Improvisations in Polyrhythmic Spatiality

Jeremy J. Ham
RMIT, Melbourne, Australia
Jeremy@surfcoastarchitecture.com.au

Abstract: This paper outlines creative practice ‘research through design’ project work wherein musical improvisation on the digital drum kit forms the methodological basis for an examination of the “Y-Condition” between music and architecture as applied to design process. Through the mass generation of drum data and the translation into the spatial domain using parametric digital design tools, spatialization of a corpus of polyrhythmic drumming in a solo context is enabled. This process enables novel models of musical analysis and representation, and also provides opportunities for a post-Xenakian integrated ‘musico-spatial design’ creative practice to emerge.

Keywords: Music and Architecture, Design Research, improvisation, parametric digital design, design process

1. Musical Improvisation as Design Research

This paper outlines elements of an integrated music-architecture research project that aims to explore the intersections between domains of creative practice. Broadly, the research aims to explore the following:

- The complexities of polyrhythmic drumming in terms of both performance practice and the musical outcomes;
- Improvisation as a generative methodology;
- Methods of using the tools, media and methods of architectural design to spatialize elements of drum based polyrhythms;
- The merging of the practices of music and spatial design, towards a novel integrated ‘musico-spatial design’ creative practice.

From these broad aims, this paper will address the principal research question addressing how polyrhythmic drumming can be brought into the spatial domain using parametric digital design tools as a means of notation and representation for the purposes of furthering understandings of the creative process. The research methodology is founded on the principles of design research as ‘research through design’ (Downton, 2003) wherein ‘designing is also a way of conducting research of the kind that design undertakes and, by this means, of producing knowledge for use in designing’. I propose that the act of making music through the interface of a musical instrument is a design activity that shares parallels with
the act of designing architecture through the interface of the pen, ruler and computer. This designerly engagement in the instrument or interface is a means of creative expression, problem solving, communicating and collaborating. Whilst there are great differences between the act of composing or improvising a piece of music and designing a building or spatial element, there are also similarities that are worthy of study.

Donald Schön (1983) has provided the basis for an understanding of how designers think, act and reflect on their work in a cycle of ‘reflection-in-action’ as ‘reflective practitioners’. Drawing upon years of lived and designed experience, the mature designer embodies a body of knowledge and skills that inform design activity as ‘tacit knowing-in-action’. Thus, designers design without necessarily knowing how they design. Musicians are ‘designers’ who ‘design’ in real time in a solo or group capacity. The design activity embodied in the creation of music in one of its many forms involves the processing of real-time decisions, reactions and responses that is informed by a body of knowledge and practice. Music-making as a form of design activity occurs in real-time, with split-second “live” delineation between ideation and output. Great live bands work together with great energy to create complex and creative music, alive with energy. The source of this energy is the musicianship built up over years of practice enhanced by the synergies of performer interactions and the unexpected outcomes that arise from improvised music.

I propose a process of musical improvisation as a methodological basis to explore the outcome of musical ‘design decisions’ and to provide the data for translations into the spatial realm. Improvisation is a complex creative activity that is the subject of much research. Improvisation involves the contemporaneous activities of composition and playing with a set of control parameters that include ‘form, timbre, texture, articulation, gesture, activity level, pitch relationships, motoric ‘feel’, expressive design, emotion, note placement and dynamics. Improvisation occurs with millisecond response times, with neuronal transmission from auditory stimuli being activated 8-9 milliseconds after stimulation, playing within a ‘closed’ or ‘open’ context (with or without external stimuli) (Pressing, 1987)’. The practice of improvisation occurs within an evolving complex system referred to as the ‘Field of Musical Improvisation (FMI)’ that explores the relationship between the actual improvisation (aesthetic choices, technical abilities, formalistic features, inter-musical knowledge), environment (technology, acoustics) and the social (artistic, ethical) behavior of the musicians mutually as well as of performers and listeners (Cobussen et al., 2010). Improvisation may occur across a wide range of musical scenarios ranging from small variations on an existing format to so-called ‘free jazz’ wherein musicians improvise in a continually evolving flow (Benson, 2003).

