but it may be possible to make other distinctions, or at least to compare the modes of performance that do exist with the ones formulated through the present research project. Again, an advantage of the cognitive approach is that such a comparison is possible at all.

As mentioned in the introduction, another area that this theory does not address is group improvisation. Improvising in groups is a very common improvisatory practice. Many important questions arise from this including understanding how musicians cooperate, how they exchange ideas in live performance, why performances are sometimes more successful than other times, and many other questions. A cognitive characterisation of improvisation could address some of these issues with current theories of entrainment as a mechanism underlying such kinds of communication that occur during group improvisation. Perhaps entrainment mechanisms differ between members of a jazz trio as compared with members of a string quartet.
This is certainly another worthy area of study, and perhaps there are many others that can be understood cognitively. The theoretical approach proposed here would be similar though. That is, the goal is to test how such mechanisms differ in different kinds of performance contexts, not merely showing that they exist in general. Any feature that could distinguish modes of performance could contribute to the construction of a taxonomy. Common-coding theory is a promising place to start, and these ideas in themselves could be used to inform an understanding of group dynamics as well (e.g., in order for members of an ensemble to communicate, they must first be able to imitate/simulate what others are doing perhaps based on common-coding principles).

Another aspect which might feel lacking here is that any distinction in cognitive process that could be made would seem not to explain how specific musical ideas (musical structures) are produced. Musicians may have different cognitive representations or processes of recall, but this would seem to avoid explaining how musical ideas are actually generated, or how they are recalled from a bank of schemata or licks. As reviewed in chapter 4, past cognitive theories have focussed on this question. The persistence of this question reflects how entrenched product-based music-analytical thinking is in trying to characterise improvisation. The particular ideas that are generated in improvisation are important and interesting—they reflect stylistic trends that can be analyzed as vehicles for meaning and negotiation with social discourses. They also raise important music cognition questions more generally. How far ahead can a musician plan and how far back can they remember what they played? If they are using licks and schemata, how are those represented and organised in the mind?

But again, the goal is to distinguish improvisation as a process, not to explain the whole of stylistic developments and music cognition. Classical performers know licks and schemata too (such as fingerings for arpeggios, Alberti bass, scales, other common figurations) and composers employ stylistic elements that carry culture meaning. What distinguishes improvisation is the way these abilities are employed, and thus this empirical research programme focuses on ways to describe process. The goal is not to explain every movement, or how styles originate and propagate. It is to explain a way of moving. One would not expect a scholar of procedural memory to be able to account for why people ride bicycles, type their names, or play musical scales even though such behaviours employ procedural knowledge.
Summary and segue

This chapter has proposed a cognitive-scientific theory of musical improvisation based on observations from several musical discourses. The following chapters outline a series of experiments which seek to test the between-group and within-group hypotheses in order to support the theory that improvisers have sensory-motor associations that have stronger links between sensation and movement, and that whilst improvising, the link between sensation and movement will be differently susceptible to disruption from altered auditory feedback.

The findings of such studies would support the hypothesis that improvisation employs different kinds of musical representations and thus contribute to a cognitive-scientific theory of how improvisation works. As mentioned above, other cognitive-scientific theories might propose hypotheses with the similar aim of differentiating between groups of musicians and within groups of improvisers, and this dissertation does not claim that common-coding theories are the only way such a difference could be drawn. However, the present work argues that it is a strong one which can account for many of the skills improvisers have and explain what it is that improvisers are doing, and also potentially serve as the basis for other types of inquiry.

Following two chapters of experiments (one for between-group studies and one for within-group studies), the conclusion suggests further research that can continue to support the present theory and hypothesis as well as elaborate on other possible approaches and how they might relate to this one.
CHAPTER 6: BETWEEN-GROUP EXPERIMENTS

The previous chapter introduced a strategy to research the cognition of musical improvisation and made specific predictions about differences in sensory-motor associations and motor planning between improvisers and non-improvisers. This chapter and the following one develop this framework in more detail and present experiments that arise from it which aim to test more specific hypotheses, demonstrating how the framework can be applied to experimental research.

The first experimental approach described in the previous chapter was to run between-groups studies. Musicians who learn to improvise may acquire knowledge of musical structures differently and may acquire different skills at their instrument than those who do not learn to improvise. They may learn to listen differently and to perform differently. In cognitive terms, as outlined in the previous chapter, different pedagogical methods and experiences may lead to differences in sensory-motor associations and motor planning processes. This chapter presents experiments focussing on differences between sensory-motor associations of musical structures between improvisers and non-improvisers.

Differences in sensory-motor associations of musical structures

Common-coding theories describe how knowledge is represented in the mind. For a given action or a given stimulus, rather than postulating separate representations for both motor and sensory aspects of that action or stimulus, common-coding theories suggest there is a single kind of code that can represent them together. This is a theory of sensory-motor associations. There is support for this in music as described in the previous chapter. A particular musical structure such as a contour or pitch has been shown to be related to the motor activity associated with the production of that structure.

So, a theory that suggests improvisers may have different sensory-motor associations underlying their representations of musical structures than non-improvisers would make a comparison along these lines. Is the sensory-motor association different somehow in the members of each group? Such a difference would theoretically arise from the differences in pedagogies and experiences as described in the previous chapter.
How could these sensory-motor associations differ? The behavioural experiments that demonstrate the existence of these effects measure response times in various ways, and error rates. A sensory stimulus can prime or inhibit a movement of some sort as measured by the amount of time it takes to perform that movement and the accuracy with which a particular movement (or judgment of some kind) is made. These kinds of values can be compared; certain participants could perform the task faster or with less errors. This would mean that they are more or less susceptible to the priming effects described by these studies. In other words, for these purposes, perhaps the co-priming effects are more robust in improvisers than in non-improvisers as measured by response times and error rates in an identification task.

Another way these representations could differ is in their complexity. That is, a musical structure like a chord has haptic, proprioceptive, auditory, and visual sensory correlates in conjunction to the motor activity associated with producing them. The same chord (in terms of the notes that comprise it) can also be played in many different ways depending on its intensity, or the movements and sounds that precede it. There could be differences in the range of sensory correlates that can prime such movements and vice versa as well as a greater robustness of movements. Representations could be more multi-modal than those of non-improvising musicians.

Why would these sensory-motor associations differ between these two groups? A more difficult question might be why they would be the same. Improvisers and non-improvisers are both types of musicians, but their pedagogies, skills, and experiences have many important differences. Learning to play music with visual notation systems and recalling specific musical structures in a particular order as classical musicians often do are not the same skills as learning to imitate, transcribe, and ‘play by ear’ as improvisers commonly practice. These different skills seem to suggest differences in how a musician would recognise a musical structure and implement it—such differences should be testable with common-coding experimental paradigms. Studies of musical performance typically do not distinguish between the different pedagogies and practices of different musicians, but there are many reasons to suspect that there is a difference, and this experiment aims to demonstrate its existence.

Of course, ‘improviser’ and ‘non-improviser’ would not be the only group one could compare in this regard. One could similarly compare different kinds of improvisers who have learned in different traditions, or make other comparisons between groups of musicians.
outside of the context of questions about improvisation. Again, this could lead to
categorisations of types of perception and cognition that reach across traditional stylistic and
cultural boundaries. The present study focuses on the categories of ‘improviser’ and ‘non-
improviser’ because that is the scope of the present dissertation, but it is worth noting here
that such a principle could extend to similar questions and comparisons in music cognition.

**Operationalising ‘non-improvisers’**

The experiments reported below compare these effects between groups of improvisers
and non-improvisers. As discussed in the previous chapter, this presents a potential problem
for such comparative studies: how do you operationalise a ‘non-improviser’? To briefly
reiterate, this problem is not specific to improvisation—a very similar problem is faced in
finding ‘non-musicians’, as is necessary for many music cognition studies. Of course people
who do not identify themselves as ‘musicians’ still have heard plenty of music in their lives
and may even sometimes have rudimentary knowledge of how to play an instrument as long
as it does not exceed a somewhat arbitrary cut-off of having so many years of experience or
training (depending on the study and how tightly the factors are controlled). In Western
culture, we have an identity category of ‘musician’ which typically means someone who is
either professionally active as a performer or composer or otherwise highly experienced
through taking lessons and performing avocationally. Of course this category does not exist
everywhere in the world, but it offers an intuitive definition which can be subjected to
scrutiny. If musicians and ‘non-musicians’ were delineated on this basis and compared in
experiments and absolutely no effects were ever found, one could either conclude that
musical training as it is defined for these experiments does not change one’s cognition in any
way and there is thus no meaningful difference between these groups according to this
variable. Some other criteria would need to be used to compare the groups, or the theory
behind those experiments may simply be unsupported. But, it is often the case that musical
training, as it is defined for these studies, does indeed make a difference to participants’
performance on a task, and thus musical training would seem to have some causal link to
changes in one’s perception and cognition.

It is the same with improvisation. There is a lay-understanding of the term. If asked,
some musicians say they ‘cannot improvise’ without typically engaging in a lengthy debate
about what exactly that means. The term, however ambiguous, is alive and well in the
discourses of Western musicians. For the purpose of this experiment and the ones that follow
in this dissertation, when I ask musicians if they improvise regularly or have improvisation training, they knew the answer. The experiment can then proceed. If a difference between groups is found, and if the groups are otherwise carefully controlled, then something about that criterion is relevant to the outcome of the experiment. Further research could then try to be more precise about what aspects of improvisatory pedagogy and experience leads to the difference, but, in any case, support for a delineation would be found and a distinction would become more and more precise with further research. Specifically, the experiments reported below identify improvisers through a self-report questionnaire (see methods section below for more details).

**Action-effect blindness**

Previous research in the general area of common-coding theories provides several possible paradigms to assess a difference between improvisers’ and non-improvisers’ music perception. Some of them need to be adapted from general perceptual experiments to address musical perception for participants who have such expertise. As described in the previous chapter, there are several common-coding studies in the musical domain. Past studies have looked at relatively simple musical structures like pitch height (does a high pitch prime a right hand movement for a pianist given the pitch organisation of a piano) and contour to compare musicians with non-musicians, or certain kinds of instrumentalists with each other. However, apart from comparing instruments, these studies do not compare different types of musicians to show how such effects may be different.

The specific hypothesis about improvisers is that because their pedagogies often emphasise imitation, transcription, and transposition—skills which, from a cognitive point of view, could be seen to foster connections between perception and action—such action-effect couplings should be more strongly linked and show greater effects in these experimental paradigms. The first experiment reported below was based on the task from Müsseler & Hommel’s (1997) experiment. In that task, participants were presented with an arrow pointing either left or right, and were told to remember it. Then, they were shown a second arrow, and had to press the first arrow key on a keyboard. Then, they would press the second arrow that they saw. This task was meant to force participants to sustain a motor plan of pressing the first arrow through the identification of the second arrow, interrupting their ability to perceive the second arrow since motor plans are thought to interact with perceptions. For example, if they sustained a left arrow motor plan, left arrows were shown.
to harder to perceive because of what the authors call “action-effect blindness”; the sensory resources necessary to identify that arrow were otherwise occupied by the planning of an action that would have a similar sensory outcome.

In the experiment described below, participants performed a similar task replacing the arrow stimuli with musical stimuli that require musical expertise—in this case, playing chords on a keyboard. Chords are musical structures that have auditory and visual correlates as well as motor correlates such as hand positions. The same chord could be played with multiple motor programmes depending on its context (what was played just before you change the fingering used to play the chord, for instance), so special care was taken to choose chords with limited fingering options (see below). Otherwise, the structure of the experiment is very similar: if musicians are required to sustain the motor plan of a chord, does it make it harder to identify similar chords? And, is the effect stronger for improvisers than non-improvisers? If so, this would point to differences in sensory-motor associations between improvisers and non-improvisers and contribute to an understanding of the cognition of musical improvisation through characterising how improvisers perceive music, and help delineate different kinds of musicians.

**EXPERIMENT 1**

**Stimuli**

This experiment used visual representations of chords. The chords chosen were all four possible closed-position (within the octave) inversions of d-minor seventh, e-minor seventh, and a-minor seventh chords (12 possible chords in total). These chords were chosen because they all use only white keys on the piano and thus have similar spacing between the notes such that a hand in the same position could play chords in the same inversion regardless of the pitch without shifting the relative position of the fingers. In this way, if the chord has the same inversion regardless of the pitch classes, the same hand shape could be used to play it. Inversion thus corresponds to hand shape.

Each of the 12 four-note chords was notated in staff notation in both treble and bass clefs such that no more than one ledger line had to be used for any given chord. There were thus 24 visual stimuli.
Participants

Eleven keyboard-playing participants ($M = 30.5$ years, $SD = 15.4$; 5 female, 4 left-handed) took part in this study. They were recruited from the University of Cambridge and Anglia Ruskin University (ARU), though not all were current students. These participants had a wide range of performance backgrounds and played many instruments, but they all played piano. 7 of the participants identified as improvisers and 4 as non-improvisers as assessed by a questionnaire (see below).

Method

This experiment was conducted in line with the prevailing policy in the Faculty of Music on the conduct of empirical research involving human participants. Prior to the experimental task, participants completed a questionnaire. This assessed their handedness using the Edinburgh Handedness Inventory (Oldfield, 1971), their improvisatory experience through asking about their training, whether they had taken lessons to improvise, whether they identify as improvisers, and how they practice improvising. It also asked about when they started playing their instrument(s), and collected other standard demographic information (age and gender). If they self-identified as improvisers, they were counted as improvisers in the analysis.

The experimental task was adapted from Müsseler & Hommel’s task described above. Instead of working with arrows as stimuli, the chords were used. Figure 6.1 provides a schematic of the experimental task. Each trial began with a 2000ms screen that displayed the message, ‘next trial’. Participants were then presented with one of the chords for 2500ms. Then a blank screen with a fixation cross was presented for another 2500ms after which a second chord was presented, always with a different set of pitch classes. The task was then to use one hand to answer whether the chord had the same shape (inversion) as the first chord by pressing ‘1’ (mismatch) or ‘3’ (match) on a computer keyboard, and then to immediately play the first chord on a nearby piano keyboard with the other hand. At the start of each trial, the hand used to respond on the computer keyboard stayed in position over the ‘1’ and ‘3’ keys (using the middle and index fingers respectively), and the hand used to play the piano keyboard started laying flat on a table in front of the keyboard. If the chord was presented in bass clef, the right hand would answer ‘same’ or ‘different’ on the computer and the left hand would play the chord. For treble clef chords, the hands were reversed. If participants did not answer within 1500ms, they received a ‘too slow’ message for 3000ms after which the next
trial would begin. If they answered incorrectly, they would receive a ‘wrong answer’ message for 3000ms after which the next trial would begin. If they answered correctly, they would receive a ‘correct answer’ message and would then have 2000ms to play the first chord before the next trial would begin. In this way, if they did not answer correctly, they would not have to play the chord.

