Improvisation, Language and the Brain in Flow:

A neurological perspective on the unique benefits of the study of improvisation for education, organisation science and life in general

Bachelor of Arts in Music Education

[BAME]

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Vienna, 31.12.2020

Statement of Originality

This is to certify that, to the best of my knowledge, the content of this thesis is my own work. This thesis has not been submitted for any degree or other purposes. I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged. This also applies to the reproduction of graphic representations and other analogue or digital materials. I am aware that contraventions will be punished and that further legal action may result.

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Abstract

It is known that improvisation is a distinct musical ability but what then are the unique advantages gained from the study of improvisation? Is something fundamental lacking in the education of musicians who cannot improvise? Is spontaneous creativity useful for education across the board? What are other potential advantages of engagement with improvisation for personal, psychological and organisational development in both individuals and groups? What light can the brains of jazz musicians shed on these questions?

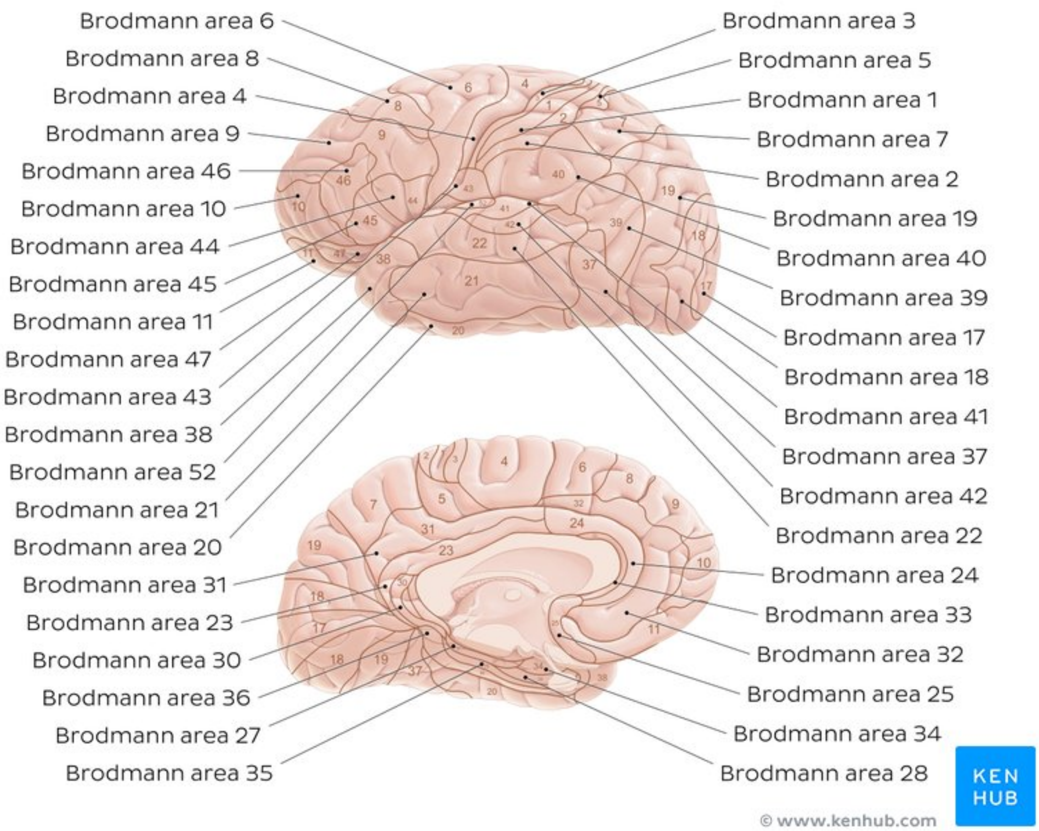
Using a literary research method this thesis presents an overview and discussion of key neuroimaging results from the first fMRI experiments ever to explicitly separate musical improvisation from prepared musical performance. As a path into the discussion, studies from recent decades in the field of music cognition are discussed in connection with psycholinguistic results pertaining to language cognition. It begins with a core question about the extent to which music may be compared with language - often cited as "the most everyday form of improvisation among humans" - since in the points of similarity and departure with linguistic improvisation, lies the key to understanding the benefits of this type of cognitive training. The aim of the ensuing discussion is to discover a scientific basis for the existence of connections between neurology, psychology and the 'jazz mentality' that are also relevant in everyday life not only in a professional musical career.

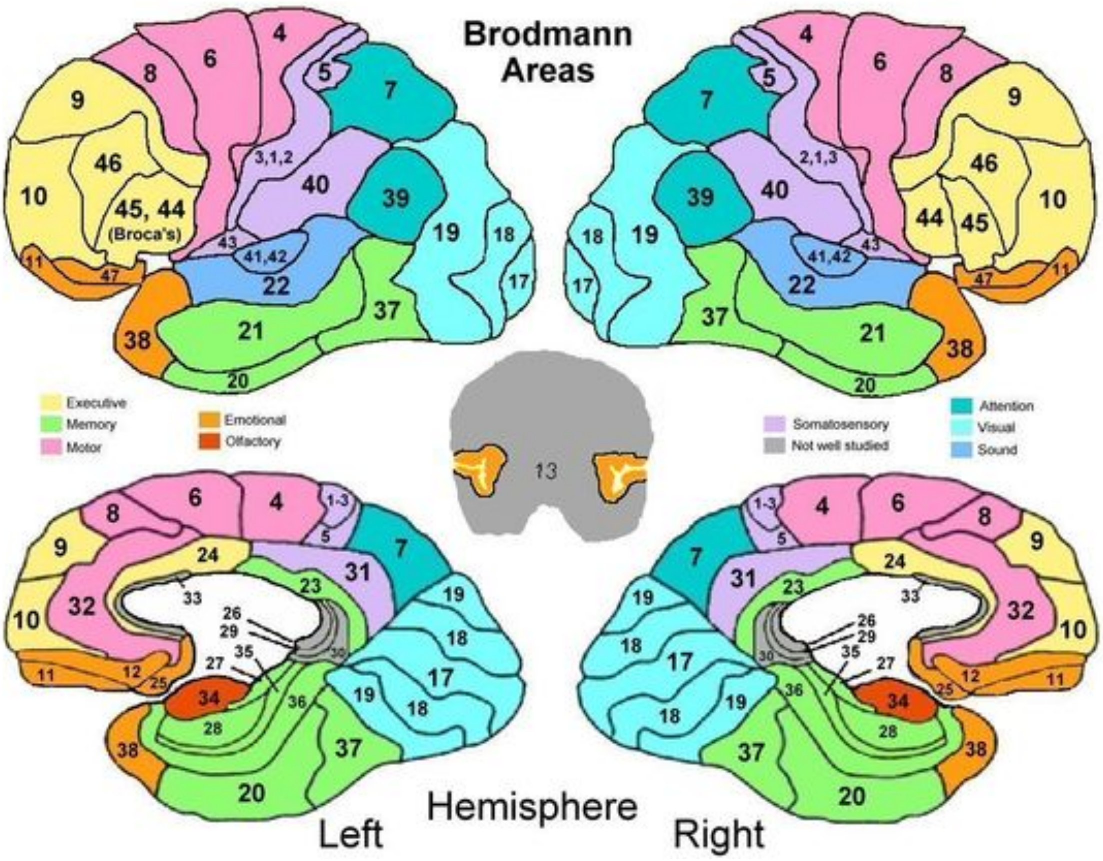
Specific fMRI experiments targeting what we may call 'jazz cognition' reveal patterns of activation and deactivation in both prefrontal and classical language areas suggesting a healthy absorption in the task of improvisation that correlates with modern conceptions of the 'flow' state. Flow states are becoming increasingly cited by psychologists and neuroscientists in analyses of cognitive processes with positive effects on both physical and mental health. Multiple other experiments using fMRI, EEG and PET scans are discussed in relation to both music and language cognition. These explain preexisting accepted theories as to the benefits of music education in general before extending them to incorporate the new data surrounding improvisation. Surveys by psychologists and musicologists who have collected large amounts of data relating to personality traits in musicians and students from different genres are also compared with and analysed in light of these neurological results.

Finally, this study investigates how 'jazz wisdom' (in this context meaning the application of lessons obtained uniquely from improvisational studies) has become increasingly cited by progressive thinkers in broader contexts beyond the realm of music. These include: organisational science, embodied cognition and calls to improve the hierarchical structures in the workplace and to direct the long-term goals of education systems towards a society with higher self-awareness.

Contents

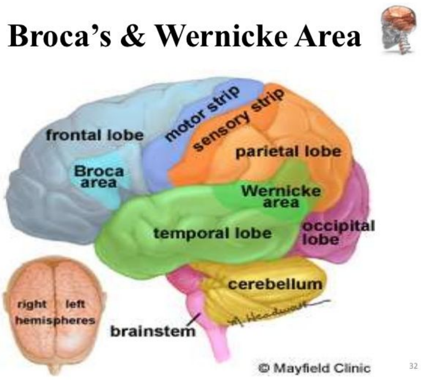
Graphic Illustrations of Brodmann Areas[1]



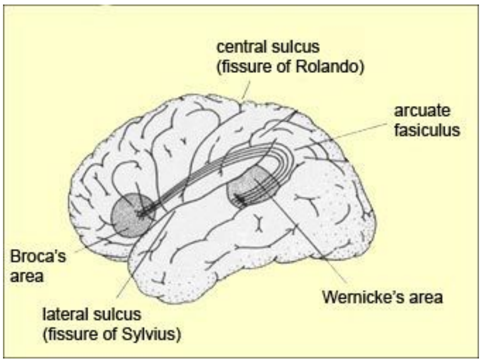


[1] See Internet and Illustration Sources on page 44

Diagrams of Key Brain Regions Discussed[2]

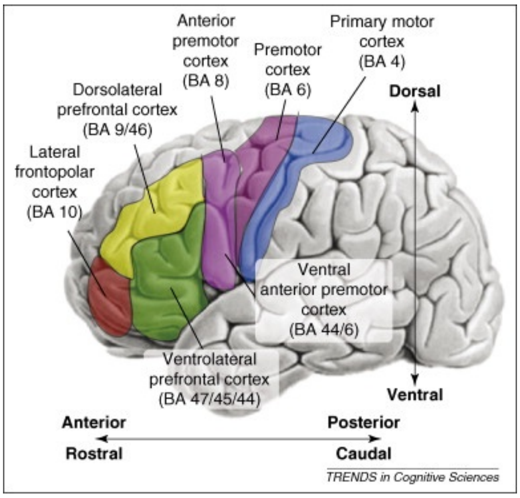


Above Left: Broca's Area and Wernicke's Area. Key regions of the 'music-speech' network. They are shown here in a diagram



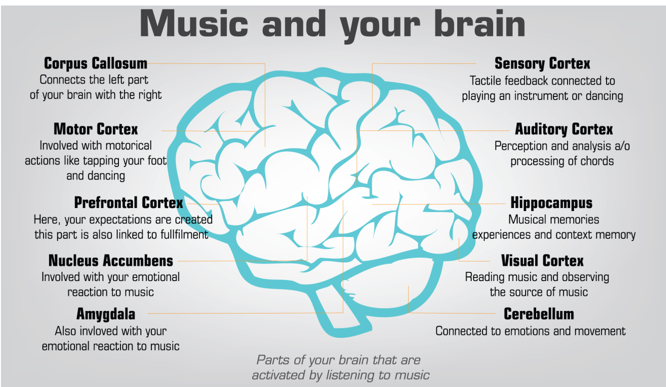
Above right: *Arcuate fasiculus*, the bundle of axons connecting Broca's area to Wernicke's. Crucial section of the 'music-speech' network.

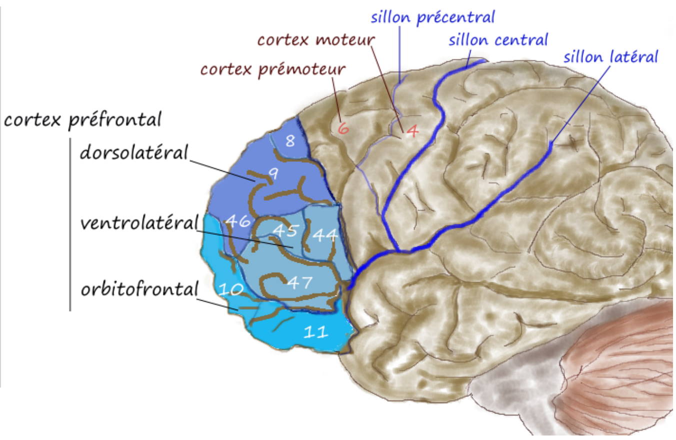
Right: Glossary of key terminology for locating brain regions.
Brodmann Areas 9/46 and 10 are key prefrontal regions.



Below left: Brain regions associated with Music.

Below right: Dorsolateral prefrontal cortex regions, motor and premotor cortices.





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2 See Internet and Illustration Sources on page 44

Preface

Music is a topic scarcely mentioned in the field of neuroscience before c.1970.[3] Since then the field has opened up to the possibility that understanding music cognition is potentially one path to a deeper understanding of the mysteries of creative endeavour.[4] In the last three decades neuroimaging technology has developed exponentially providing neuroscientists with new possibilities for devising ever more complex experiments researching the neural correlates of creativity. Researchers have even more recently begun delving deeply into the neural correlates of both prepared and spontaneous musical performance with a view to distinguishing their unique cognitive processes.

Improvisation is often almost entirely absent from modern musical training and will be the principal focus of this thesis juxtaposed with the generalised theories of music cognition that apply across the board. These theories will serve as an important backdrop. I would like to present a scientific case for the inclusion of improvisation as a valued part of well-rounded music educations.This will be based on some of the latest discoveries made in neuroimaging studies of specific cognitive processes that are seemingly developed uniquely through the practice of improvisation. Further to this I will suggest that the evidence found to support this case also has implications for including improvisational studies within all aspects of education since it could potentially increase both psychological and physical well-being. To do this it is important to be clear about the terminology used and to set some approximate boundaries for the scope of my discussion of abstract concepts. Thus each component of the analysis may remain as clearly linked to the scientific data presented as possible.

