The Dark Pattern: Towards a constraints-led approach to jazz trumpet

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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.

Phillip Slater

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This project is dedicated to my darling daughters Lucy and Daisy.

Table of Contents

This thesis is presented here in a redacted format due to Copyright and content restrictions. All HTML links, including Soundcloud, Google Maps, and Bandcamp have been deactivated. Appendix A: Practice Journal has been redacted due to privacy restrictions. *The Dark Pattern* audio recording is held by University of Sydney library and distributed commercially online.

Abstract

The constraints-led approach is a nonlinear pedagogical theory and method within the ecological dynamics framework of skill acquisition, development and performance. Ecological dynamics combines descriptions of complex movement systems developed in dynamical systems theory with insights from ecological psychology about environmentally regulated action and perception. The constraints-led approach provides a principled learning framework based upon the understanding of the learner as a 'complex adaptive system' capable of self-organisation under interacting constraints of body, task, and environment. This research project applies the constraints-led approach to jazz trumpet skill acquisition and development through the use of atypical performance contexts as an environmental constraint to improvisational practice activities. The research outcome includes an original recorded work of contemporary jazz which explores the skills and materials developed throughout the research period.

Keywords: constraints-lead approach, ecological dynamics, self-regulated practice, jazz trumpet, improvisation.

The Dark Pattern: Towards a constraints-led approach to jazz trumpet

This practice-led research project applies the constraints-led approach of ecological dynamics to jazz trumpet skill acquisition, creative development and performance. The project was completed in two stages: (i) a skill acquisition and development project following ecological dynamics practice design principles; and (ii) a performance project of original new work demonstrating the developed skills and materials.

The first stage targeted the development of performance skills through the implementation of environmental constraints upon improvisation activities. The project extends an ecological dynamics theory of nonlinear pedagogy into self-regulated trumpet practice, and it investigates whether environmental information can positively influence the development of an original improvisational style. The first stage was a preliminary project to discover and develop new skills and materials to be explored in the later performance project.

The second stage involved composing new music for jazz quintet to accommodate the newly developed improvisational style. The music was recorded and released as *The Dark Pattern* (Slater, 2019). The recording is submitted as a creative outcome of the research project and demonstrates an application of the skills acquired during the constraints-led practice period.

Ecological dynamics is a motor learning theory developed by sports science and human movement research to describe skill acquisition and development within information-rich performance environments. The theory combines concepts from dynamical systems theory with research developments from ecological psychology to develop an account of motor-skill learning and expertise based upon the framework of self-organisation under interacting constraints.

Dynamical systems theory uses mathematical and topographical representations to describe natural movement systems – weather patterns, whirlpools, schools of fish, flocks of birds, and the human body. These systems are all self-organized contextually sensitive patterns of coordination, attraction, interaction and exchange. The theory has been applied to human movement research to describe the ways in which motor-learning occurs over the developmental stages of life. Under this model, motor-skill learning involves the discovery of attractive and stable patterns of organisation between different body parts and sensory systems in self-organisational relationships under the interacting constraints of the body, the task, and environment (J. A. S. Kelso, 1995, 2009; Newell, 1986; Newell & Jordan, 2007; Thelen & Smith, 1996, 2006).

Ecological psychology is concerned with the function of human action and perception coupled in a reciprocal relationship with environmental information. This information is perceived directly – or without the need for cognitive enrichment or internal modelling – as environmental affordances. Affordances are understood as invitations or opportunities for action (Chemero, 2003; Gibson, 1979; Rietveld & Kiverstein, 2014).

Skill acquisition and development within an ecological dynamics framework involves the education of the performer's: (i) intention, (ii) attention; and (iii) calibration. Intention relates to thought processes, motivations, directives, goals, and beliefs that can guide the performer's actions. Attention refers to the search and discovery of available information within the performance environment which may be beneficial to the performer. The relevant information sources include auditory, visual, haptic, kinaesthetic, and proprioceptive forms. Ecological dynamics promotes the continual attunement between perceptual information and performance actions through calibration. This refers to the sensitive adjustments made to performance actions to enhance the exploration and exploitation of important environmental information and to discover stable yet adaptable movement patterns in dynamic performance contexts.

Practice strategies under ecological dynamics theory aim to create information-rich learning environments to guide the learner – without explicit directions or corrections – towards effective, individually unique, and self-discovered performance solutions (Davids, Button, & Bennett, 2008; Davids, Handford, & Williams, 1994; Renshaw, Davids, Newcombe, & Roberts, 2019).

The constraints-led approach is a learning methodology supported by ecological dynamics theory and nonlinear pedagogy (J. Chow, Davids, Button, & Renshaw, 2016; Davids, 2010). It conceptualises the individual learner as a complex adaptive system capable of self-organising into stable yet flexible movement patterns under interacting constraints (Davids, Araújo, Vilar, Renshaw, & Pinder, 2013; Davids et al., 2008; Davids et al., 1994; Newell, 1986). Under this perspective, skills are developed through the manipulation of important environmental and task constraints - by a coach, teacher, or physical therapist - to guide the discovery and development of new patterns of coordination by the student. Skilful behaviours are described in terms of the performer being able to explore and exploit information resources in increasingly effective ways (Seifert, Button, & Davids, 2013; Seifert & Davids, 2015; Seifert, Papet, Strafford, Coughlan, & Davids, 2019).

Self-regulated learning theory describes practice procedures used by individual learners working in unsupervised or undirected ways (Bandura, 1997; Zimmerman, Bonner, & Kovach, 1996). It outlines key methodological and strategic measures relevant to self-motivated learning in diverse fields. In recent years the model has been extended into music education research and applied to accounts of solitary practice techniques and strategies used by effective music practitioners (Lehmann & Jørgensen, 2012; McPherson, Miksza, & Evans, 2011; McPherson, Nielsen, & Renwick, 2013; McPherson & Renwick, 2011; McPherson & Zimmerman, 2002; James M. Renwick & McPherson, 2002). Much of the practice carried out by musicians is self-directed, self-motivated, and self-managed (Lehmann & Jørgensen, 2012). Individual learners must devise effective strategies to maximise the effectiveness and efficiency of their practice sessions and creative development (James Michael Renwick, 2008; James M. Renwick & McPherson, 2002). Self-regulated learning theory describes the iterative cycles of individual learning which feature the development of forethought, performance, and evaluation phases of practice.

This project expands upon my self-regulated learning methods by implementing key practice design principles from ecological dynamics and a nonlinear constraints-led approach. The project focusses upon developing the performance skills related to spontaneous improvisation and explores a creative application of the developed skills and materials in the context of a recorded performance of original contemporary jazz.

About the Document

The thesis is presented for examination as an interactive document including music examples stored in the online Soundcloud platform and maps available from the Google maps website. The sources are designed to support and compliment the thesis presentation and are an integral part of the communication of the project outcomes. The user is encouraged to explore the resources in an interactive and self-guided way.

Soundcloud

The thesis has been prepared using the Soundcloud website (***https://soundcloud.com***) to manage the performance materials created throughout the project. Soundcloud is an effective and convenient method for organising and distributing audio files. Links to the Soundcloud files are embedded within the document via hypertext links (***indicated like this***). Clicking on the hypertext link will launch a prepared Soundcloud file in a separate page within the users' browser. As such, it is necessary for the thesis to be read in a digital format on a device with internet access.

Each music example has a unique identification number generated by combining the Motive Segment number, the Session Number, and the YYMMDD date format (e.g. ***M28.S38.160812***). There are 4779 individual Segments organised into 179 practice sessions. Each practice session is organised into a Soundcloud 'playlist' (e.g. ***S38.160812***) which is a collection all the improvised motives from that practice session.

Figure 1 is a screen-shot image of the SoundCloud website illustrating Motive Segment ***M28.S38.160812***. The key features of the site are the "play" symbol and the waveform representation of the audio file.

Figure 1: A screen-shot image of the Soundcloud audio file including a reference image of the practice location, Segment details, Playlist details, a "Play" icon and a waveform depiction of the audio file.

Below the graphic "play" interface is a sample of the session details, shown in Figure 2.

S38.160812
Friday August 12, 2016
10:24am
16°C, humidity 44%, sunny, winds NE 9km/h
Clive Bissell Dr, Mount Keira NSW 2500
34°23'24.6"S 150°50'58.4"E
goo.gl/maps/aF3744y2odGkYsTF9

Figure 2: Screen-shot image of the Practice Session metadata including a Session identification number, date, time, weather conditions, street address, GPS coordinates, and Google maps link. Clicking on the link will open a corresponding Google maps page indicating the practice location position.

Figure 3 illustrates a screenshot of an alternative control panel found at the bottom of the webpage. From here, the user has the option to start, stop, rewind, fast forward, repeat, or loop the file with the control panel that appears at the bottom of the page. The audio file timeline can be used to navigate around the example whilst it is playing. Sections can be skipped or randomly sampled by clicking along the timeline. The waveform graphic illustrated in Figure 4 offers the same navigational features as the timeline.

Figure 3: A screen-shot image of the Soundcloud control panel found at the bottom of the page. The user can start, stop, rewind, fast forward, shuffle play, or loop the file. The timeline graphic can be used to navigate around the audio file. There is an adjustable volume control to the right of the timeline.

Figure 4: A screen-shot image of the audio file waveform graphic. The audio file can be navigated using this feature. Sections can be skipped, repeated or randomly selected.

The retrieval of an audio file may produce a search error, illustrated in Figure 5.

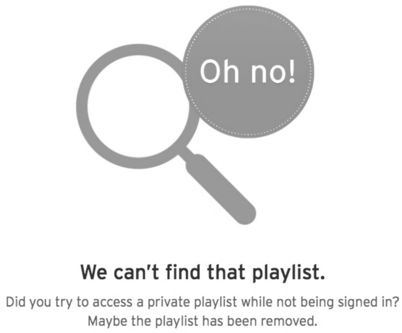

Figure 5: Screen-shot image of a search error in Soundcloud.

This error is infrequent, temporary and can be corrected by reloading the file. It is recommended that users be logged into an account to use the system, however the website is designed to work without a log-in or membership account. Users may choose to use their own private Soundcloud account, or log-in to an account created for the research project using the following account details:

User name = xxxxxxx

Password = xxxxxxxx

Google Maps

The thesis includes links to the Google maps website (***https://www.google.com/maps***) which provides a pin-drop symbol to represent the location of each practice session. The locations are identified by a street address and GPS coordinates which are embedded with a hypertext link to a location map (e.g. ***34°23'24.6"S 150°50'58.4"E***). Figure 6 illustrates a screen-shot image from Google maps.

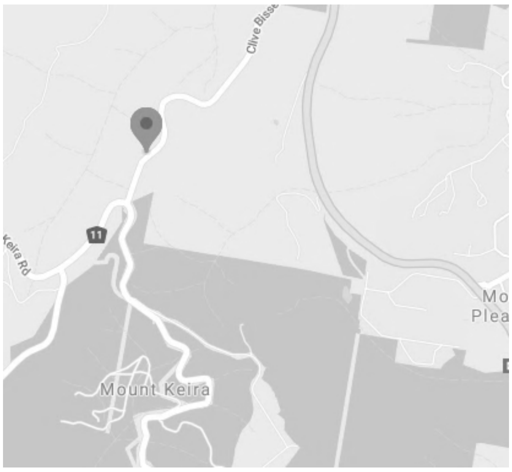

Figure 6: A screen-shot image of a pin-point location marker depicting the location of the practice session. Google maps enables the user to explore an area with a variety of tools.

The website enables the user to navigate around a location with a variety of tools, including zoom-in and zoom-out option, a two dimensional illustrated map view, a two or three dimensional photographic "Satellite" view, and a "Street View" function which provides a rotatable 360° view of the location and surrounding features from a pedestrian perspective. Figure 7 is an example of the "Street View" option.

Figure 7: A screen-shot image from Google maps "Street View" format.

Taxonomy of Materials

Chapter 5 includes examples of the improvised materials that were discovered and developed during the practice project. These are presented in a table of SoundCloud links. This provides an efficient way to negotiate the multiple examples, which are presented chronologically to allow the user to access the examples in flexible ways. Multiple examples are provided to demonstrate the variable melodic approaches and solutions. It is not necessary for the user to listen to every example, and there is no single ideal version of the materials. They are offered as a combined example of practice variability. The tables are divided into columns to encourage random nonlinear sampling of the audio files. This is to encourage comparative listening. See Figure 8 for an example of the table format.

Figure has been removed due to

HTML link deactivation.

Figure 8: Example of Chant Motive format presented in Chapter 5.

The Dark Pattern

The major creative component of the thesis is the original new work entitled *The Dark Pattern* (Figure 9 illustrates the cover artwork).

Figure 9: Front cover artwork of *The Dark Pattern* (EAR034). Photograph by Traianos Pakioufakis. Image of the author at Port Kembla Coal Terminal sea wall, 2016.

This work is available for online listening or download via the following sources:

Bandcamp

Follow ***this link*** to the Bandcamp website and enter one of the following codes (see Figure 10 for a screenshot image of the dialogue box) to commence the download of the recording:

577d-xxxx

gmwc-xxxx

3rje-xxxx

dvbf-xxxx

pgvx-xxxx

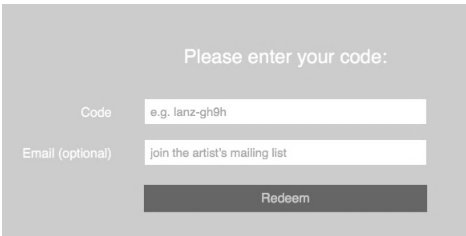

Figure 10: Screenshot image of the Bandcamp webpage. Enter one of the provided codes into the 'Code' box and press 'Redeem' to download The Dark Pattern recording. Please note, each code can only be used once. If the code doesn't work, please select another.

Soundcloud

For online listening to *The Dark Pattern* please use ***this link*** to access the recording on the SoundCloud website. Please note: the audio quality of SoundCloud is of a lower quality than Bandcamp due to the compression of the file within the system.

Supporting Materials

Appendix A: The Dark Pattern: Practice Journal

Appendix A provides the Practice Journal maintained throughout the 12-month practice project in preparation for *The Dark Pattern*. It was used to document and manage the collected data - location details, dates, times, location images, recording file numbers, and weather conditions. It is intended to be used as a reference document, and is presented here as an overview of the project. The Journal includes Soundcloud files of the practice sessions and Google map links to the session locations. Both information sources are provided to be used in an integrated way.

The Notes section of the Journal includes detailed codified classifications of practice activities. A Key for the coding system is provided. For clarity, I have only provided these codes for the first 20 session reports (S1-S20) in order to establish a working vocabulary for the skills and materials that were being explored, and to present the practice methodology of improvisation and classification. These detailed codes and descriptions are the primary materials used to establish the generalised taxonomic categories presented in Chapter 5 and represent the basic components of the skills and materials under development in the project. The remaining Notes (S21-S179) contain conceptual or theoretical accounts and reflections.

The Notes are presented in the short-hand codified style and format within which they were created. They are immediate post-practice reflections collected at the conclusion of the sessions, and represent the methods I used to capture the adaption and learning process of the project. The Notes are to be understood as my personal reflections and a valuable part of the creative process.

Research Contributions

This project makes an original contribution to research and knowledge in the following ways:

1. the application of ecological dynamics theory to music skill acquisition and development is an original extension of this learning framework into the field of creative music practice and performance;
2. applying the theoretical framework of nonlinear pedagogy and the constraints-led approach to music practice design offers a new way of developing learning activities, and provides the groundwork for potential music education research projects into the efficacy of constraints-led learning in novice musicians, particularly in the fields of informal or unstructured learning models (Green, 2008; Uehara et al., 2018)
3. the use of environmental resources as a constraint upon musical skill acquisition and development contributes an original way of thinking about intersections between music and the landscape from an enactive performance perspective as opposed to a representational compositional approach;
4. the primary creative output of the research project represents an original contribution to contemporary jazz trumpet performance.

Scope and Limitations of the Research

This section provides a brief contextual overview of the scope and limitations of the research project. The following clarification of research aims and interests attempts to position this study within several key areas of research practice, and provides a conceptual framework for understanding my research objectives.

Creative Development

Concepts of musical creativity and development are central to this research project. I define creativity in terms of the generation of new musical materials through spontaneous improvisation. Development refers to the attunement and adaptation of musical skills necessary to achieve this state of spontaneous improvisation, including instrumental technique, coordination and control, performance goals and intentions, and perceptual attention and self-awareness. The concept of creative development captures and describes the learning processes related to the intentions, attentions and calibrations necessary for spontaneous improvisation.

Musical materials are discovered and developed through spontaneous improvisation and subjectively identified as being of value and use within a broader context of ensemble performance (Boden, 2004; Carruthers, 2002, 2011; Picciuto & Carruthers, 2014). The creation of new melodic materials and techniques – the central goal of this project – can occur as a product of deliberate task-related planning, thinking, concentrated focus, and modelling (Ericsson, Krampe, & Tesch-Romer, 1993), or as a product of off-task spontaneous thought, random association, mind-wandering, daydreaming, and unplanned implicit realisations (Dobson, 2018; Irving & Thompson, 2018; Sripada, 2018; Vervaeke, Ferraro, & Herrera-Bennett, 2018). Personal insights, introspections and discoveries of novel musical materials often occur in moments of distracted or unfocussed 'random' spontaneous playing or unplanned performance consequences and 'errors'. Within an ecological dynamics framework, these implicit and unplanned occurrences offer valuable epistemic knowledge about performance parameters which can be useful in future performances, and contribute to the performers' repertoire of intention, attention and calibration capabilities (J.-Y. Chow, Renshaw, Button, Davids, & Keat, 2013; M. C. Y. Lee, Chow, Komar, Tan, & Button, 2014; Maxwell, Masters, Kerr, & Weedon, 2001; Schöllhorn, Hegen, & Davids, 2012).

The creative improvised activities within this project were often unexpected and unplanned for in the forethought phase of performance. They often emerged in unpredictable and surprising ways. The outcomes were unknowable to me before attempting the research. This project aims to exploit this tendency, and acknowledges the important contribution that these unplanned processes and outcomes make to skill adaptation and spontaneous improvisation.

The discovered skills and materials in this project are the product of combinations, configurations or blends of referent materials, idiomatic tendencies and interactional responses to prompts, triggers or cues (Brandt & Eagleman, 2017). The musical ideas are never isolated from previous stylistic conventions, instrumental practices, characteristics and features of genre, and cultural norms (deBruin, 2015; Hargreaves, 2012; Johnson-Laird, 2002; Norgaard, 2014; Pressing, 2001). The aim of the project is to develop a personal and identifiable approach to spontaneous trumpet improvisation within the broader cultural developments of the jazz-trumpet traditions.

Selection

A key idea presented here and elsewhere (Boden, 2004; Brandt & Eagleman, 2017; Carruthers, 2002; Kaufman, 2014; Miller, 1997) is that the mechanism of identifying or recognizing the value of new materials is aesthetic *selection* by the individual artist. Materials are selected for traits and characteristics which are considered valuable and useful from a subjective artistic perspective. Decisions are made, materials are discovered, developed or abandoned, and choices are explored under the subjective criteria of style, convention, genre, and taste. I introduce the evaluation criteria of *originality*, *efficiency*, and *transfer* as key selective pressures upon the materials developed within the forethought, performance and evaluation phases of this practice project.

Originality refers to trying to play something that *I want to play*, something that relates to my personal aesthetic and musical identity (Ake, 2002; E. T. Atkins, 2001; Monson, 1996). Efficiency relates to the stability of the physical patterns – I'm trying to find a way of getting around the instrument in the most efficient and effective ways for my body and physical tendencies. Transfer relates to the materials and physical patterns being adaptable and flexible. I need to be able 'improvise' with the developed skills and materials, and be able to incorporate them into a generalised aesthetic approach. The practice project is about developing intrinsic skills and aesthetics that can be adapted into an ensemble context. The practice project is designed in preparation for skills transfer into the production of the major creative work component of the research programme.

The evaluation criteria is applied – often in intrinsic, pre-reflexive and unconscious ways – throughout the improvisation process in an ongoing and formative way. The evaluation criteria relates more closely to the formation of performance intentions, attentions and calibrations, and implies an implicit objective for all of the products. As experimental and exploratory the playing becomes, I'm always evaluating for some kind of value and use in the development of skills and materials.

The creative selection process – choosing one musical approach over another - is determined by the criteria in an ongoing and subjective way. I equate the selection of materials with the idea of *attraction* – which is an important 'selective' characteristic of self-organisation. Patterns of coordination progress towards areas of attraction. The 'selection' process is really the attraction of materials and physical skills being towards the attractors of originality, efficiency, and transfer.

In this project, the selection pressures upon performance are regulated by the interaction of environmental constraints and the practice task. I don't make any further attempt to describe or define the creative development process other than to make clear that the perturbations from the environmental constraints are designed into the practice project to influence the ongoing 'selection' of materials.

Adaptation

The use of 'adaptation' as a descriptive tool of learning is supported by the ecological dynamics and development literature (Davids et al., 2008; Thelen & Smith, 1996, 2006). Learning and physical adaptations occur over multiple time-scales: from the moment-to-moment instantaneous adjustments to performance decisions and actions, to traditional learning timeframes of days, weeks, and months, through to long-term developmental changes over years (J. E. Clark, 1995; J. E. Clark & Metcalfe, 2002).

In short, this research project is focussed upon stimulating the processes of creative development through selection, adaptation and attraction of skills and materials by the implementation of an environmental constraint to my performance activities across a developmental timeframe of 12-months.

Practitioner research

This research project is being undertaken by an experienced professional trumpeter with over 35 years of practice and performance experience. I have well established practice methods and consider myself to be an effective and efficient learner within a highly self-regulated framework. In this sense, I would characterise myself as an advanced learner.

The constraints-led practice design that I implement in this project is intended as an experimental intervention upon my already well-established performance methods and practices. This project is intended to demonstrate the effects of an ecological dynamics learning perspective upon an expert performer interested in experimenting and exploring a potentially new way to think about their creative work.

Performance

In line with many current models of practice-led research investigating artistic forms of knowledge production, the performance activities within this project are to be considered integral to the communication of knowledge developed and discovered throughout the project (Barrett & Bolt, 2007; Massumi & Manning, 2014; Paltridge, Starfield, Ravelli, & Nicholson, 2012; Ravelli, Paltridge, Starfield, & Tuckwell, 2013; H. Smith & Dean, 2009).