It should be noted here that having perfect pitch in this experimental task would not help participants because the task is to compare chord inversions. It might help, for instance, if the task were to see an a-minor seventh chord and then hear an a-minor seventh chord. In that case, having perfect pitch would make a judgment about the similarity much easier. In this task, both chords were identified visually, and further, the two stimuli always had different pitch classes and thus had to be identified by similarity in shape/inversion.

Each of the 24 chords was presented 4 times. 2 of the presentations would be followed by a congruent inversion (one in each of the other two keys), and 2 would be
followed by a chord with a different inversion, 1 in each of the other keys. There were 4 blocks of trials—2 were for stimuli presented in treble clef, and 2 for stimuli presented in bass clef. Each block had 48 trials (each of the 12 chords in that clef presented 4 times), totalling 96 trials per participant. The participants were counterbalanced for which clef blocks they completed first. Within each block, the order of the stimuli was randomised. Prior to the experiment, participants completed a practice block in each clef that included only a subset of the trials in each experimental block.

Specific hypotheses

This experiment was meant to force the participants to sustain a motor plan of the first chord through the identification of the second chord. In an analogy to Müsseler & Hommel’s task with arrows, if the second chord would require a similar motor plan to play than the first chord (that is, it has the same shape and inversion), then it should be harder to perceive.

The hypothesis, based on the Müsseler & Hommel’s task, is that when chord 1 and chord 2 match in inversion, this should cause action-effect blindness in improvisers more than non-improvisers. This is because when improvisers see a chord, they may perceive it with a stronger action-effect link due to the way they learn about these musical structures, and thus be more susceptible to action-effect blindness whilst they are sustaining the motor plan for the first chord. For non-improvisers, they may perceive the stimuli differently with a weaker link and less action-effect blindness. There should be less difference in accuracy and response time between congruent and incongruent stimuli if action-effect blindness plays a weaker role.

Data analysis and results

For each participant, the average response time (in milliseconds) and the total number of errors for each condition were calculated. The total errors included incorrect responses and no-response trials (when the participants were too slow to respond). The data were arranged according to two within-group factors and one between-group factor. The within-group factors were congruence (match or not-match) for if the two chords matched in inversion or not, and clef (bass or treble) for which hand was used to respond to play the first chord, and the between-group variable was performer type (improviser or non-improviser).

The first analysis examined whether there was an overall effect of the experimental factors regardless of musician type. A two-way repeated measures ANOVA was performed
with the factors ‘clef’ (bass or treble) and ‘congruence’ (incongruent or congruent) on both the response time metric (for trials with correct responses) and the total amount of errors. For response times, there was a significant main effect of clef, $F(1,9) = 7.099, p < .05, \eta^2 = .415$. With the treble clef (with participants using their left hands to respond to the same/different task and the right hand to play chord 1), participants performed more quickly than with bass clef stimuli (in which the hands were reversed). There was no main effect of congruence, $F(1,9) = 1.703, p = .221, \eta^2 = .146$, and no significant interaction, $F(1,9) = .044, p = .838, \eta^2 = .044$.

For total errors, a similar ANOVA was performed. There was no main effect of clef, $F(1,9) = 1.631, p = .230, \eta^2 = .140$, no main effect for congruence, $F(1,9) = 1.637, p = .230, \eta^2 = .141$, and no significant interaction, $F(1,9) = 4.497, p = .060, \eta^2 = .310$.

To test the effect of musician type, a mixed-design ANOVA was conducted with the same random within-group factors and the additional fixed between-group factor of musician type. This was done for both response times and total errors. For response times, there was a significant interaction between musician type and the within-group factor of clef, $F(1,9) = 6.065, p < .05, \eta^2 = .403$ (see figure 6.2). Whereas non-improvisers had similar response times for the different clefs, improvisers were faster for treble clef than bass clef stimuli.

Given the significant main effect of clef in the original ANOVA (which did not factor in musician type), separate post-hoc models were created examining the interaction between musician type and congruence separately for each clef. Neither returned a significant effect. For total errors, the type of musician did not significantly interact with either of the within-subject variables. Further, an additional post-hoc ANOVA found no significant interaction between clef and the handedness of the participant.

A final post-hoc ANOVA found a significant interaction for total errors between block order (whether a treble or bass clef block was presented first) and clef, $F(1,9) = 16.267, p < .005, \eta^2 = .644$. When a treble block was presented first, participants made more errors on treble block stimuli whereas when a bass clef block was presented first, participants made more errors on bass clef stimuli.

Given the small number of participants (for reasons explained below), non-parametric tests were conducted as well even though the data passed the Shapiro-Wilk test of normality (qualifying it for a parametric ANOVA). Mann-Whitney U tests were conducted on the data
from each of the 4 conditions for both response times and total errors (8 tests in total) to test differences between the group of improvisers and the group of non-improvisers. The only test that was significant was the congruent treble clef condition for reaction times, \( U(11) = 0, Z = -2.646, \quad p = .008 \). Improvisers were faster than non-improvisers for this condition (contrary to the hypothesis). However, after applying a Bonferroni correction to the significance threshold and adjusting it to .00625 (by dividing the conventional .05 threshold by 8), this effect can be disregarded.

Figure 6.2: Interaction between musician type and clef. Whereas non-improvisers performed similarly for both bass and treble clefs, improvisers took longer to identify bass clef stimuli than treble clef stimuli. Error bars represent one standard error in either direction.

**Discussion**

The results do not support the hypothesis; there was no interaction between musician type and congruence. The nature of the improvisers’ musical training was hypothesized to have the first chord in the congruent condition more strongly interfere with the perception of the second chord than it would interfere for non-improvisers. The absence of this effect is most likely due to problems with the experimental design rather than the absence of the hypothesized difference in sensory-motor associations between improvisers and non-improvisers.

Clearly not many participants were included in this analysis, so the interpretation of the effects is accordingly speculative. The reason so few participants were included was because this particular version of the experiment was discontinued for various reasons that became apparent after running it (see below).
The significant effect of clef found in the within-group ANOVA may be related to greater familiarity with treble clef, making it easier and faster to perceive visually. There was not a significant interaction for response times or total errors between clef and handedness, so greater familiarity with treble clef would appear to be the best explanation for this. The different clefs were included to see if the hypothesised effect (about congruence and musician type) would work regardless of the hand used to respond, but since those hypothesised effects were absent anyway, a future experiment might leave out the clef condition to eliminate an unnecessary source of variability.

As for the interaction, only improvisers were faster with the treble clef. The most direct explanation of this is that they were more familiar with reading treble clef than bass clef whereas the non-improvisers, with their musical background emphasising score reading more prominently, were more equally familiar with both clefs. Of the 7 improvisers included in the study, 3 were left-handed and 1 was right-handed. Of the 4 non-improvisers, 1 was left-handed. A larger participant pool with a more equal distribution of handedness might attenuate this effect.

The significant interaction between block order and total errors suggests that participants improved as the experiment progressed. One possibility is that participants should have had more practice trials. The revised experiment presented below eliminates the clef condition, but also addresses learning and order effects.

The models here were run in the middle of collecting data, but when many procedural problems were observed and when the data did not seem to be trending towards revealing an effect, the experiment was discontinued after the first 11 participants. Ultimately, the insights made into why the hypothesised effects were not present helped form a new, more tightly controlled experiment (see below).

**Procedural problems with this experiment**

There were a few differences with Müßeler & Hommel’s that were necessary for the structure of this experiment, but which may have introduced various problems with the data collection. First, the time scale involved in the original study was much smaller. The average time for participants to respond to the arrows was approximately 1/3 of a second whereas the grand mean of the response times in the present study was 1023ms. The
mechanism of the effect underlying Müßeler & Hommel’s findings may not function the same way at this longer timescale.

Sustaining a motor plan of a chord is perhaps more complicated than sustaining a motor plan of a single arrow press at a keyboard given that the hand must change positions to accommodate the particular chord whereas the hand can rest over both possible arrow responses without moving. In this way, response times are much longer and the possibility for confounding variance in them is increased.

In the Müßeler & Hommel task, the imperative stimulus arrow was masked after its presentation. The length of presentation was adjusted for the participants during a pre-test phase, ranging from 14-70ms. The stimuli in the present experiment were not masked.

Another difference was that instead of making a judgment about the stimulus (e.g., whether it is a left or right arrow), participants compared two stimuli in order to respond to whether they were the same or different within a particular category (chord inversion). This still requires making a judgment about the imperative stimulus (i.e., determining its inversion), but the task was to respond by comparing two stimuli. This could have taken longer than the identification judgment alone. Another aspect of this is that the response was not directly related to the imperative stimulus. Whereas in Müßeler & Hommel’s task the motor response had an iconic resemblance to the imperative stimulus (i.e., press left if a leftward arrow is seen), in the present task the actual motor response did not match the imperative stimulus (i.e., press ‘1’ if the chords do not match). The initial idea was to have the participants play the imperative stimulus and base the timing and total errors off of MIDI data, but this was judged to be impractical as too much variation would be introduced if the pianists were not somehow able to already have their hands directly over the MIDI keyboard keys. Since the chords varied throughout the experiment, this would not have been possible. At least with a computer keyboard, the fingers can stay over the keys to reduce possible variance from the time it takes to move your hand into position.

One particularly instructive problem was that participants may have been using different strategies to accomplish the task. Only after observing participants complete the task and speaking with them afterwards in a debriefing session did it become apparent that they may have been doing different things with the hand that responded on the MIDI keyboard. Whilst it was laying flat on the table before each trial, participants may have been actively contracting muscles associated with the first chord they were meant to remember.
This could have changed whether they were relying on a motor plan, or some kind of sensory feedback such as proprioception or haptic feedback. Both kinds of cognitive activity might still cause a similar effect, but if not all of the participants did the same thing, it is an additional source of variance. Participants may have also employed different strategies to read the second chord in making their judgment. Because the task was to identify whether they had the same inversion, some may have focussed on lower level visual cues (each seventh chord inversion has a unique visual shape) rather than a more complicated cognitive appraisal of the pitch relationships.

The improvisers chosen to participate in this study came from a range of backgrounds. They all identified as improvisers, and conveniently many of them came from the same improvisation course at Anglia Ruskin University, but they varied widely with age and experience. It would be helpful to be able to more tightly control for this. Ideally, the general experimental programme should be able to investigate such differences and how they affect these cognitive properties, but it may be best to allow a more limited number of variables.

Given these differences, it also became apparent that a control condition would be desirable. This was built into Müßeler & Hommel’s task by adjusting the masking times for the imperative stimulus. It would be helpful to know in the present experiment how long it would take each individual participant to respond without having to maintain the motor plan of the first chord (and just compare the inversions). Then, the effect of sustaining the motor plan could be assessed within group as well as between groups. This was not included in this study because the hypothesis concerned the between-group interaction between congruence and performer type. However, a control condition of not having to play the second chord could help ensure that the effect of sustaining the motor plan could more precisely be measured. That being said, as identified above, the timescale may simply be too long anyway to reliably identify such effects.

Finally, while Müßeler & Hommel did not need to deal with a between-groups variable, for this study it would be helpful to more tightly control the kind of improviser invited to participate. The theory underlying this experiment outlined in the previous chapter would claim that there are many ways to improvise. Perhaps some of them would lead to the effects hypothesised for this experiment and some would not. On the one hand, perhaps there is some feature of multiple improvisatory traditions that leads to similar perceptual principles. On the other hand, for the time being, it would be helpful to see if any differences exist at all.
For this reason, it would be helpful to more tightly control the kind of musician included in the ‘improviser’ category. This experiment invited participants with any kind of improvisatory experience, and their ages, styles, and level of experience varied widely. This may have introduced additional variance that obscured the predicted effects.

Even with these differences from Müsseler & Hommel’s task and with the problems with its design, it was deemed worthy to try again with some changes to see if anything more conclusive could be found. The following experiment implements changes to respond to these problems and reruns a similar task with similar hypotheses.

EXPERIMENT 2

A follow-up experiment was designed to correct some of the problems that arose from the first attempt. This experiment kept the same rough structure, but made a few key alterations to protect against many of the sources of variability.

The second experiment no longer focussed specifically on action-effect blindness, but sought to see if any other more general effect would be present in priming sensory perception with motor activity. The experiment was redesigned to include multiple sensory modalities and contrasted conditions with and without hand movement (see below).

The participant groups were much more tightly controlled. This was accomplished by selecting improvisers from a similar tradition and with similar ages and levels of experience. To accomplish this, most of the participants were selected from the same undergraduate jazz conservatoire programme at the Birmingham Conservatoire (although a few of the improvisers included were jazz pianists of similar age and experience based in Cambridge, UK, and one was an accomplished improvising organist).

Secondly, as described in greater detail in the method below, instead of using visual imperative stimuli, auditory stimuli were used such that a judgment had to be made based on listening. The motivation for the study in the first place is that jazz pianists are thought to have a stronger link between perceptual and motor representations. Since jazz pianists emphasise connecting auditory stimuli with motor programmes (rather than, say, establishing such a link through visual score-based stimuli), it makes sense to try to activate such motor programmes with auditory stimuli in the experiment. Sounds are meant to prime or interfere with motor activity.
Third, a control condition was added in which participants do not play. With this experimental structure, the effect of congruence can be assessed, but so can the interaction between playing and congruence, and between playing and musician type. Compared with non-improvisers, playing should help the improvisers more in responding faster and/or making fewer total errors (as it should activate a stronger internal image of the chord and allow for easier comparison), and should affect responses to congruent stimuli differently than incongruent stimuli. Action effect blindness would predict that it should hinder the identification of similarly inverted chords, but at this larger timescale, this effect may not be present.

Finally, the experimental task was made less complicated. Participants no longer had to move their hands on and off the keyboard, and were required to hold a pen when not using the keyboard. This helped to control for variance introduced by participants adapting different strategies to aid in their perceptual judgment by using the free hand to move in different ways, possibly simulating the chord shape surreptitiously.

**Revised method for experiment 2**

This experiment was conducted in line with the prevailing policy in the Faculty of Music on the conduct of empirical research involving human participants. Experiment 2 had a very similar method to experiment 1 with a few key differences. The treble clef stimuli from experiment 1 were used. Participants are presented with a visual stimulus of a chord written in staff notation for 2500ms followed by a fixation cross for 1250 and then the presentation of an auditory stimulus. The auditory stimuli were created by playing the chords from the visual stimuli with a piano sound. Again, similar to experiment 1, the participants then judge whether the visual and auditory chords have the same inversion (hand shape). Since only treble clef stimuli were used, participants always responded on the computer keyboard with their left hands.

