DEVELOPING A PARAMETRIC SPATIAL DESIGN FRAMEWORK FOR DIGITAL DRUMMING

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ABSTRACT

This research operates at the intersection of music and spatial design within the context of improvised digital drumming. We outline a creative design research project founded on a series of affordance experiments that explore the ways in which the tools of spatial design can inform understandings of 'referent (Pressing 1987)' improvised patterns and phrases employed by experienced drummers. We outline the stages and process of development of a parametric computational framework using software from the spatial design industry to provide affordance (Gibson 1979) to understanding the complexities of drum improvisation.

The 'ImprovSpace' Grasshopper script, operating within Rhino3D™ enables the 3D spatialization of digital drum-based improvisations wherein the parameters of drum notes, duration and velocity all can be flexibly manipulated. Drum phrases and patterns can be compared individually and clusters of repeated elements can be found within a larger corpus of improvisations. The framework enables insights into the specific attributes that constitute individual style including micro-timing, rubato and other elements of style. It is proposed that, by bringing these improvisations into visual and spatial domain in plan, elevation and isometric projections, a theoretic musico-perspectival hinge may be deconstructed that provides insights for visually and spatially dominant musicians within reflective, educational and other contexts.

1. INTRODUCTION

This paper reports on early PhD project work founded on the practice of creative digital drumming as examined through a lens of spatial design. This research centres on the first author's creative practice as an architect and improvising drummer. Creative drumming, in this context, is the advanced playing of the drum kit with the express intention of exploring boundaries of timing, polyrhythm and space across solo and group contexts. Positioning the research on the intersection of the disciplines of music and spatial design allows theoretical, technical, representational and computational concepts and methodologies from one discipline to be used to examine the other. We are primarily interested in the ways in which spatial design tools can add to the body of knowledge in understanding musical improvisation.

The Field of Musical Improvisation (FMI) (Cobussen, Frisk et al. 2010) provides the theoretical and practical context within which creative drumming improvisations are performed. The FMI describes 'the precise progress and structure of an improvisation (as) essentially capricious,' 'between order and disorder, between structure and chaos, between delineation and transgression or extension'. In developing this parametric framework, we are attempting to make finite some of these aspects of the 'infinite' art of improvisation.

There has been a long history of architects attempting to translate music into architectural form and space. Martin (1994), in 'Architecture as a Translation of Music' established a model for the examination of music and architecture on three levels: 'Based on acoustics', 'Instrument as Architecture' and 'Layered Relationships'. Martin describes the 'y-condition' as 'the middle position of music and architecture when translating one to another,' finding an organic union between the two.

The computer thus serves as a good tool to facilitate these translations- particularly in the area of 'layered relationships'. The foundation of many music: spatial design (architecture) translations using the computer is the 'reduction of all information to a binary signal, be it a picture, a text, a space or a sound - all data is recorded as a binary sequence allowing computation as defined by programming languages and communication through networks according to transmission protocols' (Lab-au.com 2015). The principal that 'the byte shall be the sole building material (Levy 2003)' acts to enable compositional opportunities within the spatial dimension,. This also is reductionist, as not all of the properties of music can be translated adequately or completely. Mediating this 'y-condition' computationally requires the 'practiced hand' of the digital craftsperson (McCullough 1998).

MIDI data derived from digital instruments forms the basis for many translations from music into spatial design. Ferschin, Lehner et al. (2001) developed COFFEE™, a language for describing objects in space that extends the functionality of Cinema 4D™ for 3D modelling, rendering and animation. 'The main part of the translation process consists of a mapping of musical parameters, like pitch, duration, tempo, volume, instrument to architectural parameters as shape, size, position, material so that a piece of music in MIDI notation can be translated to a geometric structure containing shapes with materials'. Further parametric translations, framed as 'Spatial Polyphony' are undertaken by Christensen (2008), utilising MIDI musical data. Johan Sebastian Bach's The Well-tempered Clavier fugue is translated into ASCII text, imported into Microsoft Excel™ as numbers, then parametrically translated into form using CATIA™. Christensen concludes that the process, whilst limited, allows us to freeze the music 'in a single moment allow(ing) one to see the shape of the entire piece simultaneously, something which is not possible when listening to a performance'.