Within this project, instrumental improvisation was both the research target, and the primary method of investigation. As such, a large amount of the knowledge produced by the project is procedural, implicit, and embodied. The best communication method for these forms of knowledge are the documented creative products and outcomes. This is the view taken throughout this project, and where possible, I will allow the performed musical activities and creative outcomes be the primary communicative source.

This project is interested in applications of an alternative pedagogical approach for the purposes of exploring a new way to prepare and produce creative music. The research is offering an investigation into a possible different way to think about trumpet skill acquisition and creative performance. The research contribution being made is oriented towards a conceptual framework for practice and performance - not musical analysis. Within this project, ecological dynamics is only applied to ways of thinking about practice design and performance procedures, and to the interpretation or analysis of creative results or outcomes.

The Dark Pattern

The original creative contribution of this research project is presented as a recording of new works and improvised trumpet performances within a contemporary jazz ensemble context. The work is submitted for examination as a complete form of communication. The work is an embodiment of the skills and materials developed throughout the research project. As such, the work is offered without any explanatory exegesis, analysis or commentary, and is presented as a primary project of knowledge production.

Ecological Dynamics

Ecological dynamics provides a comprehensive motor-learning theory that has been empirically tested in both experimental settings and real-world coaching applications from beginner level novices to international-level sporting teams. The theory is support by numerous coaches and athletes, and is a valuable education tool being implemented in many movement practices (Renshaw et al., 2019; Renshaw, Davids, Shuttleworth, & Chow, 2009).

Whilst this research project makes an original application of the theory and practices associated with ecological dynamics, it is not being offered as an investigation of ecological dynamics teaching and learning methods, nor as a critique of conventional music pedagogy. My understandings of the theory and its potential adoption within artistic practices is still developing and this project represents an initial attempt at an application and investigation. I make no claims of authority within the ecological dynamics community of researchers, and offer this project as a potential extension and application.

Within my research, I use the ecological dynamics perspective to design an experimental practice project. The theories and methods of ecological dynamics are a guiding influence and motivation. However, I acknowledge that elements of constraints-led approaches appear in numerous pedagogical accounts and teaching methods.

I use ecological dynamics and the constraints-led approach as an explanatory and descriptive tool, and incorporate the key concepts and terminology of nonlinear pedagogy in the most appropriate ways for my project.

Nonlinear Learning

The nonlinear learning process supported by ecological dynamics are often unstructured, implicit, accumulative, and temporally displaced. At the time of this writing – some two years after the conclusion of the practice project – I am still discovering new skills and valuable performance processes connected to discoveries made during the practical research period. The implications from the nonlinear type of learning project I undertook have had long lasting creative and physical effects that have illustrated to me the power of the learning processes.

The ecological dynamics model of nonlinear learning offers an alternative to education models promoting 'deliberate' practice methods supported by 'formal', structured, goal oriented and targeted practice regimes (J. Chow et al., 2016; J. Y. Chow, 2013; Jia Yi Chow & Atencio, 2014; Ericsson et al., 1993). I was interested in exploring a practice program that developed creative decision making and supported experimentation and exploration as a learning tool. The nonlinear pedagogy theories of ecological dynamics provide a useful and rigorous method to implement this type of project (J. Chow et al., 2016; J.-Y. Chow et al., 2013).

Nonlinear pedagogy has developed to account for skill acquisition and performance within high pressure sporting contexts where the unfolding performance is emergent and self-organised, unpredictable, and time dependant. In my view, this made nonlinear pedagogy and ecological dynamics an excellent potential learning theory to transfer across to improvisation-based music contexts, where the performance activities are self-organised, minimally modelled, and unpredictable (Bailey, 1992; Benson, 2003).

Developmental Scale of Analysis

The skill acquisition within this project is measured at a developmental scale of analysis. The learning process is cumulative over the practice period, and changes to technical abilities and aesthetic preferences are iterative and nonlinear. Whilst many qualitative changes occurred to my skills and preferences over the 12-month practice period, I can’t specify or identify any singular moments of new skill onset or definitive periods of development and improvement. The process must be understood in terms of discovery and development that was occurring in nonlinear and implicit ways across the duration of the project. There was no pre-test or retention and transfer investigation carried out, however, in this project, *The Dark Pattern* represents the ultimate expression and demonstration of the achieved developments.

Self-Regulated Learning

I use the concept of self-regulated learning within this thesis to describe the processes used by musicians in their solitary unsupervised practice routines. Within a self-regulated practice programme, the individual learner is responsible of goal identification, task specification, practice scheduling, task duration, and performance evaluation (McPherson et al., 2013; McPherson & Renwick, 2011; McPherson & Zimmerman, 2002; Zimmerman et al., 1996).

Ecological dynamics and the constraints-led approach has developed largely in sporting contexts characterised by various levels of supervision and assessment. Coaches, trainers, managers, and team members provide useful feedback and evaluation. Practice design and constraint manipulation is typically ‘imposed’ upon the learner as a practice intervention from a coach or performance manager (Davids, Araújo, Hristovski, Passos, & Chow, 2012; Renshaw et al., 2019; Seifert et al., 2019).

I am applying the practice design features of ecological dynamics to the solitary and self-directed practice procedures of my established self-regulatory methods. This project is not connected with any discussion or analysis of the efficacy of self-regulatory learning procedures, and the model is used simply to describe the self-directed and motivated nature of the project.

Landscape and Music

This project uses outdoor locations as a practice environment to initiate skill acquisition and creative development. The practice activities are focussed upon the *experience* of playing a trumpet in this these places, and not necessarily about *expressing* these places in music. Whilst the locations have had an enormous influence upon the development of my skills, the objective of outdoor practice was for educational and not representational purposes.

The use of environmental constraints for skill acquisition and development intersects with many theories and practices emerging from fields such as human geography (Cresswell, 2004; Norton, 1989; Thrift, 2008), cultural anthropology (Ingold, 1993, 2011), phenomenology (Dreyfus, 2014; Gallagher & Sørensen, 2005; Heidegger, 1996; Käufer & Chemero, 2015; Malpas, 1999, 2011, 2015), and ecological cognitive science (A. Clark, 1997, 2008; Gallagher, 2017; Hutto & Myin, 2013, 2017; Noë, 2012; Shapiro, 2011; Varela, Thompson, & Rosch, 1991).

Spontaneous Improvisation

Spontaneous improvisation is a form of creative music making when musical materials are discovered and developed during the dynamics of performance (Bailey, 1992;

Benson, 2003; Berliner, 1994). It is not recreating or presenting pre-existing or memorised works.

Within this project, I use the term ‘spontaneous improvisation’ as a synonym for self-organisation. In my view, spontaneous improvisation is the musical embodiment of self-organisation and emergence (Bailey, 1992; Benson, 2003; Borgo, 2007, 2016).

Music and Movement

The thesis describes music performance primarily from a movement perspective, and I adopt the language of ecological dynamics to describe learning and performance. The body is described from a systems theory and self-organisation perspective. Skills are said to be ‘discovered’ as much as ‘developed’ and the focus of all movement behaviours is based upon finding stable yet adaptable patterns of coordination and control.

This prioritisation of the physical skills of improvisation does not deny the importance of aesthetics and creativity in my work. However, the practice project was fundamentally concerned with finding musical materials from the physical intervention of an environmental constraint. As such, I predominately refer to the dynamic physical aspects of musical performance corporeal terms: ‘actions’, ‘activities’, ‘patterns’, ‘coordination’, ‘control’, ‘process’, ‘procedures’, and ‘movements.’ This view intersects with conceptions of enactive, embodied, and extended cognition as it applies to understanding expert performance (Christensen & Sutton, 2019; A. Clark, 2008; Gallagher, 2017; Hutto & Myin, 2013, 2017; 2004, 2009, 2012, 2015; Shapiro, 2011; Varela et al., 1991).

Chapter 1

Ecological Dynamics

In this section I provide an overview of key ideas from the ecological dynamics literature that have been applied in this research project. The section outlines theoretical and methodological frameworks originating in dynamical systems theory and ecological psychology and offers a brief account of how these concepts transfer and translate to my creative improvisational practice.

The section presents theoretic descriptions of relevant concepts such as self-organisation, nonlinear pedagogy, constraints and affordances, patterns of coordination and control in movement systems, and the role of environmental resources in performance. These descriptions are general in nature, and oriented towards providing an explanatory framework for jazz trumpet practice design and performance. Where possible, detailed primary source materials from literature are included for conceptual clarity and precision.

Overview

Ecological dynamics is a theoretic framework developed in the sports and movement sciences to describe the ways that motor learning and performance is regulated by information sources found within the performance environment (Davids, 2010; Davids et al., 2008; Davids et al., 1994). The theory integrates explanatory features of dynamical systems theory with insights from ecological psychology, and practically applies them to research of skill acquisition, development, and expert performance (Araújo & Davids, 2009; Araujo, Davids, & Hristovski, 2006; Davids et al., 2012; Davids et al., 2013). The adoption of a systems approach to learning and development accompanied by a complimentary theory of perception and action provides ecological dynamics with a powerful framework for understanding and developing movement expertise (Davids et al., 2012; Davids et al., 2013; Glazier, 2017; Glazier & Davids, 2009). The key feature to understanding the implications of ecological dynamics theory is that, within the theory, learners are conceptualised as complex adaptive systems who are capable of self-organisation under the interacting constraints of body, task and environment (Davids et al., 2008; Davids et al., 1994; Newell, 1986).

Ecological dynamics adopts the concept of self-organisation from dynamical systems theory, which is a method of modelling and describing how movement systems found in nature form and change over time. Systems are defined here as a "correlation and coordination" of separate structural components into an "integral whole" (Juarrero, 1999). This functional and integrated unification of elements is referred to as a *synergy* (Haken, 1977; J. A. S. Kelso, 2009).

Synergy

Synergy formation is a fundamental feature of movement systems within nature, and is observable at every scale of life. This concept relates to the capability of functionally and structurally separate components to temporarily group together to act as a single functional unit (J. A. S. Kelso, 1995; J.A. Scott Kelso, 2002). Synergies are functional in the sense that they "do something" that can only be achieved when they are combined together. Synergies are always oriented towards a particular task or goal (Latash, 2008, p. 15).

Figure 11 provides a schematic representation of the various levels in the formation of a synergy. Multiple individual components or elements – described here as degrees-of-freedom - are constrained into small organised (coupled) groups. This is described in systems theory as the components moving from 'high dimensionality' (large numbers of structurally and functionally different and independent elements) to relatively 'low dimensionality' (fewer individual elements due to clumping together) under a constraint gradient. The constraint can be anything inside or outside the structural boundary of the component that causes or compels the component to act in a different way. In this diagram, the same constraint may be applied globally to each component (such as a temperature constraint). The clumping together of elements continues under the increases in constraint pressure, which eventually interact further until the synergistic function emerges.

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Figure 11: Schematic diagram of a synergy formation. The diagram depicts the individual components displaying high dimensionality of structural and functional difference. When a constraint is applied, the dimensionality is reduced, and elements become relationally coupled into units displaying more functional potential. As the constraint gradient increases, a functional capacity or energetic output of the system emerges. In the case of a musical instrument, this output is sound in the form of an energetic vibration. Excerpt from Riley et al. (2011, p. 1)

Latash (2008), Kelso (2009) and many others (cf. Chemero, 2017; Deacon 2011; and Juarrero, 1999) identify the multitude of self-organised synergies that surround us on a daily basis. Our lives are dominated by these spontaneously emergent patterns. Synergistic patterns of coordination are at every scale of observable life: from the neuronal impulses of brain function, to interactions of body parts in movement, to interpersonal synergies between people attending to a task together (J. A. S. Kelso, 2009).

The concept of self-organised synergy formation is an important foundational theory of ecological dynamics, as it explains the way that separate components can be brought together in self-organisational ways to functionally coordinate with each other. Davids and colleagues (2008) observe that:

> [w]hen we examine the microcomponents of a complex system, we observe constant interactions and fluctuations. The interactions among the individual parts of the system appear random, and there is the potential for much disorder within the whole system. For example, think of molecules of water in a stream, neurons in the nervous system, or individual blood cells in the human body. These microcomponents could potentially interact in unpredictable ways and thus result in system disorder, such as when the flow of water molecules becomes unpredictable after turbulence or when neurons in the cortex are induced by strobe lighting to fire at random, causing a seizure in people with epilepsy. However, analysis at the macroscopic (large-scale) level reveals surprisingly ordered patterns of behavior (Kauffman, 1993, 1995). At this level of analysis, complex systems exhibit coordination tendencies since individual components are capable of linking together to move in and out of functional and coherent patterns or synergies (Haken, 1996; Kelso & Engström, 2006). (p. 31)

From a trumpet performance perspective, the concept of synergy is a useful framework for understanding the complexity of the performance system. For each note, the player must temporarily coordinate a collection of structurally and functionally different components of the body and instrument. A fundamental overview of the primary performance components includes complex interactions of air pressure, lip vibration, supporting facial muscles, bone structures, tongue actions, fingering movements, sensorimotor systems, and a mouthpiece cup, a length of pipe and bell flare.[1] Each component is regulated by its own intrinsic constraints, and also coordinates in synergistic ways with the other elements through a mutual constraining, or co-adaptive effect. For instance, air pressure regulates the vibration of the lips that are constrained by the cup of the mouthpiece. Air pressure can compensate or co-adapt with lip pressure variables, and tonguing action can co-adapt or share articulation tasks with valve or lip actions.

Interpersonal Synergy

Interpersonal synergy – the way that people can coordinate and collaborate together in shared tasks – is a key feature of many performance activities. The coupling of individuals in sensitive and co-adaptive ways relies upon precise and careful perceptions of interpersonal dynamics and spatio-temporal relationships (Richardson, Marsh, & Baron, 2007; Riley, Richardson, Shockley, & Ramenzoni, 2011) and a shared task constraint or intention (Button et al., 2013; Gallagher, 2011).

Latash (2008) identifies three important characteristics of all living systems organised into coordinative synergies: sharing, error compensation, and task-dependence. He offers the following detailed example of interpersonal synergy as it relates to music performance:

> Imagine that you are conducting a choir. You want the choir to sing at a certain level of sound, but you have 50 singers to deal with. One strategy would be to tell each singer how loudly to sing. Potentially, this could solve the problem. If each singer performs exactly as instructed, this strategy will be very successful and lead to a perfectly correct level of sound. However, if

[1] Each valve combination of the trumpet affords access to a different length of tubing. There are seven valve combinations: 0, 2, 1, 12, 23, 13, 123. Each serial valve combination lengthens the instrument tubing and lowers the pitch by one semitone. Each length of tubing affords a natural series of harmonic overtones distributed in odd and even integer values (partials) of the fundamental pitch. There are typically 8-10 overtone ‘partials’ accessible by experienced trumpeters. The partials are characteristic of what are used for bugle calls. Valves are typically operated with the index, middle and ring finger of the right hand. See Huron and Berec (2009) for an overview of idiomatic valve combinations and biases.

> one of the singers sings at a wrong volume, or gets sick and decides to quit altogether, the overall level of sound would be wrong. What would the alternative be? To make use of the fact that singers can not only sing but also hear. Then, the instruction could be "Listen to the level of sound. If it is lower than necessary, sing louder; if it is louder than necessary, sing softer." Now, even if one or more of the singers decide to quit, others will hear an "error" in the overall level of sound and correct it without any additional instruction. In both cases, the singers sang together. But probably everybody would agree that in the first case, there was no synergy among the singers because each one did his or her own job without paying attention to what the others were doing. In the second case, there was a synergy because actions of individual singers at all times depended on how loudly the other members of the choir were singing. (pp. 4-5)

This example captures the distributed and compensatory effects of ensemble performance that is exemplified in skilled improvisation-based music. A constant adjustment and re-adjustment are required at every moment of performance in order to maintain the momentum of the musical performance. The coordinative synergies of improvising ensembles of musicians is beginning to attract attention from researchers interested in understanding interpersonal synergy and joint attention and intention (Hagberg, 2017a; Love, 2017; Dylan van der Schyff, Schiavio, Walton, Velardo, & Chemero, 2018; Walton, Richardson, & Chemero, 2014).

Entrainment

Related to the idea of interpersonal synergy is the functional synchronization of moving bodies that is observable in all systems that have components coupled at a single point – either through a mechanical bond (e.g. two pendula suspended from the same support), or by a jointly attended-to source of information (e.g. a starters gun in a race). The coordination of auditory-motor responses in humans to pulse-based music has been conceptualized and supported by entrainment theory (Keller, 2014; Novembre & Keller, 2018; Wollner & Keller, 2017). Entrainment is a common naturally occurring feature of all coupled rhythmical movements (Keller, 2014; Leman et al., 2013).

The mechanisms of an external information source regulating self-organized human movement provides an important conceptual and empirical link between systems theory, action and perception, and music performance (Novembre & Keller, 2018). (Gallagher, 2011; Leman et al., 2013).

Walton, Richardson and Chemero (2014) provide the results of experimental testing of interpersonal coordination between improvising pianists. The joint attention task of the pianists co-regulating performance actions is observable at multiple levels of interaction and coordination, from the purely auditory to the purely visual. Keller and colleagues (2014; 2016; 2018; 2018) support this deeply interconnected and synchronized account of music performance, and promote the importance of entrainment and joint attention as a critical feature of creative negotiation and collaboration during performance activities.

Entrainment theory also accounts for the rhythmic coupling of swinging limbs used during our movement patterns. Legs and arms operate in entrained rhythmic cycles due to their size, shape and length and to ways they are connection to the body. Marching and dancing in time to a beat is an important demonstration of the nested constraints of entrainment with interlimb coordination being regulated by the coupled segments, and the body being moved in time to the recurring beat of the music (Changizi, 2009, 2011; McNeill, 1997). This is a powerful demonstration of synergistic pattern formation. The important point being that entrainment is acting at both a physical and informational level of constraint regulating the body in multiple self-organised ways. Entrainment is a fundamental method used by humans to coordinate the body into functional patterns of organisation.

Complexity

Living systems have evolved to incorporate high levels of structural and functional complexity as a dominant feature. The *complexity* of a system is defined in relation its 'high dimensionality' of interacting internal components. Increases in the complexity of a system provides increases in the flexibility and adaptability of the system to perturbations.

The human body is an immensely complex system of multiple body parts, sensory organs, and chemical exchange systems. The adaptability and success of the human body to variable environmental surfaces, objects and events is an important product of the complexity of the various interacting systems. The efficiency and effectiveness of human systems responsible for nutrition, respiration, reproduction, and immunity are dependent upon the overwhelmingly variable ways that the components can be assembled and coordinated .

For instance, the successful movement of the human body is reliant upon a multitude of separate components interacting continuously to monitor and adjust the position of the system in relation to the ground. These calibrations are mundane and ongoing at every moment but point to the ability of the body system to self-organise the many separate components into fluent functional action.

Like the other systems involved in human movement, the complexity exhibited in musical instrument performance involves the precise interactions and synchronisation of a vast array of sensori-motor components. The multiple forms of coordination and control necessary for skilled music improvisation require the performer to exploit the self-organisational competencies of the human movement system. This provides an understanding towards developing a systems approach to music skill acquisition and creative development that acknowledges the self-organisational capacity of the body to find movement solutions to performance tasks (Davids et al., 2008).

Degeneracy

Two prominent features of successful functional movement systems are the levels of stability and adaptability they can achieve in changing conditions. Functional stability and adaptability is a product of system *degeneracy*. Degeneracy is a scientific term that describes the capacity for structurally and functionally different components of a system to perform similar tasks or achieve similar results (Edelman & Gally, 2001; J. A. S. Kelso, 1995; J.A. Scott Kelso, 2002). Edelman and Gally (2001) describe degeneracy in terms of:

> . . . the ability of elements that are structurally different to perform the same function or yield the same output. Unlike redundancy, which occurs when the same function is performed by identical elements, degeneracy, which involves structurally different elements, may yield the same or different functions depending on the context in which it is expressed. It is a prominent property of gene networks, neural networks, and evolution itself. Indeed, there is mounting evidence that degeneracy is a ubiquitous property of biological systems at all levels of organization. (p. 13763)

High levels of degeneracy provides the functional mechanisms needed by a movement system to find stability in dynamic environments (J. A. Scott Kelso, 2014). System degeneracy of the human body explains how we can effectively coordinate ourselves to perform similar tasks and achieve similar goals in functionally different ways. There are countless ways we can tie shoes, make cups of tea, catch a ball, or walk up and down stairs. These variable pathways, combinations, sequences, choices, options, solutions and decisions are all examples of the ways system degeneracy provides movement variability necessary for successful adaptable actions. In short, system degeneracy provides us with the necessary flexibility to achieve goals in a variety of ways. The fact that there is never just one single way to perform a task, is a fundamental movement principle underpinning ecological dynamics and the constraints-led approach.

System degeneracy is also scaled up to personal and interpersonal levels in ecological dynamics theory. For instance, sporting teams with high degrees of degeneracy can exploit positional flexibility and role distribution which can be implemented as a strategy within a complex phase of play. Many athletes who develop skills in informal and unstructured settings – that is, when they are required to perform many different tasks in different team positions or conditions - demonstrate higher levels of variability in their movement solutions. It is described that the variability of practice – a type of scaled-up system degeneracy – offers greater opportunities for problem solving, movement flexibility, and self-organisation (Uehara et al., 2018).

The theory of degeneracy can be adopted to conceptual frameworks of improvised music performance. The fundamental feature of improvisation is the variability and flexibility of options afforded the performer at any moment. A basic application of degeneracy theory to music education supports the idea that there are an almost infinite variety of ways in which a performance task can be achieved, and that adopting an 'idealised' or putative version of any musical activity runs counter to the basic importance of variability in healthy adaptive systems. Indeed, it is variability of performance actions that could be encouraged and developed through practice design targeting exploration and experimentation, and not perfection or re-creation.

Self-Organisation

The concept of self-organisation is critical to our understanding of the ways that systems and synergies can form spontaneously and persist over time. The application of systems theory to research into human movement and development has identified the critical role of self-organisational capacities of the body to form coordinative structures and patterns in response to internal and external constraints. The constraints of the body, the task and the environment provide the mechanisms for the system to function efficiently and effectively through processes of *self-organisation* (Kelso, 1995; Newell, 1986; Thelen & Smith, 1996). Under the pressure of interacting constraints, living movement systems form and function without the need for explicit external plans or models, and without internal executive control.