It will be made clear that, although there are many forms of improvised music which could be discussed at length, the primary focus of this thesis will be jazz improvisation not least because it forms the principal repertoire bank for my own musical studies but also because it is a musical style synonymous with improvisation. In Western, tonal music there is certainly no other commonly occurring, mainly improvised music with the harmonic, rhythmic and structural complexity of jazz and it's modern off-shoots (fusion, hip-hop etc). So jazz may be viewed as a branch of musical improvisation that itself is just one branch of improvisation in general that, in turn, is but one aspect of creativity in general. Nevertheless this 'Russian doll' effect reverses the deeper it is studied and practiced. Improvisation opens up all kinds of back doors into the rapid absorption, not only of other musical styles and the confidence to generate one's own ideas spontaneously in a variety of other contexts but also, more deeply, into an enhanced understanding of one's own self.

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[3] Sacks, Oliver. Microsoft Research (September 2016) *Musicophilia: Tales of Music and the Brain.* [online video] Available at: <https://youtu.be/gJxVD9kQdgo> [Accessed 22/04/2020]

[4] Pressing, Jeff. *Cognitive Processes in Improvisation.* Advances in Psychology Volume 19, 1984, pp345-363 <https://doi.org/10.1016/S0166-4115(08)62358-4> [Available online April, 2008]

The first time I heard the phrase "jazz wisdom" in exactly this formulation was from the Danish pianist, Niels Lan Doky in a 2016 TED Talk[5]. Immediately a number of different thoughts and feelings about my own musical journey fell into place. I realised that my decision to study jazz was as much connected with a desire to deepen my understanding of music as it was with a desire to deepen my understanding of my own nature; to confront myself (if I dare risk that cliché), and to learn how to navigate the geography of my own personality in a manner more conducive to a life of harmony with the world I inhabit. Jazz is helping me learn to listen more deeply to those around me both in music but also in daily life, how to respond to emotional stimuli and when to respond. Jazz is helping me learn to improve my relationship with the notion of mistakes and how to find something positive to learn in any of life's complex situations. I believe there is scientific evidence to support the notion that the study of improvisation develops an increased capacity for extraverbal communication with others and enhances our ability to listen to both the world around us and to ourselves.

Jazz musicians confront themselves on a daily basis revealing something of their nature every time they improvise. Although there is often much complexity in the music, even an attentive layperson can hear when the music produced is an honest expression of the performer's humanity. John Sloboda, a leading researcher on the impact of music-making (on both performers and listeners) in fact claims that his research shows most audiences are listening for exactly this.[6] An honest expression of humanity seems indeed to be what most people are listening for, even above technical perfection. The remarkable jazz pianist, Bill Evans called this the "universal mind":

> "Any true music speaks with this universal mind to the universal mind in all people."[7]

During his 2014 tenure as Charles Eliot Norton professor of poetry Herbie Hancock told many stories about the "wisdom of Miles Davis". His anecdotes refer more generally to jazz wisdom and its wider implications for students of life which, Hancock claims, we should all endeavour to remain. One important lesson Hancock learned from Miles related to the perception of mistakes. According to Hancock, Miles Davis was capable of turning mistakes (including other peoples') into moments of unique beauty in his improvisations simply because he did not perceive them as wrong, but merely as unexpected; something to challenge and extend his own capabilities for harmonising with the music he was hearing. It is my sincere belief that this attitude does not only help people to create wonderful art but is also applicable in embracing social innovation and improving the way we choose to structure our societies.

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[5] TEDx Talks (May 2016) *How Jazz Wisdom Will Change Your Life | Niels Lan Doky |TEDxCopenhagen.* [online video] Available at: <https://youtu.be/3ee-XROfON0> [Accessed 16/03/2020]

[6] SIMM (Social Impact of Making Music), (December 13, 2019). *John Sloboda / Research into Social Impact of Making Music: Issues and Dilemmas.* [online video] Available at: <https://youtu.be/d82LYI-ICq4> [Accessed 15/07/2020]

[7] BillEvansArchive (February, 2016) *Universal Mind of Bill Evans (1966 Documentary).* [online video] Available at <https://youtu.be/QwXAqlaUahI> [Accessed 01/08/2020]

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"Control of consciousness determines the quality of life."
-Mihály Csíkszentmihályi *Flow: The Psychology of Optimal Experience*

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1 - Introduction: Definitions, Methodology and Structural Overview

Improvise from Latin *improvises*: "not seen ahead of time"

1.1 Defining Jazz Improvisation and Flow States

Improvisation is a very broad term with many possible interpretations both inside and outside the musical context. Some of the scientists whose work is explored in this thesis have devised experiments to test highly varied forms of improvisation including in other disciplines such as theatre, comedy, dance and freestyle rap to name but a few. The aim of this thesis is to focus on musical improvisation within the jazz idiom although, whilst reading the journals recording recent pivotal neuroimaging experiments, it also became essential to mention parallel inquiries into two rare cases of modern improvisers of the classical *cadenza*. These provide both a broader context in which to assess the importance of the main 'jazz' experiments and a further corroboration of the universally witnessed patterns of brain activations and deactivations unique to spontaneous musical performance. For the same reason passing reference is also made to studies by some of the current key players and their research in other forms of improvisation.

Improvisation in any form must include the concept of creation in the present moment. It is often questionable as to exactly what extent a performer is improvising. How much of what is played, sung, said, gestured or in any other way produced in a performance is really created on the spot? How much are improvisers drawing on relearned material? Don't we all improvise everyday by making up sentences with the languages we know? And even within the jazz and classical idioms' there is such a range of styles or eras to choose from.

To be clear then, the phrase "musical improvisation," which, in this thesis, is often used interchangeably with "spontaneous musical creativity", refers to instrumental or vocal extemporisation based on classical music from the Western canon or from the song-form-based structures upon which jazz was originally and is most often based. These musical creations manifest either as free-standing open structures or, more commonly, within typical improvisational structures such as cadenzas in classical music or cyclic song-forms with set harmonic frameworks in the jazz repertoire. Any deviations from this definition may be in passing reference to music using modal systems outside of the Western 12-note well-tempered system (such as Arabic Maqam or Indian Rag music), or to improvisational endeavour entirely outside of a musical context. These styles and cultures are not covered in detail in this study but it is very likely that the general results pertaining to neural correlates and the extension of their unique benefits in music and beyond would also be observable in and derivable from the intense study of improvisation within their musical contexts. In fact it should be noted that in both Arabic and Indian music as in many African styles (without whose influence jazz would perhaps not have come into being) improvisation plays an essential role and is practised, to a certain extent, by all students. Nevertheless the impact of specific structural limitations imposed on improvisation within these styles would also need to be considered in a detailed study that is beyond the scope of this thesis.

Since the goal of this thesis is to extend theories found in jazz paradigms to the enhancement of improvisation-based skills in other aspects of life some leeway is required with the terminology but I will be as clear as possible where this occurs. The above-outlined definition of musical improvisation is deliberately contrasted with the everyday forms of improvisation such as generating conversation through 'improvised' speech. Any improviser will necessarily have a bank of studied music to draw on and will have some structural limitation imposed on them depending on the exact context of the music they are performing. Crucially, it is assumed that the aim of improvising musicians (as with any other performer) is to enter a state of interaction with and absorption in the present task allowing them to truly express themselves without simply regurgitating previously learned material in a mechanised fashion. Such a state directly correlates with psychological 'flow states' as will be discussed at length. Mihály Csíkszentmihályi, one of the most prolific psychologists and researchers of flow states describes them as:

> "being completely involved in an activity for its own sake. The ego falls away. Time flies. Every action, movement, and thought follows inevitably from the previous one, like playing jazz. Your whole being is involved, and you're using your skills to the utmost."[8]

1.2 Defining Creativity

Creativity is also a complex word with a broad range of possible applications. In the anglophone world creativity is often associated with problem-solving or invention. In the German speaking world more emphasis is placed on divergent thinking and the generation of novel ideas. Across the board creativity appears to be based upon self-motivated action arriving at original results despite stemming from certain combinations of 'normal' cognitive processes. Musical improvisation is self-motivated and notable for combining highly developed cognitive skills with highly developed motor skills as well as emotional expression all in the space of a moment. Multiple possibilities are generated and selected in real time requiring the engagement and collaboration of both the short and long-term memory.

If we assume that there is a common root for all aspects of creative endeavour (such as the presence of original thought at least in the sense that it is original for the person thinking it) I believe that my research provides adequate evidence to suggest that the development of improvisational skills serves to enhance one's propensity for creativity in general. That is to say, the extent to which the conscious training of a skill such as improvisation (in any form) is not to be best underestimated in its potential impact on one's awareness of creativity. Following this comes the corollary that an awareness of creativity is the path to its appreciation and ultimately to an aspiration towards it. Nevertheless it is important to set out some of the key applications of the term as it is used in various papers I analysed in preparation for this thesis.

Much recent research highlights self-motivation as an indicator of creativity. Among this is a 2009 paper by Christoph de Bézenac (Leeds College of Music) who discovers unique creative personality traits in jazz musicians when compared to their classically trained colleagues. A contemporary of de Bézenac, the Austrian psychologist, Mathias Benedek (Universität, Graz) is particularly focused on divergent thinking in his experiments. He and his colleagues have also explored self-motivation and how it correlates with creativity. One of his more recent studies is concerned with the role of inhibition in the creative process. It seems to be a common theme in the study of creativity that original thought must take place within some confines. Perhaps one could say that limits are needed in order for creative thought to surpass them or maybe that a proverbial box is required in order that one think outside it. The theme of constraint is omnipresent in jazz history from its very origin. From the call-and-response music of enslaved

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[8] Mihály Csíkszentmihályi, Interview with Wired Online Magazine, 09/01/1996 <https://www.wired.com/1996/09/czik/> [last accessed November 2020]

human beings forced to work the land through the big-band glory days of the swing era and on through bop to the modal and experimental modern styles the common thread remains: improvisation.

With respect to creativity in learning processes there have been an increasing number of experiments and studies by such researchers as Gottfried Schlaug and Aniruddh Patel whose work suggests increased neuroplasticity through functional neurological change among musicians.I hypothesise that improvisation extends and enhances some of the benefits already implicit in the study of music.

The afore mentioned 'Godfather' of Flow, Mihály Csíkszentmihályi sets out the following characteristics of creative individuals in his 1996 book, *Creativity - Flow and the Psychology of Discovery and Invention*[9]*:*

> "1. Creative individuals have a great deal of energy, but they are also often quiet and at rest.
> 2. Creative individuals tend to be smart, yet also naive at the same time.
> 3. Creative individuals have a combination of playfulness and discipline, or responsibility and irresponsibility.
> 4. Creative individuals alternate between imagination and fantasy at one end, and a rooted sense of reality at the other.
> 5. Creative people seem to harbour opposite tendencies on the continuum between extroversion and introversion.
> 6. Creative individuals are also remarkably humble and proud at the same time.
> 7. Creative individuals to a certain extent escape rigid gender role stereotyping and have a tendency toward androgyny.
> 8. Generally, creative people are thought to be rebellious and independent.
> 9. Most creative persons are very passionate about their work, yet they can be extremely objective about it as well.
> 10. The openness and sensitivity of creative individuals often exposes them to suffering pain yet also a great deal of enjoyment."

Finally it should not be forgotten that creativity is not unique to human beings especially not when it comes to problem-solving and finding suitable mates. For the purposes if this thesis however creativity will be explored in terms of humans' spontaneous generation of novel ideas and thought processes within the context of absorption in music-making.

1.3 Methodology And Structural Overview

1.3.1 - Research Question

What are other potential advantages of engagement with improvisation for personal, psychological and organisational development in both individuals and groups? What light can the brains of jazz musicians shed on these questions?

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[9] Csíkszentmihályi, Mihály: *Creativity - Flow and the Psychology of Discovery and Invention,* HarperCollins Publishers, 1996 pp58-73

This thesis is based on literary research with the central themes divided into three main chapters (parts 2-4). Following my discovery of two seminal experiments in 2008 - the first to specifically separate 'prepared' from 'spontaneous' musical performance - I began reading journals and books by the two neuroscientists who instigated them, Dr Charles J. Limb and Dr Aaron Berkowitz. Both researchers had utilised the power of functional magnetic resonance imaging (fMRI) in tandem with voxel-based morphometry to make detailed cross-sectional maps of oxygenated blood concentration levels in the brains of performing musicians. Reading their work lead to many other experiments using fMRI and other technologies such as positron emission tomography (PET) and electroencephalography (EEG) .

As I traced the course of music cognition research I discovered a time-line leading back to the type of questions Leonard Bernstein was asking in his now infamous Norton Lectures at Harvard in the 1970s. It appeared that the path most had taken into understanding the brains of musicians and notably of improvisers lead through comparisons between music and language. Indeed Dr Limb and Dr Berkowitz both discovered heightened activity in classical perisylvian brain networks (known as classical language areas) during improvisation. The central theme of this study is my hypothesis that improvisation is a unique process and thus offers unique benefits to its students beyond the scope of the study of predetermined performance only. If it can now be demonstrated that our brains are literally behaving in a unique way during improvisation, and if we can combine this with the preexisting evidence that suggests music cognition has numerous positive effects on our physical and mental health, then I believe a strong case can be made to support the hypothesis that improvisation supports unique positive development of both mind and body.

1.3.2 - Structural Overview

I begin by relating the highly complex art-form of musical improvisation to the simplest and most everyday form of improvisation that is available to anyone and is practised by the largest number of people on a daily basis, speech. Thus part 2 explores the grounding in neuroscience of the theory describing music as a 'universal language'. Just how similar to language is music and where exactly to they diverge? Here I will trace a connection between speech networks and their role in both the production and the perception of music culminating in the comparison between learning to improvise in a musical style with learning a foreign language at a later stage in life than childhood. This allows for a detailed discussion of implicit vs explicit learning that lays the foundations for the patterns of activation and deactivation in specific brain regions found by Dr Limb that are presented in detail in part 3 This chapter also serves as a summary of the types of functional differences that have been repeatedly observed in the brains of musicians.