Marcos Novak has, over a long period and through many projects, proposed that these binary data can be crafted in a designerly fashion: 'the question arises: what to do with these data? What is an appropriate poetics for a world such as this?' He proposes 'Archimusic' as 'the conflation of architecture and music' within the realm of cyberspace. He states: 'Archimusic is to visualisation as knowledge is to information', and proposes virtual acoustic displays as the sonification of 'Archimusic'. *(Novak 1992- 2007).*

Architect Jan Henrik Hansen adopts figurative and literal translations in many built works of sculpture (musical sculptures) and building elements, merging music and architecture within private practice (Hansen 2015). Practitioners like Hansen, along with academy-based researchers above prove the potential for deep examinations of 'architecture as frozen music.' We are, however, less interested in translating music into architecture, but using parametric design tools to provide affordance for the understanding of the process of making music. The emphasis is not on how the spatial model looks in terms of aesthetics, but how it facilitates new understandings of, in this case, drum-based improvisation. We outline the process of exploration in meeting this aim below.

2. THE IMPROVSCOPE PROJECT

This research, operates within the modality of 'research *through* design (Downton 2003)' at RMIT University Spatial Information Architecture Laboratory (SIAL) Sound Studios between the authors' creative practice as practicing musician (drummer) and as a practicing architect. The 'ImprovScope' project involves first-person explorations of the author's improvisations on the electronic drum kit. This scoping out of the authors' solo improvisational capacities will serve the dual purpose of contributing to the body of knowledge in relation to musical improvisation and as the basis for further creative research projects, musical compositions and creative works (see www.soundcloud.com/jjham).

Playing drum-based improvisations involves instantaneous recall and action of combinations, patterns and polyrhythms brought about by a bodily engagement in the interface of the drum kit via a pair of drum sticks (hands) and feet. Solo improvisation relies on 'closed' skills (Pressing 1987) which operates without reference to the environment and confounding factors of working with, from and to other musicians. We focus on solo playing for this paper, however acknowledge the limitations of playing alone in the studio. Further project work will extend this research into the drumming of others using the same template, however we focus on the limited context of one drummer for this paper.

King Crimson and Yes drummer, Bill Bruford recently completed his PhD on the creative practice of expert drummers. Bruford creates a cultural psychology of the western kit drummer in order to reveal aspects of creativity in performance (Bruford 2015). This research provides a comprehensive basis for both validating drummers as artists and enabling understandings of the art of kit drumming.

The skills of an experienced drum kit practitioner reflects Donald Schon's concept of 'tacit knowing in action' (Schön 1983), wherein a set of 'referent (Pressing 1987)' patterns and phrases are recalled tacitly (without necessarily knowing one is doing it) and brought into action in response to internal and external stimuli. 'Referent' patterns and phrases (riffs) are the 'go to' repertoire that has been learnt, referenced (copied) from others, adapted, built up, evolved and stylized over the players' career. The quality and quantity of these referents vary greatly between players of different skills and experience. They define the players' style and, more than that: they become the player. For example, the dynamics, signature patterns and phrases of Bill Bruford are completely different to those of Terry Bozzio. Both drummers are known for their unique style, and this style is founded on the recall and application of their referent patterns and phrases within certain musical contexts. The hypothetical question arises as to how both these drummers would respond if asked to play a series of one-minute improvisations at 100 beats per minute? How could these be compared and contrasted and how could their unique styles be identified?

The first author, a musician and architect with approximately 35 years experience playing drums, acted as the drummer for this project. The project involved working on a basic template of playing 100 drum patterns in 4/4 at 100 beats per minute for 100 beats (60 seconds) across three contexts.

1. Beat and Fill: playing a range of improvised beats and fills at 100 BPM for one minute
2. Drum Solo: playing a range of improvised drum solo's at 100 BPM for one minute, and;
3. Studio Beats: playing a range of improvisations to an overlay of three separate improvised guitar tracks at 100 BPM for one minute.

The rationale was to provide some form of template for the improvisations that allowed enough time for a reasonable level of creative expression in drum improvisations, progressing through the variable stages of initiation, ideation, formation, thematic development, repetition wind down and completion. 100 BPM provided a reasonable tempo for playing that could be used across contexts. We acknowledge that different tempi and durations will produce different data sets, however by templating the research fewer variables come into play.