For half of the blocks, participants used a nearby keyboard to hold chord 1. They did so immediately after being presented with the stimulus rather than waiting until after the judgment as in experiment 1. This simplified the procedure and prevented variance from the different strategies employed by participants as described above. In this way, they were physically sustaining the chord with their hand in its particular hand position through the judgment. For the other half of the blocks, participants did not play the keyboard with their right hands, but instead were asked to hold a pen in a typical writing position. This was to
prevent participants from covertly contracting muscles in their right hands to help them remember the inversion of chord 1. In this way, the effect of having their hands in the position could more reliably be assessed.

As in experiment 1, participants would either respond correctly, incorrectly, or be too slow, and similarly received feedback in the form of coloured text. For this version of the experiment, the timing was different. Participants had 2500ms to respond before being told they were ‘too slow’ and moving to the next trial, and did not require additional time to play the first chord as this was not part of the task. They similarly received feedback in the form of coloured text. Each block of trials had each of the 12 chords presented 4 times, 2 of which had matching auditory stimuli and 2 of which had mismatched stimuli with counterbalancing similar to that in experiment 1. Each block thus had 48 trials. Block order alternated between the ‘play’ and ‘no-play’ conditions and was counterbalanced such that half of the participants started with play blocks and the other with no-play blocks. Before the experimental blocks, participants also completed practice blocks of each condition that had half the stimuli of the experimental blocks (24 per practice block).

The experiment had 2 within-subject variables: congruence (congruent or incongruent) and response mode (play or only-look). There was one between subject variable: musician type (improviser or non-improviser).

**Hypotheses**

Experiment 2 has similar theoretical motivations as experiment 1, but with slightly different hypotheses. It is still proposed that the improvisers will have a greater interaction between sensory and motor representations of stimuli, but the notion of action-effect blindness is not invoked. Action-effect blindness interferes with the generation of motor plans, and in experiment 2 participants are not executing a plan—they are sustaining a hand position. This experiment is thus seeing whether proprioception and haptic feedback from having the hands already in position interferes or helps the similarity judgment, and whether that effect is different between the groups of participants. It is thus not directly testing motor activity but rather testing a kind of proxy in exploring whether auditory stimuli interact with the feeling of a hand position.
Experiment 2 Task

Figure 6.3: Schematic for experiment 2.

Participants

21 pianists ($M = 21.3$, $SD = 3.42$; 1 female, 21 right-handed) took part in this study: 12 non-improvisers and 9 improvisers. These participants did not overlap with those who took part in experiment 1. Prior to the experimental task, participants similarly filled in a demographic questionnaire that also assessed their improvisatory background. Their handedness was similarly assessed with the Edinburgh Handedness Inventory (Oldfield, 1971). On the questionnaire, if they both identified as an improviser and had taken lessons to improvise, they were classified as an improviser. 8 of the improvisers were jazz pianists, and one was an organ improviser (as well as piano player). 1 of the improvisers claimed not to have studied improvisation on the questionnaire, but he was recruited from the jazz piano programme at the Birmingham Conservatoire, so he was counted as an improviser. The pianists were all either students at the University of Cambridge or at the Birmingham Conservatoire.
**Data analysis**

Each participant responded to a total of 192 trials (48 in each condition). Each trial had an associated response time and was either correct, incorrect, or too slow (no response). To pre-process the data, outliers were removed according to the means and standard deviations within each participant and within each condition with a cut-off at a Z-score of 2.5 from the mean, either direction. The average response time and the total number of errors (including no response trials) were calculated for each participant under each condition. These values were used for several ANOVAs.

After pre-processing the data, and speaking with participants after the experiment, it became apparent that trials involving root position seventh chords either as the first chord (seen or played) or the second chord (the imperative stimulus) resulted in significantly fewer errors than the other chords. To assess this statistically, the lists of the total amount of errors for each inversion of each participant were compared to each other inversion with a two-tailed t-test. This was done for the total errors associated with trials with a root position chord as the first chord, and again for the root position chord as the second chord. In both cases, the number of root position chord errors significantly differed from each other chord inversion, and none of the other chord inversions significantly differed from each other according to a two-tailed t-test. For instance, if the first chord was in root position, there was a significantly different error rate from when the first chord was in 1st inversion whereas if the first chord was in 1st inversion, the error rate was not significantly different from when the first chord was in 2nd inversion (see tables 6.1 and 6.2). With a Bonferroni correction that adjusts the alpha level from .05 to .008 (for the 6 unique comparisons), some of the effects are only marginally significant. However, the trend is clear. Further, if the comparisons between the non-root position chords are not counted (as there was not a clear reason to suspect why they should significantly differ from each other), the Bonferroni adjustment would take the alpha level down to .016 (for the 3 remaining t-tests) making them all significant.
Table 6.1: p values from two-tailed t-tests comparing total errors between different inversions presented as the first chord. For example, if the first chord was in root position, there was a significantly different number of errors as compared with when the first chord was in 1<sup>st</sup> inversion.

<table>
<thead>
<tr>
<th></th>
<th>Root</th>
<th>1st</th>
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</thead>
<tbody>
<tr>
<td>Root</td>
<td>-</td>
<td>0.000329</td>
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</tr>
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<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>0.000329</td>
<td>-</td>
<td>0.728405</td>
<td>0.343756</td>
</tr>
<tr>
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<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>0.002023</td>
<td>0.343756</td>
<td>0.217498</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 6.2: p values from two-tailed t-tests comparing total errors between different inversions presented as the second chord. For example, if the first chord was in 2<sup>nd</sup> inversion, there was not a significantly different number of errors as compared with when the first chord was in 3<sup>rd</sup> inversion.

<table>
<thead>
<tr>
<th></th>
<th>Root</th>
<th>1st</th>
<th>2nd</th>
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<td>0.014784</td>
<td>0.0087</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>0.001523</td>
<td>-</td>
<td>0.346247</td>
<td>0.76603</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>0.014784</td>
<td>0.346247</td>
<td>-</td>
<td>0.548564</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>0.0087</td>
<td>0.76603</td>
<td>0.548564</td>
<td>-</td>
</tr>
</tbody>
</table>

For this reason, the data was split into two: part of it was the response times and errors associated with trials involving root position chords as either the played/seen chord or the imperative stimulus, and the remainder of the trials constituted the second part of the data (involving pairings of non-root position chords). This was not anticipated in the original design, but in retrospect, the task was quite difficult as evidenced by the high number of errors made by the participants, while the root position chords were easier to identify.

**Results: non-root position chords**

For both the response time and total errors variables, a mixed-design ANOVA was conducted on the data associated with the chords that were not in root position, with the within-group factors of congruence (match or mismatch) and mode (only-look or play), and the between-group factor of musician type (improviser or non-improviser). For response times, only trials with correct responses were included in the analysis. Response times compared within each condition all passed the Shapiro-Wilk test of normality (see table 6.3). This test was included because response times sometimes fail tests of normality and are thus unsuitable for ANOVAs. There was a significant main effect of musician type, F(1,19) = 6.905, p < .05, η² = .267. Improvisers generally had higher response times than
non-improvisers. There was a significant main effect of congruence, $F(1,19) = 5.383$, $p < .05$, $\eta^2 = .221$ and a marginally significant main effect of mode, $F(1,19) = 3.888$, $p = .063$, $\eta^2 = .170$. Congruent stimuli took significantly less time to correctly identify, and played stimuli took more time to identify than the only-look condition.

<table>
<thead>
<tr>
<th>Condition</th>
<th>W statistic</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only Look, Congruent</td>
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<td>0.14</td>
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<tr>
<td>Only Look, Incongruent</td>
<td>0.981</td>
<td>0.944</td>
</tr>
<tr>
<td>Play, Congruent</td>
<td>0.923</td>
<td>0.099</td>
</tr>
<tr>
<td>Play, Incongruent</td>
<td>0.972</td>
<td>0.771</td>
</tr>
</tbody>
</table>

Table 6.3: Shapiro-Wilk tests on response times for each within-subject condition included in the ANOVA for trials not including root position chords. All tests were not significant indicating they were normally distributed.

For total errors, there was a highly significant main effect of congruence, $F(1,19) = 10.637$, $p < .005$, $\eta^2 = .359$. Participants made more errors when the two chords were congruent than when they were incongruent. There was a marginally significant interaction between musician type and mode, $F(1,19) = 3.286$, $p = .086$, $\eta^2 = .147$. For the only-look condition, improvisers made more errors than non-improvisers; for the play condition, the reverse was true (see figure 6.4). There was also a marginally significant interaction between congruence and mode, $F(1,19) = 3.140$, $p = .092$, $\eta^2 = .142$. For congruent trials, participants made more errors looking than playing; for incongruent trials, the reverse was true.

Separate ANOVAs were run for both the between-group variables of perfect pitch (yes or no) and order of stimuli blocks (only-look block first, or play block first), both with the same within-group variables. Neither showed significant effects of these between-group variables.
Figure 6.4: Interaction between musician type and mode for total errors (non-root position chords). This effect was only marginally significant. Error bars represent one standard error in either direction.

Results: root position chords

For response times, again, only trials with correct responses were included in the analysis. Again, response times compared within each condition all passed the Shapiro-Wilk test of normality (see table 6.3). There was a significant main effect of musician type, $F(1,19) = 8.219, p < .05, \eta^2 = .302$. Improvisers generally had higher response times than non-improvisers. There was a significant main effect of mode, $F(1,19) = 14.048, p < .005, \eta^2 = .425$. Trials with only-looking took less time to make correct judgments than when participants also had to play the chords. However, this should be interpreted in consideration of the fact that there was also a significant interaction between mode and congruence, $F(1,19) = 6.057, p < .05, \eta^2 = .242$. For congruent stimuli, playing took longer than only-looking whereas for incongruent stimuli, they took roughly the same amount of time (see figure 6.5). There was a marginally significant interaction between congruence and musician type, $F(1,19) = 3.024, p = .098, \eta^2 = .137$. Congruent stimuli took more time than incongruent stimuli for improvisers while the reverse was true for non-improvisers. For response times, there were no significant effects associated with perfect pitch or block order.
### Shapiro-Wilk Test of Normality

<table>
<thead>
<tr>
<th>Condition</th>
<th>W statistic</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only Look, Congruent</td>
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<td>0.704</td>
</tr>
<tr>
<td>Only Look, Incongruent</td>
<td>0.97</td>
<td>0.728</td>
</tr>
<tr>
<td>Play, Congruent</td>
<td>0.956</td>
<td>0.439</td>
</tr>
<tr>
<td>Play, Incongruent</td>
<td>0.972</td>
<td>0.771</td>
</tr>
</tbody>
</table>

**Table 6.4: Shapiro-Wilk tests on response times for each within-subject condition included in the ANOVA for trials including root position chords. All tests were not significant indicating they were normally distributed.**

For total errors, there was a significant main effect of mode, $F(1,19) = 6.621$, $p < .05$, $\eta^2 = .258$. Playing resulted in fewer errors than when only-looking. There was a highly significant main effect of congruence, $F(1,19) = 22.230$, $p < .001$, $\eta^2 = .550$. Congruent stimuli resulted in fewer errors than incongruent stimuli. There was a marginally significant interaction between mode and musician type, $F(1,19) = 3.197$, $p = .090$, $\eta^2 = .144$. Playing reduced the number of errors for improvisers while non-improvisers had roughly the same amount of errors whether playing or only-looking (see figure 6.7). There were no main effects associated with perfect pitch or order. There was, however, a significant interaction between mode and order for total errors, $F(1,19) = 5.018$, $p < .05$, $\eta^2 = .209$. When participants completed an only-look block first, they made more errors on only-look trials than trials with playing, whereas if they completed a play block first, they made roughly the same amount of errors. To compensate for this apparent learning effect, another ANOVA was performed using only data from the second block of each mode. This ANOVA returned a highly significant interaction between mode and congruence, $F(1,19) = 20.825$, $p < .001$, $\eta^2 = .523$. For congruent trials, participants made roughly the same amount of errors regardless of mode, but for incongruent trials, only looking resulted in more errors and playing resulted in fewer errors (see figure 6.6).

**Discussion**

The hypothesis for this study was that playing should help the improvisers more than the non-improvisers because of differences in their sensory-motor associations. The hand position should have provided proprioceptive and/or haptic feedback that would aid improvisers in the identification of the second chord more than it would aid non-improvisers.

For non-root position chords, there was a marginally significant interaction between musician type and mode for the total amount of errors; playing helped the improvisers make
fewer errors while it hindered the accuracy of the non-improvisers. Having the hand in the position of the chord changed the accuracy of the improvisers for the better, supporting the hypothesis. For non-improvisers it hindered them. This can be explained with reference to the sensory-motor associations being used to identify the chords. Having the feedback from the hand in the position of the chord allows them to more accurately identify a chord when it is heard. It is somewhat puzzling, however, that non-improvisers are disadvantaged by this. Hypothetically, playing vs. only-looking should not have altered the non-improvisers performance, but playing actually disrupted their accuracy. It could be that having their hand in the position of a chord actually provided inaccurate information.

For the root position chords, there was also a marginally significant interaction between musician type and mode for total errors; playing increased the accuracy of improvisers whereas it had less effect on the non-improvisers. This supports the hypothesis. Playing would seem to offer a kind of sensory feedback that allows for more accurate identification of the chords.

These effects were only marginally significant. There are two ways this could be explored further. The first is to change the experimental design to more accurately capture the link between sensation and movement rather than the link between various kinds of sensation. What helped the improvisers was probably the ‘feel’ of the chord (the position of the hand) when they played; by having the playing of the chord trigger the sound of a same or different chord, the relationship between sensation and action could be more directly addressed. Secondly, the experiment could have more tightly controlled for who qualified as an ‘improviser’. This idea is developed in the general discussion at the end of this chapter.

Many other effects apart from those predicted by the hypothesis were also observed in experiment 2. These effects summarised in tables 6.5 and 6.6. Each is now discussed in turn.

**Non-root position chords.** The chords used in the experiment that were not in root position were harder to identify as congruent or incongruent. Because the total errors did not statistically differ between these different inversions, they were deemed to be more characteristic of the participants’ skills that the task was meant to employ.