Part 3 revolves around the two 2008 experiments that were the first clear attempts to discover the unique neural correlates of improvisation. Dr Limb's experiment is specifically focused on improvisation in a jazz-style by professional jazz musicians whereas Dr Berkowitz's more minimal experiment uses only very limited melodic and rhythmic elements in an attempt to examine the difference between prepared and improvised performance in a much more general way without allusion to any particular style of music.

In part 4 I present and analyse evidence found in the field of education research and organisation science thus exposing wider implications of improvisation's benefits outside the realm of music.I was drawn to this as an educator myself when I discovered a paper by Dr Limb and a variety of his colleagues directly suggesting changes and additions to traditional education programs that include more creativity in the classroom. I also came across the work of the organisation scientist, Frank J. Barrett (also a former professional jazz musician) who uses the jazz band as a paradigm for successful self-organising systems. The discussion of the positive impact of improvisational ability serves to reinforce the underlying theme of my thesis that self-discovery and self-confrontation are at the heart of positive social change.

In conclusion part 5 assesses the strength of my hypothesis based on the literary sources discussed. I reevaluate the evidence I have found and investigate the extent to which it supports my claim that there are unique benefits to be obtained from the study of improvisation. I also discuss the limitations of this thesis and provide suggestions for interesting areas for further research thrown up by the discoveries made in this field thus far.

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2 - The Universal Language?

"Music is the universal language of mankind."
-Henry Wadsworth Longfellow (1835)

"Music is a world within itself, with a language we all understand."
-Stevie Wonder (1976)

2.1 - Music-Speech Networks

For nearly two hundred years the notion that music is somehow a language common to all human beings has been prevalent. That music is a communal activity essential to and inseparable from humanity is clear from the fact that, for approximately 40,000 years, musical instruments have existed and there has been no known society anywhere on the planet during this time which has not embraced music and indeed elevated it to a position of importance within their culture. At the time of the renaissance music was synonymous with both art and science. Since then Western culture has come to dramatically (and almost certainly incorrectly) redefine music as one of many art forms that is neither essential to our education nor to our survival. And yet music lives on. For many it is intuitive that music fulfils a role that simply cannot be mimicked or replaced by any other art form or indeed by any other human activity.

Neurologically music appears to be clearly linked to speech thus aligning it with one of the most fundamental prerequisites of uniquely human evolution. The archaic, simplified theory that speech is processed in the left hemisphere whilst music is processed in the right has been dramatically developed in recent decades.[10] In fact the two cognitive processes appear to be so inextricably linked that modern neuroscience often refers to the "music-and-speech network".[11] Music cognition is a highly complex set of interacting processes whose individual elements are processed in different places. Complex interactions between left-hemisphere regions and their right-hemisphere homologues are now thought to be the basis of music and language cognition with an ability to influence and enhance each other but also, it seems, even to bypass each other when necessary. The field of music therapy has already made miraculous progress with patients suffering from Broca's aphasia[12] who are unable to produce spoken language. The most famous case to date being that of Senator Gabby Giffords, the former senator of Arizona[13], who relearnt verbal communication through song after a bullet through her brain from an attempted assassination in 2011 damaged her Broca's area, rendering her unable to speak. It was possible for the undamaged right-hemisphere homologue to Broca's left-hemisphere area, in functioning through music, to bypass the damaged area allowing verbal communication to occur through song. Music acted as a bridge between the hemispheres helping Senator Giffords to heal.

10 Daniel Levitin, TEDx Talks (2018) *Your Brain on Music,* [online video] Available at: <https://youtu.be/MZFFwy5fwYI>

11 Kölsch, Stefan: *Good Vibrations. Die heilende Kraft der Musik.* Berlin: Ullstein Buchverlag (2020) p48 original German: Musik-und-Sprache-Netzwerk (my translation)

12 Broca's area, Inferior frontal gyrus, Brodmann area 45 (BA45) plays an important role in language production and comprehension. [online resource] <https://www.britannica.com/science/Broca-area>. Broca's aphasia: <https://www.britannica.com/science/aphasia-pathology> (both accessed 31/07/2020)

13 <https://www.aphasia.org/stories/aphasia-gabby-giffords/>

Musicians, it appears, train exactly these types of connections between the hemispheres. In 2003 Gottfried Schlaug discovered significant functional differences in the brains of musicians that he described as structural differences "due to long-term skill acquisition."[14] Nevertheless John Sloboda has confirmed through significant testing that when it comes to music perception and an inherent ability to sense tension and release in music, human receptivity seems fairly constant despite the possibility of dramatic differences in musical ability, training and sophistication.[15] Thus the act of learning and practicing music offers supplementary neurological connectivity for the individual musician in parallel to the social connectivity among people inherent in such a communal past time. The role music plays in social cohesion further cements the notion that music is a form of communication. Activations seen in the limbic system[16] demonstrate that music can influence our emotions by stimulating the production of neural transmitters and hormones such as dopamine and oxytocin which are essential to the process of bonding and developing rapport and synchronicity between fellow human beings.[17]

And yet is music really a language? How far can the comparison reasonably be taken? There are certainly a great many similarities but the most obvious element of language entirely absent in music, is the ability to convey semantic meaning. Music, it appears contains its own 'grammar' to the extent that the existence of syntactic elements can be successfully hypothesised yet there seems to be no place or need for semantic meaning within musical phrases. The best answers we have to date can best be arrived at in light of the neurological processes involved.

This chapter will explore some of the key findings relating to the similarities and differences between music and language cognition. It will also describe the suitability of foreign language acquisition beyond early childhood as an analogue for learning to improvise music in a particular style.

2.2 Units of Meaning: Statistical Learning

In spoken language the smallest morphological unit is called a morpheme. Examples of morphemes in English would include monosyllabic sounds that cannot be divided into separate morphemes thus "come" and "cat" are morphemes whilst "cats" is not since "s" alone is a meaningful linguistic unit conveying pluralisation. One of the first direct efforts in the field of musicology to find a suitable musical analogue for the morpheme was made by Leonard Bernstein in 1973 during his tenure at Harvard as Charles Eliot Norton Professor of Poetry.[18] During his six lectures on musical grammar and musical semantics Bernstein admits that a one-to-one mapping from linguistic to musical morphemes can probably not be made. Yet, as Aaron Berkowitz

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[14] Schlaug Gottfried & Gaser Christian. *Brain Structures Differ between Musicians and Non-Musicians.* (9240) The Journal of Neuroscience, (October 8, 2003)

[15] Berkowitz, Aaron L: *The Improvising Mind: Cognition and Creativity in the Moment.* Oxford University Press 2010. p.98 referencing J. Sloboda.

[16] The limbic system: <https://en.wikipedia.org/wiki/Limbic_system> [Accessed 31/07/2020]

[17] Kölsch, Stefan. *From Social Contact to Social Cohesion — The 7 Cs.* Music and Medicine: An Interdisciplinary Journal, Vol 5, No 4 (2013)

[18] Bernstein, Leonard: *The Unanswered Question: Six Talks at Harvard.* Harvard University Press, April 1981

summarises in *The Improvising Mind*[19] music, like language combines basic elements of sound to form "units of meaning". Meaning that is perceived as meaning without the shackles of semantic connotation.

In a 1983-84 paper summarising the key ideas from their highly cited book, *A Generative Theory of Tonal Music*[20], the American composer, Fred Lerdal together with philosopher and linguist, Ray Jackendoff refer to the development of a

> "grammar of tonal music based in part on the goals, though not the content, of generative linguistics."[21]

Their work has been credited with introducing the new cognitive paradigm for music perception theory, shifting the analytical focus from musical structure to the listening process itself. Lerdhal and Jackendoff propose a grouping theory with roots in *Gestalt Theory*[22] which is based upon the notion that a listener, irrespective of musical ability unconsciously infers a

> "heard structure (having perceived the) musical surface (or) physical signal of the piece."[23]

This provides yet another linguistic angle on music cognition and reinforces the idea of a meaningful musical grammar whose perception is based on the auditory stimulation when listening to music.

Somehow music can 'make sense' without conveying conventional semantic meaning. One of the human brain's clearest abilities (as was a starting point for Lerdahl and Jackendoff) is a highly developed sensitivity to pattern recognition. Humans are able to recognise patterns in auditory stimuli and to learn a mother tongue from scratch through the process of statistical learning. Statistical learning theory in linguistics explains the process by which the brain comes to make ever more accurate hypotheses about which syllables follow each other meaningfully in a spoken language having listened to many examples of the given language over time. This process can yield results very rapidly. A linguistic experiment in 1996 (Saffran et al[24]) demonstrated that 8-month-old infants were able to recognise whether or not words belonged to a made up language after being exposed to it proving that, even at the earliest age, humans are capable of this type of statistical learning. This result sheds further light on the cognitive similarity of music and language and moves the struggle to define 'musical meaning' forward. It suggests our ability to make sense of music is based on the build up of experience we have from listening to music.

The neurological basis for statistical learning through auditory stimuli is further developed by Professor Anirruddh Patel of Tufts University who explores the cognitive mechanisms common to

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[19] Berkowitz, Aaron L: *The Improvising Mind: Cognition and Creativity in the Moment.* Oxford University Press 2010. p.103

[20] Lerdal, Fred. Jackendoff, Ray, S: *A Generative Theory of Tonal Music: A search for a grammar of music with the aid of generative linguistics.* MIT Press, 1981

[21] Lerdal, Fred. Jackendoff, Ray. *An Overview of Hierarchical Structure in Music.* Music Perception, Vol. 1, No. 2, pp229 - 252. Winter 1983-84

[22] https://en.wikipedia.org/wiki/Gestalt_psychology (Wikipedia link)

[23] Lerdahl & Jackendoff 1983-84

[24] Saffran Jenny R, Aslin Richard N, Newport Elissa L. *Statistical Learning by 8-month-old Infants.* Science: New Series, Vol. 274, No. 5294, pp.1926-1928. (December 13, 1996)

music and language via his "shared sound category learning hypothesis".[25] Patel has also confirmed through extensive testing that human beings are the only primates capable of locking onto a beat using a combination of sensorimotor regions together with the auditory cortex to make accurate predictions about the space between regular beats. Otherwise put: the model for beat-perception is based on estimating and predicting a 'distance' in terms of movement between two points using sensorimotor areas in the brain. Other primates have been trained to react quickly to a regular beat but not to internally map, and thus predict, its regularity. That is to say their brains do not recognise predictable patterns as human brains do. Important to recognise is that beat perception and the ability to 'groove', much like complex language perception, appear to be uniquely human abilities (although Dr Patel has also discovered a cockatoo named Snowball that appears to have some funky dance moves which, on a serious note, may suggest the ability to feel a beat lies in an older non-prefrontal section of the brain that is still common to birds and humans) and, further may be intimately connected[26]. Patel along with many others has shown that the brain's right hemisphere is specialised for melody processing whilst the left hemisphere, formerly believed to be solely responsible for language perception, is also highly involved in rhythmic processing.

Human beings strive to find patterns and regularity in all things. Cognition in general seems to be the mind's process of ordering stimuli. Our brain's desire to make sense of music is likely also to be a result of the overlapping brain regions involved in both language and music perception although it does not seem necessary or even important for music to convey semantic meaning. Musical improvisation sees humans experimenting with regularity, irregularity, chaos and order in real time conjuring up and sculpting sounds to create stimuli for other minds engage with.

2.3 Improvised music and Language: syntax *senza* semantics

In his 2020 book *Die Heilende Kraft Der Musik*[27], Stefan Kölsch alludes to his 2004 paper in which he postulates the existence of a uniquely musical syntax. He cites and discusses the results of an experiment carried out on newborn infants in which conventionally consonant music was played (via recordings) to them whilst they slept followed by music that had been tampered with in a manner that disrupted its natural flow including for example, unpredictable, sporadic leaps to new tonal centres or unrelated rhythmic structures. It appeared that *Broca's area* (the inferior frontal gyrus Brodmann 44/45[28]) — a crucial perisylvian language area — was working harder to process (to make 'sense' of) the altered music. The role of Broca's area has been consistently associated with syntax-processing in language so these were among the first studies that suggested an area involved in linguistic syntactic processing was also highly active in processing musical syntax. Leading music cognition researcher, Daniel Levitin has also noted the importance of Broca's area and Wernicke's area (Brodmann 22[29] in music processing. Further to this Levitin also carried out experiments involving scrambled, discontinuous music and found focal activation in another area,

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25 Patel, Aniruddh: *Music Language and the Brain,* Oxford University Press, 2008 cited by Berkowitz, *The Improvising Mind* pp103-104

26 Snowball (TM) (October 2007) *Our Dancing Cockatoo* [online video] Available at <https://youtu.be/N7IZmRnAo6s>, Snowball (TM), (December 2007) - *Another One Bites The Dust* [online video] Available at <https://youtu.be/cJOZp2ZftCw> [Both last accessed 29/12/2020]

27 Kölsch, p50

28 Cytoarchitecturally BA44 is the opercular and BA45 is the triangular part of the IFG.

29 located in the posterior region superior temporal gyrus (STG)

the left inferior frontal cortex (Brodmann 47) and it's right hemisphere homologue.[30] This region has previously been associated with the processing of linguistic structure in both spoken and signed language.

Interestingly, the notion of 'musical grammar' was first theoretically discussed by Leonard Bernstein during the 1974 *Norton Lectures* in his afore mentioned search for an appropriate musical analogue to the morpheme. The first recorded historical references to "musical grammar" in relation to improvisation however, came two hundred years before this in two separate eighteenth century treatise on improvisation by CPE Bach and Carl Czerny in which they both outline the need to practice variation of musical phrases in order to internalise the "grammar" for correct reproduction during spontaneous composition.[31]

2.4 Syntactic processing in Improvisation - "Trading Fours"

In the past two decades, Dr Charles Limb, a prominent ear surgeon and neuroscientist has directed much attention and energy to researching human creativity. The primary focus of his study has been to discover the neural correlates of spontaneous creativity in jazz improvisation but he has also investigated expert use of the voice, beatboxing, freestyle rap, improvised theatre and comedy. In 2006 Limb published a paper on the neural correlates of music perception[32] in which he summarises the neurological basis for comparisons between music and language:

> "Areas traditionally thought to be exclusively for processing language also show specialisations and asymmetries associated with musical perception….The perisylvian language regions incorporate the traditional areas known as Broca's area (Brodmann area 44-45) and Wernicke's area (including Brodmann areas 21 and 42), which are now understood to be part of a broader network for language processing (during both comprehension and production)."