Drum improvisations were played on a Roland TD20™ digital drum kit recorded in Reaper™ DAW on an iMac desktop through a Focusright Pro 40™ audio interface connected by Firewire cable. Drums were recorded in MIDI format, with drum sounds modeled in the Drumasonic plugin in Kontakt™. Improvisations, which took place over a period of months in 2015 were recorded on a Go Pro™ camera and notes and reflections taken afterwards.

The Roland TD20™ drum kit consisted of six drum pads, snare, kick and four cymbal pads (refer figure 1).

Figure 1. Roland TD20 Digital Drum kit layout

2.1 Collation and Tagging

We conducted a series of affordance experiments to test ways of translating music into other domains for processing. The project resulted in the creation of a sample set of 170 one-minute drum improvisations across the three contexts. The first affordance experiment involved txt-based tagging. Drum tracks were listened to and analysed to identify signature 'referent' drum patterns and phrases, then cut and exported as individual MIDI files and tagged according to a schema, of 'timing'; 'style'; 'complexity' and 'beat type' along with other descriptors. MIDI files were then imported into a Devonthink Pro™ database and the Ammonite™ App used to provide tag clouds to allow the easy searching of tags across the range of phrases. (Refer Figure 2, below).

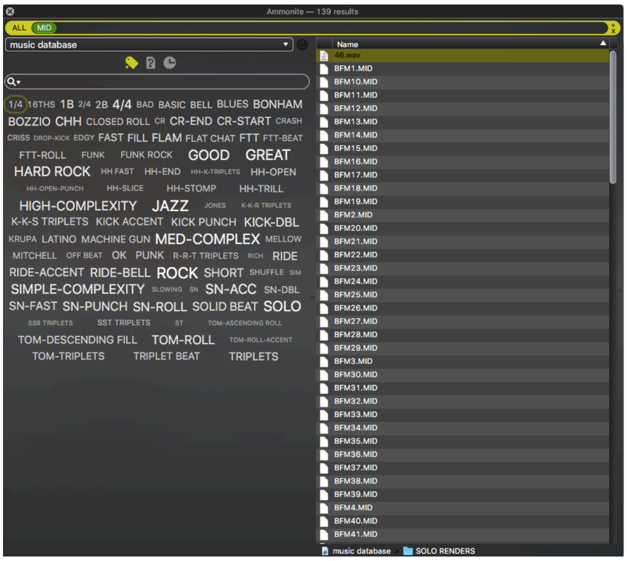

Figure 2. Ammonite Tag cloud (left) and Devonthink Pro file list (right)

These untagged MIDI files in and of their own constitute a series of data readable within a MIDI player or DAW. Importing MIDI files into MuseScore to produce scores enables trained musicians to read the notes, however contains none of the information regarding velocity, microtiming and the form and shape of improvisations. Tagging relies on word as descriptors for patterns and phrases however we needed to push the exploration further into the spatial domain in order to realize our research aims.

3. AFFORDANCE THROUGH PARAMETRIC SPATIAL DESIGN TOOLS

Breithaupt (1987) defined nine strategies for drumset improvisation that provide a context for analysis: Dynamics; Tempo (rate of strokes); Accents; Space; Double strokes/ sticking patterns; Hand to foot distribution; Motion; Special effects and Random use of all elements. These have been used to analyse drumming style of Jeff Porcaro (Artimisi 2011). Drum playing occurs as events in space and time, comprising form, shape, colour and texture. The question is, can spatial design tools offer insights into the morphology of individual drum improvisation, in terms of form, space and clustering of beats, phrases and patterns across large sample sets?

Muecke and Zach (2007) note: '*Performed in real time, music never exists as a whole at any given moment, but rather unfolds in a linear manner over time, and assumes an entity only in retrospect, in the memory of the listener or the performer. However reading a compositional music score is a process closer to perceiving space, as it exists as a whole at any given moment but may be retained by the observer only by a process of observation over time, walking around through, and above it'*. The problem is that many musicians (for example Jimi Hendrix, B.B. King and James Brown) cannot read music scores and that this inability to read may limit opportunities for learning, analysis and reflection-on-action (Schön 1983). In particular, we are interested in the affordance of opportunities for understanding for non-reading visual-dominant musicians.

Each musical interpretation tool, including traditional musical scores is founded on innate limitations and opportunities. For the mathematically inclined the Midi Toolbox (Eerola and Toiviainen 2004) allows Matlab™ analysis of note distributions, melodic contouring, tonality and a range of other functions. The Bol Processor 'produces music with a set of rules (a compositional grammar) or from text 'scores' typed or captured from a MIDI instrument (Bel 1998)'. Matlab™ and the Bol Processor offer mathematical analytical opportunities, however these require interpretive skills that many don't have.