Improvisers were significantly slower than non-improvisers. The improvisers took longer but they did not make a significantly different amount of errors. In other words, they did not take more time to ensure higher accuracy. This effect was not part of the hypothesis; there is no obvious reason why it should be so. If it had something to do with action-effect
blindness, one would have expected an interaction with the congruence factor; that is, congruent stimuli should have taken a different amount of time from incongruent stimuli. However, the effect could have arisen because of the way in which the improvisers study harmony does not typically involve this kind of a task. The way inversions are understood could be more implicit; that is, it is more linked to hand shapes and ‘voicings’ and less about explicitly matching sounds to an abstract notion of chord inversion. As is discussed below, there were effects associated with playing vs. only-looking, so the hypothesised connections may still be there.

Incongruent chords took longer to identify than congruent chords regardless of mode or musician type. This could be interpreted as a priming effect—congruent chords would have been primed since the first chord matched the second chord. But then, participants in general made more errors for congruent stimuli (incorrectly answering that they mismatched). This could be interpreted as a trade-off effect; participants took longer to identify incongruent chords, but correctly identified more of them, while congruent chords took less time to identify, but with more errors.

Further, there was a marginally significant interaction between congruence and mode; participants made fewer errors for congruent trials when playing, and for incongruent trials they made more errors when playing. Playing would appear to assist in identifying congruent chords possibly by providing an additional way to remember the inversion. Having the hand in the position of the first chord provides sensory feedback (proprioceptive, haptic, and perhaps auditory simulations) that would assist the identification of a congruent chord, but could conflict with the auditory presentation of an incongruent chord interrupting the ability to identify it correctly.
Figure 6.5: Interaction between mode and congruence for response times on trials with root position chords. For congruent stimuli, playing took longer than only-looking whereas for incongruent stimuli, they took roughly the same amount of time. Error bars represent one standard error in either direction.

Figure 6.6: Interaction between mode and congruence for the second blocks of each mode, root position chords only. While congruent chords resulted in a similar amount of errors regardless of mode, more errors were made for incongruent chords when participants were only looking, and fewer were made when playing. Error bars represent one standard error in either direction.
Figure 6.7: Marginally significant interaction between musician type and mode for total errors on root position chords only. Whilst only-looking, both groups made a similar number of errors whereas improvisers made fewer errors whilst playing than non-improvisers. Error bars represent one standard error in either direction.

Table 6.5: Significant and marginally significant effects for the trials without root position chords as either the first or second chord.

<table>
<thead>
<tr>
<th>Effects for non-root position chords</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RTs</strong></td>
</tr>
<tr>
<td>Musician type (improvisers &gt; non-improvisers, ( p &lt; .05 ))</td>
</tr>
<tr>
<td>Congruence (incongruent &gt; congruent, ( p &lt; .05 ))</td>
</tr>
<tr>
<td>Mode (playing &gt; only-looking, ( p = .063 ))</td>
</tr>
<tr>
<td><strong>Errors</strong></td>
</tr>
<tr>
<td>Congruence (congruent &gt; incongruent, ( p &lt; .005 ))</td>
</tr>
<tr>
<td>Musician type * mode (( p = .086 ))</td>
</tr>
<tr>
<td>Congruence * mode (( p = .092 ))</td>
</tr>
</tbody>
</table>

Table 6.6: Significant and marginally significant effects for the trials with root position chords as either the first or second chord.

As for the main effect of mode, when participants played the first chord, it took longer to correctly identify the second chord than when they only-looked at the first chord. The experiment was structured in such a way that participants had plenty of time to get their...
hands in position on the keyboard and then focus on the auditory stimulus, so the effect can be attributed to the fact that they had their hands in various positions when identifying the second chord and not an artefact of the time taken to get the hand into position. Further, there was not a trade-off with accuracy; participants were not significantly more accurate when playing despite taking more time. The data suggest that having the hand in position interrupted the speed at which the auditory chords could be correctly identified. It could be that having the hand in the wrong position added conflicting sensory information thus interrupting the recognition of the auditory chord. However, this factor did not interact with congruence. In other words, having the hand in a particular position could have facilitated the recognition of congruent chords, but interrupted the recognition of incongruent chords (because of the conflicted sensory feedback). Because it slowed down recognition regardless of congruence, it could be that participants adopted a different process to accomplish the task when playing that involved assessing the position of their hand for additional information. This could increase the response times without contradicting the interpretations of the other observed effects.

**Root position chords.** Given that the total errors for non-root position chords were relatively high (43.97% of trials had incorrect responses including those with outlying response times), the trials that included root position chords were also considered in the analysis. Those trials had a lower error rate (31.55% overall, again including trials with outlying response times). The structure of the experiment, of course, was similar regardless of the inversion. Considering the high total errors of the non-root position trials, the root-position trials may actually be a clearer representation of the experimental effects because participants are better able to accurately perform the task. In other words, is reason to believe there is less guessing.

For these trials, improvisers had higher response times than non-improvisers. Similar to the trials without root position chords, this is difficult to explain based on the theories and hypotheses that motivated the experiment, and the same reasoning discussed above would apply here.

Playing took longer than only-looking for the trials with root position chords. This effect was highly significant whereas it was only marginally significant for trials without root position chords. That being said, this main effect should be considered in light of the significant interaction with the congruence factor. Incongruent stimuli showed less difference in response times than congruent stimuli in which playing took more time than
only-looking. In other words, playing took longer, but it slowed down congruent stimuli more. Further, there was a significant main effect of mode for the total errors; again, there appears to be a trade-off where although played trials take longer, they are significantly more accurate. As for the interaction, although played-congruent trials took more time, there was a main effect of congruence for total errors such that congruent trials were also more accurate. These effects can thus be explained as trade-offs.

Improvisers took longer to identify congruent stimuli whereas non-improvisers took longer for incongruent stimuli. There is not a clear reason why this should be. However, this effect was only barely marginally significant, and may not be an effect at all.

Finally, as for the interaction between mode and congruence for total errors when only considering the second block of each type of trial (because of the significant interaction with block order described above), it is arguable whether this is a better indication of the effects in this experiment. However, if it is, considering the interaction between mode and congruence for response times, it suggests that playing is both faster and more accurate than only-looking. Playing would seem to help identify the chords. This should be interpreted in light of the interaction between musician type and mode for total errors, though. Improvisers are more helped by playing than non-improvisers.

**General discussion**

Müsseler & Hommel’s theory of action-effect blindness, in the end, does not appear to provide the most appropriate framework for describing or interpreting the data from either of these experiments. Nevertheless, if the experiments are reframed as an issue of cross-modal integration between sensory and motor systems, it can still characterise differences between improvisers and non-improvisers according to differences in the representation of musical structures; this is the general goal described and outlined in the previous chapter.

It remains unclear exactly what about having the hand in the position of a congruent or incongruent chord might help the improvisers make the similarity judgment. Something about the sensory feedback (haptic, proprioceptive) or internally simulated sound associated with holding the chord seems to have assisted them in making the judgment. Further experiments could focus on this effect specifically to add more evidence that it is indeed the case (as many of the effects observed here were marginally significant and with a relatively small effect size). For instance, an experiment could be set up in which playing a chord
triggered the sound of another chord and participants would be required to identify whether it matched or mismatched the played chord.

In any case, returning to the broader theoretical context of this experiment, this difference in perception identified in improvisers may underlie the kinds of skills they have, skills that are typically labelled as ‘improvisatory’. Being able to link multiple sensory modalities may be important in improvisatory contexts when playing with other musicians so as to be able to understand more fluently what is being played and appropriately respond, perhaps with imitation. From another perspective, having a strong connection between the perceptual correlates of a musical idea and its motor instantiation would allow musical ideas to be fluently transduced into movements and sounds at an instrument. The ability to imagine them at all may have its basis and genesis in a rich and varied kind of representation. In this way, differences in representation and perception can be linked with differences in behaviour and a description of improvisers’ behaviours. It is a different way of knowing allowing for a different way of moving.

The experiment relied on making a distinction between improvisers and non-improvisers. The goal was to temporarily set up this distinction to see if any difference in perception could be found. Of course the groups were not homogenous in their skills and learning styles, but even with the blunt distinction that was made, marginally significant interactions were found involving the musician type. On the one hand, it is promising that there is something about improvisers’ experiences that is not highly specific to a particular type of background. On the other hand, in developing this research programme, it could be helpful at this stage to be much more restrictive about who is able to participate in these experiments.

This could be done by developing a qualitative metric to assess improvisers’ backgrounds. If the hypotheses for these experiments are based upon certain kinds of pedagogical experiences (as outlined in chapter 5), it would be important to assess to what extent the improvisers participating in these experiments actually use those methods. To this end, such a qualitative metric could assess improvisers’ practice routines (how they normally practice, what kinds of exercises they use) as well as assess their listening practices (do they actively practice simulating what is being played when listening to other improvisers). Such assessments could also incorporate motor imagery assessment tools discussed in chapter 5.
With a more accurate picture of who these improvisers are, further progress could also be made towards assessing different modes of performance. Different characteristics could correlate with different performance on this task, or perhaps help pose a different question about how representations and/or motor processes might differ that could be tested in a different experiment. This would contribute to the taxonomy of modes of performance proposed in the previous chapter. This would also help clarify whether such differences are better characterized as a difference in kind or degree. If a qualitative score could assess to what extent improvisers employ motor imagery practices, and that score correlated with their performance on a task similar to the experiment presented here, this could form the basis for a difference in degree comparison. Alternatively, if there were categorical differences between those with any motor imagery practice versus those without, this would point to a difference in kind.

These experiments highlight the advantage of a cognitive approach. The explanation of the difference between the groups of improvisers and non-improvisers is described in cognitive terms. The classification of ‘improviser’ could be extended to many different kinds of musician inside and outside Western traditions. Would there be anything in common between them? To be sure, the structure of the experiment would have to be altered to accommodate the musical vocabulary and style of other kinds of musicians, but this would be well within reach. In this way, the cognitive approach could advance the comparative enterprise described in chapter 2.

The following chapter presents an experiment that shifts the focus from a between-group comparison to a within-group comparison of different modes of performance employed by individual musicians. Different groups of musicians may have different representations of musical structures, but how might the same musician employ different motor processes depending on the performance context? How could improvisation be characterised in this way?
The previous chapter presented experiments that compared the sensory-motor associations of musical structures in groups of improvisers with those in groups of musicians without improvisatory training or experience. This approach helped characterise how improvisers perceive music, and discussed how that kind of perception may underlie the kinds of movements improvisers are making.

This chapter shifts the focus to the motor processes underlying improvisatory movements at an instrument. If improvisation can be distinguished from other modes of performance in terms of some kind of difference in process, and indeed different kinds of improvisation can be distinguished from each other, how might differences in those processes be described and characterised? How could behavioural experiments be designed to demonstrate such differences in cognitive processes? What theory might guide the kinds of questions to be tested? How could this relate to the differences in sensory-motor associations described in the previous chapter? The general structure of this research question, as outlined in chapter 5, is to set up within-group comparisons between different performance processes within individual musicians.

Chapter 5 framed questions about improvisation in terms of common-coding theories. Improvisers may come to perceive music with a stronger link between motor and sensory representations than musicians who do not improvise due to differences in the kinds of experiences they have, and pedagogies and exercises by which they learn. Looking within groups of improvisers with similar training and experiences, a single musician can engage in multiple kinds of performance. They can improvise, play from memory, sight-read, or improvise in different ways (using muscle memory, choosing notes randomly, following explicit rules, or other ways). They may have strengths and weaknesses in these different modes of performance compared to students of classical pedagogies (e.g., they might have less experience sight reading certain kinds of notation) which could be compared between groups of different kinds of musicians, but the main point here is to compare different modes of performance within individuals to show how they might differ or be delineated from each
other in cognitive-scientific terms. This could constitute a characterisation of various modes of performance based on process, which as was argued in chapter 3, is what is needed.

In the small body of experimental studies that exist on improvisation, the motivation to compare such modes of performance in this way is most clearly found in the neuroscience literature. As discussed in chapter 4, these studies compared memorised performance and improvisation. They are generally framed in terms of understanding how improvisers are able to generate novel motor behaviours or engage free-response or pseudorandom generation mechanisms in improvisation. The idea of the improviser as the pseudorandom note generator was challenged in chapter 3 on the basis that it does not adequately account for the role of prior knowledge employed in improvisation or the different kinds of improvisation that can be performed, nor does it adequately distinguish improvisation from the choices made in supposedly non-improvisatory performance. The motivation to compare modes of performance is a good one, but some other theory is needed to motivate a hypothesis about how they might differ and why.

This other theoretical motivation also comes from common-coding theories and a focus on the practices and pedagogies of improvisers. How might such theories also describe differences between a given musician’s different modes of performance? When Sudnow describes ‘going for the sounds’, and Tristano advocates truly hearing what you are playing, this suggests that there could be differences in how ‘aware’ performers are of the sounds they are making or are about to make. If it is possible to improvise without really listening (perhaps by using familiar licks based on some kind of motor memory), improvise with listening, play from memory whilst listening, play from memory without listening, etc., then the cognitive correlates of such modes of performance could help describe what it means to improvise and to improvise in different ways. For instance, differences between modes of performance could be assessed by the way and degree to which performers are actively simulating the sounds they create at their instruments. One could imagine a naïve instrumentalist pressing keys on a piano without knowing what sounds to expect as compared with an expert performer who has a strong connection between the movement and the sound, with the sound guiding the choice of movement. An experienced performer, however, could also be one who is able to make complex sounds and understand their organisation without really ‘hearing’ what they are playing as Tristano might describe it. A classical pianist, for instance, might play a particular secondary dominant chord without realising that it has the same sonic function as the same chord in a different key earlier in the piece, or also that it
could be substituted with another chord that serves the same function (like a tritone substitution). They still ‘hear’ the chord, but are not actively aware of its harmonic function in the way a jazz player might need to ‘hear’ the chord to use it. Of course, a jazz player might not necessarily ‘hear’ it either, and many classical pianists might understand the function perfectly well! It is this kind of listening and internal perception that might distinguish motor processes between modes of performance—in what ways are the sounds of movement understood in processes of motor planning, execution, and feedback?

Such an understanding would contribute to what it means to improvise. It could help speak to questions such as how musical structures can be learned in such a way so as to be able to be employed in improvisation. In other words, two musicians might know the same structure, but only one knows it in a way that is able to be used whilst improvising. Such a motor process might underlie the kind of fluency and mastery of style that is observed in skilled improvisatory performance. In other words, in order to improvise fluently (or, do one of many things that is typically called ‘improvisation’), performers need to have this active simulation.

Why certain motor processes might underlie improvisation could again be linked to observations about practice methods and pedagogies. Practices like transcription and transposition could contribute to such differences in the cognition of musical structures. Practicing transposition would create a kind of cognitive invariance of musical structures such that multiple different movements could accomplish the same sound. This would allow for ‘going for the sound’ in Sudnow’s terminology rather than recalling particular movements. Transcription would similarly work to connect movements with sounds such that hearing a sound would be more closely linked with knowing how to play that sound (if the transcription were of someone playing the same instrument).