The perisylvian language areas have been implicated in dozens of experiments researching music cognition. Interestingly, both Broca's and Wernicke's area are often connected with syntactic processing whilst semantic processing has been more linked to the supramarginal gyrus and the angular gyrus (Brodmann 39 and 40).[33] Limb notes the multiplicity of features common to both music and language:

> "… most notably those of a hierarchical structure (syntax/harmony), a vocabulary (words/chords and intervals), tonal properties (inflection/ timbre), and a temporal clock (prosody/rhythm), which raises the question of whether or not music and language utilise the same neural structures."

Dr Limb became the first neuroscientist to specifically study jazz music with functional magnetic resonance imaging (fMRI) in 2008. The results of his first experiment will be discussed in the part 3 of this thesis in detail.

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[30] Levitin, Daniel J, Menon, Vinod. *Musical Structure is processed in "language" areas of the brain: a possible role for Brodmann Area 47 in temporal coherence.* NeuroImage 20 pp2142-2152 (2003)

[31] Berkowitz, *The Improvising Mind*, p55

[32] Limb, Charles J. *Structural and Functional Neural Correlates of Music Perception.* The Anatomical Record Part A 288A:435–446 (2006)

[33] Limb C J, Donnay Gabriel F, Rankin Summer K, Lopez-Gonzalez Monica, Jiradejvong Patpong. *Neural Substrates of Interactive Musical Improvisation: An fMRI Study of 'Trading Fours' in Jazz.* PLoS ONE 9(2): e88665. <https://doi.org/10.1371/journal.pone.0088665>, (2014)

In 2014 Limb's later study of the interactive improvised communication in jazz, known as 'trading', turned out some important data that has enabled neuroscientists to directly compare musical and linguistic discourse, at least in terms of the syntax.[34] 'Trading fours' in jazz refers to two or more musicians sharing a solo by each improvising freely on consecutive four-measure segments throughout one or more full cycles of a song's form (known in jazz jargon as a "chorus"). Trading is characterised by direct interactions between the soloists who listen intently to each other's phrases and improvise answering phrases to them. As such, trading is close to what could be termed a "musical conversation".

In Limb's experiment, jazz musicians lay on their backs in the fMRI scanner playing on a 35-key, fMRI-safe MIDI keyboard on their laps whilst another keyboardist interacted with them from the external control room. Limb devised his experiment to contain four different levels for comparison. Level one had the participants taking four measures each using a dorian scale played in a preordained manner. This was intended as a non-improvised control (still using the concept of trading) to contrast with the second level in which the participants played freely during their four bars but were only allowed to generate melodic material from the same dorian scale. Similarly the "jazz"-levels three and four used a piece of music composed and (humorously) named "*Tradewinds*" by Limb to contrast prepared performance with freely improvised trading over the chord-changes of the form.

The results of Limb's experiment confirmed much of his hypothesis that:

> "musical discourse engages language areas of the brain specialised for (the) processing of syntax but in a manner that is not contingent upon semantic processing."[35]

Specifically, Limb saw the expected focal activations in Broca's area (inferior frontal gyrus), Wernicke's area (posterior superior temporal gyrus) and their right-hemisphere homologues and, further to this, he found that, during improvised musical discourse, there were deactivations seen in the angular gyrus and in the supramarginal gyrus, both of which have been implicated in the semantic processing of language.

2.5 Learning Speech and Learning to Improvise

During his tenure as Stuart Professor of Psychology at Princeton University, British-born psychologist, Phillip Johnson-Laird endorsed the view that generating novel melodies and rhythms is comparable to spontaneous speech. Johnson-Laird defended the potential computability of human creativity — that is to say he believed in an algorithm-based model for generating spontaneous creativity — in his 2002 paper, "How Musicians Improvise". In order to do so he distinguishes between the computability of harmony (suitable chord sequences) and melody (rhythmically interesting sequences of intervals) on the grounds that the former requires the generation of "semantically coherent" sequences. Johnson-Laird does not specifically refer to syntax when distinguishing harmony from melody and rhythm but we could infer that he is using a similar comparison to that of Kölsch, Patel and Limb given that he defines the harmony as distinct from the other two in terms of its semantic coherence.[36]

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[34] Ibid.

[35] Ibid.

[36] Johnson-Laird, P.N. *How Jazz Musicians Improvise.* Music Perception, Vol.19, No 3, pp415-442, Spring 2002

In *The Improvising Mind* Dr AaronBerkowitz's insightful discussion of musical meaning through the lens of Patel's syntactic-processing hypothesis introduces the notion of musical 'schemata'. He suggests that music, like language, contains organisational patterns comprising a conceptual framework that are detected and combined by listeners and performers alike to build up larger structures of meaning.[37] This presupposes the idea that it is required of those merely perceiving music to perform cognitive operations on many past examples of music they have stored in their long-term memories in much the same way that accomplished improvisers must also operate:

> "Similarly in language, to get from mere imitation of what is heard to the construction of novel utterances (that have perhaps never been heard) requires performing cognitive operations on the acquired knowledge to determine its underlying rules and properties."[38]

Considering this in relation to how a jazz musician studies 'licks' (examples of celebrated phrases originally improvised by jazz masters) it becomes clear that exactly these processes are occurring in the way each of the elements (e.g melodic intervals, harmony, rhythm and time feel) are analysed in the context of their relation to the whole structure. In other words, much like the way we save many examples of language, we save up examples of music and our brains are able to abstract patterns from these learned paradigms by individually processing their underlying schemata.

At this stage it should be noted that this conscious dissection of multiple examples for the purpose of being able to spontaneously reproduce limitless variation is a process unique to the study of improvised music. The study of improvisation has long since been lost from the tradition of classical music and is practised today to a high level by precious few proponents. Berkowitz highlights this 'deficiency' found among many trained musicians in terms of neurological processes that, if not practiced, are simply not acquired.

> "… (S)ome of Western society's most praised classical musicians lack true productive competence."[39]

The productive competence to which Berkowitz refers here must be consciously practiced and achieved over a significant time period. The brain must be deliberately fed as many examples as possible so it may learn how to generate its own novel variations. As such it may not be the case that the rather unconscious learning of a mother tongue provides the best analogy for learning to improvise.

2.5.1 Jazz as a Foreign Language: The Four-Stage Model

It would appear that spoken language is a form of improvisation in which all healthy human beings can participate. As such it is tempting to draw a comparison between 'improvised' everyday speech and improvised art forms. Caution is needed here since it should first be noted that much of everyday language consists of formulaic expressions and 'programmed' verbal responses to stimuli. Various studies estimate the average proportion of daily use of formulaic expression between 25% - 30%. Further to this, the level of internalisation of a mother tongue is normally so complete from the early childhood years of immersion that the aptness for analogy

37 Berkowitz p105

38 Ibid. p110

39 Ibid. p99

with learning to improvise music in a particular style breaks down. This is not to say that no part of mother-tongue-learning is suitable for the analogy but that certainly for the conscious part, a more appropriate analogue for improvisation in music would be found in the way a foreign language is learnt later in life than early childhood.

In 1989 Willem Levelt's seminal publication in the field of psycholinguistics entitled *Speaking* appeared postulating a four-part model for speech.[40] These are (after paraphrasing and simplifying):

1. Conceptualisation: an idea to be communicated forms in the brain.
2. Formulation: an appropriate set of words/phrases are selected for the job.
3. Articulation: the brain sends a motor program down to the vocal apparatus which is executed thereby producing speech.
4. Self-monitoring: parts of the brain scrutinise the speech in real time correcting any perceived errors and assessing the success of the transmission.

In his discussion of the model in relation to spontaneous musical creativity Berkowitz notes how apt this model is for analogy with the way we learn to improvise music if we consider our level of conscious perception of each stage.[41] When speaking in the mother tongue there will be very little (if any) awareness of the middle two stages of this model since they have already become so routine over time. When speaking a foreign language however, there is heightened awareness of each stage (perhaps most notably stages 2 - 4) and it becomes possible to draw one-to-one comparisons with the processes involved in improvisation. One possible example could be:

1. Conceptualisation: a cadence such as a II - V - I chord progression
2. Formulation: a choice of stylistically varied licks arise based on knowledge of the style and the current 'mood' of the tune.
3. Articulation: a motor plan for playing an instrument or singing is sent and executed.
4. Self-monitoring: aural and kinaesthetic monitoring of playing/singing.

The self-monitoring should not be confused with self-consciousness since improvisers often refer to relinquishing control during spontaneous performance. The neural correlates of 'letting go' will be discussed at length in the part 3.

2.5.2 Implicit and Explicit Learning

Another way of formulating the difference between speech in a mother tongue and speech in a foreign language relates to the fundamental difference in the way each is learned. The mother tongue is learned implicitly through immersion and out of the necessity to learn verbal communication. Implicit learning is a form of learning where the learner is not conscious of the process by which they learn. Implicit learning has different neural correlates than explicit learning. A foreign language is learned explicitly through long hours of arduous conscious input and deliberate repetition of new words and phrases.

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[40] Levelt, Willem J.M. *Speaking: From Intention to Articulation.* MA: MIT Press. 1989

[41] Berkowitz, *The Improvising Mind* pp146-7

Whilst, for the most part, learning to improvise must take the form of conscious studying, it is also the case that much important learning takes place unconsciously through what Paul Berliner describes as "immersion".

> "Only immersion in the music's oral literature and the assistance of fluent speakers of jazz enable learners to grasp the actual components and their variants that improvisers use to construct complex musical statements."[42]

2.5.3 The Neuroscience of Implicit Learning

Jazz musicians' main goal is to (explicitly) internalise material and underlying concepts until they are able to improvise fluently as they would having learnt implicitly. They explicitly train to the level of implicit knowledge and ability except in the rare cases of musicians who grew up improvising jazz to a high level from early childhood (for example Fats Waller). In the same way music has the power to help connectivity between regions and even hemispheres in the brain the study of improvisation requires transcendence of the explicit-implicit learning divide. Rigorous, consistent deliberate practice of circumscribed exercises are used to achieve ultimate liberation from all constraint.

Two important brain regions which have been found to be involved in the types of cognitive processing associated with implicit learning are the lateral orbital prefrontal cortex (LOFC, Brodmann 47) and the cerebellum ('little brain'). The LOFC is in the prefrontal cortex which is already an area associated with mammalian information processing but it is also linked to unconscious learning processes and will be discussed in further detail in light of Dr Charles Limb's other experiments on improvising musicians in part 3. The cerebellum is located down behind the top portion of the brain stem and is sometimes referred to as the 'reptilian' or 'primitive' brain since the brain stem and the cerebellum are the main structures also found in reptiles. Neuroimaging results have previously suggested that the cerebellum is implicated in implicit or 'unintentional' procedural learning, such as is particularly relevant to the learning of a mother tongue and also to learning the nuances of a musical style through immersion.[43]

Dr Aniruddh Patel has worked extensively on human beat perception that strongly engages the motor system. He has hypothesised that it works by the brain modelling measured movements corresponding to the temporal structure of a regular beat. The brain maps the temporal distance between beats in the same way it would spatially map the distance between discreet points. According to Patel the cerebellum is the "downstream" receiver of information from the motor cortex but, crucially, recent evidence collected by Patel has used an analysis of white matter (messenger neurones) to suggested a looped structure in which the cerebellum is also relaying information back up to the motor cortex as we perceive or rather 'feel' the beat.[44] [45] Beat perception is important to all musicians but it could certainly be argued that jazz musicians are inclined to focus more energy on metronomically measured rhythm and time-feel in the practice

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[42] Berliner, Paul: *Thinking in Jazz: The Infinite Art of Improvisation.* The University of Chicago Press (1994) p123

[43] Ferrucci et al. *Modulating Human Procedural Learning by Cerebellar Transcranial Direct Current Stimulation.* Cerebellum Vol 12 pp485-492. 2013

[44] Music and the Brain Santa Fe, (Feb 27, 2014) *August 4: Music, Cognitive Function, and Language-Aniruddh Patel PhD.* <https://youtu.be/187vlgPqDP4>

[45] Cannon, Johnathan J. Patel, Aniruddh D. *Specifying the motor system's role in beat perception. Submitted to* Trends in Cognitive Sciences, (April 2018)

room than classical musicians whose music is often based on fluctuating rhythms and directed group interaction. It may transpire that certain circuits involving the motor cortex develop differently in jazz musicians than in other types of musician.

2.6 Discussion

The connections between syntactic processing in both music and language cognition allow for a strong analogy between the two. Despite the fundamental difference in the type of information conveyed both seem to be forms of communication. Music develops the brain's interconnectivity and its capacity for finding and recognising patterns in sound. Learning to improvise is thus similar to learning a new language to fluency. A musical education devoid of improvisation leaves musicians unable to create their own phrases. Thus they are only able to read out written phrases using visual prompts rather than developing the ability to have a free conversation with other musicians using the language freely and creatively. Nevertheless, when we zoom in to the deepest levels of close comparison it appears that, whilst there is plenty of overlap in the neural process governing speech and language processing, there is still much to be discovered about just how similar music and language cognition really are. The absence of semantic meaning in music (at least music without lyrics) is the fundamental difference although it seems to have no bearing on music's power to provoke and perhaps also convey emotions using a syntactic framework alone. To what extent do musicians tell stories through music? And how autobiographical are the stories? A neurological examination of these questions ensues in part 3.