Self-organisation refers to the capacity of systems to be regulated by the constraints ecology. Renshaw and colleagues (2019) observe that:

> [i]n complex adaptive systems, spontaneous order can emerge between system components, such as individual fish schooling together in response to the presence of a predator. Parts of a complex adaptive system can form rich patterns or synergies, which are coordinated states that emerge due to the inherent capacity for parts to self-organise. *Self-organisation* refers to the spontaneous tendencies for adjustment and adaptation of system components to changes in other parts of the system, without the need for executive micro-management of each component. Many biological systems, such as a flock of birds, a school of fish, a colony of ants or human movement systems are *open* to continuously exchanging energy and matter with the environment. Complex systems are extremely sensitive to existing environmental conditions and rich patterns can form between system components as energy is exchanged with the surrounding environment. (pp. 13-14)

In describing skill acquisition and movement behaviours from a systems perspective, Clark (1995) highlights the coordinative power of self-organisation and the removal of homunculus accounts of internalised control mechanisms:

> Constraints alone are not sufficient enough to give us movement. There must be some process that gives rise to organized action. In dynamical systems, this process is self-organization. Highly complex systems comprised of multiple simpler elements governed by dynamical principles will spontaneously develop organization or patterns; that is, they will self-organize (Werbos, 1994). Systems of high dimensions, such as the neuromusculo-skeletal system, will form patterned action from the constituent elements. For example, energetic systems that are far from a state of equilibrium will find a stable equilibrium point, and therefore

> an organisation, under certain sets of constraints. No little man in the brain is needed to command the system to organise in a specific way. Rather, a pattern emerges from the constraints through the process of self-organization. (p. 175)

The moment-to-moment skilful and automatic adjustments of flexible spontaneous movement demonstrated in expert performance is made possible through the exploitation of these self-organisational tendencies of systems in dynamic environments (Araújo & Davids, 2009; Araujo et al., 2006; Davids et al., 2013). Self-organisation of complex systems is considered to be the primary source of skill development within ecological dynamics theory and methodology (Davids et al., 2008; Davids et al., 1994; Juarrero, 1999; Renshaw et al., 2019). A complex adaptive system is defined by Riley and Turvey (2001) as involving:

> multiple levels, contains many interacting parts, displays nonlinear interactions between parts and between levels, exchanges energy or matter with the environment and exists away from equilibrium, and demonstrates relational, emergent properties that result in the whole being different from the sum of its parts.
>
> Systems that meet the definition of complex systems are found throughout nature, in physics, biology, economics, and chemistry, for instance. The principles that govern the behaviour of complex systems seem to apply across both scales of nature and fields of inquiry. Thus, systems studied in disparate fields often display remarkable behavioural similarities and are often modelled by similar equations. (p. 160)

From this perspective, ecological dynamics proposes education programmes which encourage self-organisational development of coordination processes through the manipulation of key constraints relating to the performer, the performance task, and the performance context. In my view, this makes ecological dynamics an excellent educational framework for developing and acquiring skills for music improvisation. It is from this understanding that I have sought to apply ecological dynamics theory and methodology to this research project. Under this framework, I conceptualise *spontaneous improvisation* as a musical form of self-organisation.

Hysteresis

The history of a system constrains its future actions by removing certain options from the repertoire of opportunities (Deacon, 2011; Juarrero, 1999). The concept of system *hysteresis* is an important contributor to our understanding of the ways in which constraints regulate movement and performance options over time. Juarrero (1999) observes that:

> . . . complex adaptive systems are essentially historical. They embody in their very structure the conditions under which they were created (including the chance events around which each self-organized stage reorganizes). The unrepeatable, random fluctuation or perturbation around which each phase of a sequence of adaptations nucleates leaves its mark on the specific configuration that emerges. The structure of a snowflake, for example, carries information about the conditions under which it was created. Each level is uniquely and progressively individuated, as is the developmental and behavioral trajectory of each organism (p. 8)

The intrinsic dynamics of movement behaviours – that is, initial 'conditions' of structure, their starting positions, the history of what they have previously done, and their future development and change over time – provides an important foundational framework for understanding development, growth, and learning (Araújo, Hristovski, Seifert, Carvalho, & Davids, 2019; Deacon, 2011; Juarrero, 1999; J. A. S. Kelso, 1995). Systems 'learn' from previous patterns of organisation and develop from these previously discovered and developed patterns. In this sense, learning is defined as the development and adaptation of previously acquired skills, biases, or preferences(L. B. Smith & Thelen, 2003; Thelen, 2005; Thelen & Smith, 1996).

At no point is a living system ever free from the constraints of time and change, nor is it ever without a history of activity that regulates its future actions. This is the fundamental idea of dynamics theory and is an essential feature of all self-organisation. Within the ecological dynamics framework, hysteresis offers a powerful tool for educating the attention and calibration of performance actions. For instance, environmental features offer important information sources useful in anticipating future events. The position of bodies, limbs, fatigue, muscular development, training, nutrition, and injury are all conceptually identified as hysteresis constraints upon future performance possibilities (Araujo et al., 2006; Araújo et al., 2019).

Perturbation

Perturbations refer to anything within or surrounding the system that disrupts, or challenges the systems' stability. The system can be caused to assemble, disassemble, reassemble or retain its arrangement in response to the perturbation. Complex systems are more robust than simple systems due to the increased capacity to absorb or adjust after perturbation (J. A. S. Kelso, 1995; J.A. Scott Kelso, 2002).

The constraint gradient indicated in the schematic diagram of synergy formation shown earlier (Figure 2) represents a pertubation to the system which initiates the self-organisation of its component parts into functional units. By this definition, perturbations are not necessarily negative occurances, but cause the system to 'work' by applying a load or pressure to the system parts (P. Atkins, 2010).

Some perturbations challenge a system globally or persistently over time, for instance, gravity, whilst others are temporary or discrete. Kelso (1995) offers that living systems are intrinsically coordinative because they are intrinsically dissipative, and are continually perturbed by the ongoing demands of energy exchange. This framework of intrinisc perturbations to living systems is captured in Kelso's theory of coordination dynamics (J.A. Scott Kelso, 2002; J. A. S. Kelso, 2010), and is an important foundational theory of self-organisational learning methods promoted by ecological dynamics (Davids et al., 2008; Davids et al., 1994; Newell, 1986; Thelen & Smith, 1996).

Perturbation is an important factor of adaptation process in systems. Systems refine and adjust their organisation in relation to the applied 'load' or resistance of the perturbation. Systems can be perturbed in a multitude of ways and scales of disruption, from requiring a minor adjustment of the systems' coordination through to a catastrophic interruption requiring a complete reassembly.

Degrees-of-Freedom

The functional role of complexity, degeneracy, and synergistic organisation within human movement systems is explored in Bernstein's (1967; 1996) influential *degrees-of-freedom* problem. Bernstein identified a fundamental problem of human movement: how is it possible that the highly complex human body - with its multitude of segments and moveable parts - can functionally combine these parts together to achieve stable yet adaptable movements (Nikolai A. Bernstein, 1967; Niikolai A. Bernstein, 1996). The answer was found in understanding and describing the mechanisms in which body components are temporarily *frozen* into larger units of organisation to coordinate and control movement. The degrees-of-freedom of a limb segment are reduced by this process of temporary functional unification, making it an easier object to control.

The degrees-of-freedom problem can occur at many scales of analysis – from the organisation of cellular components of a simple organism, to bodies undertaking complex movement patterns, to interpersonal coordination of individuals in collective activities, and community organisations. Davids et al. (2008) expand upon Bernstein's original formulation:

> Degrees of freedom (dfs) are the independent components of a complex system that can fit together in many different ways. For example, insects in a colony are independent dfs whose actions need to be coordinated to build a nest or feed progeny. In the same way, the large number of available muscles, joints, limb segments, and bones in the body exemplify the dfs of a complex system. This huge number of dfs in the human motor system is a kind of a curse for computational accounts of skill acquisition and performance (Kugler & Turvey, 1987). This is because it seems that a hierarchical control system with an executive agent in charge needs to be aware of so much information on where each individual part is in space, what it is currently doing, and how its position in space might change over time during performance. (p. 20)

Degrees-of-freedom are also released or *freed* in precise timings to accommodate flexible movement responses. Novice performance is characterised by large amounts of restrictive freezing, resulting in stiff, inflexible, and unstable performance solutions. With experience, the expert discovers how and when to release degrees-of-freedom resulting in far more fluent and flexible movement solutions. Davids et al., (2008) observe:

> [a]ccording to Bernstein (1967), the initial coordination patterns for tasks such as casting a fishing rod or maintaining balance on a surfboard begin as fixed, rigid linkages between body parts. This early learning strategy helps people cope with the extreme abundance of dfs in the motor system. The assembly of a functional coordination solution is beyond the learner's capacity and so the problem of controlling the movement system is managed by "dysfunctionally, suboptimally or overly" constraining the available motor system dfs (Broderick & Newell, 1999, p. 166). A common, but by no means universal, observation is that learners reduce the

> active regulation of individual mechanical dfs at the motor system periphery to a minimum. With learning and experience, the fixed characteristic of coordination is progressively altered as movement system dfs are released and allowed to reform into different configurations or synergies for specific purposes. (p. 44)

Repetition-Without-Repetition

Another important contribution Bernstein (Nikolai A. Bernstein, 1967; 1996) makes to our understanding of the human movement system is his description of the observable *repetition-without-repetition* characteristic of movement patterns. The movement degeneracy provided by complexity of the body system and its various temporary synergies and degrees-of-freedom all combine to create intrinsic variability within all human actions. Even within mundane repetitive tasks – Bernstein (1967; 1996) famously researched the hammer-strikes of a blacksmith – there are wide discrepancies in the pathway of actions used to achieve the task objective. The repetition-without-repetition idea describes how similar problems are solved in similar ways when under similar constraints (such as limb joint configurations, task objects, environmental resources), but with variation as the fundamental performance feature. Not only are there many ways to solve movement problems, but similar actions will intrinsically produce variation (Nikolai A. Bernstein, 1967; Niikolai A. Bernstein, 1996).

Pattern Formation

Self-organisation within the system infers the formation of patterns of coordination and control between components, which are established through the stable yet flexible emergent processes of action. If the organisational interaction is persistent, then a pattern emerges. A pattern process refers to a type of relationship between objects over time, and describes the fundamental building blocks of synergies. All movement behaviours are complex combinations and sequences of coordination and control patterns. These behaviours rely upon fundamental actions called *order parameters*. An order parameter is a term used in complexity science to describe patterned events, for instance limbs moving under constraint in *relative phase*.

Relative phase is a fundamental pattern of coordination and control of two coupled system components, and refers to the simple available pattern of relations between the objects: in-phase, or similar motion; and anti-phase, or opposite motion. Relative phase denotes each permutation of these combinations. Two independent moving objects can also be out-of-phase, or disconnected from each other. Persistent relative phase of components is a fundamental pattern of organisation observable in all living systems and provides the theoretical foundation for interpersonal coordination (J. A. Scott Kelso, 2012; Krabben, Orth, & van der Kamp, 2019; McNeill, 1997; Riley et al., 2011).

Stability

The emergence and persistence of a pattern of coordination and control relates directly to the *stability* of the system. Stable patterns of organisation are capable of more varied responses to perturbations due to their inherent flexibility and complexity. This tendency makes them more attractive and persistent over time. Davids and colleagues (2008) discuss stable systems in terms of their sensitivity to environmental conditions:

> Because they are relatively open systems, dynamical systems can adopt different states of organization and harness surrounding energy sources to form stable patterns of organization. In nature, open systems are capable of receiving and outputting energy into the flows surrounding them, which means that they are sensitive to changes in their surroundings. (p. 32)

A feature of pattern formation in complex systems is the *attraction* displayed by the system towards particular types of preferable coordination. Attraction relates to the most regular or obvious pathway to stability that the system can find. The system is attracted to stability in the sense that it will fall into this pattern before other less stable patterns. Davids and colleagues (Davids et al., 2008) state:

> In neurobiological systems, attractors represent coordination tendencies among system components and are roughly synonymous with functional coordination patterns in the repertoire of a movement system. A good example of coordination tendencies is locomotion in humans when a runner's legs coordinate into an antiphase pattern (when one leg is in the stance phase supporting the body, the other leg is in flight, allowing gravity to accelerate the runner's centre of mass in a series of controlled falls). (p. 32)

The stable and persistent patterns of coordination displayed by complex systems are referred to as *attractive states,* or *attractors*. An attractor describes the region or *basin* (or valley, or canal) within which complex systems display stability and can persist.

> The stable and functional patterns of organization exhibited by open systems are called attractors. For example, in a physical system formed by billions of molecules of water in a stream, an attractor is a stable region of system state space where the resulting force vector (that is, the direction and magnitude of any interacting forces on system flow) converges to a minimum (e.g., as in a vortex). (p. 32)

Dynamical systems theory often portrays these attractors as topographical *landscapes of attractions*. A landscape of attraction depicts the possible pathways, or states, that a system can occupy at any moment in time. The pathway taken by the system will depend on the type and amount of perturbation present in the state-space. Figure 12 displays Waddington's (1957) famous metaphorical illustration of the self-organisation process of cellular development depicted as a pebble rolling down a valleyed perturbation and attraction 'landscape.' This image has become an important representation and conceptualisation of learning and development of self-organised dynamic systems (like humans). A critical point about the pebble's traverse is that it is a self-organising process. This cascade metaphor of development and learning has been applied by Thelen and Smith (1996, 2006), Kelso (1995; 2002; 2014), and Davids and colleagues (2008; 1994) to describe the skill acquisition and development process.

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Figure 12: A landscape of attraction. Waddington depicted epigenetic development and cellular fate as an equivalent process to a pebble rolling down a hill. Ridges and saddles perturb or constrain the pebble into stable channels and valleys. Once a valley has been entered, it's progression follows on until the next ridge or saddle is encounter. This is described as a bifurcation of potential pathways or developmental possibilities. Excerpt from (Waddington, 1957, 2014).

Stability within the landscape of attractors is represented as the continued progression of the pebble through the valleys, which are created by perturbations of the surrounding hills and saddles and the erosive action (or hysteresis) of previous pebbles.

Kelso (2006) illustrates the important complimentary nature of stability and instability as a continuous interaction governing organization. Figure 13 illustrates the dynamic relationship between the two states.

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Figure 13: Kelso (2006) illustrates the complementary states of stability and instability in movement systems. The perturbation of the hill creates the two "fixed points" or snapshots of stability and instability. In dynamic contexts though, action is an interaction between these two states. Extract from Kelso (2006, p. 127)

Multistability

The bifurcations within the state-space relate to stable pathways the rolling pebble can take. Each split in the attractor basin represents an equally valid and available pathway through the attractor landscape. The system (rolling pebble) has multiple ways it can progress, and it's ultimate pathway (in Waddington's original formulation, the specification of the cell type) is determined through a process of self-organisation under the inherent constraints provided by the surrounding perturbations, the structural constraint of the round pebble, the gradient of slope and the persistent force of gravity. This multiple states of available stability of the pebble is referred to as multistability. The more options the pebble has to progress down the hill, the more stable it can remain.

The multiple pathways of the attractor landscape create a multistable state-space whereby the rolling pebble has several ways of maintaining stability of its action. The multiple pathways are referred to as *phase states* within dynamics systems theory. Each pattern and pathway represents a particular 'phase' option of the system. The shift from one pathway – or pattern of organisation – to another is called a *phase transition*. Davids et al. (2008) offer:

> In the study of open systems, scientists have been interested in the phase transitions that can emerge spontaneously in complex systems. Phase transitions are movements of the microcomponents of a system into and out of different states of organization. In weather systems, for example, the dynamics among system components typically lead to no large-scale changes in system behavior. There is merely a lot of underlying fluctuation that mildly affects system stability. However, critical changes in the energy arrays surrounding the system, such as a rise in atmospheric pressure within a weather system, can alter system stability and lead to macroscopic changes and reorganization into a different state (thunderstorms in tropical regions). Phase transitions form the basis of self-organization in complex systems, and examples of such pattern formations have been observed in open biological, physical, and chemical systems, such as when randomly moving fish gather into a synchronized school as a predator approaches. (p. 36)

This phase transition capacity of complex adaptive systems was described by Hakan, Kelso, and Bunz (Fuchs, 2013; Haken, Kelso, & Bunz, 1985; J. A. Scott Kelso, 2008) in their HKB model of bimanual coordination (see Figure 3). The model provides a theoretical explanation of self-organised transition between two stable patterns (or relative phase) of finger coordination under the constraint of a *control parameter* (in the original experiment, the control parameter was accelerating metronome tempo). Davids and colleagues (2008) describe the experiment:

> The relative phase of any two oscillating systems (e.g., each leg used in walking) is the phase lag in one system's cycle of movement compared with the other. When the study participants began oscillating in the antiphase pattern, they eventually switched to an in-phase pattern as metronome frequency increased. The sudden phase transitions from one state of coordination to the other were not brought about by some intentional change prescribed by the participant, but through the self-organizing properties of the motor system. (Davids et al., p. 37)

The pattern of finger waggling switches spontaneously from anti-phase to in-phase movement when the increasing tempo reaches a critical threshold without any cognitive control from the individual. This important observation has been applied to other self-organised patterns of coordination, including interpersonal body language, animal movement patterns, models of motor learning (Davids, Brymer, Seifert, & Orth, 2014; Davids et al., 2008; Fuchs, 2013; Krabben et al., 2019; Newell, Liu, & Mayer-Kress, 2008). Figure 14 displays an illustration of the bi-manual phase transition experiment.

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Copyright restrictions.

Figure 14: Finger oscillations in Kelso's (1981, 1984) experiments in self-organization and relative phase. Extract from Davids et al., 2008, p. 38)

The self-organised coordination patterns of bimanual movement systems is applicable to the articulation system of trumpet performance. Players must coordinate the actions of the tongue and the fingers operating the valves in relative phase combinations of in- and anti-phase (in-phase would be when the tongue and finger simultaneously move; anti-phase would be when the tongue and finger movements are sequential).

As the tempo or speed of a performance activity changes, the potential patterns of articulation coordination switch. For instance, single tonguing each note is much slower than valve-slurring every note. Expert improvising trumpeters are skilled at allowing the articulation system to self-organise itself to best meet the demands of the performance speed, changes in phrase direction, volume and register.

The same relative phase explanatory framework can be scaled to musical interactions and coordination, with anti-phase activities representing antiphonal (turn-taking, question and answer, conversational, ‘call and response’ type organisations) versus in-phase relationships of unison synchronisation (hymn singing, group recitation, rhythmic entrainment). In a general musical sense, anti-phase is a fast and cheap performance method affording co-adaptive behaviours and interaction-dominant approaches. In-phase coordination is ‘costly’ – it requires explicit coordination and organisation (composition-based works), complex cueing (conduction, count-ins, metric schemas, common propositional rules and knowledge structures, plans), and often minimised individual agency (Bailey, 1992; Cummins, 2019).

Meta-stability

The multistability of the attractor landscape creates a special type of stability characterised by dynamical systems theory as *meta-stability*. When movement systems have multiple pathways towards, or transitions between attractors, the system can become both stable but poised for action between possible attractor options. The concept of metastability tendencies of complex adaptive systems is an important contributor to our understanding of the variability and flexibility exhibited in living movement systems (J. A. S. Kelso, 1995; J.A. Scott Kelso, 2002; J. A. Scott Kelso, 2012). Chow and colleagues (2011) describe the meta-stable system feature as:

> . . . an important characteristic observed in complex systems when they are poised between states of order and instability (Kelso, 2008). Meta-stable states have been defined as

> ‘dynamically stable’ states which allow systems to remain poised between stability and instability (Kelso, 1995). It has been observed that, in the meta-stable state, rich interactions can spontaneously emerge within complex systems when previously uncorrelated system components or processes suddenly become interconnected under constraints (Guerin & Kunkle, 2004; Juarrero, 1999). Meta-stable states in complex neurobiological systems are significant because varied and creative patterns of behaviour can emerge as individual system components co-organize or co-adapt as specific goals are achieved. (Jia Yi Chow, Davids, Hristovski, Araújo, & Passos, 2011)

A *meta-stable performance region* is defined as a persistence of the meta-stable tendency. Ecological dynamics promotes the importance of meta-stable performance regions in the acquisition and development of motor skills because the performance region helps to educate the learner to search of information to guide appropriate decisions. If the performance system is capable of a variety of actions, the performer must develop the ability to attune to information sources to guide performance actions. Ecological dynamics supports a constraints-led approach to creating these useful meta-stable performance regions by manipulating the available resources used by the learner to self-organise responses.

> In a meta-stable performance region, component tendencies of independence coexist, explaining how rich and varied movement patterns can spontaneously emerge in dynamic sport environments as an individual adapts his/her motor behaviours to achieve particular performance goals . . . In a meta-stable performance region one or several movement patterns are weakly stable (when there are multiple attractors) or weakly unstable (when there are only attractor remnants), and switching between two or more movement patterns occurs under interacting constraints. (Seifert et al., 2013)

Figure 15 is adapted from another of Waddington’s (1957) attractor landscape illustrations. This image depicts the underside of the landscape being ‘manipulated’ by adjustable ropes. This metaphor is a useful tool for understanding the ecological dynamics approach to manipulating the constraints affecting the attractor landscape of learning in order to guide the individual learner towards discovering their own motor ‘pathways’ or movement solutions to performance activities (Davids et al., 2014; Davids et al., 2008; Davids et al., 1994; Renshaw et al., 2019; Renshaw & Davids, 2014).

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Copyright restrictions.

Figure 15: The dynamics of constraints in an evolving environment. Excerpt from Waddington (1957, 2014). This diagram represents the dynamic underside of Figure 4. An evolving environment with attraction basins (canals) appearing and disappearing over passing time.

Constraints

Constraints are the multitude of variables that define the phase space of the systems (Davids et al., 2008). Constraints are an important fundamental feature of all systems, and create the initial and ongoing conditions under which the synergy is formed and maintained. The development of the synergy is described as *emergent* from the interacting constraints upon the system. These constraints refer to both the internal structures and capabilities of the system components, and to the constraints applied to the system from the surrounding environment.

> Constraints both limit and enable the number of behavioural trajectories that the system can adopt. It seems that complex systems are able to exploit the constraints that surround them in order to allow functional patterns of behaviour to emerge in specific contexts. (Davids et al., 2008, p. 33)

In living systems, a third class of constraint is added in the form of the function or task that the living organism is performing or trying to achieve. Kugler, Kelso and Turvey (1980, 1982) offer that the study of constraints offers another perspective to Bernstein's (1967) degrees-of-freedom problem.