Given the context of this research at the intersection of musical and spatial design domains, it is natural for us as spatial designers to search within their domain for tools, methods and media that provide affordance (Gibson 1979) to the complexities of drum improvisation. An 'affordance is what one system (say, an artifact) provides to another system (say, a user). The concept of affordance is relational because of the complementarity entailed between two interacting systems (Maier and Fadel 2009).'

3D CAD modeling provides affordances to break down the 'invisible perspectival hinge that is always at work between common forms of representation and the world to which they refer' thus acting to limit comprehension in design processes. Working beyond the limitations of the perspectival hinge requires training and experience. A person's ability to interpret the three-dimensional reality of a building through the representations of plan, section and elevation are at the core of the concept of the 'perspectival hinge'.

We are interested in the proposition of a 'musico-perspectival hinge' within the musical domain that acts between the musical output and the score. Just as architecture students limit their understandings of their building design through orthogonal drawings, musicians may also be limited in their understandings through traditonal scores. As spatial designers, we interface with design information visually and spatially every day- in the form of drawings, models, written notes and in Computer-Aided Design (CAD). We have thus attempted to mediate this 'musico-perspectival hinge' to bring into the spatial domain the outcome of split-second decisions on timing, drum selection and phrasing, complex overlays of polyrhythms and subtle velocity changes on the digital drum kit.

3.1 The Pure Data™ Patch

The second affordance experiment involved the development of a Pure Data™ patch that reads, records and plays MIDI drum improvisations, outputting MIDI data to a display window. This window provides an isometric projection of the MIDI data based on a representation of the digital drum kit with snare at centre, kick at bottom and radiating arrays of tom toms and cymbals (Refer Figure 3). Velocity is represented by note colour. Parameters such as velocity and note diameter can be adjusted. This patch brought drum-based MIDI information into the dynamic visual domain however we found imitations in readability, time fixation and location of events in time. Whilst the patch allowed 3D representations on screen, we found that it did not provide much meaningful information or means of breaching the theoretical musico-perspectival hinge.

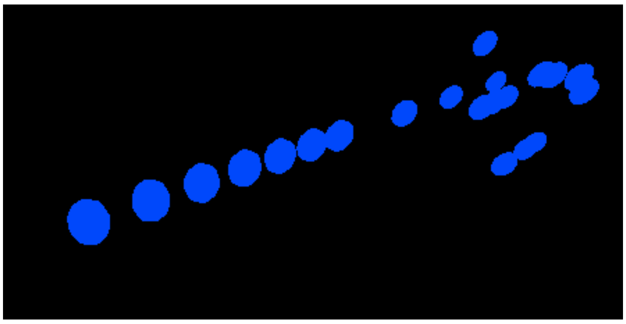

Figure 3. Pure Data Extended patch display

3.2 The 'ImprovSpace' Grasshopper Script

The third affordance experiment involved the use of Rhinoceros3D™ v5 with the Grasshopper™ (GH) plugin to build a flexible parametric framework that enables spatialisation of MIDI drum improvisations in plan, section, elevation, perspective and isometric projections. Parametric digital design, unlike other forms of 3D CAD modeling, (in this case) is based on basic user defined mathematical rules, which can be manipulated to alter 3D virtual objects. These basic user defined mathematical rules are based on the parameters within raw MIDI file reformatted into a comma separated value (.csv) file using the open-source Sekaiju application. The Grasshopper™ script reads data from columns in the .csv file for tempo, 'drum note', 'velocity', 'note on' and 'note off' over time to 1/1000ths of a beat accuracy. These data are separated and sorted using standard Grasshopper components to result in a series of points in space for each drum note with velocity and note length data attached. The virtual sequencing within the redefined midi.csv matrix allowed for basic manipulation of virtual spatial representations of instrumental sounds. The GH interface allows the additive manipulation of spatial data and the ability to use 'sliders' to review multiple .csv files. MIDI data can also be compiled so that several drum improvisations can be overlaid onto each other to identify repeated themes and patterns.