Johnson-Laird's algorithmic models stretch the analogy even further to suggest that certain parts of musical grammar (the harmony) can be imbued with something comparable to semantic meaning in the context of tonal music theory whilst the rest (melody and rhythm) need only be syntactically correct. Spoken and written languages must of course be both syntactically and semantically correct in order to fulfil their primary function in human communication. This is not to say that language devoid of semantic meaning, syntactic correctness or even both at once cannot be used artistically and still be recognisably language. In such instances however language is certainly not fulfilling its primary function. The borders at this stage begin to blur once again. Poetry, which albeit does mostly contain at least one or the other, is interestingly often referred to as music and the Charles Eliot Norton Professorship at Harvard, often held by composer-musicians like Hancock and Bernstein is in fact, a professorship of poetry.

Levitin's, Kölsch's and Limb's results along all coincide with Aniruddh Patel's "Shared syntactic integration resource hypothesis"[46]. These demonstrate the collaboration of trans-hemisphere brain networks integral to both speech and music processing. In his book, *Music, Language and the Brain,*[47] Patel seeks to avoid drawing a superficial analogy between music and language by deliberately restricting his study to encompass the neural mechanisms of instrumental music and ordinary spoken language. He thereby acknowledges that each musical element (melody, rhythm, harmony etc) is processed differently and the intricacies seem even more vast the further studies zoom in. It would perhaps be essential to break down each process into as many constituent parts as possible in order to truly obtain meaningful data pertaining to music and language cognition at a deeper level than the various superficial yet valid points of similarity. Patel (as all the leaders in

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[46] Berkowitz, *The Improvising Mind* p110 [referencing Patel, Aniruddh: *Music Language and the Brain,* Oxford University Press, 2008]

[47] Patel, Aniruddh: *Music Language and the Brain,* Oxford University Press, 2008

the field of music cognition) recognises that the brain separates the ordinal from the temporal meaning that pitch, inflection and rhythm are used differently in music and language noting that:

> "music processing accepts a narrower range of precision encoding (than language)."[48]

In conclusion, music is like a language in so far as it is a form of communication that can be perceived as meaningful. An argument can be made that analogues to grammatical constructions exist in music. This is corroborated by the significant overlap in Music-Speech network activations in the brain. Statistical learning can allow humans to organise, recognise and eventually manipulate patterns in music. Freedom in the use of musical 'language' can perhaps only be obtained by using music as a form of communicating one's own ideas; by improvising. Nevertheless the analogy of music as a universal language is incomplete since each musical parameter would need to be directly comparable to a suitable analogue in verbal communication the structure of which is primarily optimised for the successful transfer of semantic information. In his 2006 summary of brain regions involved in music perception Dr Limb refers, for example, to pitch and rhythm being used differently in music and language. Further research deconstructing musical parameters and their neural substrates into parts seems to be essential in order to fully understand the distinct relation of language cognition to musical improvisation and the supplementary neurological impact of spontaneous creativity.

So brain region activations show music is another form of communication similar to yet distinct from language in which openness and intent listening are required. Improvising musicians must engage fully with the ideas being communicated with them by others. They must learn to take ideas and roll with them, make them their own and use them to create. In short, improvisers must say "yes" to others and must me able to communicate in music as fluently as in language. Rather than activations then, the key to understanding the mysteries of this mercurial art form may lie in the accompanying deactivations in the brain. Spontaneous creation, flow and fully absorbed engagement with the present moment may require shutting down active self-monitoring in the brain and getting out of one's own way.

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[48] Music and the Brain Santa Fe, (Feb 27, 2014) *August 4: Music, Cognitive Function, and Language-Aniruddh Patel PhD.* <https://youtu.be/187vlgPqDP4>

3 - Flow: The Neuroscience of Jazz Wisdom

"Enjoyment appears at the boundary between boredom and anxiety, when the challenges are just balanced with the person's capacity to act." - Mihály Csíkszentmihályi

3.1 2008: A Neuroimaging Odyssey

In 2008, neuroscientists Dr Charles Limb and his associate, Allen Braun completed their two-year long project of building an fMRI-safe MIDI keyboard for the purpose of a long-awaited neuroimaging experiment to be carried out on improvising musicians whilst they performed jazz music live in the scanner.[49] This was to be the first full-scale brain-imaging study to specifically target jazz improvisation with blood-oxygen-level-dependent (BOLD) imaging. Coincidentally, in the same month of the same year, with no knowledge of each other's work, ethnomusicologist, Dr Aaron Berkowitz and psychologist, Daniel Ansari carried out a similar experiment also using fMRI to examine the neural correlates of musical improvisation.[50]

Limb and Braun presupposed that:

> "musical improvisation (is) a prototypical form of spontaneous behaviour, with the assumption that the process is neither mysterious nor obscure, but is instead predicated on novel combinations of ordinary mental processes."[51]

And their hypothesis was:

> "that spontaneous musical improvisation would be associated with discrete changes in prefrontal activity that provide a biological substrate for actions that are characterised by creative self-expression in the absence of self-monitoring … (and) that alterations in prefrontal cortical activity would be associated with top-down changes in other systems, particularly sensorimotor areas needed to organise the on-line execution of musical ideas and behaviours, as well as limbic structures needed to regulate memory and emotional tone."[52]

The Limb/Braun experiment had four tasks (two control tasks and two respective, improvised counterpart-tasks) similar to Limb's subsequent 'trading' experiment outlined in the previous chapter. The participants had two rehearsed tasks, one using simple scalic material and the other being a composed melody (called a 'head' in jazz jargon) over a 12-bar jazz-blues chord progression to be learned by heart. The improvised counterpart-tasks to these included improvising with the same scale as in the scalic task and improvising original melodic lines over the 12 bars of the jazz-blues. All tasks took place in an fMRI scanner and were analysed using

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[49] Limb Charles J, Braun Allen R. *Neural Substrates of Spontaneous Musical Performance: An fMRI Study of Jazz Improvisation.* PLoS ONE 3(2): e1679. <https://doi.org/10.1371/journal.pone.0001679>, (February 2008)

[50] Berkowitz, Aaron L, Ansari Daniel. *Generation of Novel Motor Sequences: The Neural Correlates of Musical Improvisation.* Elsevier, NeuroImage Vol. 41 (No.2): pp535 - 543, July 2008. [Available online March 4, 2008]

[51] Limb, Braun (2008)

[52] Ibid.

SPM99 technology[53].

The Berkowitz/Ansari experiment took a different approach separating melodic freedom from rhythmic freedom for separate as well as simultaneous analysis within a significantly more limited musical context. The participants in Berkowitz's experiment only had five keys (C, D, E, F and G) on their keyboards. Using a four-task structure each task was performed at a fixed tempo of 120 beats per minute. The first task was the control condition in which neither rhythmic nor melodic freedom was allowed. For this participants were asked to memorise a set of preordained 5-note sequences (e.g an ascending or a descending scale from C up to G or G down to C). These sequences were to be played using only quarter notes. The musicians would then be allowed to 'improvise' their own choice of notes whilst maintaining a constant stream of quarter notes for the melodic-freedom-only task. For the rhythmic-freedom-only task they were allowed to improvise rhythmically but only using one of the preordained 5-note sequences. Finally, for the 'improvisation' task, the musicians could vary both their choice of pitch-orders (ordinal variation) and their rhythmic expression (temporal variation) thus creating 'fully' improvised melodies. This structure allowed Berkowitz and Ansari not only to compare improvisation with a non-improvised control but also to check for differences in brain activity during melodic and rhythmic improvisation in isolation.

3.1.1 Simultaneous Discoveries and Contextualisation

Before proceeding to a discussion of the results it should be noted that, since these were the first neuroimaging studies of jazz improvisation with (in both cases) less than ten participants (six in Limb's and eight in Berkowitz's experiment from which one participant's data was considered void), the amount of data collected is far too small to stand alone as conclusive. Nevertheless, the similarity of the results in both cases, combined with a retrospective standpoint from which much corroborating evidence from other experiments in the intermediate decade can also be taken into account, allow for an extra dimension of significance to be attributed to both Limb and Berkowitz's discoveries. Further to this, the nature of a creative art form like jazz in which professionals master the process of improvisation, means that the subjects of such experiments are potentially very good choices for presenting a general overview of functional brain differences during performance. A mediocre or beginner jazz musician would probably yield significantly less conclusive evidence as to the neural correlates of jazz improvisation although they may provide an interesting area of comparison.

In both his paradigms Limb observed matching patterns of activations and deactivations in the prefrontal cortex, sensorimotor and limbic regions of the brain:

> "activations during improvisation were matched by deactivations during the control tasks, and vice-versa, when each comparison was compared to the resting baseline."[54]

Limb observed deactivation in the lateral orbital prefrontal cortex (LOFC), the dorsolateral prefrontal cortex (DLPFC circa Brodmann 46) as well as in the dorsal portions of the medial prefrontal cortex (MPFC circa Brodmann 10). Crucially however he observed focal activations towards the centre in the MPFC. This region has previously been associated with the production of autobiographical narrative and could therefore suggest that jazz improvisation contains an

[53] https://www.fil.ion.ucl.ac.uk/spm/software/spm99/

[54] Limb Braun (2008)

element of telling one's own story; of self-expression through music such as one may intuit from the nature of the art form. Interestingly these patterns were observed both for the musically simpler scalic improvisation as well as in the musically more complex blues improvisation. This result demonstrates that one can tell a story with the 'language' of music irrespective of the complexity of the language used. As Miles Davis would remind us:

> "Don't worry about playing lots of notes. Just find one pretty one."

The MPFC has also been linked to self-organisation and

> "…internally motivated, self-generated, and stimulus-independent behaviours."[55]

This last point allows for an interesting parallel to be drawn with a 2009 paper by Christoph de Bézenac and Rachel Swindells based on their survey at Leeds College of music in the UK entitled, *No Pain No Gain?* In which they found, through systematic inquiry, that jazz musicians are, on average, more self-motivated than classical musicians.[56] This discovery is corroborated by Austrian psychologist, Matthias Benedek who discovered that jazz musicians generate more unique artistic opportunities for themselves than classical musicians.[57]

Both the DLPFC and the LOFC have been implicated in the process of self-monitoring such as would correspond to stage 4 (self-regulation/correction) of the speech model discussed in the previous chapter on music and language. They are:

> "thought to provide a cognitive framework within which goal-directed behaviours are consciously monitored, evaluated and corrected."[58]

Deactivations in prefrontal cortex regions have also been associated with states of altered consciousness such as dream-states, meditation and hypnosis. It is interesting to note the comparison between jazz improvisation and these states that all come under the broad definition of 'flow-states'. The LOFC has also been associated with the reading of body language and the (self-)assessment of what constitutes socially acceptable behaviour. The deactivations witnessed in these regions therefore suggest a disengagement of conscious self-monitoring as an integral part of opening up the mind to enter the flow-state required for improvisation. Improvisers, as is intuitive for artists performing in real time, can neither worry too much about the possibility of making mistakes, nor spare too much concern for how 'socially acceptable' their spontaneous creations may or may not be. Taken together, the patterns of activation and deactivation in the prefrontal cortex are consistent with the notion of freedom and self-expression in the absence of self-monitoring and, by association therefore, an alleviation of self-doubt at least during musical performance. From this alone it could certainly be inferred that improvisation presents a path to a positive flow-state in which musicians judge themselves less and engage more freely in self-expression than musicians performing only previously learnt music. And there is more.

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[55] Limb, Braun (2008)

[56] De Bézenac, Christophe, Swindells Rachel. *No Pain No Gain? Motivation and Self-Regulation in Music Learning.* International Journal of Education and the Arts, Vol 10 (No.6), (May 13, 2009)

[57] Benedek Mathias, Borovnjak Barbara, Neubauer Aljoscha C, Kruse-Weber Silke. *Creativity and Personality in Classical, Jazz, and Folk Musicians.* Elsevier, Personality and Individual Differences 63 pp117 - 121, (February 22, 2014)

[58] Limb, Braun (2008)

Berkowitz also discovered a similar pattern of deactivations, including in the DLPFC. Specifically, he found that both rhythmic and melodic improvisation:

> "modulate(d) activity in … (the) rostral cingulate zone (RCZ, Brodmann 32) of the anterior cingulate gyrus (ACC, Brodmann 24, 32, 33), the inferior frontal gyrus (IFG - part of Broca's area), the ventral premotor cortex and the dorsal premotor cortex (synonymous with DLPFC)."[59]

The former two regions have been associated with decision-making and with the process of selection between different options. Thus the combination of activations in these overlapping brain-regions suggests the process behind improvisation involves the generation and selection of novel sequences. The spontaneous generation and selection of novel sequences could be considered a crucial element of self-expression comparable to instantaneously generating and selecting appropriate formulations and speech inflections for the purposes of telling a story or relaying information of any kind.

Improvisation increased activity in sensorimotor and neocortical sensory areas of the brain during Limb's experiment, notably in the superior and middle temporal gyrus (STG, MTG) which are part of Wernicke's area (crucial to Music-Speech Networks as discussed in part 2). Limb also observed activations in the angular cingulate gyrus (ACC) during improvisation. The ACC has been consistently linked to decision making and selection suggesting that its involvement with improvisation is associated with instantaneous selection of particular novel sequences from a multiplicity of choices.

Thus far the neuroscience of improvisation points to a lack of self-monitoring and self-doubt surrounding the generation of unique musical sequences as well as an ability to instantaneously select which one will be transformed into a motor program for execution (performance). That Broca's area and Wernicke's area both play a role in improvisation has already been seen retrospectively in the previous discussion of Limb's 2014 experiment of trading fours. Berkowitz hypothesises specifically that the activations in the IFG relate to the syntactic verification of selected musical phrases during improvisation.

Activations in the limbic system were discussed more thoroughly in Limb's experiment where

> "the deactivation of the amygdala and hippocampus … observed may be attributable to the positive emotional valence associated with improvisation, consistent with studies that have reported these limbic structures to be less active during perception of music that is consonant or elicits intense pleasure."[60]

This seems to suggest that entering the flow-state of improvisation is largely a positive emotional experience although Limb does note that the role of other deactivations in parts of the limbic system are less conclusive and require further study.