Of course, there are modes of performance that might typically be called improvisatory that do not employ such a link between perception and action. Perhaps the muscle-memory player who relies heavily on stock phrases is not really listening. This mode of performance may have some other kind of difference in motor process that could differentiate it from memorised performance, or from other modes of performance. In other words, an account of improvisation based on common-coding theories is not meant to be the only possible way to characterise differences between modes of performance. Until another way is proposed, however, common-coding theories seem to offer a promising way to describe differences.
It should also be noted that it is possible that improvisers, given the way their training focuses on linking sounds with actions, would always have such a strong link in any mode of performance. Whether they are playing from memory, or improvising in various ways, because they have learned musical structures with a strong link between perception and action, they will always necessarily employ those linked representations regardless of the way they are playing. It may be that, on the whole, this would be true comparing various modes of performance between groups of musicians with and without the improvisatory-type musical training. However, it does not mean that improvisers are always moving in the same way. If it comes down to different ways of moving (some with active simulation and some without), within-group differences could still be detected in principle. In any case, this would be a valid objection to raise, and further experiments could look for these effects.

In short, hypothetically, improvisation should differ in regard to its motor processes specifically with regard to the nature of the internal sensory simulation associated with the motor planning. Certain kinds of improvisation might generate more of an internal image than others, or than when performing from memory. An experiment could be set up to observe such differences when performers are playing in different modes. Some kind of structural analysis could be employed to compare the product of performances produced under different laboratory conditions.

So, there are two questions to proceed in constructing such an experiment. First, how can a given performer’s strategies be reliably manipulated in the laboratory, and what kinds of data analysis could reveal and describe such processes? If common-coding theories offer a way to begin questioning what might characterise certain improvisatory cognitive processes, how can one structure an experiment to test how such motor processes might differ?

**Altered auditory feedback**

Common-coding theories motivated the perception experiments in the previous chapter, but they can also support experiments on differences in motor planning. According to the theory, in that perception and action share a representational domain, motor planning should generate internal sensory images and vice-versa. By experimentally manipulating the dynamics of this interaction by changing the ability of participants to ‘hear’ those internal images, motor planning could be manipulated, allowing inferences to be made about differences in motor processes. These kinds of effects are described in some of the common-coding literature as resulting from various kinds of Altered Auditory Feedback (AAF).
AAF offers a way to disrupt motor planning by providing conflicting sensory feedback corresponding to the execution of a motor action. Such alterations introduce an artificial mismatch between an action and that action’s normal perceptual consequence either by altering the content of the feedback (such as changing the pitch) or altering its temporal location, usually through Delayed Auditory Feedback (DAF) by which, as the name implies, feedback from an action is delayed by a specified amount of time (usually a fraction of a second). Here, I use the term AAF to refer to alterations in general, and DAF as a subtype of AAF. The AAF experimental paradigm can be used to disrupt performances of different kinds in order to make inferences about motor planning and execution.

Wing and Kristofferson (1973a, 1973b) examine timekeeping mechanisms using a tapping task in which participants are required to tap as evenly as possible. They model two kinds of variance in the inter-onset intervals (IOIs) of the taps: motor variance is the portion of variance at the local level where a particular tapping action might be a bit early or late whereas clock variance refers to a global shift in the average IOI. Wing and Kristofferson argue for the presence of a central timekeeping mechanism.

Inferences about the mechanism underlying the disruptive effects of AAF have been refined in the speech literature (see Howell 2004 for a review). One question is whether AAF is disruptive due to mechanisms that monitor feedback contents. Howell, Powell, & Khan (1983) argue that DAF is disruptive based on conflicting rhythmic information regardless of feedback contents. The so-called ‘displaced rhythm hypothesis’ suggests that the disruptive effects of DAF are due to a mismatch in rhythm between production and perception, and the mere rhythmic mismatch disrupts the ability to process both effectively.

These experimental techniques and theories have been adapted to examine musical performance. The associations between the sounds made by particular movements at an instrument that are acquired through years of training can be disrupted with this technique. These studies on music apply various kinds of altered auditory feedback (including DAF, but also various kinds of alterations to the pitch contents of the feedback) to the performance of short melodies at the keyboard (see Pfordresher 2006 for a review) and voice (Pfordresher & Mantell, 2012). DAF has been shown to slow the production rate of performances (Finney, 1997; Gates, Bradshaw & Nettleton, 1974) and increase the variability of timing (Pfordresher & Palmer, 2002).
The research on AAF in music has provided converging evidence for some of the theories of AAF disruption, but has challenged the claim that a time-keeping mechanism is the sole explanation for disruption. Finney (1997) showed that DAF was less disruptive if the feedback contents were also altered, suggesting the content of feedback plays some role in the mechanism of disruption. Similarly, Gates & Bradshaw (1974) showed that listening to different music while trying to play is disruptive to timing, but less-so than DAF. Pfordresher (2005) tested the importance of structural similarity, showing that structurally similar feedback is more disruptive than random or systematically altered feedback. Again, this implies that the content of the feedback plays some role in disruption.

Pfordresher’s series of studies focuses on this issue in detail. Pfordresher & Palmer (2002) showed that subdividing can lessen the disruption caused by DAF, indicating that there may be a timing hierarchy governing where events should fall, and that disruption may result from an active attempt to fit feedback into that hierarchy which would result in errors if the feedback were artificially altered. Pfordresher (2003) dissociated disruption due to motor planning and disruption due to motor execution. If the feedback contents were altered in a particular way by making the current note being played sound like a previous note in an isochronous series (where each note has the same duration), such feedback would result in increased production errors while mere DAF (that is, with perceived events feedback occurring in between executed events) results in increased IOIs and IOI variability. In this way, the contents of the feedback matters, but it matters in motor planning, not in motor execution. This finding suggests there are additional disruption mechanisms at play than just Howell, Powell, & Khan’s displaced rhythm hypothesis.

One of the advantages of applying AAF techniques to music is the ability to test for effects of expertise by comparing musicians and non-musicians, a comparison that would be more difficult to make with speech experiments. Pfordresher (2005) showed that non-musicians also show similar effects of AAF when instructed to play passages at a piano with action notations. It appears from this study that long term acquisition of perceptual-motor links is not necessary for such disruption to occur, but that a more immediate association can be learned in a short amount of time. Perceptual-motor links may still be important as a feedback monitor, but not one that relies on years of training. That being said, van der Steen, Molendijk, Altenmüller, & Furuya (2014) recently showed that expert pianists show less disruption from temporal perturbation compared to non-musicians, relying less on auditory feedback in the performance of certain sequences of notes.
As it stands, while various kinds of AAF clearly have a disruptive effect on musical performance, and while it is clear that it has something to do with timekeeping mechanisms and some kind of interruption with normal sensory expectations generated from motor planning, the precise mechanisms of AAF disruption are yet to be understood. Pfordresher (2005, 2006) and Novembre & Keller (2014) both link AAF studies with theories that link action and perception. This is a promising way to frame the findings of AAF studies.

In order to advance this research agenda and to use it to support the theories about improvisation outlined in chapter 5, a few gaps should be noted in the existing literature. Despite testing for differences between musicians and non-musicians (e.g., Pfordresher’s (2008) study that found pianists were more disrupted than non-musicians by certain kinds of altered feedback), there is less sensitivity to differences between types of musicians. While it is true that musicians with different levels of expertise have been compared, different kinds of musicians—i.e., who have learned through different pedagogies, practice methods, and experiences—have not. In this way, a between-groups comparison between improvisers and non-improvisers could assess the effects of AAF to see if different pedagogies lead to stronger links between motor planning and sensory simulation, and thus to different amounts of disruption due to AAF. However, while this, too, could be a profitable line of research, the experiments described below are aimed at comparing different modes of performance within individual musicians and thus focus on a second gap in the existing literature.

This second gap that could be addressed is that AAF experiments on both speech and music typically use short, well-rehearsed and often memorised passages for recitation. In this way, some kind of motor plan is provided for participants. For music, this typically means short melodic passages memorised at the experimental session. For speech, passages can be read, memorised, or a single syllable could be repeated. These experiments do not compare different kinds of performance as an experimental variable. Improvisation and memorised performance probably do not use the same kind of motor planning (at least at some level). Understanding how the motor planning differs and how different modes of performance might be differently susceptible to AAF could advance theories of improvisation, and an understanding of the reasons AAF is disruptive. If AAF is more disruptive to certain ways of making movements, this could potentially help dissociate different components of disruption induced by AAF. The experiments in this chapter follow from this. The general structure of these experiments will be to compare different modes of performance under AAF conditions.
to demonstrate and characterise differences in their underlying motor processes, specifically with regard to internal sensory simulation.

**Operationalising improvisation**

Before describing the theories and hypotheses of these experiments in more detail, the issue of operationalising improvisatory performance needs to be addressed. Chapters 2, 3, and 5 devoted considerable time to the concept of improvisation and how it would be difficult to operationalise, opting instead for a notion of a plurality of modes of performance. That being said, in order to compare these modes, participants still need instructions about what to do in an experiment. Some notional definition of improvisation must be offered. Or, rather, it must be assumed. In order to compare improvisation with rehearsed performance in the experiment described below, participants are asked to improvise. The meaning of this term is understood tacitly. No participant asked what was meant by ‘improvise’ in the experiment. In fact, additional performance criteria were introduced to encourage them to improvise in different ways, but they were not explicitly told to adopt a different mode of performance; rather, they were always told, simply, to improvise. In this way, the meaning of the term can be assumed initially. Then, whatever it is that participants do when told to improvise (and it should not be assumed that they do the same thing) can be analysed with various metrics in order to explain and potentially recategorise various performance processes.

More specifically, for these experiments, some standard forms of improvisation would need to be used. Certain kinds of jazz performance are commonly understood as improvisatory and it can thus act as a stepping stone in a research programme on a path to a more nuanced and empirically supported definition. Piano playing is assessed in these experiments largely because of the ease of data collection and analysis with MIDI. Further, for the first experiment, jazz piano bass lines over a standard chord progression (Rhythm Changes) are used as a way to compare improvisatory process with bass lines over the same chord progression played from memory (which are learned before the experimental session—see the method section below).

Finally, in terms of assessing performances within AAF paradigms, errors as such cannot be measured for improvisatory playing. There are no wrong notes in improvisation—at least that could be reliably measured. It is true that some notes might be less common or preferred than others, or that some might be ‘unintentional’ (which could potentially indicate
a disruption in motor planning), but it would be very difficult to measure these objectively. Instead, other metrics such as timing fluctuations must be used to analyse the data.

### EXPERIMENT 3

The goal of this experiment is to characterise how improvised and memorised performances differ with regard to their underlying motor processes. This will be assessed using DAF. If, whilst improvising, performers are using their ‘inner ear’ to guide them, they may be more disrupted by the effects of DAF. The DAF should interfere with their ability to match the feedback with the internally generated expectation, resulting in disruption. Memorised performance may rely less on internal simulations of the sound and more on a well-rehearsed motor programme that is less reliant on feedback to guide the movements. If the displaced rhythm hypothesis is the only source of disruption, different modes of performance should show the same level of DAF-induced disruption because rhythmically speaking, the tasks are identical (to produce isochronous bass lines). If the different modes of performance show different levels of disruption, this would point to a difference in motor processes based on the internal simulation of sounds generated. This would begin to fulfil the goals outlined in chapters 3 and 5 in establishing a process-based definition of improvisation.

In order to try to manipulate the degree to which the improvisers are able to internally simulate the sounds they are producing, an additional factor of key will be assessed. Goldman (2013) found that when improvisers played in an unfamiliar key (B major), they played more diatonic pitches and with less variation between pitch classes (as assessed by information theory’s entropy measure) than when playing in a familiar key, B♭ major. This suggested a different strategy adopted by the musicians. When they were not as familiar with the association between movements and sounds (as would be the case in an unfamiliar key, corresponding to an unfamiliar ‘feel’), they used a more explicit strategy of using scale tones. For the purpose of this experiment, an unfamiliar key may represent a situation in which the musicians are less able to rely on familiar motor patterns and must rely more on auditory feedback to more deliberately choose appropriate notes. Thus, the unfamiliar key should be more susceptible to the effects of DAF. This represents two different kinds of improvisation (modes of performance) being tested experimentally, requiring different strategies on the part of the performers.
Method

This experiment was conducted in line with the prevailing policy in the Faculty of Music on the conduct of empirical research involving human participants. 10 jazz pianists participated in the experiment (\(M = 20.0, SD = 2.6\) years; 9 male, 9 right-handed). 7 were jazz piano students at the Birmingham Conservatoire, 2 were undergraduate jazz pianists at the University of Cambridge, and 1 was a graduate jazz pianist at the University of Cambridge. Before arriving at the experimental session, the participants were sent two bass lines composed by the researcher to be memorised. Each was a single chorus (32 bars) of Rhythm Changes (over the chord progression of George and Ira Gershwin’s jazz standard, *I Got Rhythm*). One was in Bb, and the other was an identical bass line transposed to B. The bass lines consisted only of crochets (see appendix A).

Each participant played 4 trials of bass lines under 8 conditions. Each bass line was a single chorus of Rhythm Changes (32 bars). The conditions were organised by 3 factors with 2 levels each: mode = improvised or memorised, feedback = delay or no delay, and key = Bb or B. The tempo was set at 120 bpm. The delay was 333 ms, or two thirds of a single beat. This level of delay has been shown to be very disruptive (Gates, Bradshaw, & Nettleton, 1974), and in that different levels of delay are not being compared here, it will suffice for the purpose of this experiment. Before each trial, participants were given verbal instructions about whether to improvise or play the bass line from memory, whether there would be a delay or not, and in which key they should play. For improvised trials, participants were instructed to improvise a walking bass line over Rhythm Changes. They were further instructed to only play crochets during improvised trials and only to play one note at a time. Participants all used their left hands to improvise the bass lines as is typical in this style of playing.

At the beginning of each trial, participants heard a single bar of a metronome click and then played with the metronome for eight bars during a synchronisation period. During this period, there was a never a delay. For this period, participants played a repeating major arpeggio, one note per beat, in the key of the succeeding bass line (either Bb-D-F-D or B-D#-F#-D# repeated 8 times). Following this, the participants would then go into the bass line of the type verbally specified by the experimenter before each trial. If there was a delay, it would automatically start after the last bar of synchronisation (see figure 7.1).
Figure 7.1: Schematic of the experiment. This represents one trial. The participants were verbally instructed under which condition to play before the start of each trial.