Once the MIDI.csv files are imported into GH as data streams, many spatialization options are available. A process of design exploration examined the ways in which drum improvisations could be represented meaningfully as vectors, curves, surfaces and meshes. A key attribute of parametric modeling is the ability to design spatial elements through the manipulation of the parameters. Thus models are flexible, and can adjust to enable the exploration of options during the design process. The framework we have developed allows this across multiple parameters easily and effectively.

We adopted a stylized representation of the drum kit that related directly to the playing of the drum kit (See figure 1, above). The ImprovSpace GH script stylises this representation of the drum kit in a way that is intended to be easy to interpret and understand as a semiotic or symbolic representation, and in 3D as a representation of patterns and phrases over time. The layout is based on the Snare drum at the centre of two Golden Section spirals-one to track tom toms and a second to track cymbals (Refer Figure 4, below). These drums are colour coded to allow further visualization and understanding of the drums.

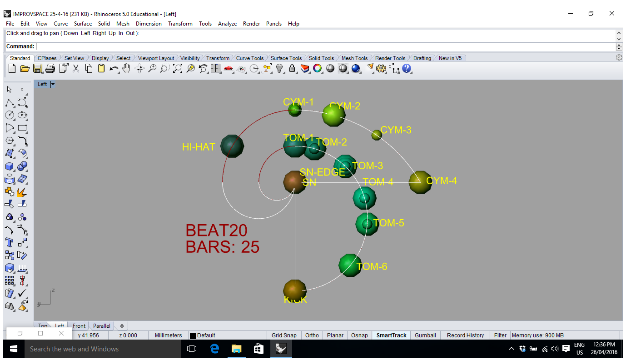

Figure 4. Schema for the representation of the Digital drum kit

This spiral frame in the X-Y plane is arrayed into the Z plane, with each array representing a beat or solo at 100 BPM for the bar length of the improvisation, pattern or phrase. This enables a temporal fixation to the theoretical time structure of the Beat and Fill, Drum Solo, Studio Beat or smaller phrases derived from longer improvisations. Drum improvisations are represented in plan (top left), elevations (bottom left and bottom right) and isometric, perspective or other projection (top right) (Refer Figure 5) and can be animated and 3D printed as haptic music scores.

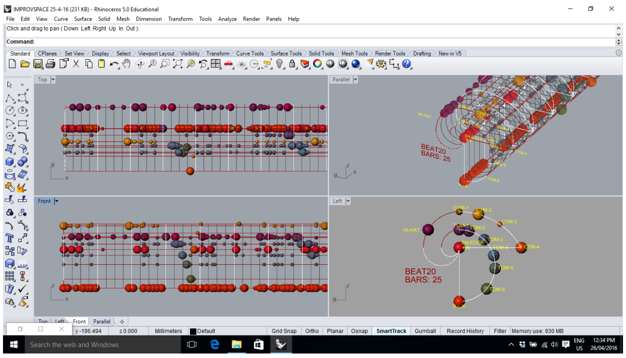

Figure 5. Rhino3D ImprovSpace GH script screenshot of Beat and Fill improvisation No. 20.

100 ‘referent’ samples from the ‘Beat and Fill’ and ‘Solo’ improvisational contexts have been extracted to provide a lexicon of the scope of improvisational referent drum patterns and phrases. Tags associated with these samples have been added to a separate .csv file then read into the ImprovSpace GH script. This allows for the cross-referencing of text-based information with the spatialised output. Using the Slider in the GH script, users can cycle through the 200 samples, quickly accessing text tags, plan, elevations and isometric projections (Refer Figure 6). The complementarity of this interface allows shortcomings of understanding in one viewpoint to be compensated for in another.

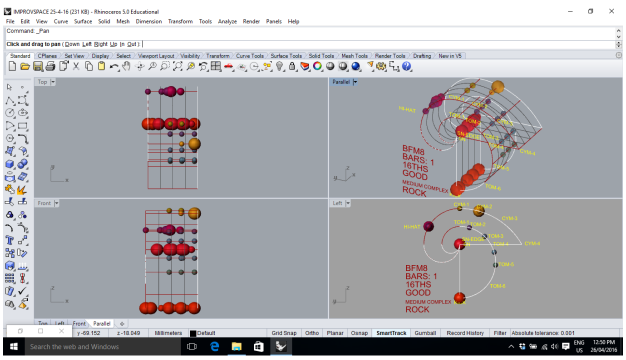

Figure 6. Rhino3D ImprovSpace GH script screenshot of Beat and Fill Sample No. 8.