> Constraints can be either physical or informational. Physical constraints can be structural or functional in the human movement system. For example, the size and grip strength of a child's hands are structural physical constraints that influence how that child can pick up and manipulate an object such as a toy train or a large ball during play. Functional physical constraints include processes such as reactions and perceptual abilities, which support movement performance. Informational constraints, on the other hand, are the various forms of energy flowing through the system, such as the pheromones for insects, light reflected from a toy train, or sound waves that a child perceives when a ball bounces across the floor. Young children explore haptic (touch) informational constraints as they pick up and play with objects in their environment. Informational constraints help to shape requisite movement responses and support the coordination of actions with respect to dynamic environments. (Davids et al., 2008, pp. 33-34)

Newell (1986; 2007) identifies the threefold model of body, task and environment constraints as the foundational mechanisms of human movement and behaviour. The interaction of body, task and environment constraints accounts for the range of movement possibilities available to the human system. Its development and learning over time is understood in terms of changes in the moment-to-moment constraints upon the system, including growth, changes in strength through ageing or injury, enhanced or degraded sensory perceptions, the tools at hand, and the to-be-achieved task objectives(Newell, Kugler, van Emmerik, & MacDonald, 1989; L. B. Smith & Thelen, 2003; Thelen & Smith, 1996).

The concept of a constraint here, differs from other more common uses of the term, which conceives of a constraint as a restriction and inhibitive limitation to actions and events. Within the movement sciences, constraints are described as conduits for action possibilities. Constraints guide and regulate movement through providing intrinsic structure and functionality to system components. They don't prescribe the action or apply an explicit design or plan; they only remove or limit certain options from consideration. Renshaw and colleagues (2019) observe that:

> A fundamental question in science is: how does order emerge in complex physical, chemical and biological systems as they change over time? That is: how do they evolve, adapt, develop, mature, alter, modify, adjust and (re)organise? The answer lies in the surrounding energy patterns in an environment that act as *information* that pressures (i.e. constrains) complex systems to adapt over different timescales (milli- seconds, minutes, weeks, months, years and millennia), resulting in different interactive patterns emerging between system components. Nature abounds with complex systems such as flocks of birds, insects, human societies, sports teams and organisations. (p. 13)

Human movement is regulated by the specific constraints of our bodies. For instance, the structure of the leg constrains the possible action potentials of the individual runner by providing constraints to leg actions. The constraints of the knee, ankle, and hip joints help to freeze structural degrees-of-freedom and create the functional unit of a controllable leg. The constraints of the multiple joints, tissues, ligaments, and tendons are intrinsic to the leg structure, and provide the initial conditions for developing coordination and control (L. B. Smith & Thelen, 2003; Thelen, 2005; Thelen & Smith, 1996).

The specific constraints of the individual body interact dynamically with the constraints of the task being completed and the environmental context within which the task occurs. Task constraints relate to goal-orientated motor behaviour, and includes basic types of actions such as standing, walking, sitting, eating, speaking. Task constraints are often nested into groups of multiple tasks and sub-tasks. Identification of the task-at-hand depends on selecting an appropriate scale of analysis. The movement task of a blacksmith can be analysed at multiple scales: from grip pressure, elbow force, wrist angle, shoulder rotation, respiration, hand-eye coordination, and standing posture. Task constraints also relate to the goal of the blacksmith: making a tool or object out of heated metal. Ecological dynamics solves this problem of analysis by focusing upon the interaction between the individual and the environment as the most useful scale of analysis (Davids & Araújo, 2010; Davids et al., 2008).

Environmental constraints upon action include the surfaces, objects and events of the surrounding location of activity. Environmental resources such as ambient light, temperature, availability and distribution of food, and other people are all important constraints upon movement. Newell and colleagues (Newell & Jordan, 2007; Newell & Ranganathan, 2010) define environmental constraints as anything external to the performer's body, including tools, musical instruments, sporting equipment, vehicles, and furniture. Davids and colleagues (Davids, 2010; Davids et al., 2012; Davids et al., 2008) extend to this definition by including community and cultural expectations and attributes, economic pressures and opportunities, historical resources and documents, recordings and artefacts, and institutional support mechanisms into the ecological dynamics framework of constraints.

The study of constraints has become an important feature of ecological approaches to skill acquisition and development. The nonlinear pedagogy approach of ecological dynamics focuses upon the manipulation of key constraints to educate the learner to attune to important information to regulate performance activities (Jia Yi Chow et al., 2007; Jia Yi Chow et al., 2011).

Affordances

Gibson (1979) defines key information sources within the environment as affordances, or opportunities for action.

> An affordance is neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective–objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behaviour. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer. (p. 129)

According to Gibson (1979), the environment contains meaningful information which is actively 'picked-up' or perceived by agents through the action-perception system.

> The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. The verb to afford is found in the dictionary, but the noun affordance is not. I have made it up. I mean by it something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment. (p. 197)

The perception of affordances is scaled to the available resources or characteristics of the agent (Warren, 2006; Warren & Fajen, 2008). The type of skills or physical attributes that the agent possesses greatly influences the type and scope of affordance interaction.

> An affordance . . . is a resource that the environment offers any animal that has the capabilities to perceive and use it. As such, affordances are meaningful to animals: They provide opportunity for particular kinds of behaviour. Thus, affordances are properties of the environment but taken relative to an animal (Chemero, 2003, p. 182)

The affordance concept has evolved over subsequent years to include the many ways that environmental affordances can direct actions in pragmatic and epistemic ways (Hutchins, 1995, 2014; Kirsh, 2001, 2008; Kirsh & Maglio, 1994). The use of work spaces, tools, reminder objects, signs, and maps are all - under ecological psychology theory - varieties of affordances (Costall, 2012).

In recent years, affordance theory has been applied to conceptualisation and design of many tools and devices (Norman, 2013). Ecological psychology compliments the self-organisational and constraints theories of dynamics systems theory, and offers an account of ways that environmental information influences human behaviour. Ecological psychology compliments the self-organisational and constraints theories of dynamics systems theory, and offers an account of ways that environmental information influences human behaviour by constraining possible activities (Araújo & Davids, 2009; Araújo et al., 2019; Davids et al., 1994).

The affordance theory relates directly to idiomatic capabilities of musical instruments. De Souza (2017) discusses the characteristic size, shape, vibratory source, and choice of materials of instruments provide performance opportunities in variable ways in terms of their affordances to the performer. For instance, the portable design, robust construction, and relative loudness of trumpets makes them suitable for a variety of performance contexts. The natural harmonic overtones of the air column within the trumpet affords a selection of pitches distributed in irregular interval configurations (decreasing in interval width as the player ascends in register). The size and shape of the mouthpiece cup affords different types of timbral combinations and articulation options. The three-valve design of a trumpet provides a chromatic scale affordance unavailable to valveless bugles.

Much like the pitch-space affordances of fretted stringed instruments, whose design features include strings that can be performed in linear ways (lengthways along the string) or in vertical relationships across different strings, the pitch-space of the trumpet affords two basic pitch configurations: an ‘overtone’ pitch-space of notes relating to the natural harmonic series; and an equal-tempered chromatic pitch-space of semitones (De Souza, 2017, 2018).

The valve construction of the trumpet affords characteristic articulation and inflection patterns, including rapid changes of pitch and ornamentations created by alternate valve combinations.

Action-Perception Coupling

According to Gibson (1979), we move to perceive useful features of the world, and the features of the world – which are distributed around us - compel us to move. The perceptual system of the body incorporates the movement at every level. Our eyes are constantly moving, and are set inside head capable of tilting and turning; the head is attached to a flexible neck and moveable limbs and torso capable of upright movement which is regulated by the sensory information. Gibson (1979) proposes that the visual and movement systems are inextricably linked and reciprocal in their functionality[2].

The theory of coupled action-perception establishes the basic conditions of the human movement system and provides pivotal link between action-perception systems and the environments in which they exist. The action-perception system has evolved to cope within information and resource rich environments: if both action and perception are for gathering useful information and resources from the world, then the resources of the world are also in a direct reciprocal relationship with the movement system (Gibson, 1979; Heft, 2001).

In discussing wayfinding, locomotion and learning from an ecological psychology perspective, Heft (2013) observes:

> Skill learning involves finding ways to act such that a desired outcome results, whether that is producing a dish with specific taste qualities or finding an efficient way from point A to point B. Such actions cannot take the form of a rote performance (e.g., an algorithm) unless the context for action is guaranteed to remain the same from one occasion to the next—which is unlikely considering the variations attending any circumstance. For this reason, all skilled action requires an on-going sensitivity to the developing context for action—which is another way of saying that it is a perception–action process. In an on-going manner, actions are contingent on the circumstances that arise through prior actions. Just as the act of blending a cake batter involves monitoring its developing consistency as a guide to continuing action or playing a piano piece involves monitoring what is produced as a guide to adjusting the ongoing action, wayfinding likely involves generating a particular perspective flow and adjusting action to maintain or alter the intended flow of perceptual structure. The contingent nature of skilled performance rules out the usefulness of a general, abstract strategy or a "program" for decision making and action. (p 273)

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[2] Gibson (1979) focuses almost entirely on visual perception. Others (Fajen, Riley, & Turvey, 2008; William W. Gaver, 1993a; William W . Gaver, 1993b; Heft, 1988, 2013; Turvey, 1992) have extend to Gibson's (1979) affordance concept by applying it in different sensori-motor contexts.

Direct Perception

According to Gibson (1979) the 'information pick-up' or identification, selection, and use of the affordance is an active and *direct* process of exploration without the need for cognitively 'mediated' or indirect perception (1979, p. 139). Surfaces, objects and events offer agents opportunities or invitations in meaningful ways without any interpretive function necessary (Gibson, 1979).

Indirect perception – the sort supported by cognitivist theories of brain-based information processing and enrichment – involves the use of internal models, plans, or interpretations of neutral, impoverished and raw 'stimuli' which is imprinted upon the sense organs (Gibson, 1979). In this formulation, the brain is tasked with 'reading' the information presented to it via the senses, and converting the stimuli into some sort of intelligible or actionable plan in a top-down executive process.

Ecologically direct perception, on the other hand, is actively achieved by the agent and unmediated by internal mental processes (Gibson, 1979; Michaels & Carello, 1981; Shaw, 2003). Within the theory, this direct relationship is distinguished by the avoidance of cognitive 'mediation'.

The theory of direct perception provides a connection between the self-organisational capacities of systems to form and maintain patterns of coordination without the need for an executive controller, to the information sources present in the environment that are acted upon directly without the need for modelling or interpretation.

A key contribution of ecological dynamics is the theory of expert performance being directed by increasingly precise and sensitive attunement to the available resources within the performance environment. Renshaw and colleagues (2019) summarise the ecological dynamics orientation towards environmental information:

> A fundamental question in science is: how does order emerge in complex physical, chemical and biological systems as they change over time? That is: how do they evolve, adapt, develop, mature, alter, modify, adjust and (re)organize? The answer lies in the surrounding energy patterns in an environment that act as *information* that pressures (i.e. constrains) complex systems to adapt over different timescale (milliseconds, minutes, weeks, months, years and millenia), resulting in different interactive patterns emerging between system components (p. 13).

The three part model of intention, attention and calibration training promoted by ecological dynamics extends the developments of the direct perception model of Gibson and subsequent contributions within ecological dynamics theory by Michaels and Carello (1981), Jacobs and Michaels (2007), Heft (1988, 2013), Fajen, Riley, and Turvey (2008), Warren (2006) and others.

Within ecological dynamics models of learning and performance, affordances are considered to be environmental constraints upon performance activities. Attunement of a learner's attention towards relevant environmental information affordances provides the necessary constraints for the learner to calibrate performance actions in sensitive and self-organised ways (Araújo et al., 2019; Davids et al., 2008; Komar, Potdevin, Chollet, & Seifert, 2019).

The Perceptual-Motor Landscape

The concept of a perceptual-motor landscape combines key features of the coupled action-perception system with environmental information sources. Similar to the attractor landscape concept, the perceptual-motor landscape (sometimes called *perceptual-motor workspace*) seeks to provide a framework for understanding the possible activities that can occur within a defined environment. The perceptual-motor landscape concept is outlined by Renshaw and colleagues (2019):

> Complex adaptive systems can influence, and in turn are easily influenced by, the (optical, acoustic and neural) energy flowing in and around them. For example, fish can use on-board sources of energy to swim in any direction in the vast ocean, but instead are constrained by optical information (sight of an approaching predator) to school in rich patterns, swirling to confuse and distract attention.
>
> In sport, individuals are also engaged in the free exchange of matter and energy, moving to provide and perceive information from surrounding energy flows. An invasion game defender engaged in a 1v1 dyad will be attuning to various optical energy flows such as the visual information from the body angle and orientation of the attacker, ball position and the location on the pitch. The defender will also be providing optical energy via the positioning of the leading foot and the distance from the attacker. (p. 14)

Dynamical systems theory provides useful conceptual tools to understand the way that systems can self-organise themselves in stable and flexible ways under the interacting constraints inherent in their structure and functional abilities and their surrounding physical environment. Ecological psychology offers a way incorporating perceptual information from the environment into the theory of self-organised action.

Summary

This section has introduced the key theoretical frameworks integrated into the ecological dynamics learning perspective. Conceptual tools and models from dynamical systems theory are combined with key theoretical and empirical findings from ecological psychology to provide an alternative learning and development pedagogy based on the processes of self-organisation under interacting constraints. The following section outlines the constraints-led approach in more detail, and summarises the application of nonlinear learning approaches to jazz trumpet skill acquisition and development.

Chapter 2

The Constraints-Led Approach

This section provides an overview of the constraints-led approach and its implementation to skill acquisition and development programmes. The section introduces several key principles of nonlinear pedagogy and outlines how these principles have been applied to my project of jazz trumpet development.

The constraints-led approach is the primary learning framework promoted by ecological dynamics theory. The approach focuses upon developing skills by encouraging the self-organisational processes of learners through the search for performance solutions under interacting constraints. The approach supports search and discovery activities by manipulating key task and environment constraints to assist the learner in finding new patterns of movement in response to information in the performance space. Figure 16 provides an overview of ecological dynamics theory and the mechanisms of learning promoted by the constraints-led approach. Manipulations to a constraint can cause new action-perception information that the learner can use to discover a new movement pattern or more efficient action solution.

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Figure 5: A schematic diagram of ecological dynamics which captures the learning mechanisms of the constraints-led approach.

In this section, I establish the theoretical foundation for the practice project that I implemented using the constraints-led approach and nonlinear pedagogy techniques. The theory is important to understand in that it provides a useful context for understanding how concepts like self-organisation, perturbations, and metastability can be applied in music practice situations. This theory adds an explanatory framework which helps in the understanding of alternative approaches to learning and development. Importantly, these theories are describing all naturally occurring events and processes observable in the many systems that surround us daily. As such, they provide rigorous and robust way of thinking about music practice and performance.

Constraints Framework

This approach expands upon Newell's (1986) systems theory approach to human coordination development which characterises learning as a process of self-organisation regulated by three primary interacting constraints, including the body, the task and the environment. The illustration in Figure 8 depicts Newell's original depiction of the interaction constraints of human development.

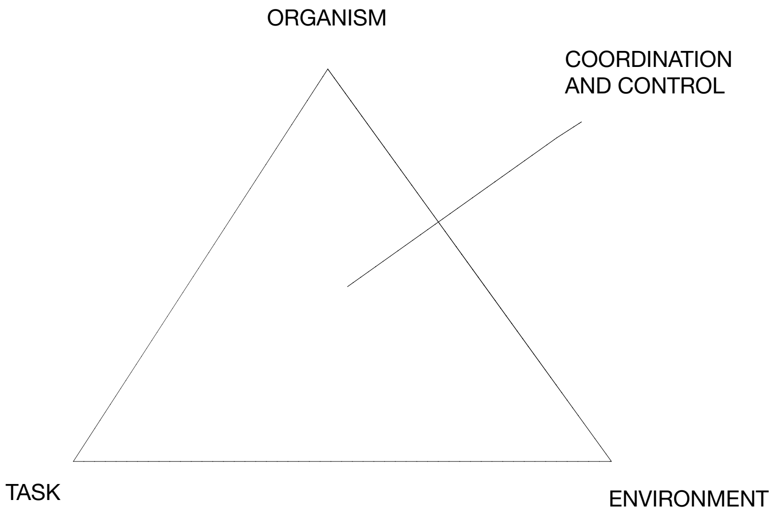

Figure 6: Newell's (1986) schematic diagram of the interacting constraints to human development. Adapted from Newell (1986, p. 348).

Organismic constraints

Newell's (1986) initial model depicts organismic constraints as those relating to the physical structure and function of the body:

> [c]onstraints reside at each level of analysis of the organism. Relatively time independent organismic constraints are typically interpreted as structural constraints whereas the relatively time dependent constraints are viewed as functional constraints . . . at the macro level of analysis, body weight, height and shape are assumed to be structural constraints to the

> development of coordination because of their very slow . . . rate of change with development. In contrast, the development of synaptic connections is often taken as a functional constraint. (p. 348)

Ecological dynamics promotes an individualised approach to learning, and takes into account the relative level of development achieved by the learner (Davids et al., 2013; Renshaw et al., 2019). The intrinsic capabilities of each performer changes over time with accumulated effects of practice and growth, or the temporary sudden changes of injury and fatigue, and the adaptations and knowledge from prior learning and experience. The constraints-led approach promotes developing skills from these unique intrinsic characteristics of the performer. Ecological dynamics theory extends the body constraints definition to include implicit cognitive attributes such things as goals, beliefs, fears, habits, motivations, preferences, emotional states as potential constraints upon performance. Also included with the regulating constraints of the performer are the guiding intentions, attentional states, and calibration capabilities.

The important organismic (performer) constraints of interest to my research project include the intrinsic body dynamics of trumpet playing - respiration, control, coordination, fatigue, articulation – and the attunement of improvisational intentions, attentions and calibrations. My project is concerned with understanding trumpet playing through these physical procedures, and to discover ways to explore and exploit these constraints. For instance, re-calibrating aesthetic intentions to better accommodate natural breath cycles or exploring materials emerging from efficient articulation actions. This is in opposition to traditional accounts of learning focussed upon the physical actions being forced to comply with pre-determined materials.

The application of a 'bottom-up' and body specific approach to developing performance skills and materials aligns this project with embodied accounts of music making (De Souza, 2017; V. Iyer, 2002; Dylan van der Schyff et al., 2018). In my view, the constraints-led approach offers a pedagogical framework for those interested in exploring creative music making processes that harnesses the body-instrument relationship as the primary constraint mechanism regulating performance activities and offers an alternative theoretical perspective to cognitivist and propositional approaches to improvisation.

An important part of the constraints-led practice design is the careful assessment of the performer constraints, with a view to understanding the specific circumstances influencing the individual learner (Renshaw et al., 2019). My research project is directed under self-regulatory procedures. I have a high level of implicit self-awareness of my performance abilities and characteristic biases. I'm interested in the use of constraints-led methodology to introduce some variability into my practice process to encourage the discovery of new or different way of thinking and playing. The body constraints of intention, attention and calibration are the primary physical skills I'm interested in targeting within this project.

Environmental constraints

Environmental constraints relate to surfaces, objects and events that are external to the organism. Newell (1986) describes the experimental manipulation of environmental constraints to examine their influence over coordination and control behaviours:

> Any constraint on the organism-environment interaction that is not internal to the organism can be viewed as an environmental constraint. It is useful . . . to distinguish between environmental constraints that are general and those that are task specific . . . environmental constraints are those that are not manipulated by the experimenter and are relatively time independent. Environmental constraints may include gravity, natural ambient temperature, natural light and other environmental features that are not usually adaptations of the task. However, these environmental features can be manipulated for a given individual by changing the environment in which the activity takes place. Shifts in geographical location on earth change the impact of gravity on the performer, in addition to the natural ambient temperature and light. (pp. 350-351)

Constraints-led practice design involves the deliberate manipulation of the environmental constraints of a performance context to guide the search and discovery of useful information. Within sports practice sessions, this may include the number and position of players, the size of the playing field, the size of the target, or the changes in controllable ambient conditions such as lighting, temperature, terrain, slope, or weather conditions (Araújo & Davids, 2009; Brymer & Davids, 2013; Davids et al., 2008; Renshaw et al., 2019).

Practice design within a constraints-led approach is focused upon creating a performance context enabling learners to discover meaningful connections between their actions and the relevant available information which may be an important regulator for future activities. By manipulating the surrounding surfaces, objects and events, this type of learning method can reduce the need for explicit performance directions. This permits learners to experiment with finding an individualistic movement solution. The critical idea being promoted here is the role of self-organisational processes of the learner being enhanced in variable ways under the influence of environmental information.

The influential role of environmental constraints upon trumpet performance is supported by three intrinsic features of the instrument: it's *design*, its *volume*, and its *playing posture*. Each of these features has been developed in a close reciprocal relationship between the environmental constraints and it's functional affordances.

Trumpet design has evolved over thousands of years of iterative experimentation and adaptation in structure, shape, and construction materials (Wallace & McGrattan, 2011). It is a handheld, portable, robust, acoustic and inexpensive object. These factors combine to afford the instrument opportunities to be used in many performance contexts across a wide variety of environments. Over many centuries, the instrument has been adapted for mobility – both in terms of moving into different places to play, but also the ability to move whilst playing – marching, walking, standing, dancing, and horse-riding have all been co-adapted with trumpet design (Wallace & McGrattan, 2011).

The affordance of mobility provides the intrinsic conditions for the instrument to be experienced in many different environments – from practice studios, bedrooms, school auditoriums, sporting events, cathedrals, shopping centres, jazz clubs, busy street corners, subway stations, concert halls, and military services. Each location affords an array of acoustic characteristic (and socio-cultural histories and traditions) that the trumpeter must attune to. Often these performance environments constrain the performer in perceived negative ways because the pre-composed performance materials were not intended for the particular acoustic characteristics, and therefore not optimised for a given environmental constraint. For instance, music selected for reverberant church environments may be unsuccessful in a dry sounding jazz venue, and vice versa. I'm interested in exploring environmental constraints to positively influence my improvisation choices and to promote the discovery and development of new skills and materials through the attunement to the affordances of atypical contexts.