After the first 16 trials, participants took a short break. The order of the conditions was counterbalanced between participants. Participants played on an 88-key weighted MIDI keyboard. Responses for each trial were collected as MIDI files using Logic Pro 8. Delay was controlled automatically by interfacing Logic Pro 8 with MaxMSP. Participants completed a short questionnaire with demographic information following the experimental task.

Data analysis

Pre-analysis. Before conducting a statistical analysis, several steps were necessary to process the data. First, the first and last bars of the bass lines were eliminated from analysis (regardless of the condition). This was a conservative measure as sometimes participants would slow down at the end of the bass lines, and the sudden introduction of DAF after the synchronisation period may have caused additional disruption.

Next, for the memorised trials, it was necessary to identify wrong notes and exclude them from analysis. Several types of these errors were present in the data. Sometimes participants would play alternative sections of a bass line during a memory trial (such as replacing a particular bar with a new bass line). This sometimes happened for a measure or more. Sometimes single notes would be wrong, or displaced by octaves or other intervals. Sometimes note orders were reversed. A conservative approach was taken by which any note (and its associated IOI) that deviated from the memorised bass line was discarded. Another type of error occurred in both memorised and improvised trials. Sometimes participants would accidentally play two notes at once (‘clusters’). Sometimes the delayed auditory feedback would make them stumble and play more than four notes in a given bar of music (‘stumbling’). Sometimes participants would intentionally use non-crochet rhythms (such as dotted note figures). All of these notes were also discarded. As a further conservative measure, the note immediately before any of these errors was also eliminated to avoid errors in motor planning that preceded the actual error.
What remained was a list of crochet notes with associated IOIs (here understood as the amount of time before the next note was played). The average and standard deviations were calculated along with the Z-score for each IOI (calculated relative to each individual trial) after the other error notes were removed. A limit for outliers was set at 2.5 standard deviations. IOIs lying outside these limits were then eliminated as well.

3632 notes were eliminated from analysis due to these various errors and outliers. This constituted 9.96% of the possible notes to be included, 36480, which was calculated by multiplying the 320 trials (32 trials for each of the 10 participants) by 120 possible notes per trial included (32 bars per trial, 4 notes per bar, less the notes in the first and last bar = 120 notes per trial).

The other preparation for data analysis was to number each of the notes in the improvisation. For memorised trials, this meant numbering the notes that should have been played (1-128). If an extra note was played, it was not counted in the analysis. In improvisations, this meant numbering the notes 1-128. This was only ambiguous when clusters, stumbling, and non-crochet notes were present. Such notes were discarded and the numbering would restart afterwards. For example, if the second beat of a bar was meant to be note number 34 but it was actually a cluster of two notes, those two notes would not be counted, and the third beat of the bar would resume at number 35. Through listening to the improvisations, it was possible to make such judgments. In the event that the improvisations went beyond 128 notes (sometimes participants would mistakenly play more than one chorus, or repeat sections of the chord progression), only the first 128 notes were counted.

The final data ready for analysis was the remaining list of IOIs, each with an associated note index—i.e., its place from note number 1-128 in the bass line. These lists were used for calculations of the tempo drift (a linear regression of the IOIs for each trial), the average IOI for each trial, and the coefficient of variation (CV) for each trial. These metrics were used to assess the disruptive effects of DAF. The average IOI and CV were chosen as metrics of disruption based on Pfordresher’s (2003) analysis.

**Discarded trials.** For memorised trials, if participants made too many errors, they were discarded. This was made on a case-to-case basis. If errors were consecutive, such as a memory slip for one or two measures, it was possible to keep the remaining data for that trial as the rest of it was regular enough to reasonably analyse tempo drift and IOI variation. If, however, memory slips occurred throughout a trial, the performance was sufficiently...
disrupted to invalidate such analysis. A total of 7 memorised trials were discarded. Sometimes improvisations were discarded. For example, one participant went into double time (playing twice as fast) for portions of certain trials. These were discarded. Occasionally participants would abandon trials due to excessive disruption from the delay. Sometimes sections of the chord progression were omitted. In both of these instances, trials were discarded. A total of 9 improvised trials were discarded. This left 153 memorised trials and 151 improvised trials to be included in the analysis.

Results

**Tempo drift.** Several measures were considered to assess tempo drift. First, for each trial, a linear regression was conducted on the IOIs using the IOI values and their associated index (from 1-128). The Pearson Product Moment Correlation Coefficient was calculated. Such a value would represent one form of DAF-induced disruption in the data. A three-way repeated measures ANOVA was conducted with the factors mode (improvised or memorised), feedback (delay or no delay), and key (B or Bb) on these values. There was a highly significant main effect of feedback, \( F(1,9) = 30.896, p < .001, \eta^2 = .774 \) (trials with delay had significantly higher tempo drift), and a marginally significant main effect of key \( F(1,9) = 3.517, p = .094, \eta^2 = .281 \) (trials in B major had a higher correlation than trials in Bb). There was a marginally significant interaction between mode and feedback \( F(1,9) = 4.189, p = .071, \eta^2 = .318 \), and a marginally significant interaction between mode and key \( F(1,9) = 3.895, p = .080, \eta^2 = .302 \).

It may have been that with additional subjects, whether such effects were significant would become clearer. However, the R\(^2\) values were very small \( (M = .009, SD = .012) \) making this particular metric difficult to interpret. Thus, despite having marginally significant differences between conditions with regard to the correlation coefficients, because the R\(^2\) values were so low, the tempo drift was deemed negligible.

**Average IOI.** The average IOI for each trial was then considered as another way to assess timing disruption. A repeated measures ANOVA with the same factors as described above was conducted on these values. Highly significant main effects were observed for the factors of mode, \( F(1,9) = 11.579, p = .008, \eta^2 = .563 \) (improvised trials had higher average IOIs than memorised trials as seen in figure 7.2), and feedback, \( F(1,9) = 25.190, p = .001, \eta^2 = .737 \) (delayed trials had higher average IOIs than trials without delay as seen in figure 7.3). No effect was found for the factor of key. A highly significant interaction was found
between mode and feedback $F(1,9) = 14.570, p = .004, \eta^2 = .618$ (see figure 7.4). The delay disrupted both improvised and memorised trials, but it disrupted improvised trials more. A marginally significant three-way interaction was found between mode, feedback, and key, $F(1,9) = 3.458, p = .096, \eta^2 = .278$.

Figure 7.2: Mean IOI as a function of mode. Improvised trials had higher average IOIs than memorised trials. Error bars represent one standard error in either direction.

Figure 7.3: Mean IOI as a function of feedback. Trials with DAF had higher average IOIs than those without. Error bars represent one standard error in either direction.
Figure 7.4: Interaction between mode and delay for mean IOIs. Average IOIs for improvised trials were raised more by the presence of DAF than those of memorised trials. Error bars represent one standard error in either direction.

**Coefficient of variation (CV).** The CV was calculated as an assessment of overall IOI variability. The higher this value, the more variation in IOI there was relative to the mean. A repeated measures ANOVA with the same factors as above was also conducted on these values. There was a significant main effect of mode, $F(1,9) = 6.775, p = .029, \eta^2 = .429$ (improvised trials had higher CVs than memorised trials as seen in figure 7.5), and a highly significant main effect of feedback, $F(1,9) = 27.589, p = .001, \eta^2 = .754$ (delayed trials had higher CVs than trials without the delay as seen in figure 7.6). There was a significant interaction between mode and feedback, $F(1,9) = 5.998, p = .037, \eta^2 = .400$ (see figure 7.7). No significant effects were found for key.

**Correlations.** One possibility was that participants adapted to the DAF over time, perhaps developing deliberate strategies to ignore it, or otherwise figuring out ways to lessen the effect. To this end, the correlation between the average IOI for delayed trials and their trial number in the experiment was assessed. The condition order was not the same for each participant, so trial conditions were sorted first by whether they had delay, and then by trial number. There were 8 delayed-improvised trials, and 8 delayed-memorised trials for each participant. For example, the first delayed-improvised trial’s average IOI for each participant was averaged to get the first data point for the correlation. Three Spearman correlation tests were performed. The first examined all of the trials with delay. The average IOI decreased over the course of these trials, $r(14) = -.721, p = .002$, meaning that IOIs moved towards the target BPM specified by the synchronisation phase. The second examined the individual
correlations of improvised trials with delay and memorised trials with delay. Both returned significant correlations. For improvised trials with delay, the average IOI also decreased over the trials, $r(6) = -0.929, p = 0.001$, and for memorised trials with delay, the average IOI also decreased over trials, $r(6) = -0.976, p < 0.001$ (see figure 7.8).

![Figure 7.5: Mean CV of the IOIs from each trial as a function of mode. Improvised trials had a higher average CV than memorised ones. Error bars represent one standard error in either direction.](image)

![Figure 7.6: Mean CV of the IOIs from each trial as a function of feedback. Trials with DAF had a higher average CV than those without. Error bars represent one standard error in either direction.](image)
Figure 7.7: Interaction between mode and feedback for the CV of the IOIs from each trial. The average CV for improvised trials was raised more by the presence of DAF than the average CV of memorised trials. Error bars represent one standard error in either direction.

Figure 7.8: Mean IOI changes over trials. The later improvisation trials with delay and the later memory trials with delay generally had lower average IOIs (closer to the target tempo of 120 bpm, 500ms) than the earlier occurrences of those types of trials.

The third examined the correlation between the placement and the difference between the memorised and improvised trials (e.g., the difference in average IOI between first memorised trial with delay and the first improvised trial with delay). The difference did not change significantly over the course of the trials, \( r(6) = .476, p = .233 \). In other words, the delayed improvised and delayed memorised trials similarly changed over the course of the experiment.
Similar correlation tests were done on the CV metric. For all of the delay trials regardless of mode, the average CV was not significantly correlated with its ordinal occurrence, $r(14) = -.403, p = .122$. For improvised trials with delay only, the CV metric did not significantly correlate with its ordinal occurrence, $r(6) = -.500, p = .207$, and for memorised trials with delay only, the CV also did not significantly correlate with its ordinal occurrence, $r(6) = -.524, p < .183$.

**Discussion**

The key findings of this study have to do with the interactions between DAF and the mode of performance. DAF did affect all of the performances, as past research would suggest, but, crucially, it affected the improvised performances more than the memorised ones. When improvising, DAF is more disruptive to the performers than when they are playing from memory, as measured in terms of average IOIs and in terms of variability between IOIs.

The hypothesis motivating this study was that the difference would arise as a result of having a stronger internal simulation of the sound associated with the motor planning, making improvisatory performance more susceptible to disruption when the feedback was delayed. Memorised performance, by contrast, could be executed with less listening (similar to the findings of van der Steen, Molendijk, Altenmüller, & Furuya (2014) discussed above in which expert pianists listened less). Memorised performances could rely more on familiar motor activity and require less feedback to guide the movements making them less susceptible to the disruptive effects of DAF. The experiment cannot conclusively show that the hypothesis was supported (see below) because an alternative explanation is that well-rehearsed passages actually have stronger internal simulation that would make them less susceptible to the distraction of a conflicting exogenous stimulus. In other words, despite the conflict introduced by the delay, because the sensory simulation is so strong, they are better able to ignore it. This problem could be elucidated with further experiments (see below). For now, this experiment was successful in showing that there is some difference in this regard between the modes of performance, a consideration that is relevant for the interpretation of AAF findings more generally.

Previous work with DAF has been motivated to demonstrate the nature of sequence planning and execution and situate it within theories of common-coding. If actions and their perceptual consequences share a common representational domain, artificial disruptions to
timing and feedback contents of actions should disrupt the brain’s mechanism for accurately monitoring and producing those actions. As discussed above, it has been established in the literature that trials with DAF are slower and more variable than those without. It is also not wholly surprising that there were main effects of the CV for the mode of performance—that is, that improvisations showed more variation in timing. Berkowitz & Ansari (2010), discussed in detail in chapter 4, had previously observed in the analysis of their behavioural data that improvisations had greater timing variability than the performance of memorised sequences. This study has replicated those findings.

Improvisations had higher average IOIs than memorised bass lines. A post-hoc ANOVA determined that this effect was only present with the delay. In other words, normal feedback trials did not show a significant difference between memorised and improvised performances while delayed trials showed a significant main effect for the factor, mode, $F(1,9) = 13.008, p = .006, \eta^2 = .591$. This is explained below with regard to the significant interaction between mode and feedback.

Returning to the displaced rhythm hypothesis, if the rhythmic mismatch between the motor activity and the feedback were the only source of disruption, one would have expected there not to be an interaction between delay and mode. Rhythmically speaking, the tasks were identical. Otherwise, they were controlled (as much as was feasible) for the other musical aspects of the performance. The delay was causing disruption due to some other aspect of what it means to improvise, or play from memory.

Another important consideration is the effect of key. For this experiment, key represented a way to induce different kinds of improvising. While the factor only reached marginal significance in the analysis, it is worth discussing. The hypothesis was that B major improvisations should be more disrupted because the motor activity is less rehearsed and thus relies more on auditory feedback. The improvisational strategy here, based on reasoning from Goldman (2013), would be more explicit and deliberate note choosing rather than relying on familiar motor activity. This should have made B major trials more susceptible to the effects of DAF when improvising, with less of a difference between keys for memorised playing. In other words, there should have been an interaction between delay and key, but only for improvised performances (memorised trials in both keys could be played without relying on feedback). The main ANOVAs for both average IOI and CV did not return significant effects associated with key. Thus, the data did not support this hypothesis.
However, considering the marginally significant 3-way interaction for the average IOI metric reported above, a post-hoc ANOVA was conducted examining improvised and memorised trials separately. Improvised trials showed no effects associated with key for either the average IOI or CV metrics. Looking at the memorised trials alone, there were no effects associated key for with the CV metric, but there were significant effects for the average IOI metric. There was a significant main effect of delay, $F(1,9) = 17.670$, $p < .005$, $\eta^2 = .663$ (delayed trials had higher average IOIs than trials without delay), a significant main effect of key, $F(1,9) = 6.825$, $p < .05$, $\eta^2 = .431$ (trials in B major had higher average IOIs than trials in Bb), and a significant interaction between delay and key, $F(1,9) = 5.728$, $p < .05$, $\eta^2 = .389$ (the delay raised average IOIs for both keys, but it raised the average IOI for the B major trials more—see figure 7.9).

![Interaction between delay and key](image)

**Figure 7.9**: Interaction between delay and key for average IOI, memorised trials only. This post-hoc analysis showed that while introducing the delay affected trials in both keys, it raised the average IOI more for B major trials.