3.1.2 Related results: music and the voice

Since his original experiment in 2008 Limb has continued to examine the brains of improvisers using BOLD imaging. His subjects have included jazz musicians, classical musicians who also

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59 Berkowitz/Ansari (2008)

60 Limb/Braun (2008)

improvise, free-style rappers and beatboxers as well as improvising actors and comics. Broadly speaking his experiments invariably reveal the same pattern of activation and relative deactivation in the brain regions discussed lending further significance to the idea of the brain getting out of its own way during improvisation across the board. The variations observed in performers from different genres and disciplines are also very interesting and provide a larger framework in which to interpret the significance of the deactivations associated with improvisation. For example, artists who improvise with words often have heightened activity in language areas whilst rhythmic improvisers have supplementary motor activation strengthening the notion that rhythm-perception is modelled as movement by the brain.

Among the other important results are those of world-renowned singer-bassist, Esperanza Spalding, classical bass vocalist, Soloman Howard and Freestyle Love Supreme beatboxer, Chris "Schockwave" Sullivan.

Soloman Howard is a bass who also sings gospel and improvises vocal jazz solos. He also plays afro-cuban percussion. Limb designed several different tasks developing his experiment to include cross-genre comparisons. Not only did he discover the same pattern of activation and deactivation for memorised vs improvised tasks but Limb also witnessed more deactivations in general when Soloman was singing jazz and gospel as opposed to classical music. This could potentially also be due to the technical complexity involved in Soloman's classical singing since he is predominantly a classical performer. Once again the same implications that jazz music (and now Gospel) is soothing for the brain are found in this experiment even in a performer who is not as at home in the genre as he is in classical music.[61]

Esperanza Spalding is a bass player and singer who has developed independence between the two to the extent that she can simultaneously improvise bass-lines whilst singing free accompanying figures and vice versa. During the memorised control condition (singing the previously unknown melody over a backing track of Limb's C-minor Blues, *Magnetism*) Esperanza's brain was even more active than those of other jazz musicians with every sensorimotor cortex firing simultaneously. With the smooth transition into improvised material over exactly the same backing track Limb found immediate relative deactivations not only in the prefrontal cortex as with Soloman Howard and with Mike Pope et al. back in 2008 but also in many of the sensorimotor areas that had just been active. Limb proposes that this may be because Esperanza is most often playing bass when she sings and improvises vocally.[62] In the following task where Esperanza was asked to first sing then improvise her own melody to the jazz standard, *My Favourite Things*, still using the original words of the song, Limb found a similar pattern in the deactivations with the inclusion of central activation in the autobiographical MPFC (medial prefrontal cortex).[63]

When Chris Shockwave Sullivan was asked to beatbox a regular (memorised) rhythm along to a jazz standard and then to improvise a rhythmic solo on the same song the typical pattern of activation-deactivation was extended to include activity in his supplementary motor areas during the improvisation task only.[64] When trading fours with improvisation there were significant activations in classical perisylvian language areas. As previously seen in Limb's trading

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[61] The Kennedy Centre (September 2019) *Music and the Voice: Brain Mechanisms of Vocal Mastery and Creativity | Sound Health.* [online video] Timecode: <https://youtu.be/FoDbMf28Xtk?t=2608> [Last accessed 22/08/2020]

[62] Ibid. Timecode <https://youtu.be/FoDbMf28Xtk?t=2996>

[63] Ibid. Timecode <https://youtu.be/FoDbMf28Xtk?t=3072>

[64] Ibid. Timecode: <https://youtu.be/FoDbMf28Xtk?t=3792>

experiments, Shockwave was using language areas including Broca's area and sections of the auditory cortex to have a conversation in beatbox.[65] When discussing these results live at the Kennedy centre Limb suggests a possible reverse of the traditionally held belief that language came before music in the story of human evolution. Perhaps language is indeed a subset of music. Although the study of improvisation-cognition is relatively new and there is still very little data, there is already enough for Esperanza Spalding to speculate:

> "…I wonder if there are any implications for how playing improvised music … has a soothing effect on the brain."[66]

3.1.3 Alternative Perspectives: Embodied Mind Theory

Until now neuroscience has treated the brain rather like a computer that happens to be part of our biological composition but that performs its role in much the same way it would should it be capable of existing outside the body. Limb's conjecture that spontaneous creativity is a neurologic product, relates the idea behind the Church-Turing thesis (that claims the computability of all computable functions) to the fields of psychobiology and neuroscience. This idea was also explicitly stated in Johnson-Laird's discussion of algorithmic models for improvisation[67] . Limb decides to see the brain as an organic computer that can run multiple simultaneous processes and thus 'calculate' creative responses to stimuli. It should be noted that, when asked by Limb for their views on this, two prominent jazz musicians with whom Limb has been working with for a few years, Vijay Iyer and Esperanza Spalding do not seem entirely comfortable with this notion[68]. Iyer immediately invokes the 'embodied mind' theory on which he has written extensively himself, claiming that the production of spontaneous thought in the brain is intimately connected to the brain's location within a moving body that is constantly receiving and generating sensorimotor stimuli. Limb concedes the point and reformulates his assumption as the simplified notion that the brain controls the body. Iyer and Spalding accept that assumptions of this kind are required for scientists designing experiments but both feel it is not necessarily such a one-way process of control.

Embodied mind theory is quite new but has been gaining traction in both the fields of psychology and neuroscience so it is worth noting as having the potential to reframe the results of Limb's experiments. The idea of the brain getting out of its own way does seem to tie in well with the notion of a symbiotic sensory process behind cognition in which the body's movements aid the brain in achieving flow. A less cerebral form of living in the moment may be attainable through absorption in the physical sensations of creative practice.

3.2 The Positive Outlook of a Brain in Flow

According to Mihály Csíkszentmihályi, the highly focused mental state conducive to productivity is characterised by complete immersion in the task at hand:

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[65] Ibid. Timecode: <https://youtu.be/FoDbMf28Xtk?t=3858>

[66] Ibid. Timecode: <https://youtu.be/FoDbMf28Xtk?t=3176>

[67] Johnson-Laird (2002)

[68] The Kennedy Centre (Jun 2017) *Jazz, Creativity and the Brain - Sound Health: Music and the Mind.* [online video] Clip available at timecode: <https://youtu.be/AiljM3o2m_E?t=2333> [last accessed 10/08/2020]

"with a feeling of focus, involvement, and pleasure in the process or work…flow can be attained through meeting a challenge, solving a problem, discovering something new…"[69]

He continues to suggest that people feel at their best when in a flow state. Two of the professions that are repeatedly associated with flow states are jazz musicians and surgeons. Thus the amateur jazz musician and professional ear-surgeon, Dr Charles Limb seems to be an ideal neuroscientist for the job of researching the neural correlates of jazz improvisation. Since the term was coined by Csíkszentmihályi in c.1990 the flow state has been linked to happiness and positive mental outlook by a number of psychological studies. One important experiment by researchers at St Bonaventure University showed that people rate flow states experienced together with other people as more enjoyable.[70] Since jazz music is nearly always performed in a group we can derive that the experience of flow sought by improvising musicians is both positive and pleasurable. Csíkszentmihályi describes eight characteristics of flow[71]:

1. Complete concentration on the task;
2. Clarity of goals and reward in mind and immediate feedback;
3. Transformation of time (speeding up/slowing down);
4. The experience is intrinsically rewarding;
5. Effortlessness and ease;
6. There is a balance between challenge and skills;
7. Actions and awareness are merged, losing self-conscious rumination;
8. There is a feeling of control over the task.

Since a study by Arne Dietrich in 2003[72], the field of neuropsychology has linked flow states to deactivations in the prefrontal cortex of the type seen in Limb and Berkowitz's 2008 experiments. Leading classical-music improviser, Robert Levin refers to a state of self-observation, "getting out of one's way … and being a spectator"[73] during improvisation. Aiming to be as a drop of water carried by the river.

3.2.1 Motivation

Striving to achieve a flow state is a conscious process that requires motivation. Motivation can either be extrinsic (externally controlled) or intrinsic (internal). The motivation to achieve flow through music-making often begins extrinsically where contact with a teacher is required to keep a student motivated but it can then develop into intrinsic motivation and must do so in the cases where students excel beyond the capabilities and even the imaginations of their teachers. Limb's MPFC activations provide a neurological correlate for the internal motivation of jazz musicians

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69 Mihály Csíkszentmihályi *Finding Flow,* 1997, p.66. cited in Elwood, K., Henriksen, D., Mishra, P., & The Deep-Play Research Group. *Finding meaning in flow: A conversation with Susan K. Perry on writing creatively.* TechTrends, 61(3), 212–217. (2017).

70 Walker, Charles J. *Experiencing flow: Is doing it together better than doing it alone?* The Journal of Positive Psychology, Vol. 5, Issue 1 pp3-11. 2008

71 positivepsychology.com <https://positivepsychology.com/mihaly-csikszentmihalyi-father-of-flow/> (online resource) [Accessed 11./08/2020]

72 Ibid.

73 Berkowitz, *The Improvising Mind.* p125

which is corroborated by Benedek's[74] and de Bézenac's[75] surveys. Both surveys show that jazz musicians do more playing for fun than their classical colleagues. De Bézenac's survey also shows that the emphasis placed by conservatoire students on the importance of a teacher is much higher among classical students than jazz students. The same study also shows that a higher proportion of classical students where strongly motivated to learn an instrument externally (by their parents or an influential guardian) at an earlier age than jazz students who often started playing later in life for self-motivating reasons. It may well be the case that self-motivation is a prerequisite quality for a successful career as a jazz musician whereas one may well be capable of having a successful career in classical music (for example in an orchestra) with a much lower level of internal motivation. This said, it is likely that self-motivation plays a role in the development of child prodigies in whichever genre of music they appear such as in the case of the classical pianist, Gabriela Montero. Interestingly, Montero also likes to improvise.

3.2.2 Connectivity: At One with Oneself and with Others

Another key finding from Limb's experiments include the synchronicity of the brain with itself during improvisation. 'Connectivity' is a term referring to how well synchronised the brain is with itself during consciously performed processes. Having scanned Gabriela Montero's brain during both prepared and improvised performance, Limb found an abnormally high level of connectivity in her brain during improvisation.[76] That her brain appeared to be more synchronised with itself indicated a state of inner harmony while she extemporised freely on Bach's Minuet in G. These findings further solidify the notion that improvisation can induce flow.

As Charles Walker[77] discovered, flow states are best experienced in groups and this too has a neurological foundation involving the brain's chemistry. In *Die Heilende Kraft der Music,* Kölsch provides a list of cognitive processes upon which music making and music perception have been shown to have a positive influence[78]. These are

1. Perception

2. Attention

3. Memory

4. Intelligence

5. Sensorimotor skills

6. Emotion

7. Social Participation (integration)

Increasing correlation between intelligence and creativity is accumulating in Mathias Benedek's

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[74] Benedek et al (2014)

[75] de Bézenac, Swindells. *No Pain No Gain?* (2009)

[76] <https://youtu.be/AiljM3o2m_E?t=5078>

[77] Walker, Charles J. *Experiencing Flow…*2008

[78] Kölsch, *Die Heilende Kraft der Musik*. p154 (my translations)

pioneering work in creativity cognition.[79] Socialising involves the production of neural transmitters and hormones such as dopamine and oxytocin that create the sense of togetherness with other human beings such as friends and close family members. Taken together it would appear that improvising music in a group causes the brain to be better synchronised with itself whilst inducing a state of happiness in the company of fellow human beings. It could perhaps be suggested here that, if human beings spent more time engaging in flow-state-inducing activities with one another, that it may have a positive affect on levels of conflict, aggression, tribalism and other power-based disputes.

De Bézenac cites a study (by Ryan and Deci in 2000) in the field of self-determination in which they list three basic human needs:

1. A sense of relatedness
2. Competence
3. Autonomy

His own study proceeds to suggest that musicians who engage with improvisation achieve all three in their musical life more often than musicians who only ever engage in prepared performance. The key element appears to be the amount of pleasure experienced during both listening to and playing music. Jazz students, claims de Bézenac, listen to music simply for fun more often than classical students. A further connection between an improviser's outlooks and the positivity of flow states is found in their ability to see the positive potential even in unexpected situations.

3.3 The improviser's Relationship with Learning and Mistakes

In his first Norton lecture: *The Ethics of Jazz,* Herbie Hancock relates a personal anecdote about playing with Miles Davis in Stockholm in 1967:

> "The band was hot! We were communicating almost telepathically it was like a dream, the kind of night that every musician hopes for … Miles was in the middle of his solo and it was building and building and Miles gets to the peak of his solo and I play this chord and it is 100% completely entirely" (…pauses for dramatic effect…) "wrong."[80]

He goes on to explain how time stood still and how crushed he felt for ruining the vibe of the performance and yet in the next instant Miles improvised a phrase which incorporated the awkward chord into the flow of his solo. Hancock explains that Miles had not heard the chord as a mistake but merely as "unexpected" and had used the surprise to enrich his spontaneous creation. It is safe to hypothesise that the areas of Miles' brain responsible for sensing and correcting error where deactivated or rather synchronised with the flow state devoid of conscious self-monitoring in this instant. Paul Berliner's famous book, *Thinking in Jazz* provides examples of the way jazz musicians can collectively deal with mistakes. Drummer Max Roach talks from

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[79] Benedek, Mathias. Jauk Emanuel. Sommer, Markus. Arendasy, Martin. Neubauer, Aljoscha C: Intelligence, creativity and cognitive control: *The common and differential involvement of executive functions in intelligence and creativity.* Intelligence, Vol 46, pp73-83, Sept-Oct 2014

[80] *Herbie Hancock: The Ethics of Jazz | Mahindra Humanities Center*
Timecode: <https://youtu.be/EPFXC3q1tTg?t=3682>

personal experience:

> "if two players make a mistake and end up in the wrong place at the wrong time, they may be able to beak out of it and get into something they might not have discovered otherwise."[81]

Danish jazz pianist and composer, Niels Lan Doky's first musical example in his Ted Talk on jazz wisdom is called the "wrong note example"[82] in which he explains that jazz musicians are in fact in the habit of dealing creatively with notes they play that may not have been intended. They do so by not panicking or worrying about the note and immediately improvising phrases following the note that make its unexpectedness meaningful. How this relates to language is interesting. This could be reformulated in terms of the connection outlined in the first chapter of the present study between music and language; jazz musicians are used to syntactically reframing an isolated musical morpheme to imbue it with a feeling of correctness despite its being theoretically incorrect. As Lan Doky points out, it is only ever possible to move forwards in time, so once an 'incorrect' note has occurred this is simply the best and most positive way to preserve the continuity of the music. Lan Doky extends this notion to life in general with an amusing anecdote about living on the 32nd floor of a New York apartment block where the lift was broken for a few weeks during which he could only access his home via the stairs. He immediately saw the positive in the situation, cancelled his gym membership and profited from the free fitness studio the broken lift afforded him.[83] The art of improvisation is fundamentally linked to looking on the bright side, the "*Sunny Side of the Street*".