The loud volume capabilities of the trumpet has afforded it with many tasks relating to temporal and positional signalling, that is, performing a directive task of attracting attention or sending a coded message. The evolutionary trajectory of the instrument has seen it adapted for many time-critical performances contexts such as battlefields, rituals, public announcements, and other forms of interpersonal signalling. The critical feature is the interacting constraints (distance, background 'noise' and moving bodies) regulating the production of signal clarity and reliability. These performance factors not only relate to the reception and interpretation, but also the reliability of its precise and accurate performance in stressful performance settings. An unsuccessful signal could have serious implications.

Signalling under environmental constraints of distance, temperature, stress, and movement have had a significant effect upon the adaptive development of skills and materials.

The trumpet tradition is shaped by three basic responses to environmental constraints: (i) bandwidth, (ii) fidelity, and (iii) amplitude (Palmer, Jones, Hennessy, Unze, & Pick, 1989; Sterelny, 2001, 2011). Bandwidth refers to both the sonic environment that the trumpeter must segregate from to be heard (Bregman, 1994), and the methods that a trumpeter can use to increase the codification of the message. The communication potential of the instrument is increased with every additional variable in intervallic shape and rhythm. Fidelity and amplitude provide the strength and clarity of the signal to be heard clearly and interpreted at a distance. These can be considered as self-organised performance response to environmental constraints of background information (environmental noise) and task (communication). The trumpeter is going to selected and develop performance solutions that reliable and stable, yet adaptable enough to change message content. These constraints help to shape the way we can understanding basic trumpet performance techniques. Bugle calls have all been selected and adapted for bandwidth and fidelity of the signal within challenging environmental constraints.

The intrinsic playing posture of the instrument – that is, the perpendicular position of the instrument in relation to the face; upright stance; and outward orientation of sound production – affords the player the use of (i) forward eye-gaze whilst playing; (ii) movement of playing posture; (iii) forward directional orientation of sound production towards visible (and audible) environmental surfaces, objects and events. These factors afford the ability to look and move around, and aim the trumpet bell at different features of the environment to regulate or perturb the performance activities. My project proposes that these mechanisms for environmental interaction can meaningfully impact upon spontaneous improvisation development.

In order to initiate a constraints-effect upon my performance activities, I have developed an experimental practice plan that introduces an atypical performance context intervention. The constraints-led approach promotes the use of environmental resources as ways to shape performance options available for the learner to select from. The atypical performance contexts offer radically variable performance options and affords many opportunities to guide performance attentions and calibrations.

Task constraints

Newell (1986) defines task constraints in terms of to-be-achieved actions and objectives:

> . . . the focus of task constraints is the goal of the activity and the specific constraints imposed. Three categories of task constraints are proposed. These relate to: 1) goal of the task; 2) rules specifying or constraining response dynamics; and 3) implements or machines specifying or constraining response dynamics . . . All tasks have goals that relate to the product or outcome of the action. In the majority of tasks, the way in which the performer may satisfy the outcome of the act is not specified. That is, most tasks do not specify the pattern of coordination to be utilised by the performer. (p. 352)

In later refinements of the basic theory, Newell and Jordan (2007) simplified environment tasks to include all objects external to the performer. This relates directly to the status of closely coupled implements such as sporting equipment, prostheses, manual tools, and musical instrument. The constraints-led approach considers implements used in the task as being task-constraint related - but with inherent characteristics and dynamic properties (for instance, the construction techniques and materials of a ball will affect the performance opportunities it will afford and encourage).

Within my practice project, task constraints relate to intentional performance activities: both the goal of the action, and the action itself. Performance tasks include the improvisation of melodic materials, and the various developmental operations I intentionally ‘apply’ to a target motive to initiate new materials, such as ‘repetition,’ ‘fragmentation,’ ‘transformation,’ and ‘sequential development.’ Generalised task intentions like ‘playing the trumpet now’ can be progressively attuned into more nuanced sub-tasks such as ‘play the trumpet loudly’ or ‘play the trumpet so no-one can hear it’ or ‘play the trumpet like a birdcall’ or ‘play the trumpet in time with that recurrent sonic feature’. Often, the task objective is sub personal, unspecified, or recognised retrospectively. However, the task constraint is still relevant even in when I am performing in deeply absorbed of flow-like performance states.

Spontaneous improvisation is a specific type of musical task which imposes unique sets of constraints upon performance activities, which typically require the individual to conceptualise and articulate musical ideas without prior preparation or explicit planning under the interacting pressures of time and the audience.

Task constraints can refer to strategic planning and performance frameworks used to control improvisational content creation. Within this project, I identify three fundamental improvisational task constraints that are were used regularly to organise the performance activities. These strategic tasks include: (i) referent strategies; (i) idiomatic strategies; and (iii) interaction strategies. These task constraints provided open strategic control parameters to regulate the performance activities, but were not explicitly prescriptive of performance particulars.

Task constraints such as duration, register, volume, and note length can impact upon current and future performance options due to the effects of hysteresis (Deacon, 2011; Juarrero, 1999). The difficulty of some tasks, or a state of fatigue, may constrain performance activities into other less exertive regions – different registers, lower volume levels, descending a motive, use of a specific fingering pattern, or stopping the performance. These are all relevant responses to the interacting constraints.

Constraints vs Prescriptions

Newell (1986) provides the link between the constraints upon the coordination system and its ability to self-organise through the theory that constraints to the movement system are not prescriptions for specific actions. The complex interaction of body, environment and task makes variable and individual approaches implicit to the development of coordination by a system that is always under changing conditions. No prescription can possibly account for the variable demands placed upon the system to find stable and responsive patterns of organisation. The movement system must find its own organisation methods based upon the unique set of circumstances constraining it.

The idea of constraints being used as a learning tool requires the design features of the practice activities to be accommodating to intrinsic self-organisational processes. Effective constraints-led methods provide the learner with opportunities to discover and develop individualised responses to task demands. This includes the learner developing individualised ways of thinking about the task, developing the attentional capacities of awareness towards important information that may help the performance activities, and to be able to skilfully adapt and adopt movement patterns and strategies that may be effective for a specific constraint. The constraint, however, is never explicitly directing the performer's actions.

Newell (1986) describes constraints in terms of providing a collection of possible solutions to action problems. It is the mechanism of constraint interaction that provides the most important limitations upon potential coordination. For instance, the environment constraint of a mountain provides very different problems to the up-hill walker versus the down-hill cyclist. The constraint isn't prescribing how the task should be completed, it is only providing a constraint upon certain possible effective actions. With experience, both practitioners will discover strategies to better cope with the mountain environment. Future attempts may be shaped by variations to the task parameters – they may be late for an appointment, or have a sore foot, or racing a friend. It is the interaction of body, task and environment that provides the most useful frame of reference for understanding the relative appropriateness of the activities being performed. Helping the practitioner identify the role of each type of constraint, and to experience the dynamic ways they can interact, provides a way for the learner to attune to relevant information in more effective ways. The enhanced sensitivity of the experienced performer to slight changes within any of the interacting constraints can lead to a dramatically different self-organised form of coordination and control. This is the key learning framework promoted by the constraints-led approach.

Constraints-Led Practice Design

The constraints-led approach develops teaching and learning tasks based upon key practice design principles (Davids et al., 2008; Renshaw, Chow, Davids, & Hammond, 2010; Renshaw et al., 2019). The key features of ecological dynamics learning frameworks include: (i) meta-stable performance regions; (ii) task variability; (iii) nonlinear pedagogy; (iv) constrain-to-afford; (v) education of intentions, attentions, and calibrations; and (vi) representative practice design (Davids et al., 2008; Renshaw et al., 2019; Seifert et al., 2013). These key features offer important alternative ways to conceptualising both the mechanisms of learning and the role of the educator, who is responsible for designing the learning environment. Within the self-regulated procedures of my practice project, these planning and implementation strategies are all self-controlled and self-directed. This is an important feature of many practice projects of musicians, who need to develop skills in self-regulatory methods of self-managing practice objectives. My view is that the constraints-led approach is an appropriate method to apply within self-regulated practice projects because of the clear theoretical and methodical guidelines implemented in the practice design principles.

Meta-stable performance regions

Practitioners and coaches can manipulate environmental and task constraints to create and sustain a meta-stable performance region whereby the learner must select appropriate performance patterns of organisation from multiple equally valid options. The education of decision making and rapid task switching – described in systems theory as spontaneous phase-transition - provides the learner with experience in making effective choices between the available response options to satisfy the interacting constraint demands. This equates to educating the learner to make good performance decisions in response to the available performance information – that is, learning to do an effective action (individual abilities), at the right time (self-organisation) under the current performance conditions (environmental constraints).

This enhances the development of stable and flexible performance actions, which are defining characteristics of expert performance (Davids et al., 2014). A flexible repertoire of performance actions can assist the performer in maintaining the performance activities towards their intended goal (1995; 2002; Pinder, Davids, & Renshaw, 2012). Within performance contexts, the concept of spontaneous phase-transition refers to the highly complex combinations of coordinated movements and activities emerging spontaneously from the dynamics of interacting constraints. For instance, the improvising trumpet must make constant calibrations in articulation patterns between the tongue, fingers, lips and air which are coordinated into patterns in variable ways to satisfy the task demands of register, direction change, interval type, and tempo. These can be described as phase transitions between several stable patterns that self-organise in response to the performance dynamics.

Hristovski and colleagues (2006) provide a useful description of meta-stable performance regions in athlete decisions making. Their study focusses upon understanding how boxers make decisions about the types of strikes they can use in response to their distance from a target. It was observed that by adjusting the target range – based upon individual characteristics such as arm length – could encourage more variable and flexible kinds striking to spontaneously occur without prescriptive or explicit directions. The experimenters could locate unique target distances that would encourage more rich and varied responses from the subject. Identifying and describing this area of movement variability in responsive activities to an environmental constraint can guide the development of training routines to encourage the learner to explore and exploit a more varied repertoire of self-organised performance actions (Hristovski, Davids, Araújo, & Button, 2006; Latash, 2012; Pinder et al., 2012). Seifert et al. (2013) describes the importance of this study in that it captures how "placing a performer's perceptual, cognitive and action systems in a meta-stable region of performance enhanced their exploratory behaviours" (p. 171).

The implications of identifying these characteristic performance regions that encourage more exploration and exploitation of available resources are important in the practice design of my research project. The primary objective of my research is to investigate the ways in which an atypical performance context may enhance my improvisational skills and materials. The atypical contexts were selected for integration within my practice in order to provide a meta-stable performance region which may guide me into discovering new ways of approaching instrumental improvisation. The creation of a meta-stable performance region through the environmental constraint manipulation offered by atypical contexts contributes a new way of conceptualising my music skill acquisition by focusing upon changing the 'where' of the practice activities, and not explicitly focussing upon the 'what' (Araújo & Davids, 2009)

Task variability

Task variability is an important feature of ecological dynamics practice design. Expert performance is characterised by the ability to switch between multiple tasks effortlessly and with continuity. Performance within dynamic contexts requires high levels of adaptability to cope with the multitude of performance demands. Ecological dynamics supports the discovery and development of flexible performance solutions by adopting variable practice conditions through the manipulation of practice task schedules, practice environments, and task intensities. Repetitive blocked practice schedule is used when appropriate, but task variability is a preferred method of educating intention and commitment in the learner. Davids et al. (2008) explain:

> [b]ecause movements cannot be stereotypically repeated in an identical manner (Newell et al., 2006), the role of repetition in practice has come under scrutiny. It seems that requiring learners to adapt their movements under variable task constraints has considerable merit in helping them learn how to interact with complex environments. (p. 23)

Within my application of a constraints-led approach to practice, I support the task variability principle in a number of key ways: (i) the conceptual framework of intrinsic repetition-without-repetition; (ii) the removal of cognitive prompts; (iii) the intrinsic variability of location; (iv) the use of duration constraint.

Intrinsic repetition-without-repetition provides a useful conceptual framework for understanding that variability is a central feature of all movement patterns and activities. When this is coupled with creative practices like spontaneous improvisation, the learner is inevitably faced with large amount of possible variability of performance options. The task of spontaneous improvisation confers an intrinsic amount of variation and difference between sub-task constraints (volume, articulation, register, interaction, and so forth). As players make decisions within unfolding improvisational streams, a wide array of performances skills is brought to bare upon the performance task. Fast pre-reflexive responses to emergent musical affordances provides large amounts of variability for the performance system, so, the implementation of spontaneous improvisation as a practice task embeds intrinsic variability into the practice tasks.

The principle of task variability is supported by the removal of cognitive prompts or epistemic performance tools. The practice design implemented in my practice project restricted the use of musical equipment and reference materials. There were no notepads or musical transcriptions to guide performance decisions and the structure the practice process. Variability was supported by the exclusion of anything that would draw my attention towards repetitive types of error-correction practice as opposed to exploratory and experimental forms of improvising.

Each location of the practice project provided variable environmental features to guide improvisation activities. Differences in the surfaces, objects and events of each playing situation encourage different responses and types of performance actions. Distant surfaces or objects encourage changes in performance characteristics to 'reach' or 'activate' the space. Absorbent acoustic features may encourage a more focus upon articulation, pitch stability or ornamentation as a way to cope. Subtle ongoing calibrations in volume or air pressure or lip engagement can be educated through variable acoustic environment features. The intrinsic performance variability arising from the trumpet playing posture can literally mean that any subtle changes within the performance system (orientation towards different surfaces at different distances, for instance) can educate the player understand the influence of the features upon sound production and performance choices. The combination of constraint awareness and intentional accommodation and adaptation to 'optimise' the performance solution can lead to a powerful alternative learning mechanism.

Nonlinear pedagogy

A linear pedagogy is defined by as a teaching method based upon explicit direction of the learner, repetitious drills, high levels of critical assessment and error recognition, and the use of idealised or to-be-achieved models of performance (J. Chow et al., 2016). Learning in linear pedagogy is described as a gradual increase in abilities, gradual increase in practice tasks from easy to hard, and a gradual increase in the learner closing the gap between their performance outcomes and the idealised model (J. Chow et al., 2016; J. Y. Chow, 2013; Jia Yi Chow et al., 2011). The acquisition of skills is thought to be proportionally related to the amount of 'deliberate' or formal learning activities the individual undertakes (Ericsson et al., 1993).

An important characteristic of the constraints-led approach is the promotion of a nonlinear pedagogy framework (J. Chow et al., 2016; Renshaw et al., 2019). This theory of learning relies upon the self-organisation of skills, and the self-directed discovery and development of useful performance solutions without explicit direction or correction of movement patterns.

Nonlinear pedagogy acknowledges the complex interaction and interrelatedness of the components of the performance system. Small changes to any value in any component can have significant effects upon the system's stability and output. Conversely, major alterations or perturbations may have little effect upon the persistence and stability of the pattern of organisation, or may spontaneously encourage the discovery and development of new and improved patterns.

Nonlinear pedagogy actively promotes the use of alternative learning pathways to guide the learner towards new ways of thinking and doing in response to unpredictable or unplanned events. The constraints-led approach exploits the role of nonlinear learning by provide a context for events to occur, but refrains from offering explanation or description of the desired result. This type of 'open' practice programme invites the learning to search and exploit the available relevant information for their task objectives, and uses the perturbation concept to apply pressure to the learners' cognitive and physical activities. Perturbations within the nonlinear system initiate new patterns of coordination to emerge, and new performance intentional and attentional attunement to emerge.

My practice project identifies and applies three important nonlinear pedagogy concepts within the broader constraints-led methodology. These concepts refer to variable ways of introducing perturbations to improvisational skills and materials, and include: (i) stochastic resonance, (ii) differential learning, and (iii) contextual interference. Each of these theoretical constructs has made important contributions to our understandings of motor learning and development, and have emerged through separate research areas, however, I combine them here as a useful way to conceptualise the learning benefits derived from my applications of nonlinear pedagogy techniques.

Stochastic resonance

Stochastic perturbations are scientifically explained as the effects of random and unpredictable events upon a system's formation and ongoing stability (McDonnell & Abbott, 2009). Nonlinear pedagogy initiates learning and adaptive development through exploiting inherent movement variability and fluctuations by introducing stochastic perturbations to learning tasks (Schöllhorn et al., 2012). Stochastic perturbations are useful ways of adding random variability to practice tasks and encouraging experimental and exploratory behaviours in the learner as the to-be-completed task may never have been experienced before (McDonnell & Abbott, 2009; W.I. Schöllhorn, Mayer-Kress, Newell, & Michelbrink, 2009).

Stochastic perturbations within learning methods exploit a characteristic component of nonlinear pedagogy in the exploitation of *stochastic resonance*. Stochastic resonance is a learning explanation adapted by nonlinear pedagogy from signal theory which states that the introduction of 'noise' to a system (or signal) can strengthen the amplitude, strength and stability of the system (McDonnell & Abbott, 2009; W.I. Schöllhorn et al., 2009; Simonton, 2003). The 'noise' – in the form of random variables, perturbations, attentional shifts, or constraints – encourages stabilisation in other areas of the system and increases adaptive responses. The perturbations offer a 'load', pressure or obstacle to the system that encourages adaptive responses and learning.

The concept of stochastic resonance is an important mechanism for change within the application of a constraints-led approach to improvisation development. Most importantly, the framework allows the reappraisal of events that would – under more deliberate linear approaches – be considered as errors, mistakes, or unintended consequences. The concept of stochastic resonance acknowledges the potential worth of these events, and encourages practitioners to be sensitive and open to incorporate any useful discoveries or occurrences and try to maximise a learning yield from each opportunity. Further, the notion of stochastic resonance can positively impact upon the awareness to elements within the performance activity which may be useful in terms of creating or expanding upon existing bandwidth, fidelity and amplitude capacities. For instance, when playing softly on the trumpet during my practice intervention on a cold day, I noticed that the inherent raspy 'buzz' in my sound from my inflexible cold lips actually helped the sound to 'hang' more in the space. This otherwise suboptimal sound production actually educated me in the ability to increase performance fidelity and bandwidth which - as significant performance realisation - was further explored and developed. The key idea here is that nonlinear pedagogy offers a conceptual framework for understanding and accommodating the potentially positive effects from random of unplanned events or outcomes, and to create open learning contexts that encourage experimental and exploratory behaviours.

Differential learning

Differential learning approaches are characterised by large amounts of task variability carried out under error-free conditions, without corrections or explicit performance directions, and the introduction of task perturbations to guide the learner into experimentation and exploration modes of performance. Differential learning supports the development of repetition-without-repetition methods, and tasks are never expected to be performed the same way twice. There is no single ideal way to perform any task, and performance solutions are unique for each individual (Nikolai A. Bernstein, 1967; Schöllhorn et al., 2012; Wolfgang I. Schöllhorn, Michelbrink, Welminsiki, & Davids, 2009). Schöllhorn and colleagues (2012) describe the differential learning approach as:

> . . . the fluctuations in the learner's subsystems . . . are exploited during learning, because they have the potential to destabilize the whole system. This destabilization process can lead to an instability that has the advantage of requiring less energy in order to achieve a new stable state of organization for the learner. By amplifying these observed fluctuations, the system is additionally confronted with the potential limits of possible performance solutions. Consequently, a self-organizing process is initiated and exploited that forces the system to instigate a new coordination strategy which typically results in the emergence of more effective or more stable movement patterns. (p. 102)

Although a differential learning approach is a nonlinear pedagogical method, in its initial formulation it differs from the constraints-led approach originally contributed by Davids and colleagues in its specification of task constraints:

> The differential learning approach is mainly characterized by taking advantage, for the purpose of learning, of fluctuations that occur, without movement repetitions and without corrections during the skill acquisition process. This approach can be considered as highly nonlinear

> because of learners constantly performing the whole complex movement with permanently changing stochastic perturbations. (p. 102)

Differential learning offers a useful practical framework for introducing stochastic perturbations to music practice, in particular, the use of spontaneous improvisation as a way to initiate non-propositional types of music making. Propositional approaches – present in most forms of deliberate and formal practice – are characterised as containing 'correctness-conditions' which mediate or shape the performance activities. Failure to satisfy the correctness condition equates to an 'error' and obliges the learner to try again under the direction to close the gap between the 'correct' version of events that their incorrect performance. Propositional materials can take the form of externally modelled versions of an event – for instance, a notated composition and exercise – or internal cognitive models – audiation, or memorised harmonic schema or rhythmic patterns. The propositional approach is predicated upon how 'correct' the performance activity is.

The differential learning approach presents an alternate error-free pedagogy where practice tasks are not specifically designed to achieve a 'correct' outcome, but are about initiating search and discover activities that will benefit the individual in later performance contexts.

Differential learning is a useful way of conceptualising skill development for improvisational contexts where there is no pre-existing model of version of the performance against which a correctness-condition can be established. Propositional comparisons against an idealised version of a performance is impossible in freer kinds of creative performance, which means that we need a new learning strategy based upon intervention and exploration in place of error-correction and re-creation.

Contextual Interference

Contextual interference is another nonlinear pedagogy which introduces stochastic perturbations to practice design through the implementation of random or self-controlled task-switching (Barreiros, Figueiredo, & Godinho, 2007; Pauwels, Vancleef, Swinnen, & Beets, 2015). By performing tasks in variable order, the learner is encouraged to develop adaptive mechanisms satisfy the changing demands of each different task. This nonlinear method is in contrast to more deliberate practice models of repetitious block practice of similar or identical practice tasks until the task is evaluated as completed or correct. Contextual interference introduces the possibility of novel patterns of organisation being discovered and developed through the perturbation of constant variation and emergent positive blends or combinations of techniques. Contextual interference is a method of sustaining a meta-stable performance region by encouraging the rapid transition between techniques. This is further supported through self-controlled task switching (Keetch & Lee, 2007; Wu & Magill, 2011).

Contextual interference effect can be achieved in spontaneous improvisational activities through the regular switching of performance strategies used to generate or organise materials (Newell & P.V., 1992; Russell & Newell, 2007).

Constrain-to-afford

Constraints are instituted into the practice design to encourage the discovery of useful forms of information. Ecological dynamics promotes the attunement to environmentally situated information sources under a guiding framework of *mutuality* between the performer and the environment. Mutuality refers to the equal importance and responsibility given to environmental features for regulating performance activities. The constraints-led approach is a useful method for re-addressing traditional forms of 'organismic-asymmetry' which relegate the environmental aspects of a performance as subordinate to the intentions of the performer (Davids & Araújo, 2010). By addressing the mutuality of performer and performance context, the constraints-led approach discourages the de-coupling of performance activities from the array of information sources which may guide performance decisions.