This effect is in line with the hypotheses, although it is unclear why it is not present in improvised trials as well. B major bass lines would seem to have more disruption due to DAF because they are less robust and rely more on the feedback to guide the actions. It may be that this small effect is present in the improvisations as well, but did not show up given the other sources of variance. Alternatively, if all improvisations are more reliant on feedback than memorised trials, that effect may take precedence over the smaller effect of key.
Problems and alternative explanations

One potential problem with this experimental setup is the effect of familiarity with the musical material being performed. The memorised bass lines were necessarily practiced whereas the improvisations were not rehearsed. The observed effect could be interpreted as an effect of familiarity or exposure to the material. The argument here is that improvisation engages perceptual-motor processes differently than music recalled from memory. Improvised music is also, in some sense, ‘memorised’ in that many of the movements and sounds created at an instrument are themselves well-rehearsed. They are also, arguably, well-practiced. Even though improvisations may not have a pre-determined structure note-for-note, their components and the processes that are used to produce them are familiar and common. What is left in this potential objection, then, is the way in which music is recalled from memory, which is the very difference trying to be explained and supported through this experimental design.

Another issue is in the claim that the improvised condition was more disrupted because of a stronger internal simulation of the image. This is not necessarily the case. One might think that the memorised performance would have a stronger internal simulation in that it is well-rehearsed; that is, the performers know exactly what sounds will come and thus have a stronger expectation associated with their motor activity. Even if it is the case that the memorised playing can avoid the effects of DAF by relying on familiar motor patterns without listening to the effects, the internal image may still be strong; instead, performers might be relying on the familiar motor activity and thus less reliant on the feedback to guide their actions. If this is the case, it might be better argued that improvised playing relies on the feedback more in order to help plan the next movement because the amount ahead that is planned at any given time is shorter. This could open this line of research into the motor planning literature (e.g., Palmer & van de Sande’s (1995) study that measured the range of motor planning in musical performance). The number of notes planned in advance might negatively correlate with its susceptibility to disruption by DAF. If improvisation has shorter spans of notes planned at a time, that might explain its increased susceptibility to DAF.

Another point to note is that past research has used error rates (rather than just changes in the IOIs) to measure the disruptive effects of DAF. As mentioned above, it would be very difficult to reliably identify ‘errors’ in improvised trials. It is not impossible in
principle; some of the things the participants played seemed unintentional and the result of
disruption from DAF (the ‘stumbling’ and ‘clusters’). However, to precisely and reliably
quantify these would be problematic as there may have been other less visible ‘errors’. For
instance, unintentional notes may have been played (notes that did not follow the original
motor plan because of DAF disruption), but then the performer may have changed course to
make that erroneous note fit, making it invisible as an error. Pfordresher (2003) concludes
that timing disruption is evidence of problems with motor execution whereas errors in
performance are evidence of problems with motor planning. The present study does not
measure errors; disruption is only measured through timing disruption, and thus according to
Pfordresher’s conclusion, evidence of motor execution errors. However, given that the
improvised and memorised conditions were identical tasks rhythmically, and the significant
interaction between mode and delay, it would seem to suggest that something other than
motor execution problems led to the increased disruption—that is, internal sensory simulation
underlying motor planning.

A final issue to raise is to note that even though the instructions to each participant
regarding when to improvise were the same, different participants (or the same participant at
different times) may have improvised in different ways. For instance, sometimes they may
have been improvising by employing passages of bass lines they had remembered from other
performances whereas sometimes they may have been actively avoiding such recognised
passages. This would hopefully be taken care of by the large number of notes and trials
analysed in this experiment, but it could also be that some participants always stuck to one
strategy whereas others always stuck to another. Figuring out a way to differentiate between
these modes of performance would aid a more precise analysis method for future
experiments. Such variation in the strategy employed (the mode of performance) could
change the susceptibility to DAF.

**Future steps**

Improvisatory musical performance has been shown here to be more disrupted by
DAF than performance from memory. This experiment has thus demonstrated a difference in
motor process between modes of performance that is not based on ideas like novelty and free-
generation (as previous experiments have formulated their questions), but rather in terms of
perception-action links that are theoretically connected to the way improvisers learn and
practice music.
Of course, many questions remain unclear from this experiment and these conclusions. Future experiments could continue to elucidate these matters. The first has to do with expertise. The participants in this experiment were jazz piano students. They were accomplished, but not professionals. Professional musicians have years more experience at the instrument, possibly in a wider variety of musical contexts. The way in which an expert might play a memorised bass line might be closer to the way that expert would improvise it. That is, they may play the bass line ‘as though it were improvised’, engaging their perceptual-motor processes in a more similar way. Thus, the claim here is not that ‘improvisation’ necessarily simulates internal images more strongly, but rather that certain kinds of playing do, and those kinds of playing are often associated with what it means to ‘improvise’. In other words, again, one could improvise in different ways, some of which show this effect more than others.

Second, if the disruptive effects of DAF are explained in terms of a stronger generation of internal sensory predictions, and those sensory predictions are the result of the way improvisers learn and practice, then it would seem that all modes of performance used by this group of musicians should have similar sensory predictions and similar disruption from DAF. Why would it only affect one kind of performance? While it may be a goal for improvisers to ‘truly hear’ what they are playing, this does not mean that they do it all the time. One mode of performance may emphasise the link more than another, as would seem to be the case in the experiment. However, one way to explore this question would be to conduct a similar study, but compare improvisers and non-improvisers both playing from memory with and without DAF. If the differences in training and practice methods permeate all modes of performance to some extent, one would expect a between-groups difference to be found in this possible future experiment.

Third, it is still not completely clear whether DAF was more disruptive to improvisation because improvisation had stronger internal sensory simulation, or because memorised performance could rely on another way to perform that could ignore the feedback. Memorised performance could have weaker, stronger, or the same kind of sensory simulation; the experiment cannot tell for certain because it might be less disruptive for a different reason; that is, during memorised performance, the participants may have simply been better able to ignore the feedback by relying on motor memory. In fact, part of what this means might be that the familiar movements had stronger internal feedback that could
overrule the audio feedback provided in the experiment. Several kinds of future experiments could clarify this matter.

This could be accomplished by varying two other experimental factors. One would vary feedback contents as well as timing (as past experiments described above have done). By varying the feedback contents in addition to the timing, it should be possible to dissociate the effect of the rhythmic mismatch from the possible effect of the feedback conflicting with an internally generated image. Past studies discussed above have shown that altering the feedback contents can lessen the effects of DAF. If this is because the altered feedback would not conflict with the internally generated image, and improvisation generates a stronger image, it should lessen the effects of DAF more for improvisatory playing. Memorised playing should not be helped as much by altering the feedback contents. This would strengthen the claim that motor planning during improvisation is linked with stronger internal simulations of the sensory images.

The other experimental factor would be to induce the use of another mode of performance by forcing participants to use novel motor plans to produce otherwise familiar musical structures. For instance, in playing bass lines, participants could be instructed to use only their index finger. While this kind of playing is somewhat awkward, it would mean that even familiar musical structures would require novel motor activity (presuming participants do not normally practice this way). Improvisation and memorised playing should become more similarly disrupted by DAF in this case given the unfamiliar motor situation introduced to both. In other words, the interaction between mode and delay that was observed in this experiment should disappear if participants use only one finger to play.

It would also be helpful to know the extent to which familiarity with a musical passage affects susceptibility to DAF. This is similar to the improvised versus memorised comparison, but it could be made more basic. For instance, different types of passages could be compared varying according to two factors. Passages could either be extensively rehearsed or superficially rehearsed, and passages could utilise familiar tonal relationships or unfamiliar atonal ones. Because the feedback from the atonal passage should be less predictable, this could help dissociate the effect of whether DAF is disruptive due to stronger or weaker internal simulations. The well-rehearsed versus relatively-unrehearsed contrast could help determine whether familiar motor patterns are more or less disrupted by DAF.
Finally, future experiments along these lines could focus more specifically on timing mechanisms. Pfordresher & Dalla Bella (2011), for instance, conducted a DAF experiment examining the movement trajectories of fingers to help explain the mechanism of the disruptive effects of DAF. Incorporating this methodology could help investigate how improvisers might be moving their fingers differently; the finger movement trajectories could help differentiate different motor planning and execution mechanisms between modes of performance as assessed through DAF experimental paradigms.

Conclusions

To conclude, what does all of this say about how people improvise and what improvisation is? As discussed above, there are many types of improvisation. The participants in the study may have several strategies they adopt to improvise depending on the performance context. Everyone has a different brain, body, and set of experiences, so any generalisation of performance mode necessarily must leave out some of this variation. The goal is to forge a model that can classify trends in these strategies and link them to cognitive and neuroscientific correlates. The improvisatory mode of performance used for this task is evidently more disrupted by DAF than playing from memory. This is a characteristic, and thus a way to distinguish between modes of musical performance. Future studies could refine such a characteristic, or search for others.

It is important to note that this kind of a study could be adapted to other musical styles, and the theories could potentially be transferred to other creative domains. Other musical styles (including non-Western ones) could similarly be tested in such an experimental paradigm given adequate adaptation of the data collection method (e.g., instruments that cannot be recorded through MIDI would need a different way to measure IOIs) and similar conclusions could potentially be drawn. Even if a musical tradition in question does not have separate categories for improvised and non-improvised music, participants could still be asked to perform under different modes of performance by, for instance, comparing ‘repeated’ passages (perhaps through imitating another musician) with ‘original’ ones. Or, perhaps there are other modes of performance that an ethnomusicologist could help delineate for the purpose of experimentation.

As for other creative practices, this experiment begins to shift questions about improvisation to more general questions about the different ways people move (plan movements, sensory correlates of those plans, etc.). This attitude can be applied to
understanding different kinds of movements in other creative domains (dance, speech, etc.). The idea of ‘modes of performance’ could be applied to dance, for instance, in considering how the execution of a well-rehearsed routine differs from an improvised one. Of course it would be more difficult to experiment on this with something like DAF, but similar theoretical principles could be applied to understand the difference.
CHAPTER 8: CONCLUSIONS AND FUTURE DIRECTIONS

This dissertation has developed a coherent cognitive-scientific approach to researching musical improvisation. It has situated this cognitive approach within ethnomusicological, historical, and critical literatures on improvisation, demonstrating the in principle challenges faced by a scientific approach for a behaviour as complex and creative as improvisation. It argued that definitions of improvisation across a range of literatures implicitly consider the phenomenon from the perspective of its products rather than its process despite the fact that questions of process motivate the inquiry in the first place. It reviewed previous cognitive literature demonstrating how it, too, relies on product-centric thinking and often is not sensitive enough to questions of process and differences between improvisatory processes. Generally, to form a foundation for a scientific approach, it moved the focus from considering improvisers as free generators or pseudorandom note-choosers to questions about the different ways musicians acquire, represent, and employ musical knowledge that only appears similar when analysed after a performance.

Theoretical contributions to an understanding of improvisation

The few existing studies on the cognition of musical improvisation are not unified in their approach. Part of the problem is the difficulty of operationalizing the phenomenon, and the need for firmer musicological and critical grounding to justify the questions that are asked in this literature. This dissertation introduces a well-grounded foundation of questions about improvisation with clear ways to expand and build to accomplish the gradual goal of characterizing various modes of performance through cognitive-scientific experimentation.

Common-coding theory offers a clear way forward, but other cognitive-scientific paradigms may be applicable. The advantage offered by this dissertation is the theoretical framework. The goal for a cognition of improvisation has been set and justified, allowing various other experimental directions to become integrated. As previously noted, this comes with the additional advantage of helping to unify an understanding of improvisatory practices in different musical traditions as well as in different creative genres (e.g., dance and speech).
Empirical contributions to an understanding of improvisation

The experiments presented in this dissertation provide support for a distinction between the way different groups of musicians, delineated according to their experience with improvisation, perceive music. This has helped characterize how improvisers perceive music, and what it means to know about music in an improvisatory way. Given that different musicians may know about these same musical structures, understanding these differences in perception and cognition helps to explain why some are able to improvise with them and others are not. This also contributes to an understanding of how improvisers learn about music differently than non-improvisers, and how differences in learning affect differences in musical cognition and performance.

The experiments also showed that within groups of improvisers, improvising was more susceptible to delayed auditory feedback than was memorized performance. This demonstrates differences in the motor processes employed for different modes of performance. Improvisation should thus be understood as having characteristic underlying motor processes not just in terms of free-response generation (as characterized by the neuroscientific literature), but according to differences in the sensory simulation of musical structures during performance.

Of course, there are many other modes of performance that could be postulated to advance this research. Improvised versus memorised performance is one kind of distinction, but multiple kinds of improvisation (as induced by playing in different keys in the experiments presented here) were also introduced. Multiple other ways of dividing modes of performance could be implemented experimentally. The ones used here have been described cognitively (according to differences in sensory simulation and motor processes). This has not led to an obvious taxonomy that can be gleaned, but it begins to show how different kinds of performing have different cognitive correlates, some of which align with what is typically considered to be improvisation. Again, to emphasise the point, these different modes of performance can be used in performance contexts that are typically considered to be well-rehearsed or memorised as well. For instance, a concert pianist may engage different modes of performance whilst playing a particular piece, sometimes relying on their ear to guide the emphasis of certain harmonies, and sometimes relying more on strongly rehearsed motor patterns to execute a difficult technical passage. Musical structures, while apparently similar for a post-performance analysis, can be employed via different processes. The ones
necessary for the skills typically attributed to improvisers tend to have particular characteristics, as described by the experimental work presented here.

**Major limitations and future directions**

One of the major limitations of the experiments presented in this dissertation is the demographic categorisation of improvisers and non-improvisers. While the experiments serve as an initial, relatively rough comparison, the theories suggest there could be multiple different ‘kinds’ of musicians; more specifically, the argument is that different kinds of musical experiences lead to systematic differences in music perception. It is promising that even with blunt categorisation, effects can still start to be observed; further research could test whether there are commonalities between many different improvisatory traditions as described in chapters 2 and 6.

However, future experiments should also work to more precisely characterise the kinds of backgrounds individual musicians have. For instance, qualitative methods could be combined with experiments similar to the ones described here in order to more precisely link particular practices, listening behaviours, performance experience, and pedagogical methods with particular changes in cognition. A relatively rough questionnaire was used here, but a more precise questionnaire or interview instrument could make the data analysis more precise, and more strongly link the findings to particular aspects of musicians’ backgrounds. For instance, this kind of a qualitative research tool could be combined with future neuroscientific studies proposed and described below.