Berkowitz summarises that improvisers need

> "just the right balance between control and letting go."[84]

This state is clearly reflected in the patterns of activation and deactivation in the prefrontal cortex found in his and Limb's 2008 experiments. It also takes the right approach to learning in the practice room, where every jazz musician has spent their ten thousand hours. But not only learning to follow externally prescribed rules.

3.4 Summary and Discussion of Key Results

Since Limb and Berkowitz's groundbreaking experiments on the neural correlates of improvised music, the field of music cognition has opened up to the possibility that improvising is a unique cognitive process within music-making that is connected to a wealth of positive, flow-oriented states of mind. Research into creativity has begun to actively compare jazz musicians with other types of musician to find out what the effects of training to improvise musically have on other aspects of learning, social participation and innovative behaviour. So far there have been some clear results. When analysed in light of each other, the results of Dr Aniruddh Patel, Matthias Benedek and Christoph de Bézenac show that: musicians in general, display higher levels of

[81] Berliner, Paul: *Thinking in Jazz: The Infinite Art of Improvisation.* The University of Chicago Press (1994). p.383

[82] *How Jazz Wisdom Will Change Your Life* Timecode: <https://youtu.be/3ee-XROfON0?t=275>

[83] Ibid. Timecode <https://youtu.be/3ee-XROfON0?t=434>

[84] Berkowitz, *The Improvising Mind.* p148-9

neural plasticity[85] than non-musicians, further to this: that jazz musicians score higher on tests of divergent thinking and other tasks associated with creativity[86], that jazz musicians are more self-motivated, more autodidactic and more self-organising than other types of musician, and even that statistically more jazz musicians (and folk musicians) experience more pleasure in what they do than classical musicians[87].

The neural correlates of these results appear to lie in a pattern of deactivation in prefrontal and rostral cingulate regions of the brain associated with self-monitoring and error correction simultaneously with activations in specific prefrontal areas involved in self-expression, in speech-areas associated with syntactic processing and in the limbic system where positive emotions based on neural transmitters and the production of 'happy' hormones arise.

There is mounting evidence for universal qualities of music through which self expression may be communicated across cultural (and physical) boundaries. There is certainly, already sufficient neurological evidence for a discussion as to the importance of incorporating the development of creativity in education systems[88] and the inclusion of improvisation in music education. Improvisation may hold the key for learning to let go without losing focus, to navigate the peripheries of comfort and the known. Cultivating the art of spontaneous creativity may be a path to self-confidence and adaptability to help find internal tranquility and to help people succeed in the most rapidly changing technological environment the human race has ever seen.

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85 (Neural plasticity can be defined as the ability of the central nervous system (CNS) to adapt in response to changes in the environment or lesions. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4880010/>

86 Benedek et al. 2014

87 deBézenac, Swindells 2009

88 Limb Charles, Gregory Emma, Hardiman Mariale, Yarmolinskaya, Rinnie Luke. *Building Creative Thinking in the Classroom: From Research to Practice.* Elsevier, International Journal of Education Research 62 pp 43 - 45, July 2013

4 - Wider Implications of Jazz Wisdom Beyond Music

"I used to think that running an organisation was equivalent to conducting a symphony orchestra. But I don't think that's quite it; it's more like jazz. There is more improvisation."

– Warren Bennis

The final research-chapter of this dissertation explores the wider implications for and applications of jazz wisdom in light of the neurobiological and psychological results examined in parts 2 and 3. Two main areas outside the realm of music where improvements are suggested to be attainable through embracing jazz wisdom are: organisation science and the school-based education system. In 2013, Dr Charles Limb and a group of colleagues put together a treatise on how creativity can be nurtured in the classroom in which they include an endorsed list of suggestions for small changes and inclusions in school teaching that would go a long way to encouraging students to think creatively and, by extension, critically.

Creativity is an area sorely lacking in the official national curriculums of most countries. It is very hard to imagine how raising students' awareness of their own ability to think new thoughts and to question the origins motivations and validity of the information they receive could have anything other than a positive effect on their outlook. It would surely be harder for people to be manipulated by, say, populist politicians with insidious plans to further personal power through exploitative means and campaigns of misinformation if every educated person had also been trained to think for themselves, to appreciate original thought and to question and evaluate their own thoughts as well as other people's thoughts.

This said, in many individual establishments throughout the world things are beginning to move in the right direction but focus on creativity as a worthy pursuit is sadly still absent from most typical school educations. Most systems are still based on the principles of the 19th century where the priority was producing factory-workers who could follow rules without asking too many questions and, at best, settle in to a job for forty odd years prior to a comfortable retirement. As many modern thinkers (such as Yuval Noah Harari[89]) are beginning to expose, the rate of change in job markets is now so intimately linked to a hastening technological advancement, that, to avoid redundancy, it will likely become the most important human skill to be adaptable and to be able to improvise solutions, to retrain and to go on learning new skills at any given point in life.

4.1 Single and Double Loop Learning Models: The Classical vs Jazz Dichotomy

In a 1998 paper organisation scientist and jazz musician, Frank J. Barrett discusses alternatives to typical hierarchical structures in companies where the jazz band serves as a paradigm for self-organising systems. He, like Berkowitz, refers to the need for relinquishing "some degree of control" in order to "strike a groove" (jazz jargon for a band finding a common time-feel as a basis for improvising tension-and-release-infused music together as an entity).[90] Jazz musicians' performances often take the music to the brink of chaos. Only by listening and working together

[89] Harari, Yuval Noah. *21 Lessons for the 21st Century*. Spiegel & Grau, New York, 2018

[90] Barret Frank J. *Coda – Creativity and Improvisation in Jazz and Organisations: Implications for Organisational Learning*. Institute for Operations Research and the Management Sciences, Organization Science Vol. 9 (No.5): pp605 - 622 (INFORMS), (1998)

instinctively in each passing moment do they navigate their unique paths through the unknown, sometimes on the brink of chaos. In order to achieve freedom there must be just enough of a common thread by which the musicians orient themselves, and of course there is the question of the unique way in which a jazz musician learns.

So how does a jazz musician prepare for the unprepared? Assuming, given the recently found evidence, that there are unique neurological processes involved in improvisation, a natural corollary would be that jazz musicians must practice performing these processes. In a seemingly paradoxical situation parts of their brains must train for deactivation. They must find a way to enter a state of mind that allows for spontaneous creativity in the practice room. Part of this process, according to Barrett involves "provocative competence," a concept referring to deliberately breaking out of habits by adopting a more fluid relationship with any rules being followed.

Most classical learning processes, and most companies for the past few centuries follow a single-loop model for learning. Single-loop learning prioritises the correction or, better still, the avoidance of error within a given rule structure. The rules are followed to the best of the musician's ability, the results are heard and an assessment is made as to what extent success or failure to create the desired result has been achieved. Discussion and improvement are based upon refined efforts to repeat the process with ever closer adherence to individual rules the only path to fixing problems. The rules themselves are considered sacrosanct. Provocative competence, as Barrett notes is not fully compatible with a single-loop model for learning. Jazz musicians require a double-loop structure that involves modifying the rules where necessary so that unexpected results are not necessarily considered wrong. Basically, double-loop learning requires three skills:[91]

1. self-awareness
2. honesty or candour
3. taking responsibility.

It is neither the intention of this study to suggest that these characteristics are lacking in all classical musicians, nor to suggest that every student of jazz possess them all automatically but it could certainly be argued that to reach an advanced level in jazz these qualities would be prerequisite. Thus, a jazz attitude to practice and learning stands to achieve them.

4.2 Organisation Science: Self-Organising Systems

The sociological field of organisation science arose approximately a century ago with Chester Irving Barnard, who argued that an organisation is a complex system of cooperation where an understanding of its individual workers is paramount to comprehension of the whole system.[92] In more recent times organisation scientists studying how companies are organised and managed have begun to explicitly cite jazz wisdom, embracing the jazz band itself as a paradigm for self-organising systems.

In 1998, jazz musician and organisation scientist, Frank J. Barrett wedded his two life-long occupations with the realisation that jazz bands present a great analogy for self-organising

91 <https://organizationallearning9.wordpress.com/single-and-double-loop-learning/>

92 <https://www.britannica.com/topic/institutionalism#ref1181286>

systems "optimised for social innovation"[93] and a counterpoint to traditional hierarchical systems of leadership, managing directors and bosses. In 2012 the organisational scientist Penelope Tobin begins a paper entitled, *Jazz Leadership* evoking a cool jazz-noir basement scene in which she invites her readers to picture themselves as part of the grooving band on the dim, smoky stage, sharing ideas with great musicians:

> "Take a look at the band. Who's the leader? If you watch an orchestra, you can spot the top dog right away. He is (usually) up on the podium, removed from the others, the only one with the complete "plan" in his hands. The jazz group, on the other hand, offers up no such easy clues. The leader is indistinguishable. Each player takes the limelight when it's their time to lead, and stands aside when it's another's. Behind the scenes, the jazz-leader is responsible for the vision and the strategy. But in performance, leadership and 'followership' rotate."[94]

Barrett's paper outlines seven characteristics that allow jazz bands to improvise coherently and maximise social innovation. These provide a clear framework for how he suggests jazz wisdom could be applied more widely to systems organisation.[95]

1. Provocative competence. This means deliberate efforts to interrupt habit patterns. Barrett discusses multiple examples of how innovators such as Miles Davis constantly threw their band curve balls to disrupt patterns of comfort and inspire original thought.

2. Embracing errors as a source for learning. This relates to section 3.3 of the present study on the improviser's relationship with mistakes for which the neural correlates found by Limb and Berkowitz appear to be deactivations in the dorsolateral prefrontal cortex (DLPFC) and angular cingulate gyrus (ACC). John Sloboda's discovery that most audiences prefer an expression of humanity over technical perfection in a musical performance is also a testament to a healthy relationship with mistakes.[96]

3. Shared orientation toward minimal structures that allow maximum flexibility. This point relates to the way a jazz band takes a musical skeletal musical framework (such as a lead sheet) and uses it as a basis for an infinite number of variations during which each band member can contribute something unique. Barrett argues that innovative companies such as Gore-Tex have a fluid approach to taking on new employees by which they are invited to "find something to do" rather than follow a designated prescribed role.

4. Distributed task: continual negotiation and dialogue towards dynamic synchronisation. Synchronisation appears to be a keyword in the neuroscience of improvisation and it is also important in social innovation. An abstract yet poignant parallel may be drawn between the brain's internal synchronicity (its connectivity in flow) during creative expression and the synchronicity of people viewed as nodes within a self-organising system.

5. Reliance on retrospective sense-making. This was discussed in relation to the jazz wisdom's use of double-loop learning discussed in section 4.1.

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93 Barret. Frank J. 1998

94 Tobin, Penelope. *Jazz-Leadership.* ChangeThis, 106.03

9595 Barret. Frank J. 1998

96 Fakultet muzicke umetnosti Beograd (July, 2020) *John Sloboda, Keynote Lecture, PAM-IE 2019 Belgrade Conference.* [online video] Timecode: <https://youtu.be/_AvjmB1Id8w?t=1403> [Accessed 26/08/2020]

6. Hanging out: Membership in a community of practice. Here Barrett discusses the same "immersion" Paul Berliner refers to as a crucial part of learning to "speak" the language of jazz. Patel, Berkowitz, Levitin and Limb all allude to unconscious or implicit learning in some form and the field of neuroscience is beginning to discover areas associated with this type of learning such as the lateral orbital prefrontal cortex (LOFC) and the 'reptilian' brain (cerebellum and brain stem).

7. Taking turns soloing and supporting. This section refers to the wholistic way a jazz musician internalises music. In jazz, it is rarely sufficient to learn your part alone. A fundamental understanding of the music (or rather, the ability to hear and understand as much of what is happening as possible in real time) is the essential ingredient of a jazz musician's training. Improvisation in jazz does not only refer to playing great individual solos. In fact, more time is spent by most jazz musicians listening to other people's solos and trying to help them shine with improvised accompaniments. This revolving relationship with the limelight helps to cultivate a sense of togetherness and to protect against superfluous wielding of power (at least with respect to the actual performance of the music). Spending more time saying "yes" to other people's ideas helps groups of humans to grow together and to maximise their collective productivity.

4.3 Education and Jazz wisdom: 8 Suggestions for Developing Creative Practice in the Classroom

During the past few decades a body of research linking academic achievement and music instruction in children has proliferated yet the type of musical instruction has often not been specified or has been assumed to be based on traditional classical music instruction. Thus, few studies have focused specifically on the learning advantages acquired by students of improvisation. A 2019 study[97] has suggested it is necessary to carry out further study into specific types of music-making since it may well be the case that there are links between the study of improvisation and levels of cognitive flexibility.

Dr Aniruddh Patel has found that learning music increases neural plasticity[98] which mediates the type of functional differences in brain structure discovered by Schlaug[99] (discussed in the first chapter of this study). Patel, (like Kölsch, Lerdahl and Jackendoff) has also explained that music involves processing complex hierarchical sound sequences that help with learning languages and with the recognition of subtle differences in pitch and inflection. He also believes his research demonstrates that learning a musical instrument helps with linguistic development and speech in addition to developing sensorimotor areas.[100] Stefan Kölsch discusses various results pertaining to the influence of musical training on classroom advantages. Among these were:

1. Christo Pantev 1998 - highly developed response to piano tones in 5-year-old children with pianistic training[101]. This indicated clearly that musical talent can be developed and is most likely not innate.