Constraints can be usefully employed to uncover otherwise unrecognised affordances within a performance situation. New performance solutions may emerge from a shift of attention to an otherwise unknown available affordance. For instance, constraining an individuals' vision may direct performance attentions towards other useful information within the performance context from auditory, kinaesthetic, haptic or proprioceptic sources.

Education of intentions, attentions, and calibrations

The education process of the constraints-led approach directly targets three areas of performance skill: the intentional goals; the attentional focus; and the ability to calibrate actions in flexible and adaptive ways to changing situations. Intentional goals include the task and sub-task objectives used by performers to arrange and assemble their performance systems. A shift in the scale or nature of the performance space may initiate new performance objectives, or remove possible options. For instance, the reduction of players in a team sport may influence the intentional strategies deployed by the athletes to cope with the extra space. Within the constraints-led approach – and supported by dynamical systems theory – intentions are considered to be important constraints in their own right, and any manipulation of the intentional framework of the learner may have positive educational results (Deacon, 2011; Juarrero, 1999; J.A. Scott Kelso, 2002; J. A. Scott Kelso, 2019; Renshaw et al., 2019).

Attentional focus –what is being paid attended to – during performance can be educated through constraints manipulation targeting the search for information in the perceptual-motor workspace. Constraints-led practice design can switch the performer's attention from an internal process-based focus towards the produced outcomes of performance within the environment. An external focus of attention has been implicated in the efficacy of self-organisational processes and expert performance in the protection of procedural forms of knowledge – which is a formulation of movement and cognition characterised by deeply embedded or automatic actions (Johnson & Proctor, 2004; Wulf, 2013; Wulf & Lewthwaite, 2016). Constraint manipulation may lead to an awareness of subtle changes in the performance environment which may be perceived by non-dominant performance information which can help to shape activities, for instance the auditory feedback from an event or the visual information of performance in music performance providing cues or triggers to performance activities.

The flexible adaptations and adjustments performers must use in dynamic contexts can be educated through the manipulation of key constraints promoting task variability and changes in environmental conditions (Renshaw et al., 2019). Importantly, the constraint-led approach advocates for the preservation of performance actions intact to the relevant performance information typically found in performance contexts. For instance, the use of artificial devices in sporting contexts such as robotic ball delivery systems can inhibit information pick-up relevant for batting calibrations necessary for successful performance in competition. The constraints-led approach encourages task simplification for educational purposes – which may involve manipulating the speed, force, or regularity of tasks – as opposed to task decomposition – which would involve removing actions from their ecological informational relevance (Renshaw et al., 2019; Renshaw et al., 2009; Renshaw & Davids, 2014).

Representative practice design

An important design feature of effective constraints-led practice is the ecological relevance of the practice tasks being implemented (Renshaw et al., 2010; Renshaw et al., 2019; Renshaw et al., 2009). Ecological representativeness (Brunswik, 1949) refers to the validity of practice tasks in preparing the performer for the realistic demands of performance situations. The constraints-led approach advocates for practice design to feature as much representativeness for learners so that action calibrations effectively match the likely information sources encountered in actual performance settings (Davids et al., 2008; Renshaw et al., 2019; Renshaw et al., 2009).

Summary

This section provided an outline for the application of a constraints-led approach to jazz trumpet skill acquisition and development. The practice design principles of the constraints-led approach were combined with an overview of the fundamentals of nonlinear pedagogy, differential learning, and contextual interference effects. The following section will present an experimental application of the constraints-led approach to a 12-month trumpet practice project investigating the effects of an environmental constraint manipulation in the form of atypical performance contexts.

Chapter 3

The Practice Project

The results from this practice project are organised into two separate sections and presented over the following two chapters. This first section outlines the project design and implementation, and provides an overview of the atypical performance contexts used within the constraints-led practice project. The section provides an overview of the perturbations and affordances offered by the atypical contexts and describes the effects upon my performance activities.

The second section (see Chapter 4) presents a taxonomic overview of the variable types of improvisational responses that emerge from the nonlinear constraints-led practice. It provides multiple examples of performance activities to illustrate repetition-without-repetition practice outcomes and describes the broad types of improvisational strategies used to satisfy the interacting constraints applied by the practice design.

Overview

The research project involves implementing environmental constraints upon my trumpet practice processes to encourage the discovery and development of improvisational skills and materials. The specific skills being targeted by the project relate to my abilities in forming physical patterns of coordination and control which enable the spontaneous improvisation of original, efficient, and transferable melodic materials. Within the ecological dynamics method, skill acquisition and development refers to the process of attuning the performers' intentions, attentions, and calibrations through the implementation of constraints.

Practice Design

The practice design was planned to achieve new skills and materials as outlined in the project overview. The design introduces a three-part practice task to guide the discovery and development activities. The three primary practice tasks are:

1. spontaneous solo trumpet improvisation
2. 20-minute duration
3. atypical performance context

Spontaneous improvisation

Spontaneous improvisation is referred to in this project as a specific form of performance that has no pre-determined format or scheme upon which the musical activities aim to reproduce or recreate (Bailey, 1992; Benson, 2003). The spontaneous improvisation task provides a constraint upon performance intentions, in that skills and materials are under the pressure of having to generate and perform ideas dynamically. This continual pressure of invention directed me towards exploring and exploiting many kinds of environmental features and to use surrounding information sources for inspiration and direction. Within this project, I define spontaneous improvisation as a creative and self-organisational process emerging from the interactions of trumpeter-trumpet-environment (Borgo, 2007; J. A. S. Kelso, 1995; Walton et al., 2014).

Solo trumpet

The skills being targeted by this project are specifically related to *trumpet* improvisation, which implicates an intrinsic set of bodily constraints. The skills being developed directly impact the coordination and control of these implicated systems.

The multiple affordances of the trumpet enabled a variety of sonic environments to be explored and exploited in variable ways. Surfaces and spaces could be investigated for resonances and reflections. Objects and structures such as drain culverts, bridges, or creek valleys could interesting and unusual acoustics. Distant objects could provide interesting attentional foci to organise performance activities. Each of these environmental features were accessible for musical exploration because of the affordances the instrument design, volume capabilities, and intrinsic playing posture. Figure 18 provides an illustration of the visual array afforded by the intrinsic playing posture.

Figure 7: Typical view whilst playing the trumpet. Corresponding eye-line and instrument orientation affording visual cueing and sound projection towards environmental surfaces, objects and events. In this image I am watching and listening to a lyrebird at Mount Keira.

The trumpet is performed *solo* without any musical accompaniment or support. This task constraint - in the form of musical stimulus removal - initiates the search for other forms of internal and external information to regulate the performance activities. An unintended consequence of the ‘solo’ task constraint is that the skills and materials that emerged focused upon developing autonomous melodic materials that were capable of self-organisation by momentum-creating devices like contour changes, cycles, cells, repetitions, transformations, and fragmentations (see Chapter 5). The intrinsic feeling of agency, efficiency and coordination of the performance system emerged as the most dominant feature of the practice activities. In short, I discovered materials that were physically pleasurable and efficient to play (Latash, 2000, 2008, 2012; Newell et al., 1989).

20-minute duration

The duration task constraint was applied to the practice design to provide enough constraint to the physical system to promote adaptations of strength and conditioning, and to initiate physical and mental fatigue as an exploratory strategy. The 20-minute task is representative of a single 'set' of practice[3].

Atypical performance contexts

The atypical performance contexts were implemented in the practice design as an efficient method for applying an immersive intervention upon the physical and informational constraints relevant to trumpet performance. The atypical performance contexts alter the way the trumpet sounds, feels, and responds due to the variable environmental characteristics. The contexts provide a wide variety of visual and auditory information to guide my focus of attention. Three categories of atypical contexts were selected for the project: a Landscape context, an Industry context and a Motorway context.

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[3] My typical daily practice routine is organised into 20-minute units distributed across several hours with a 10-20-minute rest period between each practice set.

Procedure

Practice session schedule

Each 20-minute practice session was completed once per day over a 12-month period, however, there were several interruptions to the project for several weeks. There were 179 practice sessions completed.

Location selection

Practice locations were selected from three categories of atypical performance contexts, and included positions at Mount Keira,[4] Cordeaux Dam,[5] Port Kembla Coal Terminal,[6] and the M1 Princes Motorway[7]. Each location was within a 10km radius of my house. Each practice session playing position was unique, and no attempt was made to return to an exact location. The project was not focussed upon the performance effects of any one particular environment, but about the cumulative effects of the atypical playing contexts over the 12-month timeframe.

All session locations provided vehicle access, and were open to the general public. Permissions were sought from several authorities, including The Wollongong Scouting Association (for access to Mount Keira Scout Camp, see Figure 19), Shelldrill (for access to O'Brien's Drift mining shaft and tunnel, see Figure 20), and JK Williams Construction (for access to Clive Bissell Drive during a period of road closure, see Figure 21).

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[4] ***https://goo.gl/maps/9ymrzFJcWtLGZ7pR6***; ***https://en.wikipedia.org/wiki/Mount_Keira***

[5] ***https://en.wikipedia.org/wiki/Cordeaux_Dam***; ***https://goo.gl/maps/4g1fe6W1gn8zcLdV7***

[6] ***https://en.wikipedia.org/wiki/Port_Kembla_(seaport)***; ***https://goo.gl/maps/rmmLSG1FC9TphmoXA***

[7] ***https://en.wikipedia.org/wiki/Princes_Motorway***; ***https://goo.gl/maps/z6i4ettZ4gUyRBMk6***

Figure 19: A practice location at Mount Keira Scout Camp driveway with small bridge and culvert and Byarong Creek.

Figure 20: Vacant mining shed at O'Brien's Drift with large reverberant open shaft and tunnel within.

Figure 21: Road closures at Clive Bissell Drive enabling safe access to atypical practice locations.

Health and safety

The practice project was carried out under University of Sydney Occupational Health and Safety guidelines. Safety measures included the use of a high-visibility vest, protective clothing and footwear, and vehicle hazard lights. Figure 22 displays a night-time practice session with vehicle hazard lights.

Figure 8: Evening practice location with vehicle hazard lights. Clive Bissell Drive, Mount Keira.

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Data collection

Each session was recorded on a tri-pod mounted Zoom H5 portable digital recorder. Images and location GPS data were collected using an Apple iPhone 6S and Google Maps. Weather conditions were collected from the Australian Government Bureau of Meteorology website prior to the session.[8]

The recorded audio material was later transferred from the H5 soundcard to a computer and checked for technical errors. At the conclusion of the project, the sessions were edited into trial segments, labelled with individual session and trial catalogue numbers, and transferred into a session report for classification, reflection and evaluation. The edited session segments were uploaded into Soundcloud[9] and arranged into session playlists[10]. The session report combines audio examples of each trial, images of the atypical performance

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[8] ***http://www.bom.gov.au***
[9] ***https://soundcloud.com/discover***
[10] ***https://soundcloud.com/phil_slater/sets/s1160618-1/s-WkstC***

context, location information, and reflective session notes. The session reports were compiled into the Practice Journal (see Appendix A).

Session notes

Practice journaling is an effective way to enhance learning activities within self-regulated processes and is a regular educational feature of practice-led research projects (Barrett & Bolt, 2007; McPherson & Renwick, 2011; McPherson & Zimmerman, 2002; Zimmerman, 2000; Zimmerman et al., 1996). Journaling is a developmental method I have used throughout my practice career, and have found it to be a useful tool for identifying conceptual frameworks and techniques.

The Notes procedure evolved over the course of the practice project: from a detailed taxonomic approach into a descriptive and conceptual account (See Appendix A). In this project, note taking was an important part of understanding the improvisational methods and strategies, and provided an epistemic scaffold for skill development (Kirsh, 2001, 2008). Whilst the Notes provide a useful overview of the trajectory of the project, the positive benefit of journaling is the process of critical self-reflection undertaken in completing them, and not the communicative information in the entries themselves (Barrett & Bolt, 2007; Bolton, 2010; Ghaye, 2011; H. Smith & Dean, 2009). Figure 23 displays examples of typical entries.

> *Fri 16/9/16 PKCT breakwater; 12:39pm; 17*c;*
>
> *Waves and rhythms; pentatonic "gamelan" sweeps and cells; irregular "rock" cells: jagged, sawtooth, atonal, densely intervallic and chromatic; B pent with some blends: aiming for blended pent.; sounds of ocean n wind n industry: you can't fight them, or control them, or*

drown them out: you can only blend, recede, embed, camouflage or emulate. Brings me back to the question: what to play?

Mon 30/1/17 Port Kembla Coal Terminal breakwater 18:03

Windy; waves breaking; trumpet sound deflecting off boulders; very different melodic feeling to previous (calmer?) visits; wind distracting?; melodic materials ranging from angular array (rock emulation?) to smoother, slower builds; nothing goes with you! Nothing reacts or changes; you're either playing to blend, to emulate, or to juxtapose; harmony?; how to play harmoniously with the ocean?

Thurs 23/3/17 Mount Robertson "picnic area" 14:00

Incredible place; rock ledge overlooking SW mount Keira, lake Illawarra, steelworks, port Kembla, etc; amazing >5sec echo around mount Keira; pointillistic material to create sonic 'mists' i.e. not so interested in immediate sounding material but constructing melodies to resonate in the space to create mists, clouds, densities of pitch clusters, etc like pianistic playing (Abrahams) with sustain pedal down (similar to Cordeaux dam pylon playing . . . harmonic or 'chordal' versus atonal, but, still thinking 'vertically' and texturally; rhythmic cells and cycles to 'sound' like clusters and mists; rhythmic material created by tonguing or rhythmic 'resetting' of the cells to create or maintain momentum (without circular breathing, which inhibits/alters timbral manipulation and changes 'pivot' structure of melodies (i.e. contour of lines created a lot by articulation/movement patterns of tongue and finger combinations); 'bounce' or rebound effect of pivot = arban drills and noodles ie. momentum or melodic energy or something is gathered = like the diving board analogy = a way of pre-setting or engaging muscles and airflow?

Figure 23: Excerpts from the Practice Journal depicting the improvisational strategies and reflections. See Appendix A (S1-S20) for examples of the detailed taxonomic descriptions of skills and materials.

Classification of practice activities

A basic taxonomical categorisation procedure was used to identify, describe and label the improvised practice activities. The classification system was not intended to provide a close analysis of performance outcomes, but to provide a codified framework for understanding the developed skills and materials. In order to preserve an ecological dynamics representative practice design principle - to preserve the spontaneous element of the creative responses - the classification process was developed and completed at the conclusion of the 12-month practice period.

Each session recording was segmented into individual phrases ranging from several seconds to a several minutes. The phrase length was determined through auditory similarity of events. The taxonomic classification of materials occurs at 'motive-length' scale of resolution, and is focussed upon identifying dominant or important performance characteristics from a motivic, technical or stylistic framework. This 'phrase-length' segmentation was considered to be the most ecologically relevant scale with which to review the materials.

Each session was assigned an identification number containing session number and date (e.g. S1.160618) and each performance trial was assigned a unique catalogue number (e.g. M5.S1.160618) for evaluation and categorisation.

The segments were analysed for motive content and grouped into three general improvisational strategy types: (i) Referent based; (ii) Idiomatic based, and (iii) Interactive types of improvisation. The categories are based upon three conceptual frameworks of idea generation in improvisation, and represent a cognitivist method (Hargreaves, 2012; Johnson-Laird, 2002; Norgaard, 2014; Pressing, 2001), and embodied approach (De Souza, 2017; V. Iyer, 2002, 2004, 2016; V. S. Iyer, 1998), and a distributed and ecological account (Borgo, 2007; Hagberg, 2017b; Linson & Clarke, 2017; Dylan van der Schyff, 2019; Dylan van der

Schyff & Schiavio, 2017; Dylan van der Schyff et al., 2018). See Chapter 5 for the classification groupings and detailed descriptions.

Chapter 4

Atypical Performance Contexts

The environmental constraints of the practice design were manipulated by the implementation of an atypical performance context. The atypical performance contexts are defined as areas not designed for music performance. The selection criteria for the locations was that they needed to be: (i) outdoors, (ii) exposed to the weather, (iii) exposed to human activity; (iv) exposed to some sort of 'natural' environment; and (iv) within 10 minutes of my house.

The role of the constraint intervention was to promote the discovery and development of new improvisational skills and materials in response to varied environmental perturbations (Noë, 2012; Rietveld, 2008; Rietveld, Denys, & Van Westen, 2018; Rietveld & Kiverstein, 2014). Each context was introduced into my practice routine to provide constraints upon habitual performance patterns and improvisational biases. The selected environments were grouped into three categories:

(a) Landscape contexts;

(b) Industry contexts;

(c) Motorway contexts.

Landscape Contexts

The Landscape contexts were outdoor bushland areas within the Mount Keira region of the Illawarra Escarpment.[11] These environments were richly varied and sonically complex places to play a trumpet. For instance, the many irregular and uneven surface affordances could be explored and exploited with pitch, volume and direction choices. Ground coverings - including mixtures of leaf litter, rocks, fallen trees, hollow logs, dirt, and grass - contributed sound absorption, reflection and deflection in unpredictable ways. Objects - people, vehicles, rocks, ponds, creeks, trees, animals and insects - were always present. A wide variety of events - birds tweeting, insects biting, deer running, wallabies hopping, frogs croaking, cicadas calling, hunters shooting, fisherman yelling, lyrebirds copying, rain falling, wind gusting, clouds misting, vehicles braking, and weather changing - were common sources of both inspiration and distraction.

The locations were a mixture of uncovered and open spaces, partially tree covered, or dense forest. The topography was varied, including cleared flat sections, steep sloped hills, creek embankments, riparian corridors, valleys, and the vertical cliff face of the Illawarra Escarpment. These all provided unpredictable sonic characteristics which could be utilised for trumpet playing. The following examples (with included hypertext links) provide a sampled overview of the Landscape contexts (See Appendix A for the complete selection).

Practice Session S13.160708, Clive Bissell Drive, Mount Keira.

Figure 24 displays an example of a Landscape Context in Mount Keira demonstrating complex ground covering of leaf litter, mud, bark and small twigs and a mixture of vegetation densities. Bushwalkers and mountain bikers were common in these performance contexts,

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[11] See ***https://en.wikipedia.org/wiki/Illawarra_escarpment***

which would make me think about the variable ways we can use the environment to guide our actions.

Figure 24: Example of a Landscape Context. Session ***S13.160708*** Clive Bissell Dr, Mount Keira ***34°22'39.6"S 150°51'31.2"E***

Practice Session S38.160812, Clive Bissell Dr, Mount Keira.

Figure 25 displays another section Clive Bissell Drive. This location of road was a remarkable acoustic space for trumpet performance. A small creek channel and powerline easement provided a warm resonant playing environment. The combination of bitumen road and over-hanging leaf canopy heightened the acoustic characteristic. A rock face 100 metres from this location provided an excellent enriching reverberation and echo for the very loud upper register motives. The practice sessions here were often accompanied by frequent lyrebird songs.

Figure 25: Example of a Landscape Context. Session ***S38.160812,*** Clive Bissell Dr, Mount Keira. ***34°23'24.6"S 150°50'58.4"E***.

Practice Session S132.170323, Robertson's Knoll, Mount Keira.

The image in Figure 26 is overlooking the south-western slopes of Mount Keira from an adjacent cliff of the Illawarra Escarpment. The distant surfaces below offered external attentional foci to direct the sound production towards. The valley below could be 'activated' by sound production at certain pitch frequencies and volume levels. This encouraged experimentation with explosive bursts of air pressure and heavy articulation - often creating random multiphonics or timbral distortions which could be developed. The production of these techniques was self-organised and nonlinear under the interacting constraints of task (i.e. play loud enough to echo in the valley), environment (the valley below), and body (lip, air and tongue dynamics).

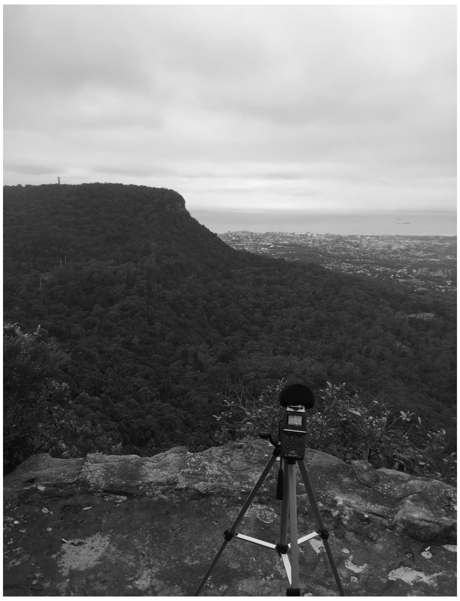

Figure 26: Example of a Landscape context. Session ***S132.170323***, Thursday March 23, 2017, Robertson's Knoll, Mount Keira NSW 2500, ***34°24'07.9"S 150°50'26.0"E.***

Practice Session S145.170421

Figure 27 illustrates a practice location on a walking track within the Mount Keira Scout Camp property. The steep slopes are created by the Byarong Creek below. Natural geological systems offered metaphorical ways of thinking about self-organisational processes found in nature and their relevance to music making. In particular, slopes like this would prompt me to think about Waddington's (1957) image (Figure 12) of the falling pebble which I would imaginatively translate into musical 'cascade' motives. These musical gestures are a combination of small melodic cells, recurring elliptical cycles, and contour sequences.

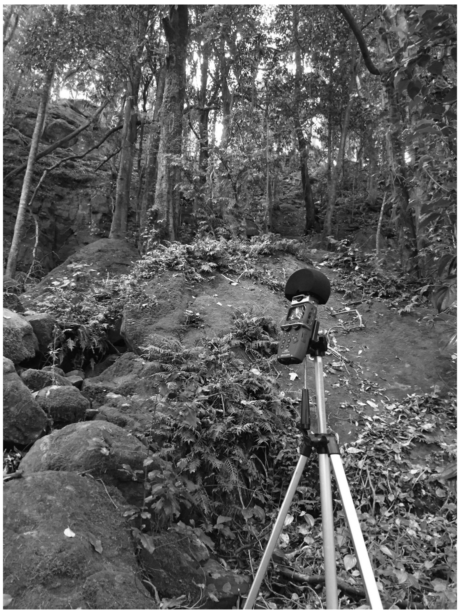

Figure 27: ***S145.170421***, Friday April 21, 2017, Unnamed Road, Mount Keira Scout Camp, Mount Keira NSW 2500, ***34°24'04.0"S 150°50'50.5".***

Practice Session S46.160823, "The Creek," Mount Ousley.