**Informing future work on group interaction**

As described in the introduction, the dissertation in general did not address group interaction theoretically or experimentally, and group interaction is arguably a crucial part of much improvisatory behaviour. Of course it would be important to develop this line of research as well, but the theories and findings presented here could be applied to that project. Many of the conceptual questions would share the same hurdles. How could group improvisation be compared across genres or cultures? How could one study group improvisation scientifically? What experiments could one design and how would hypotheses be generated? How do classical chamber music groups communicate differently than improvising groups? Further, the kind of perceptual and motor characteristics that characterise improvisatory ways of knowing could be the very same ones that allow for
effective communication in an interactive context. Knowing what the other person is playing and being able to imitate and manipulate it is the same kind of knowing that was used to justify the experiments presented in this dissertation. A similar theoretical model could be shared.

**Informing future cognitive work**

Even if the primary thrust of this dissertation is in establishing a strategy to gradually define various modes of performance through cognitive-scientific experimentation, and even if examining sensory-motor associations and motor processes is a promising theoretical premise, there are surely other cognitive questions about improvisation that might be pursued. Some would clearly follow from this research, and other projects might adopt a different theoretical perspective altogether, but within the same general research strategy and ontological perspective about what improvisation is.

As for the studies that might adopt different theoretical perspectives, a study of intergroup interaction would seem necessary. For instance, one could conduct research on the difference between inter-musician communication in different kinds of collaborations. How does the way communication in a jazz combo differ from how members of a string quartet communicate with each other? Seddon & Biasutti (2009) have approached this question. There is a large body of current research on how musicians communicate in ensembles that could be further applied to understanding improvisatory interaction, as well as adapting ideas from this dissertation. The point is that a focus could be comparative in order to help establish what it is that distinguishes improvisatory group communication from rehearsed group communication, or between a plurality of ways of communicating. With this focus, the research strategy presented in this dissertation could preserve its aims of characterising modes of performance with cognitive-scientific theories when applied in this new context. Further, it may well be that the mental imagery and motor planning groundwork that has been laid here could relate to other processes of communication in improvisatory settings. Perhaps improvisers are able to communicate in these channels that require simulation and mental imagery whereas classical musicians use different channels because of such differences in cognitive representations of musical structures. For instance, Novembre & Keller (2014) discuss how action-perception links inform musical coordination. The kind of understanding of musical structures necessary to improvise solo music could be the same kind necessary to
effectively communicate those structures to other performers. In other words, the experimental tracks could potentially be linked.

As for future studies that could further secure the claim that certain kinds of sensory-motor associations enable what is typically called improvisatory music making, and examining differences in motor processes according to their tendency to activate sensory simulations, perhaps one of the most promising directions to take this work is into the neuroscientific domain. The theories presented here suggest clear neuroscientific research strategies, theories, and hypotheses.

As noted in chapter 4’s literature review of the existing neuroscientific research on musical improvisation, this research is the most akin to what this dissertation aims to accomplish. It compares mental processes between musicians improvising as compared with playing from memory, and it compares neuroanatomical differences between musicians with improvisatory experience and those without. While the research aims are in line with the present project, and the experimental designs are roughly similar to what would follow from the present theories, the specific implementation of them are hindered by an operational definition of improvisation that is theoretically questionable. In other words, there are many other questions to ask outside of the pseudorandom note-generation conception of improvisation.

The perceptual experiments from this dissertation could be adapted for fMRI or EEG methods. Do improvisers have stronger motor cortex activation when listening to music with which they are familiar as compared with idioms in which they cannot improvise? Is there a similar effect for musicians who cannot improvise? Do improvisers have different neurophysiologies of musical imagery in general? Many questions arise from the research questions this dissertation presents.

One specific path that would be to pair neuroscientific experiments with a more precise description of musician’s backgrounds and practice methods. This would combine qualitative and quantitative methods to more precisely characterise modes of performance and their neurophysiological correlates. An interview instrument could be developed to assess various aspects of a given musicians’ practice methods, how they were taught, their listening behaviours, and their different performance strategies. Such interviews could be used to develop categories and indexes. To what extent does a given musician engage in
mental practice? How much transcription is actually done? This would give more resolution than the relatively coarse distinction between improviser and non-improviser.

Such categories and indexes could then be paired with neuroscientific experimental data. For instance, a study could be done that pairs these qualitative interviews with EEG measurements. Participants from different groups (improvisers vs. non-improvisers, different kinds of instrumentalists) could view and listen to stimuli that simultaneously present images of hands at their instrument of expertise (depending on the group) playing a particular chord with audio stimuli of congruent or incongruent chords, similar to the experiments described in chapter 6. EEG could reveal mismatch negativity artefacts that might vary in strength between musicians depending on the kind of practice methods, experiences, and pedagogies in their personal musical backgrounds as assessed by the interview.

fMRI is another neuroscientific method that could be used to investigate cross modal perception in different groups of musicians. Behavioural methods were used in this dissertation to make inferences about the extent to which sensory and motor representations interacted, but fMRI could offer another way to observe such cognitive differences. Again by pairing a more in-depth interview with functional neuroscientific observation, more precise conclusions could be drawn. Specifically, the fMRI task could present participants with various cross-modal stimuli of musical structures (staff notation, pictures of hands, sound) and assess the extent to which participants engage their motor systems to identify the musical structures. Participants may accomplish an identification task with different neurophysiological processes depending on their classification from the interview.

Finally, fMRI could also be used to investigate motor correlates of different modes of improvisation. The neuroscience studies that have already been performed do not distinguish between different improvisational strategies. Three conditions could be compared within a common structure (such as playing over a chord progression): improvisation without any explicit experimental stipulations, improvisation according to an experimentally specified rule (such as always using a particular combination of intervals), and intentionally random improvisation where participants are asked to choose notes as randomly as possible within the chord progression. While all of these conditions would constitute ‘improvisation’ in a music-theoretical sense in that the notes are not pre-determined, their motor processes could be compared and might engage different kinds of processes. Of course this is a rough sketch of an experiment and hypotheses would need to be developed, but the point is that
neuroscientific methods could aid in the gradual goal of delineating types of musical perception and performance modes.

**Informing future ethnomusicological work**

This dissertation claimed that the cognitive approach it establishes is based on experimental research with jazz musicians, but can extend its claims and hypotheses to other musical traditions to help explain those improvisatory practices. The explanations it has forged are based on cognitive principles of mental imagery and motor planning, so in principle similar theories could be taken to other traditions and replicated there. For instance, if a sitar player aimed to replicate exactly what had just been played in an improvisatory performance, would one find similar cognitive dynamics to those found in the studies here with jazz pianists? If one introduced a delay as with the pianists in the delayed auditory feedback experiment presented here, would similar effects be found?

In practice, this is still a great challenge. A lot of work would need to be done to effectively adapt such experiments to other traditions in ways that would make sense to the participants. The adaptation would need to be sensitive to the peculiarities of each of the traditions—perhaps it would be nonsense or impossible to ask an improvising musician to play ‘from memory’ in certain traditions due to the absence of such a concept or practice or the absence of written notation that might underlie such a concept. Some of the theories presented here might still apply—that is, that improvisers rely on this particular type of sensory-motor association—but a comparative study within that tradition might not be possible in the same way.

However, one might instead compare different types of improvisation or modes of performance. The superordinate term becomes useful here as it is noncommittal in this regard. An ethnomusicologist properly versed in the musical traditions in certain cultures might be able to identify groups of musicians with differing pedagogies and conduct a similar comparative study. As was argued in chapter 2, the terms of study would be different, but the cognitive principles might very well be similar enough to forge an intercultural theory. A practice like learning to imitate a master could be explained through common-coding theories, and as such a theory of how one learns to improvise could use cognitive principles to extend to different traditions.
Informing future creative cognition work

One of the exciting possibilities following from this research is further comparative study between creative behaviours. Just as there is much work to be done to compare performance processes in different world music traditions, one could similarly compare different creative behaviours to see if they share any of the principles suggested by this dissertation. When a dancer improvises as compared to performing a scripted choreography, could similar principles be used to describe their modes of performance? Or, improvised theatre as compared with scripted plays? For instance, Sawyer (2006) has compared the way improvised theatre performers communicate with musical improvisers’ communication characteristics.

As for experimental studies, of course, this would be much harder to examine in practice. Dancers and actors cannot record their responses on MIDI keyboards for a relatively quick digital data analysis. However, it is conceivable that similarly motivated methods could be adapted to examine these behaviours. As for theories specifically concerning motor planning and sensory motor representations, there may be more indirect ways to measure such differences. For instance, one could compare hip-hop dancers in a group all performing the same, tightly rehearsed movements to the same hip-hop dancers improvising a routine. It would take an expert dancer to help identify what kinds of experimental disruptions might be designed, but in principle similar theoretical predictions would apply. Or, dancers who have more experience improvising may have differences in perception to dancers who work from scripted moves in a way that is analogous to the findings presented in this dissertation.

The theoretical framework developed in this dissertation to study improvisation could thus be applied to reasoning about other creative behaviours and contribute to general theories of creativity. In that improvisation is generally considered to be a creative behaviour, understanding it contributes to an understanding of creativity. The critical analysis of the improviser as the pseudorandom note generator is also a critical analysis of creativity; scientists working to study creativity in the lab could thus build upon this kind of perspective to operationalise other kinds of creative behaviours in the laboratory.
Improvisation and expertise

As mentioned above, more precise qualitative methods could be used to assess the kinds of practice methods and experiences of the experimental participants. A related issue is that of expertise: even if the improvisers had very similar practice methods and experiences, some could be more advanced or have more experience than others. Expertise has been partially addressed in some of the neuroscience studies discussed in chapter 4, although, again, having another theoretical framework could help ask more critically sound questions. In other words, another possible research direction to examine expertise would be to ask how sensory-motor associations of musical structures change over the course of a musician’s education. How might such observations converge and diverge with musicians learning through different pedagogies and practice methods? Is there some other qualitative shift that distinguishes an expert from an amateur? How would this relate to other forms of expertise?

Exploring the role of the audience

Studying solo improvisers may be something like studying solo speakers. There is certainly a lot to learn about how people are able to form coherent statements by themselves, but the interest and motivation to study such a thing largely comes from its interactive character. People can improvise alone and there is much to learn about what they do when practicing or playing without an audience, but ultimately it would be helpful to understand not only how they interact with fellow musicians, but with audiences as well.

The experiments in this dissertation have focussed on solo performers. Another possible extension of this research would be to consider how improvisers interact with listeners. Some of the ethnomusicological literature cited in chapter 2 highlights the importance of having an educated audience, and having an audience present for any performance would at least on the surface seem to change the performer’s behaviours. How does the presence of a listener change improvisatory processes? How does specific knowledge of a listener modulate those processes? Does it matter if the performer knows how informed the audience is? Theory of mind literature could help enhance this aspect of improvisation. To what extent are performers able to judge what audience members are thinking or what they know about music, and how do they bend their improvisations to best resonate with their audience?
Informing future pedagogical work

Over the course of completing this project, one question that has repeatedly arisen in discussion is what practical applications this research might have. This is a question faced by most researchers, and given the scientific character of this particular project, it seems particularly accountable to produce practical results in that scientific knowledge often has an expectation to be instrumental. One of the hallmarks of a scientific understanding is a closer connection to being able to manipulate some aspect of the object of understanding, hopefully with the aim of improving some aspect of human experience. For instance, an understanding of physics can help engineers build sturdier bridges or taller buildings for societies that deem such structures necessary or helpful. A scientific understanding of some aspect of the mind could help a psychologist or educator accomplish some desired aim by providing therapies or designing pedagogies to urge people towards desired states of mind and knowledge.

Apart from informing future research and making blue skies claims about how an understanding of improvisation and creativity could lead to unforeseen applications, the most obvious and immediate connection with this research programme is to pedagogy. Many classical musicians claim not to be able to improvise. This problem, of course, has much to do with what one counts as improvisation, but it is also clear that such comments are often meant to compare themselves to jazz musicians who are able to ‘improvise’, whatever is meant and understood by their use of the term. A major factor in this is that the way jazz musicians learn to play is significantly different and emphasises different skills. As argued here, such differences in pedagogies lead to differences in skill sets and differences in music perception and cognition.

The thesis does not offer a better way for musicians to learn to improvise. If classical musicians want to learn to improvise, they could practice how jazz players practice, or participate in pedagogical traditions from an improvisatory musical tradition. However, the kind of scientific study presented in this dissertation could help characterise what it is about improviser’s practices and pedagogical methods that lead to the skills they have. If a student musician wished to acquire those skills, they could thus adopt those aspects of the methods. In this way, a scientific understanding could explain why certain pedagogies are effective, or which aspects of them are most effective and promote those aspects, thus fine-tuning pedagogies of improvisation.
As for the blue skies claims, to paraphrase a speech at a recent research event at Wolfson College given by Leszek Borysiewicz, the current vice-chancellor of the University of Cambridge, research that does not have an apparent application may simply not have an application yet. This may be more apparent in physics (does string theory have any practical applications?) but it is also true for psychology. The present work on improvisation contributes not only to a cognitive-scientific understanding of music, but also has potential contributions to theories of creativity, and contributes to ways in which one can compare and contrast different musical traditions and different kinds of creative behaviours. It may not be obvious how this might change the way people engage with creative behaviours or what technologies might be developed in conjunction with these ideas, but understanding how people learn to perceive and act potentially has explanatory value outside of a purely musical domain.

**Concluding remarks**

Bailey (1992) in his seminal work on improvisation reflects on theories of improvisation:

I couldn’t imagine a meaningful consideration of improvisation from anything other than a practical and a personal point of view. For there is no general or widely held theory of improvisation and I would have thought it self-evident that improvisation has no existence outside of its practice. Among improvising musicians there is endless speculation about its nature but only an academic would have the temerity to mount a theory of improvisation. (p. x)

Bailey would seem to object to a unified theory of improvisation. Improvisation, to Bailey, is primarily understood through performance, and through one’s own ideas and experiences.

Is there anything to be said about improvisation beyond its practice? Absolutely. This dissertation has done that. Can a theory of improvisation be complete? Probably not. No theory is complete. But that is not the goal. There is still something to be understood about improvisation beyond its practice. Even Bailey’s quote was taken from a book he wrote about the nature of improvisation!

In this dissertation it has been claimed that being able to do something is not the same as knowing how it works. That being said, knowing how something works is not the same as being able to do it! Of course both sides of this theory/practice dichotomy have value and it is not clear why they should not embrace each other and work to be synergistic. Indeed, the questions that are asked in this dissertation grow out of observing, appreciating, and
participating in practices. There is no goal here to prescribe what people should do or how they should think whilst improvising. However, this does not mean that there are not questions to be asked about how and why people do the things they do. And, it would be quite ironic not to ask questions and interrogate a concept that itself seeks to champion freedom!
REFERENCES


Participants memorised this bass line prior to participating in experiment 3. They also memorised the same bass line transposed to B major.