3.3 Design Development

The development of the ImprovSpace GH script was a design exercise undertaken by musician/ spatial designers. This design process involves reflection on the usability of the script, problems and opportunities for further research. The development of the script brought a Eureka moment when, after working through tagging and the PD patch, a full 3D model of each improvisation was available. As a non-reading spatially-dominant musician, opportunities were created to access multiple ‘referent’ patterns and phrases quickly and effectively. By bringing these into the spatial dimension, we argue that they have more meaning for us. Patterns can be overlaid onto one another, quantized patterns compared with unique user patterns, and users can be compared with one another.

This can be provided for in the home studio using relatively cost-effective tools such as a PC laptop, Reaper™ DAW, Rhino3D™ and MS Office™ suite. The limitations of computational capacity are felt when large compilations are inputted into the GH script. This is a function of the large number of drum events being played being computed. In the case of comparing all drum Solo’s, the computer locks up when computing 120,000 drum events, making analysis difficult.

The ability to rotate views, zoom in, pan in the Rhino3D viewports provides considerable affordance to understanding drum improvisations in the spatial dimension. This is further enhanced by the multiple spatial outputs available and the flexible modeling of notes, velocity and duration. As a framework, this provides considerable research potential for other musicians to develop understandings of their music within a reflective and educational context.

4. FURTHER RESEARCH

This particular method of data manipulation is not limited to just drum beats – the midi.csv format can support other instruments where the pitch of the notes remain the same for their duration (‘note on’ to ‘note off’). More sophisticated clustering of riffs, sequence similarity criterion, classification of certain musical phrases based on predefined user criterion (such as tempo or velocity variation e.g. *accelerando, ritardando, crescendo, decrescendo*) could be applied. However, the computational effort required for such classifications may require lower level computer languages (more computationally efficient than the graphical scripting capabilities in Grasshopper3D). Though, embedding custom components within the Grasshopper environment to manage heavy computational tasks may be an option.

The next stage of the research utilizes the ImprovSpace script to compare the styles of different drummers. We have conducted further affordance experiments in the area of 3D printing and Virtual Reality applications.

As musicians and spatial designers, we are interested in cross-over opportunities into the realm of digital craft. Although the project started on the premise that the focus was on process and not product, as a by-product, we have found a unique means of generating complex spatial forms that reside within contemporary musical practice. As spatial designers, this improvised outcome has triggered unforeseen artistic spatial design opportunities (Refer figure 7, below). These opportunities are being explored in association with musical opportunities derived from composing with the MIDI samples using layering, processing and other techniques in Kontakt Battery. Further potential is being explored in the 3D printing of drum improvisations, patterns and phrases and the capacity for these to be able to read and interpreted by musicians.

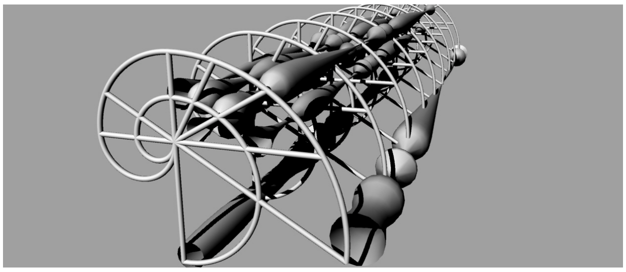

Figure 8. Rendering of lofted artistic representation.

5. CONCLUSIONS

We have outlined a series of creative practice affordance experiments that explore the translation of music into the spatial domain. This has culminated in the development of the ImprovSpace Grasshopper script that utilizes a 3D symbolic representation of the digital drum kit that can be read in plan, section, elevation and 3D. This parametric computational framework allows the flexible manipulation of the parameters of drum-based improvisations to be adjusted to provide affordance to new insights into the elements of micro-timing, polyrhythm, drum selection and other factors that make up an individual style. The framework allows non-reading visually and spatially dominant people opportunities for further understandings of their lexicon of patterns and phrases that make up their style. As such, this appropriation of technologies of the spatial design domain gives meaning to the 'infinite art of improvisation' within a musical domain. Although we focus on the development process for this paper, we see considerable opportunities for this musico-spatial design practice to enable deeper understandings of both domains, and the spaces between. Thus, the research presented forms the basis for further exploration in the form of 3D printing, cross-drummer comparisons and musical and spatial design experimentation.

Acknowledgments

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