The creek featured in Figure 28 runs from Mount Keira to the ocean through the suburb where I live. The many stream channels in this area have helped to shape the steep slopes of the suburb into a complex topography of hills and valleys. Every action in this area is regulated by the slope gradient – walking, bicycle riding, skateboarding.

As a youth I learned to use the hills for skateboarding and discovered and developed techniques and skills to cope with the steep environmental constraints. These adaptations were self-organised and implicitly incorporated in self-regulated ways. This natural intuitive exploitation of the slope affordances became a conceptual model for my trumpet practice in the atypical performance contexts, and I began to approach playing the instrument as if I was 'riding' or harnessing the available information.

The circular water movement in the pond shown in Figure 28 was beautiful to improvise with and offered images of cyclical patterns to melodically incorporate, accompany or translate. Being surrounding in this environment - with natural movement systems continually self-organising into a myriad of patterns - became a powerful metaphor for my improvisational activities. Ecological dynamics offered me a conceptual framework and language to identify the role of self-organisation and its application to improvisation, and to identify its processes in the surrounding world.

Figure 28: ***S46.160823***, Tuesday August 23, 2016, Mount Ousley NSW 2519, ***34°23'58.6"S 150°52'20.3"E.***

Practice Session S163.170521, Unnamed Road, Mount Keira Scout Camp.

Figure 29 is a picture evening mist in the Mount Keira Scout Camp. Night-time practice sessions afforded an array of insect and frog calls - creating rhythmic patterns and textures. The restricted visibility automatically attuned my auditory sensitivity to the environment, and to the haptic sensations of the trumpet.

Mists, clouds, and sudden dramatic weather changes are a prominent and evocative feature of the micro-climate of Mount Keira, and are a constant reminder to me of the complex self-organisational systems creating these patterns and synergies.

Figure 29: ***S163.170521***, Sunday May 21. 2017, Unnamed Road, Mount Keira Scout Camp, Mount Keira NSW 2500, ***34°24'02.0"S 150°51'04.4"E.***

Practice Session S173.170609, Mount Keira Rd, Mount Keira.

This location was between to escarpment face of Mount Keira and a deep valley of Byarong Creek. Vehicles traveling along the road (see Figure 30) would produce receding doppler-shifting drones as they ascended into Mount Keira - added interesting pitch drones and rhythmic patterns to interact with.

Figure 30: ***S173.170609***, Friday June 9, 2017, Mount Keira Rd, Mount Keira NSW 2500, ***34°24'16.2"S 150°51'05.2"E.***

Practice Session S105.170214, Robertson's Lookout Walking Track

Figure 31 displays a section of walking track near Robertson's "Bluff." This site afford many different types of birdlife, and had a beautiful playing acoustic. The birdcalls would provide irregular and elliptical rhythmic patterns and pulses to entrain or interact with. I began playing much shorter and fragmentary phrases as the practice period progressed - the shorter, fragmented approach was more easily adaptable. I began to notice that the only long sounds in these environments were from machines. I began to wonder about the short bursts of sound from a signal theory perspective, and became highly senstivie and attuned to the lengths of my notes. The binary of long v. short sounds became a fundamental organisational feature of my developing improvisational strategies.

Figure 31: ***S105.170214***, Tuesday February 14, 2017, Robertson's Lookout Walking Track, Cordeaux NSW 2526, ***34°24'03.9"S 150°50'27.9"E.***

Industry contexts

The Industry contexts were selected for inclusion in the project design because of the affordances provided by their variable surfaces, objects and events. The playing positions included the Cordeaux Dam[12] complex, Port Kembla Coal Terminal sea wall[13], Bluescope Steel carpark[14] an M1 construction site, the abandoned O'Brien's Drift[15] mining site, and miscellaneous shelters and building structures. These sites included flat open spaces, hard regular or angular surfaces, machinery, open reverberant enclosures, and large-scale industrial constructions. Each site had a

[12] ***https://en.wikipedia.org/wiki/Cordeaux_Dam***
[13] ***https://en.wikipedia.org/wiki/Port_Kembla_(seaport)***
[14] ***https://en.wikipedia.org/wiki/BlueScope***
[15] ***https://www.illawarra-heritage-trail.com.au/wordpress/?page_id=1705***

history of use and cultural legacy which – at times – provided contextual (non-musical) framework to think about and respond to. The following examples provide an overview of the Industry performance contexts.

Practice Session S27.160724, Picton Rd, Cataract

The site in Figure 32 was located near the M1 Motorway and included various roadworks infrastructure, piled materials, high speed vehicle noise and exposure to the wind and sun. Directing my trumpet between the stacked road barriers (visible in the image) created an interesting reverberance that could be explored with register and volume changes. The bare and exposed environment created a very crisp and fragile acoustic condition which regulated me towards exploring different types of vibrato.

I was challenged by the lack of musical accompanying stimuli which lead me into experimenting with repetitive sequential materials. The intrinsic dynamics of fatigue and limited pitch range of the trumpet self-organised the sequential materials into short ascending cellular motive or 2 or 3 (short and sharp ascents are far more energy-efficient) and longer descending figures (descending slowly on the trumpet is very efficient). These melodic patterns of ‘fast-up, & slow-down’ became an effective solution satisfying the task constraint of continuous solo trumpet improvisation.

Figure 32: ***S27.160724***, Sunday July 24, 2016, Picton Rd, Cataract NSW 2560, ***34°21'55.0"S 150°51'25.0"E.***

Practice Session S28.160727, Jardine St, Fairy Meadow

Figure 33 illustrates a site within an industrial complex. The site was surrounded by small factories, and the session was regulated by the distractions and interruptions. Not wanting to disturb the factory workers, I explored ways to sonically hide within the surrounding soundscape. The practice session was characterised by extremely soft playing due to the environmental constraints. During this session I explored imitating many sounds of the environment, including a drill, insects, and frogs.

Figure 33: ***S28.160727***, Wednesday July 27, 2016, Jardine St, Fairy Meadow NSW 2519, ***34°23'16.2"S 150°53'31.4"E.***

Practice Session S47.160824, Byarong Park, Mount Keira

Figure 34 displays a site under a barbeque structure in Mount Keira. The shelter affordance was selected because of the heavy rainfall. The combination of rain on the tin roof and surrounding trees created an appealing texture to improvise with. The situation encouraged a flute-like timbral approach reminiscent of a shakuhachi - a performance tradition I have a deep interest in. The reference to shakuhachi qualities is initiated by the philosophical and aesthetic tradition of shakuhachi performance being explicitly connected to nature. The long-tone motives here were intended to accompany the sound of falling rain.

Figure 34: ***S47.160824***, Wednesday August 24, 2016, Byarong Park, Mount Keira NSW 2500, ***34°24'27.1"S 150°50'53.5"E.***

Practice Session S55.160904, Seawall Rd, Port Kembla.

This practice session was conducted on the Port Kembla Coal Terminal seawall. This environment afford the entraining rhythmic patterns of the breaking waves with the angular visual stimulation of the concrete blocks. My improvisational activities in this context were often guided by the intention of combining these two attentional information sources into a cohesive response through calibration of motives, techniques and aesthetics.

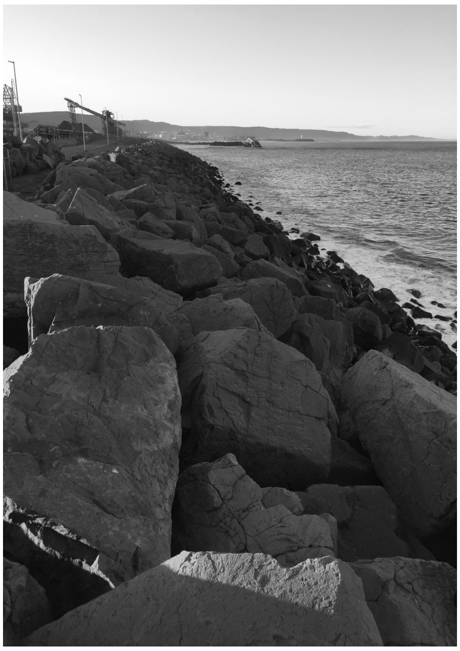

Figure 35: ***S55.160904***, Sunday September 4, 2016, Seawall Rd, Port Kembla NSW 2505, ***34°27'25.1"S 150°54'02.9"E.***

Practice Session S61.160916, Seawall Rd, Port Kembla

Figure 36 presents another practice location in the sea wall. A different outlook and different rhythmic patterning of the ocean instilled the repetition-without-repetition model of pattern formation, and trained my attention towards the subtle variations in the environmental information array which surrounds and guides our actions.

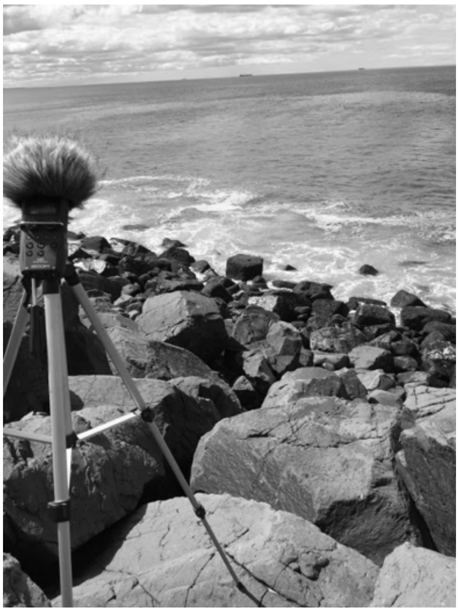

Figure 36: ***S61.160916***, Friday September 16, 2016, Seawall Rd, Port Kembla NSW 2505, ***34°27'29.2"S 150°54'03.2"E.***

Practice Session S102.170211, Mount Keira Scout Camp, Mount Keira

Figure 37 illustrate a practice site within the Mount Keira Scout Camp. This small bridge and creek culvert were explored with short bursts of sound which would create an excellent effect under the bridge and down into the Byarong Creek channel. These small built-infrastructure features within landscape environments were an attractive practice place because of the variety of sound events and surfaces to improvise with. This site included the sound of the creek, frogs, lyrebirds, low-level distant vehicle drones, and insects – all of which would combine to create in incredible complex texture of independent streams of sound. Finding an appropriate way to engage with these sites led to aesthetic developments that would eventually have a positive impact upon my performance aesthetics and musical preferences. This would include a more ‘layered’ approach that relied less upon strictly entrained rhythmic materials, and more towards ‘assemblages’ or collages of sound.

Figure 37: ***S102.170211***, Saturday February 11, 2017, Mount Keira Scout Camp, Mount Keira NSW 2500, ***34°24'01.7"S 150°51'03.6"E.***

Practice Session S104.170213, Harry Graham Dr, Mount Keira

The abandoned O’Brien’s Drift mining shed shown in Figure 38 covered a deep tunnel descending to a disused mine shaft connected to the Mount Nebo mine. Performing in this space created an incredible underground resonance as the sound travelled through the tunnel complex. This novel performance experience encouraged new types of materials and articulations to be explored. I sometimes played in the space during periods of rain, and this would contribute other sounds to the practice sessions.

Figure 38: ***S104.170213***, Monday February 13, 2017, Harry Graham Dr, Mount Keira NSW 2500, ***34°24'08.6"S 150°49'59.1"E.***

Practice Session S93.170202, Seawall Road, Port Kembla

Figure 39 depicts the irregular angular shapes of the seawall, which provided visual information to translate musically but also created interesting reflection patterns of sound. In this practice session, I was accompanying a group of workers in the coal terminal and trying to find materials to play that would still allow me to hear them clearly. This task constraint provided a valuable insight into the role of volume as a control parameter for improvisation within an ensemble context.

Figure 39: ***S93.170202***, Thursday February 2, 2017, Seawall Road, Port Kembla NSW 2505, ***34°26'49.2"S 150°54'00.1"E.***

Throughout the developmental rehearsal period for *The Dark Pattern* I implemented a volume constraint by suggesting that we perform acoustically – no amplification on the bass, no fold-back monitor speakers. Over the hours of rehearsal and performance we develop a completely new relationship to ensemble performance (and to our instruments) due to the 'global' volume constraint. This initiated a range of adaptive shifts in our performance coordination patterns due to the challenge of having to hear each other. The music became more sensitive and interactive due to everyone having to find a useful niche in the performance ecology.

When recording *The Dark Pattern* compositions, we retained the volume constraint by eliminating the use of head-phone monitoring. This meant that we would need to record the performance in one single room, with no editing, and no sound separation. The resulting music is our emergent musical responses under the volume constraint.

Practice Session S48.160825, Unnamed Road, Port Kembla

Figure 40 is an image from the Port Kembla harbour. This practice session was guided by the environmental sounds of the coal loader ships and wind through the loose materials on the fence. I became more interested in the ‘integration’ of my performance activities – playing something to accompany or offset the surrounding sounds – than using the sounds for imitational or representational purposes. If playing with a bird call, I became interested in playing materials that afforded the ability to hear the sound, and fit-in with the sound. These two task constraints can help to regulate performance options in many interesting ways.

Figure 40: ***S48.160825***, Thursday August 28, 2016, Unnamed Road, Port Kembla NSW 2505, ***34°27'44.0"S 150°54'06.6"E.***

Practice Session S95.170203, Bluescope Steel North Gate, Port Kembla

The location in Figure 41 provided playing information from the surfaces of the distant bridge, and the frog calls and insects in the marshland beyond the fence creating an incredible complex cacophonous texture to improvise with.

Figure 41: ***S95.170203***, Friday February 3, 2017, BlueScope Steel North Gate Car Park, Port Kembla NSW 2505, ***34°26'39.9"S 150°52'47.1"E.***

Practice Session S124.170309, Cordeaux Dam, Avon

Cordeaux Dam wall (Figure 42) provided variable surfaces and enclosures to explore with improvisational activities. This site afforded many different approaches, and educated the attentional and calibration aspects of my performance techniques. This type of experimental practice procedure was influenced by nonlinear differential learning approaches in which tasks, goals, or objectives are often implicitly discovered or unspecified. The learner is encouraged to experiment and explore – or merely experience – the constraint manipulation. Subtle shifts in trumpet direction or a change in the visual array initiated a whole new collection of constraints and affordances to discover. The educational benefit is in learning to attend closely to the shifts and changes, and to discover the connects between the actions being performed and the perceptual information that those actions create.

Figure 42: ***S124.170309***, Thursday March 9, 2017, Cordeaux Dam, Avon NSW 2574, ***34°20'20.8"S 150°44'51.8"E.***

Practice Session S130.170319, Cordeaux Dam, Avon

The enclosure of the dam wall pylon (Figure 43) afforded a rich reverberant performance space which caused an immediate shift in the performance coordination and control patterns. The change in environment acts a control parameter (or rate limiter) to the stable and attractive self-organised patterns of performance.

Figure 43: ***S130.170319***, Sunday March 19, 2017, Cordeaux Dam, Avon NSW 2560, ***34°20'10.0"S 150°44'43.9"E.***

Motorway contexts

The Motorway performance contexts were located along the M1 Princes Motorway that runs diagonally across and down the Illawarra Escarpment. The contexts were characterised by near constant vehicle noise – heavy trucks, cars, and motorcycles – and structural features such as large storm water drain pipes, bridges, water retention basins, and small culverts. The infrastructure affordances were explored and exploited in spontaneous musical ways. Of the three atypical performance contexts, the Motorway was the most challenging in terms of the environmental conditions for performance. However, the perturbations encouraged me to discover improvisational strategies to 'cope' with the situation, including imitation and integration with the soundscape.

A characteristic feature of the M1 Motorway context is its geographic location and the long and steep section of the topography. This causes the heavy vehicles to use regular gears shifts on the ascent, and the use of noisy drum or exhaust brakes on the descent. The close proximity of the Mount Keira escarpment face provides a reflective surface for the sound, causing it to amplify into the surroundings. Slowly evolving doppler-shifted truck brake sounds is a ubiquitous (and interesting) sound source at the Motorway sites. The following examples provides an overview of the key Motorway sites.

Practice Session S22.160717, M1 Motorway, Mount Keira

Figure 44 displays a view from a Motorway practice location. These were very noisy playing positions that heavily constrained the performance activities. The juxtaposition of the surrounding landscape with the road infrastructure offered interesting examples of the different patterns of organisation in land management. The metaphoric disparity between the straight lines of the built environment and the self-organisational and complex emergent shapes of the landscape provided the initial idea to 'decompose' (Sterelny, 2011) trumpet playing to the natural overtone series and bugle-call figurations of its signalling tradition.

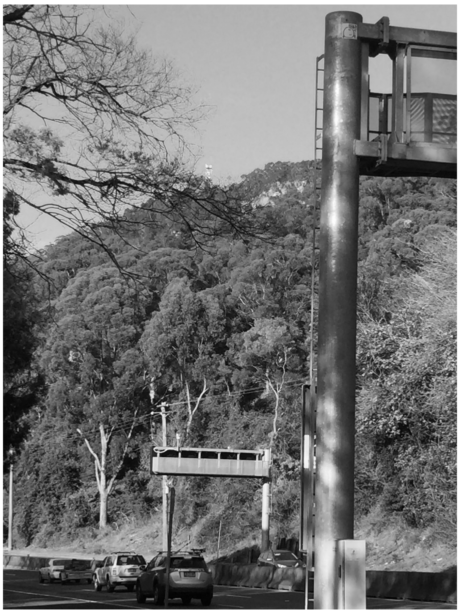

Figure 44: ***S22.160717***, Sunday July 17, 2016, M1 Motorway, Mount Keira NSW 2500, ***34°23'22.8"S 150°51'29.8"E.***

Practice Session S25.160722, M1 Motorway, Keiraville

The Motorway contexts offered environmental features such as these large stormwater pipes (Figure 45). Similar to the Cordeaux Dam pylon structures, these pipes afford a dramatically different acoustic environment which can regulate the performance actions into new exploratory behaviours. Many calibration discoveries were made within these unique performance structures, however, the transfer of the skills to ensemble performance was difficult to the idiosyncratic affordances of the pip structure. Valuable skills and materials were uncovered, however, which contributed in nonlinear ways to my overall intrinsic performance competencies.

Figure 45: ***S25.160722***, Saturday July 23, 2016, M1 Motorway, Keiraville NSW 2500, ***34°23'58.3"S 150°52'06.1"E***.

Practice Session S39.160814, M1 Motorway, Keiraville.

Figure 46 is an image of the same drain pipe illustrated in Figure 45, however, a change in position dramatically changes the affordances of the pipe structure. Sound production and direction are constrained into trying to 'activate' the pipe resonance in alternative ways, which can initiate a different set of performance calibrations.

Figure 46: ***S39.160814***, Sunday August 14, 2016, M1 Motorway, Keiraville NSW 2500, ***34°23'58.3"S 150°52'06.1"E.***

Practice Session S43.160819, M1 Motorway, Mount Keira

These small culverts (Figure 47) afforded a different resonance to the larger drain pipes. Performance in these locations was often constrained physically by the calibration of my playing posture. Crouching, sitting, or bending to activate the culvert resonance often created unpredictable changes in the performance characteristic of the body and instrument. For instance, a more vertical orientation of the trumpet (towards the ground) results in changes to the condensation within the mouthpiece cup and the instrument, which can be explored and exploited in unpredictable rhythmical patterns.

Figure 47: ***S43.160819***, Friday August 19, 2016, M1 Motorway, Mount Keira NSW 2500, ***34°23'23.2"S 150°51'29.2"E.***

Practice Session S36.160807, M1 Motorway, Keiraville.

Figure 48 displays a water retention system controlling the stormwater runoff from Mount Keira. The extensive water management systems surrounding the Motorway contexts provided metaphorical frameworks for thinking about musical activities – flows, streams, cascades, pools, retention basins, floods, dams. The complex dynamic hydrology systems of the Illawarra Escarpment became an overarching conceptual and metaphoric framework for my improvisations and the embodied phenomenal experience of the performances through the constraints of the atypical performance contexts.

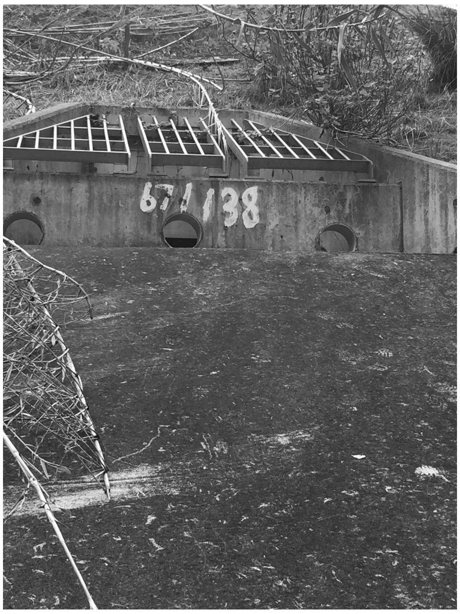

Figure 48: ***S36.160807***, Sunday August 7, 2106, M1 Motorway, Keiraville NSW 2500, ***34°24'03.5"S 150°52'08.6"E.***

Practice Session S16.160711, M1 Motorway, Balgownie.

Figure 49 is an image of a practice Motorway location which afforded environmental information from the highway, the acoustic qualities of the escarpment wall, and the distant view of the ocean horizon. This provided a unique meta-stable performance region whereby I was poised between different information sources and areas of attraction. The transitioning between these information attractors provided a unique set of performance constraints which could be usefully explored to discover new patterns of melodic organisation.

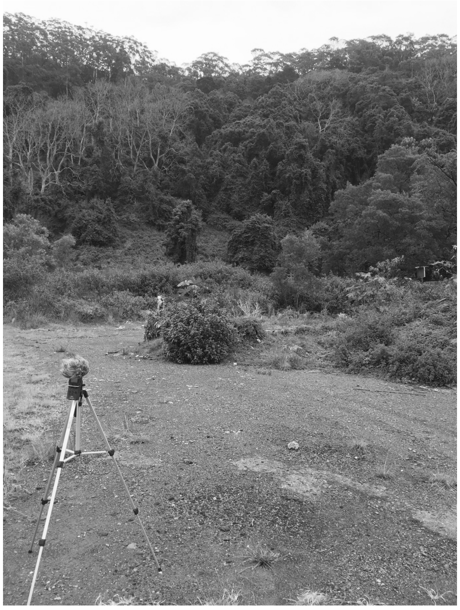

Figure 49: ***S16.160711***, Monday July 11, 2016, M1 Motorway, Balgownie NSW 2519, ***34°22'56.0"S 150°51'36.0"E.***

Summary

This section provided an overview of the atypical performance contexts introduced into the practice design of the research project. Three types of contexts - Landscape, Industry and Motorway - were selected to explore through spontaneous solo trumpet improvisation. A taxonomic organisation of the performance materials is presented in the following chapter. See Appendix A for the complete collection of atypical performance contexts and the recorded practice sessions.