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97 Norgaard et al. *The Effect of Jazz Improvisation Instruction on Measures of Executive Function in Middle School Bands.* Journal of Research in Music Education. Vol 67, No. 3, pp339-354. August 2019

98 Exploring the Impact… Timecode: <https://youtu.be/e7QOPu2cDSU?t=942>

99 Schlaug. 2003

100 Exploring the Impact… Timecode: <https://youtu.be/e7QOPu2cDSU?t=1022>

101 Kölsch, *Die Heilende Kraft…* p55

2. Patrick Wong 2007 - (similarly to A. Patel) musicians recognise inflection and pitch modification in language and foreign language more precisely than non-musicians.[102]
3. Sylvain Moreno 2008 - Moreno's experiment separated 8-year-old school children with no prior musical training into two groups. Each group was given either two hour-long music lessons or painting lessons per week over a six-month period. Thereafter the musical group scored higher in tests on reading-out-loud and articulation than the painting group. The musical group also had notable synaptic developments associated with pitch recognition.[103]

Limb et al's paper on developing creativity in the classroom sets out eight methods for school teachers to implement for the nurture of creative thinking and enhanced engagement with school children.[104] Their connection to jazz wisdom is very clear:

1. **Supply students with a wealth of information in specific content areas, and take steps to ensure that students retain that information.** All too often there is a prescribed way of learning a topic. Variation is the key to maximising engagement and the capacity for retaining information. A clear parallel can be drawn with de Bézanac's discovery that jazz musicians prioritise learning lots of repertoire off by heart rather than the more classical approach of spending months perfecting one piece.[105]
2. **Ask students to offer multiple ideas to any open-ended prompt and remind students to make each solution as varied as possible.** In other words: Have a jam! Jazz musicians spend a lot of time jamming with each other to open up new musical paths together, to share ideas and discover more together. Why should this fun and rewarding process be excluded from the classroom? Teachers, after al, at least the good ones, are still themselves students of life.
3. **Encourage idea generation by posing questions or problems that have more than one correct response.** A jazz solo is one of an infinite number of possible paths through a musical structure. Jazz wisdom reminds us that there are often multiple right answers.

4. **For each potential solution that a student suggests, ask the student to also think about implications and implementation.** Jazz musicians will listen analytically to thousands of pieces of jazz during the course of their formation always remaining open to the possibility of hearing something new to learn from. They will think a great deal about how a jazz master chose to 'say' what they did, when they did and maybe even why they did.

5. **Include group work opportunities when presenting multi-part problems.** Although there are many phenomenal solo artists in jazz, the overwhelming majority of jazz music is performed by improvising groups working together in self-organised harmony with each other. As Matthias Benedek reminds us, group work maximises exposure to new ideas which in turn provokes higher levels of creativity in individuals.[106]

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[102] Ibid. p56

[103] Ibid. p57

[104] Limb et al. *Building Creative Thinking in the Classroom…* 2013

[105] de Bézanac, Swindells 2009

[106] Benedek et al. 2014

6. **Give students a novel relationship and have them generate items that, when related, exemplify that relationship.** This point relates to inspiring divergent thinking and adaptability; both traits Benedek found to be more common in jazz musicians than in both classical and folk musicians.[107]

7. **Provide students with two or more unrelated ideas and ask them to find a novel relationship.** Creative individuals develop higher levels of cognitive control and cognitive flexibility. Jazz musicians display higher levels of creativity by several accepted measurements.[108]

8. **Include external mediators in certain group work situations.** Jazz musicians practice to optimise their potential for creativity in the moment. In order to do this effectively they must find a way to give structure to the infinite possibility of things they could practice. Setting ones own goals and holding oneself to account in analysis of how well these goals are met are among the most fundamental attributes of the successful jazz student.

The conclusion to the paper is worth noting since it reinforces the increasing need for creativity in our ever-changing society:

> "The skills necessary for progress in our society, regardless of context, are continually changing with the priorities of our economy and our culture more generally. Currently, our economy is transitioning from one based on manufactured goods to one based on information and new ideas. As a result, future progress and achievement will require citizens to have a strong foundation of knowledge as well as the ability to think creatively. These capacities are critical for success not only in the professional world but also in education: content knowledge and creative use of that knowledge are what make it possible for students to apply what they have learned to solve new problems in situations that differ from those in which information was initially learned".[109]

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[107] Ibid.

[108] Ibid.

[109] Limb et al. 2013

5 - Conclusion

5.1 Summary and Analysis

The initial impetus for my thesis was a wish to examine the results of recent experiments by pioneering neuroscientists exploring the neural substrates and psychobiology of musical improvisation. Following this it has been my intention to discuss how these results — being first real attempts at discovering the neural correlates of what has also been called jazz-wisdom — have significant implications for the development of mental fortitude, self-awareness and many other forms of psychological well-being. In so-doing I intended to support the idea that the study of improvisation, though on many levels similar, contains fundamental elements that are distinct from typical classical learning processes whose principal aim is to reproduce perfect representations of prescribed musical works. That the two processes are distinct seems intuitively the case and now the field of neuroscience has begun to discover clear differences in brain activity supporting this claim. Further to this, in addition to enhancing and extending musical ability beyond the level of musicianship required for these learning processes, I wished to explore recent studies that claim the study of improvisation leads more naturally to a creative, self-assured and convivial musical personality. I wished also to offer a broader context in which to consider negative representations of 'typical' links to psychopathology in the creative genius of great jazz musicians such as appeared in the British journal of psychiatry written by Geoffrey Wills in 2003.[110] As I read further into the research of both speech and improvisation independently, simultaneously with those studies whose purpose was to compare the two processes at the cognitive level, channels opened up to a much larger bank of scientific data supporting the hypothesis that improvisation with music, whilst highly comparable to improvisation with language, is a unique cognitive process. A set of neurologic processes in fact, that offer unique channels for accessing flow states, acquiring and applying wisdom both in and beyond the world of music. As such, two important conclusions which I draw from this investigation are: 1) that the findings of modern cognitive science show beyond doubt that it is unwise to leave music out of our education system, 2) the corollary that the lack of improvisational studies in higher music education creates a deficiency in musicianship that cannot be otherwise redeemed and 3) that improvisation awakens the mind to new levels of flexibility and freedom that are essential to the positive development of organisation science and a move away from rigid hierarchical power structures that are no longer considered the best way to achieve productivity and harmony.

[110] Wills Geoffrey I. *Forty Lives in the Bebop Business: Mental Health in a Group of Eminent Jazz Musicians.* British Journal of Psychiatry 183, pp255-259, 2003

5.2 Areas for Further Research

As is noted in so many of the journals I have analysed in this study, the cognitive mechanisms associated with the complex interactions of interconnected brain-networks that produce 'creative' thought are still poorly understood. Individual researchers delve ever deeper into researching highly specific tasks to discover how they relate to the strongest existing theories about the roles of different regions. Their magnifying glasses often reveal the intrinsic multiplicity of each individual cognitive process. The further one zooms in the less it seems that any individual cognitive process is in fact a single process. This is also the case for the universe in general at the quantum level.

My research has touched on many related areas that all provide rich new ground for research and discovery. I believe my research has provided a strong case for the recognition that improvisation enhances a musical education. Further to this I have discovered adequate grounds for my claim that improvisation is one path for anyone to discover more about themselves and to raise their awareness towards seeking and creating more positive interactions with other people. It is clear that each of these claims need to be explored in even more detail and that further clear proposals for how to integrate more creativity into standard education programs are required. These would most likely best come from interdisciplinary think tanks combining the research of neuroscientists with those of education psychologists and teachers. I have only explicitly mentioned one such journal (Limb et al in section 4.3) that provides specific suggestions for engaging students with more creative tasks in the classroom designed to improve their abilities in divergent thinking and in the critical evaluation of original ideas. This is a good start and I have outlined the eight branches of suggested activities and modifications in detail but there is so much room for further research in this field.

Dr Charles Limb's experiments present the first clearly defined attempts in neuroscience to understand the neural substrates of jazz improvisation. As I read his papers and listened to his own evaluations of his own work there were so many areas thrown up where I hope soon to see further developments. The activations Limb witnessed in the limbic system were attributed to the "positive emotional valence" of music-making but as yet there have been no conclusive interpretations of the accompanying deactivations in the limbic system that may for example relate to the overcoming of fear and anxiety through improvisation. Also, since Limb's experiments were all carried out on professionals at a very high level of musical ability it would also be interesting to see if similar brain activity would be found in improvisers at lower levels of technical proficiency in order to conclude that the study of improvisation is helping to develop positive functional change in students at any level.

It would also be useful to have comparative research take place within the improvised music traditions from other cultures such as Indian classical music or Arabic Maqam music where improvisation plays a key role for all musical performers. There we would no doubt find more generalised results contributing crucially to a broader understanding of the related neuroscience.

In this thesis only passing references were made to these cultures but I acknowledge the wealth of potential to be mined from further research into them.
Finally, I am sure we would all love to hear more about Snowball the dancing cockatoo. Is this cockatoo a freak anomaly? Can all Cockatoo's dance like Snowball? Does this have implications for the neurological basis of human beat perception lying in more primordial regions of the brain? I think I have a Masters thesis in the making here!

5.3 Evaluation of Methodology

During my investigation I discovered that a powerful recurring theme in the neuroscience of spontaneous creativity is its ubiquitous comparison to speech, the form of improvisation nearly every human being can and does to some extent engage in and especially the acquisition of new languages later in life as a suitable analogue for musicians learning and practicing how to improvise. This juxtaposition of spontaneous speech and spontaneous musical creativity has been present in some form in nearly every publication on the topic and appears thus to be the best path into understanding the neurology of both processes. It is important here to allude to the often tacit yet crucial underlying hypothesis that all human action can be analysed as being a neurologic product since this is taken as axiomatic when devising the types of experiments that have been carried out thus far. In the same breath however a note of caution is introduced from the most recent challenges to the notion that it is fully understood how neurologic products arise. Do they even originate in the brain itself, or are brain processes inseparable from the motions of the body in which it is housed?

One of the most intriguing discoveries made during my research was the 'embodied mind' hypothesis that has been gaining traction for two decades in the fields of psychology and, increasingly, neuroscience. I have only been able to make fleeting reference to it but, given the fundamental link between the kinaesthetic and the cognitive processes of producing music I believe it lights the way towards highly fertile ground for more research into the neuroscience of improvisation. The theory suggests that neurological processes must necessarily be considered in relation to the brain's physical location in a body whose motion and physical existence in its environment is the brain's only means of interacting with its surroundings. This line of thought would further postulate that music cognition is fundamentally inseparable from the physical act of making music.[111] Embodied cognition seems to open up further channels for exploring the nature of the 'flow state' which lies at the heart of (and is perhaps the ultimate goal of) spontaneous creativity as indeed of any immersive activity where the agent seeks to lose a sense of self, of ego and of time, merging temporarily with the task at hand, like a drop of water carried along by a river as Mihály Csíkszentmihályi puts it.

With my research based on literary sources from comparatively very recent experiments I must

[111] Iyer, Vijay. *Embodied Mind, Situated Cognition, and Expressive Microtiming in African-American Music.* University of California Press. Music Perception: An Interdisciplinary Journal, Vol 19, No. 3 pp387 - 414, Spring 2002

reiterate that many of the conclusions drawn are as yet only supported by preliminary scientific data that could easily be developed or refuted in years to come. Nevertheless I maintain that so many of the findings seem to correspond so fully with the intuitively held beliefs about the uniqueness of improvisation as a path to accessing flow states in which body and mind are better synchronised with each other that I consider it unlikely any of the discoveries made will be fully falsified. There is certainly room for development as in all other fields in neuroscience.

5.4 Final Thoughts

This thesis has drawn on important results from the fledgling field of improvisation-cognition neuroscience to advance and reinforce the case that the study of and participation in jazz music is one way (by no means the only way) to develop creativity, to nurture an understanding of how to learn, to optimise one's learning for social innovation and to encourage team work in the absence of unnecessary hierarchical structures. Jazz is a music born of the fundamental human desire to be free. It is an expression of the unshackled human spirit that refuses fetters even when its body is bound. It is undoubtedly an artistic celebration of one of the most important keys to human survival: the ability to improvise, to think on one's feet, to produce beauty in the face of desolation, to evolve and to live life to the full.

As Dr Charles Limb himself puts it when asked by Esperanza Spalding what he thinks are the "healing" applications of his research on creativity:

> "Improvisation and music-making is a very socially bonding and personally transformative experience and we don't understand why it is the case or how it is the case and how we should take that experience that some people get to experience and transfer it to people (who) have never had that experience. I do believe that, through this research, eventually, and it might be 20, 30, 40, 50 years, maybe well past my lifetime, (that) we're going to know how to take human creativity and apply it in new ways that are more everyday and so it won't just be in the realm of artistic genius … that we could make ordinary human beings more creative on an every day level. Now if we could accomplish that, let's say we could make our society 10% more creative. I think the world would be a phenomenally better place.[112]

Being creative is an essential part of what it means to be human. Without the ability to improvise humans would not likely have evolved so far. Is that not alone an argument to include the cultivation of creativity as a fundamental aspect of education?

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112 <https://youtu.be/AiljM3o2m_E?t=3751>

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Page 1:
<https://www.kenhub.com/en/library/anatomy/brodmann-areas>

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Page 2:
Top left: Broca's area Wernicke's area and lobes
<https://www.pinterest.at/pin/859272803873135794/>

Top right: Broca & Wernicke Connection
<https://www.qwant.com/?q=https://httpsi.pinimg.com broca wernicke&t=images&o=0:4b829363ba4bb1c5452c4b262a83add5&size=all&license=all&freshness=all&color=all&imagetype=all&source=web>

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Further illustrations and detailed diagrams can be found via links at
<https://en.wikipedia.org/wiki/Brodmann_area>

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Andrew Gorman, Vienna, 31.12.2020