Chapter 5

A Taxonomy of Materials

This section provides an overview of the types of motivic materials discovered and developed during the practice period. The motives have been categorised into three groups that represent different improvisational methods of organisation, including: (i) Referent type motives; (ii) Idiomatic type motives; and (iii) Interactive type motives. Table 1 provides an overview of the different categories.

REFERENT	IDIOMATIC	INTERACTIVE
Drone	**Noodle**	**Integration**
Chant	**Tweet**	**Entrainment**
Flute	**Articulation**	**Imitation**
Pendulum	**Jazz**	**Resonate**
Stream	**Bugle**	
Cluster	**Multiphonic**	
Array	**Microtonal**	
Fragmentation		
Transformation		
Repetition		

Table 1: An overview of the taxonomic categories of the performance activities.

The Referent group is a collection of motives which are based upon improvisational templates such as a stylistic framework, a contour shape, or a structural process. The Idiomatic types are discovered though the exploration of trumpet-specific affordances, including articulation patterns, technical adaptations, and the trumpets' characteristic pitch-space organisation. The Interactive motives emerge through a direct attunement of performance activities towards the surround surfaces, objects and events of the atypical performance contexts, and include processes of integration, imitation and spatial attunement.

The taxonomic organisation process provides a primary analysis of the performance outcomes and offers a simplified way of communicating the discoveries. The classification process has converted the raw data yield of 4779 session motives into generalised categories of description. The selected resolution of taxonomy is kept at the 'motive' scale of analysis. This provides a method for understanding the intrinsic variability of melodic approaches by providing a framework for comparative assessments.

Each of the motives is an emergent product of an ecological dynamics practice project. The application of a constraints-led approach to spontaneous trumpet improvisation has resulted in a wide variety of developments and discoveries. Recorded examples of the practice activities are offered within the thesis as the primary data outcome of the research project. As such, the provided audio examples are the richest way to communicate the research outcomes. Each recorded motive is offered as an original research contribution in its application of a nonlinear constraints-led approach practice design, and in the original primary content produced by the project.

Referent category

The referent category represents a collection of improvised materials that use a template as an organisational feature. The templates include (i) stylistic frameworks (Drone, Chant, and Flute); (ii) contour archetypes (Pendulum, Stream, Cluster, Array, Cells, Cycles, and Sequences); and (iii) operational processes (Fragment, Transform, and Repeat).

Drone

The 'Drone' is a type of simple melodic improvisation characterised by the use long sustained notes, often with circular breathing, and timbral manipulation. The Drone provides stability to the improvisational materials, and is often used as to establish a pitch centre within the unaccompanied context. I sometimes used Drone motives to provide a counterpoint to the environmental sound events. Throughout the project, Drone adapted into a fragmented version with Example 1 presents a selection of Drone motives.

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Example 1: Improvised Drone referent motives

Chant

'Chant' motives relate to a style of simple melodic improvisation reminiscent of vocal chant or hymn types of motives. Chant melodies are originally characterised by slow paced stepwise pitch movements in repetitive sequential rhythmic arrangements. I'm attracted to this type of motivic material because of the difficulty in making the trumpet express a simple voice-like quality, but also because this motive-type is very stable and reliable. Eventually this motive was adapted into more flexible and variable types of materials.

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Example 2: Improvised Chant referent motives.

Flute

The Flute refers to the influence of flute-like timbres, motivic gestures and ornamentation, in particular, the shakuhachi honkyo-ku repertoire and performance techniques (Franklin, 2008; Karhu, 2005; R. Lee, 1992; Watazumido, n.d.). This referent follows on from a long-standing personal interest in traditional Japanese music, and shakuhachi performance. Several different approaches to The Flute motive are demonstrated in Example 3.

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Example 3: Improvised Flute referent motives.

Pendulum

The Pendulum explores motivic development based upon repetitive patterns of register change and angular contour. The Pendulum emerged as a useful organizational strategy that expanded the sonic and melodic range of the instrument in its solo application. The Pendulum is expanded upon by fragmentation and repetition, and provides a melodic approach that is intrinsically rhythmical and metrically self-organising. The discovered Pendulum motives have become an important conceptual framework for my post-project melodic materials. See Example 4 for an overview of the variable approaches to The Pendulum.

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Example 4: Improvised Pendulum referent melodies.

Stream

Stream motives are rhythmically constrained continuous improvisations of rapid textural pitch densities. The Stream can be linear or a more complex waveform contour. Stream does not prescribe pitch or interval classes, but, the continuous task encourages conjunct stepwise motion. See Example 5 for several versions of the Stream.

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Example 5: Improvised Stream referent motives.

Cluster

The Cluster motive (see Example 6) constrains melodic improvisation into close arrangements of pitch within a very small interval range. The motive encourages the development of harmonically ambiguous static pitch densities, and often incorporates microtonal inflections by alternate valve combinations, circular-breathing and multiphonics. Clusters can be short in duration and embedded within a longer phrase structure, or longer durations of melodic development.

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Example 6: Improvised Cluster referent motives.

Array

Array is a melodic contour motive that generates a randomised pitch order over a wide range of the instrument. The Array approach creates a rich atonal resonance within reverberant spaces, and can contribute harmonically ambiguous and rhythmically varied melodic structures. Example 7 provides a selection of Array motives.

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Example 7: Improvised Array referent motives.

Cells

The Cells motive (see Example 8) is an approach to melodic invention based upon combing multiple cellular units. The motive allows for regular changes of direction and more easily affords natural breathing. Cells provide a high level of flexibility and complexity due to the capacity to combine multiple interval types in variable contour and articulation combinations.

The Cells approach emerged in direct response to respiratory constraints upon performance, which were experienced in many trials of the early practice sessions. I found it difficult to sustain a long melodic line in solo performance because of the frequent pauses for inhalation. Cells emerged as a way to fragment the melodies into small organisational units of monads, dyads, and triads, and I discovered ways to articulate these in interesting groupings of polyads. The Cells approach was a significant development to my performance conception, and represents a shift away from a long melodic line preference, to a more modular, flexible, and complex melodic patterning.

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Example 8: Improvised Cell referent motives.

Cycles

The Cycles motives organise cellular structures into repetitive configurations and elliptical patterns. Cycles create a complex combination of repetition and change, and contribute an interested approach to solo improvisation. The Cycles are interesting when combined with fragmentation and irregular pulse and rhythm. Example 9 illustrates a selection of Cycles and demonstrates the variable approach to the motive type.

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Example 9: Improvised Cycles referent motives.

Sequence

Sequence motives are repetitive structural units based upon representing a melodic idea in similar but varied iterations. Typically, sequences related to melodic motives being transposed to different scale degrees (i.e. diatonic sequences), or transposed into new key centres. In this instance, the Sequence method provides a pragmatic tool for motivic development and cohesion in combination with Cells motives. Example 10 illustrates a variety of Sequence motives.

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Example 10: Improvise Sequence referent motives.

Fragment

Fragment motives are adapted from other melodic types and contribute an irregular pulse and metric structure to repetitive melodic patterns, such as Pendulum, Cells, and Sequences. The Fragment materials are highly variable versions of repetition-without-repetition type performance. See Example 11 for a selection of Fragment activities.

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Example 11: Improvised fragmentation tasks.

Transformation

Transformation is a similar process-based motive as Fragment and Sequence. Transformation is a parsimonious sequence manipulation involving a section of a motive being developed (transformed) whilst the remaining notes repeats un-altered. This is a 'common-tone anchor' technique used to create cohesion and melodic structure. Transformation motives are adaptations of Cells and Cycles and add variability to established melodic figurations. Example 12 provides a selection of Transformation motives.

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Example 12: Improvised Transformation referent motives.

Repeat

Repeat is a fundamental motivic strategy exploring the many ways that repetition within spontaneous improvisation can create structure and cohesion. It is similar to the other process motives in that it is applied as a manipulation to pre-existing motives. Various applications of this motive are presented in Example 13.

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Example 13: Improvised Repeat referent motives.

Idiomatic Category

The idiomatic category of motives is a collection of responses to the atypical performance context based upon explorations of trumpet affordances. The idiomatic activities relate to music materials generated primarily through the exploration of trumpet-specific techniques and affordances. These include: (i) adapted exercises (Noodle, Tweet); (ii) articulation affordances (Sforzando, Staccato, Tongued-multiphonics); (iii) Jazz; (iv)Bugle; and (v) extended techniques (Multiphonics, Microtonal, Alternate Fingering)

Noodle

The noodle pattern combines and coordinates a sequence of valved chromatic clusters with a rapid lip-slur interval action. The action is named after a characteristic melodic movement introduced as a trumpet exercise by Frink (Frink, 2007; Frink & McNeil, 2003; Ganong, 2015). The drill targets trumpet embouchure stability and flexibility through the combination of a descending chromatic task with a harmonic lip-slur interval task. The noodle exercise action is adapted into this idiomatic strategy. Example 14 presents a number of Noodle motives.

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Example 14: Improvised Noodle idiomatic motives.

Tweet

The Tweet motive is an articulation pattern producing a rapid two-note slur and is another adaptation of a Frink exercise (Frink, 2007; Frink & McNeil, 2003) used to develop embouchure stability, flexibility and control. The Tweet combines a forceful single-tongue articulated note followed by an ascending or descending lip slur to a staccato second note.

Tweet motives are exploited to accommodate very fast changes of pitch, and is linked together into characteristic fragmented dyad streams. The tweet articulation pattern provides an agogic accent ornamentation similar to a reverse acciaccatura note, and develops precise coordination between the lip-slur action, air stream and the tongue action, and develop idiomatic skills for rapid register changes.

The Tweet pattern is often used for abstract imitations of birdcalls or frog-like rhythmic patterns and probe musical motives. It is capable of very short, sharp and high-volume materials. See Example 15 for a variable selection of examples.

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Example 15: Improvised Tweet idiomatic motives.

Articulation

Three type of high-volume Articulation motives are explored in the atypical contexts, including sforzando, staccato, and tongued-multiphonic patterns. These motives emerged from environmental constraints of spatial dimension. Large open environmental spaces afford high volume trumpet performance otherwise unavailable during indoor practice. These motives contribute interesting accenting potentials for melodic materials. Example 16 demonstrates several examples of sforzando, staccato, and tongued-multiphonic

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Example 16: Improvised Articulation idiomatic motives.

Jazz

Jazz motives explore various idiomatic combinations of articulation patterning used in jazz trumpet performance. These are typically described as ‘swung’ patterns and often utilise a ghost-tongue coordination pattern where the tongue partial obstructs the flow of air creating a percussive ‘dead’ note which sounds shorter, softer, and with an altered timbre. This type is articulation is used predominantly within streams of quavers in an ‘back-tongue’ configuration (which accents the off-beats of the metric structure) and in the pivot notes where a change of melodic direction is required (typically, the ghost-note is the lower pivot note). The change of timbre and percussive shortness of the ghosted note provides a way of creating rhythmic variation through the use of agogic accenting. Example 17 demonstrates several experimental applications of the Jazz referent.

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Example 17: Improvised Jazz idiomatic motives.

Bugle

Bugle motives are idiomatic skills and materials emerging from the affordances of the overtone series configuration of the instrument. The overtone series is exploited as an efficient interval scaffold enabling rapid register changes and complex contour creations. The Bugle motive affords Sequence structures and harmonic series Transformations, which includes transforming a motive by changing its harmonic starting position. Bugle materials are often embedded within Cells and Cycles. Example 18 demonstrates various examples of the Bugle motive discovered during the project.

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Example 18: Improvised Bugle idiomatic motives.

Multiphonic

Multiphonic motives explore the effects of the extended technique of trumpet multiphonics or note splitting. The motive is developed into several different types of effects, ranging from relatively stable multiple intervals, through to very unstable distortions of sound. The Multiphonic motives are discovered through random experiments with lip and air coordination patterns. The physical constraints of the trumpet afford the Multiphonic as both a product of the naturally occurring harmonic overtone series, and as a product of the instrument mouthpiece design which enables a player to calibrate their lips in variable ways in response to cup, rim, and bore dimensions. The Multiphonic motives are often discovered through interactions with acoustic characteristics of the environment. Increases in volume, for instance, can synergise a multiphonic emergence in accidental or unpredictable ways. Through attending to the haptic and auditory information of the Multiphonic, the motive can be stabilised for use as an expressive and expansive technique. A practical observation of the timbral manipulation includes a positive stochastic resonance effect upon the trumpet sound allowing for a decrease in performance volume output (positively impacting endurance and agility) with minimal loss of sound penetration or audibility. In other words, I discovered that adding some noise to the trumpet sound through extra buzzes or distortions allows me to have greater control of the instrument during performance. A selection of Multiphonic motives is presented in Example 19.

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Example 19: Improvised Multiphonic idiomatic motives.

Microtonal

Microtonal motives expand the tonal palette of the improvisational approach to trumpet playing. These motives were discovered and developed through experimentation with trumpet valve combinations and the possible variable valve options offered by characteristics of the natural overtone series. In certain partials of the series, the same approximate pitch can be found with multiple different valve combinations, typically with an identifiable small shift in tuning and timbre. This type of pitch degeneracy can be explored and exploited in various ways to create interesting textural effects and melodic motions. Many of the Microtonal motives were discovered through attempting to blend into the nontonal sonic environments of the atypical performance contexts. For instance, imitating a birdcall, or a truck pressure brake sound often involved calibrating the pitch centre of the notes. Attention to the haptic and auditory feedback provided learning opportunities in trumpet performance coordination and control. A selection of the discovered motives is provided in Example 20.

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Example 20: Improvised Microtonal idiomatic motives.

Interactive Category

This category represents a collection of motives discovered through explicit musical interactions with the surrounding environmental features. The motives include explorations of: the auditory scene (Integration); forms of synchronisation (Entrainment); abstract evocations (Imitation, Translation); and spatial activations (Resonance).

Integration

Integration motives are experimental and abstract attempts to incorporate my performance activities within the sonic niche of the environment. It requires an attentional focus upon the auditory scene and calibrate my performance actions to create a response which blends into the surroundings. The Integration is not intended to be camouflage of imitation, more an intentional focus upon making the materials sound like they belong in the environment. This is a creative response to the sonic affordances of the environment and involves the calibration of volume, pitch choice, rhythmic structures, and register. Integration motives are incorporated into Drone, Chant and Flute melodic conceptions. Multiple versions of Integration are presented in Example 21.

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Example 21: Improvised Integration interactive motives.

Entrainment

The Entrainment motives were created in response to environmental features which were incorporated as a constraining rhythmic pattern, and used to coordinate my spontaneous improvisations. Recurring but irregular pulse streams provided interesting frameworks to attune to. These elliptical rhythmic patterns have greatly influenced the adaptation of the Cells motives which afford a flexible approach to phrase construction and enable melodic materials to be continually calibrated in efficient ways to coordinate with unpredictable rhythmic structures. Entrainment motives were discovered whilst improvising with environmental features like breaking ocean waves of the ocean, rhythmic pulses of insects, frog call patterns, metronomically moving trees, recurrent vehicle noise, rainfall and complex birdcall timing structures. A selection of Entrainment motives are provided in Example 22.

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Example 22: Improvised Entrainment interactive motives.

Imitation

Imitation materials are experimental attempts to represent an environmental feature in an abstracted musical form. The Imitation is not supposed to be a literal attempt at simulation, but an intentional calibration of performance patterns to evoke a target source. These included birdcalls, truck exhaust sounds, frog patterns, and wind sounds. The evocation of environmental sounds provided an interesting approach to skill acquisition and motivic development, and initiated many unpredictable spontaneous discoveries and performance realisations. Example 24 presents a selection of different Imitation motives.

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Example 23: Interactive Imitation tasks.

Resonance

The Resonance motives explore the acoustic space of the environment. This type of playing creates reverberations and sound colour characteristic through register, articulation and volume calibrations. The intention to experiment with the sound features of the surfaces in sometimes guided by a distant view or object. The task to 'activate' an environmental response or 'reach' a distant object provides an effect external focus of attemtion that constrains the self-organisation processes of coordinating the separate performance elements into a cohesive synergy producing short, sharp, penetrating bursts of sound. A selection of Resonance motives is provided in Example 24.

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Example 24: Improvised Resonance interactive motives.

Summary

This section outlines the three general categorisations of improvised motives – referent, idiomatic, and interactive types - that describe the types of materials that were discovered and developed throughout the 12-month practice project. Each motive group was sub-categorised into separate example-types and illustrated with multiple version. The implementation of an ecological dynamics learning principle - task variability - produced many musical examples following a repetition-without-repetition improvisational framework. This section demonstrates many developmental outcomes emergent from the constraints-led approach, and provides musical evidence of the effectiveness of nonlinear pedagogical approaches to trumpet skill acquisition and development. These developments are explored and exploited in creative ways throughout *The Dark Pattern*.

Chapter 5

The Dark Pattern

This section presents the major creative output of my research project, and provides a brief introduction to the production procedure. The work is a recording of original contemporary jazz performances entitled *The Dark Pattern*. The music was composed, rehearsed and recorded at the conclusion of my 12-month constraints-led practice project, and is presented here as a demonstration of the creative performance application of the skills and materials developed throughout the practice period. The recording is considered to be an extension of the ecological dynamics approach and displays the creative potential of this method.

The work is submitted as an accompanying creative component of the thesis and is offered as an original contribution to contemporary jazz practice. The recording embodies the definitive statement and outcome of the research project. The performances captured and presented in the recording process are the primary source material of my research, and as such, stand alone as the principal form of knowledge production. The recording is presented as a complete knowledge artefact without analysis or exegesis, and is intended to be examined as sound information. As a work of art and a form of personal expression, the recording is offered here to be experienced as a creative product and opens itself to multiple subjective interpretations and experiences.

The focus of the recording project was to explore and exploit the technical and creative changes that occurred throughout the practice project. The music was conceived and composed to afford the variable types of improvisational strategies I had become attuned to using throughout the environmental practice period. The recorded trumpet performances, however, were made in a deeply intuitive, interactive, pre-reflexive and absorbed way. Each trumpet improvisation is to be understood as a spontaneous performance event emerging in self-organisational ways under the environmental constraints of the ensemble members, the studio space, and the recording equipment.

Participants

The recording features pianist Matt McMahon (b. 1971), drummer Simon Barker (b. 1969), bassist Brett Hirst (b. 1973), and tenor saxophonist Matt Keegan (b. 1977). All participants are professional musicians living and working in Sydney, Australia.

The performance was recorded and mixed by Richard Belkner at Free Energy Device, Chippendale, Australia, and mastered by Christoph Stickel at CS Mastering, Vienna, Austria. The completed recording was published by Earshift Music (EAR034) and distributed by MGM Australia.

Critical reception

The Dark Pattern was publicly released on August 8, 2019. It has received positive critical reviews and feature articles published by Australian media outlets, including *The Sydney Morning Herald*, *The Australian*, *Loud Mouth* and ABC Radio National's "The Music Show." The recording was nominated for the 2019 Australian Record Industry Association (ARIA) Music Award for Best Jazz Album, was a finalist for the 2019 Australian Music Prize, and was recognized as a "Best of 2019: Albums of the Year" in New York City Jazz Records magazine.

Chapter 7

Conclusion

This practice-led research project investigated the application of a constraints-led approach to jazz trumpet skill acquisition, creative development and performance. The project was completed in two separated stages. The first stage involved a 12-month practice intervention focused upon the exploration and exploitation of environmental resources for spontaneous trumpet improvisation through the integration of atypical performance contexts within the practice project.

The second project involved the composition, rehearsal and performance of original contemporary jazz music which was recorded and released as *The Dark Pattern*. The recorded work was intended to integrate and accommodate the technical and creative developments which were discovered during the environmental practice project. The work represents a significant and original creative application of ecological dynamics theory and method, and makes an original contribution to current understandings of contemporary jazz practice.

The atypical performance context practice project was guided by key principles of nonlinear pedagogy and implemented the practice ideals of self-organisation under constraints, as promoted by ecological dynamics. The improvisational activities were regulated in complex and implicit ways by the interacting constraints of the body, the task, and the environment. The important fundamental features of trumpet performance - including the portability, volume, and playing posture – provided the intrinsic dynamics that enabled the exploration and exploitation of environmental information sources through spontaneous improvisation. These exploratory activities reciprocally fed back into the discovery and development of new skills and materials. This learning process was highly self-organisational, implicit, unstructured, and emergent.

Ecological dynamics provided the theoretical and methodological framework for this alternative pedagogical approach to self-regulated learning processes, and offered the key practice design principles necessary for initiating and encouraging the self-organisational learning methods. The key features promoted by the constraints-led approach - task variability, constrain-to-afford, self-organisation under interacting constraints, and representative practice design – were guiding design features of my practice project. These were combined with nonlinear pedagogy theories of stochastic resonance, differential learning approaches and contextual interference to initiate and understand learning and development processes from a self-organisational and systems-based approach. In my view, these important conceptual learning frameworks offer a principled method for understanding skill acquisition and development in dynamic artforms like improvisation.

The practical application of the ecological dynamics perspective to my self-regulated learning process provided a valuable new way for an experienced and expert performer to methodically explore new ways of thinking about their creative practice – which often is reliant upon implicit and deeply procedural ways of working. The important attractor objectives of originality, efficiency and transfer, provided an evaluative and selective process which guided the performance activities into new and personally interesting areas to be explored in the recorded performance project.

The practice documentation procedures of recording, journaling and taxonomic categorisation provided me with the opportunity to informally appraise and reflect upon the learning process, and identify key improvisational strategies used to organise the performance activities.

The creative application of the skills and materials within a performance context provided the framework and motivation to discover and develop a new personal approach to ensemble-based music making. The resulting new work – *The Dark Pattern* – represents an important change in my technical and aesthetic preferences and abilities. In my view, the recording makes an important contribution to my working practices through the extension of the explanatory framework from ecological dynamics into creative music making. Self-organisational processes offer useful descriptions of jazz ensemble performance, and the nonlinear constraints-led approach advocated here is an effective and efficient way to encourage emergent performance activities.

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