Spatial designers also engage with a large number of design parameters that are determined by the brief and site, and evolve over the course of ill-defined and ‘wicked (Rittel and Webber, 1973)’ problem solving and making. Whereas the physical parameters that comprise a building may include form, mass, void, fenestration, material, structure and services, the means through which architects consider, design and arrange them to form a building is long and slow, and often is reliant on the input from specialist consultants. Perhaps the most appropriate way to consider the commonalities in music and architectural design activity is to relate the improvisation to the sketch. Both of these design activities involve initial creative responses to a set condition or problem, are low risk and are generally spontaneous.

2. Drumming as Creative Practice

The creative practice at the heart of this paper is the merging together of the author’s dual practices of architecture and digital drumming and furthers previous research relating to music and parametric spatial design improvisation and 3D Spatial Drum Notation (Ham, 2016; Ham et al., 2016; Ham, 2017; Ham et al.,
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Whereas drummers are often societally defined by one or more negative ideological tropes that are founded on aesthetic/mind versus hedonistic/body, racism, the downplay of intellect and prejudice against unpitched instruments (Bruford, 2015), drumming is actually a complex activity that requires highly evolved spatio-temporal awareness, hand-eye co-ordination across all four limbs, musicality and physical fitness (Unknown, 2008) and intelligence (Cleland, 2008; Jones, 2017).

Drummers ‘play’ with the musical parameters available to them during performance to construct beats, fills and in the generation of drum solo work. King Crimson drummer, Bruford recently completed a PhD on the creative practice of the western kit drummer. He defines a ‘Functional- Compositional Continuum (FCC)’ wherein drummers’ ‘functional practice seeks to establish stylistic competence, (whilst) compositional practice seeks to establish stylistic individuality, commonly manifested in choices surrounding the embodied constructs of ‘touch’ and ‘feel’ (Bruford, 2015). Bruford defines the four ‘levers of control’ as the temporal, the metrical, the dynamical and the timbral as forming the foundation for drumming performance. Creative engagement in exercising these levers of control over a performance career helps define a set of ‘referent’ patterns and phrases that define the performers’ musical style (Pressing, 1987). Thus, creative drummers operating on the compositional end of the FCC possess a refined capacity to produce complex polyrhythmic drum patterns: by the velocity-controlled placement of layers of drum notes, using all limbs, in and around a set temporal structure to deliver a designerly musical intention or response.

Polyrhythmic drumming forms the temporal foundation to complex music such as Latin, Jazz and African music. Polyrhythmic drumming involves the playing of overlays of differing numbers of notes between two or more limbs across a common time signature. As an example, a simple 3:2 polyrhythm may involve repeating three strikes on a snare drum at the same time as repeating two strikes on a bass drum. The production of polyrhythms ‘require(s) the simultaneous production of two conflicting but isochronous motor sequences (Summers and Kennedy, 1992). Jazz music, for example, is defined by a ‘swung’ 3:4 or 3:2 beat, as a series of triplets played on a cymbal over a 4 or 2 count on the bass drum and snare, played at a set tempo.

Music, and cultural associations with music, are directly related to the time signature. As music has evolved through the ages, dominant time signatures have changed from 2/4 for marches, 2/4 time for waltzes, 6/8 for jigs, 12/8 for shuffle blues and doo-wop and 4/4 time for modern day rock music. In the domain of western rock music, performers such as The Mars Volta, King Crimson, Mastodon, SoundGarden, Lamb of God and Frank Zappa utilize the drummer to provide complex polyrhythmic beat structures as the foundation for even more complex overlays of instrumentation. Zappa, in particular, was known for composing extremely complex song structures of high ‘statistical density’ such as ‘The Black Page’. Virtuoso drummers such as Terry Bozzio, Thomas Prigden, Stuart Copeland, Jo Jo Mayer and Brian Dailor provide the model for how highly compositional drummers have complete bodily engagement in the instrument to produce highly complex polyrhythmic patterns and phrases through improvisational processes in real time, in solo and accompanied contexts.

3. Spatializing Polyrhythm

The great Iannis Xenakis provides the model of how practitioners with dual skills can engage creatively in the musical and spatial domains separately and through integration. Much work relating to music and architecture occurs, however, in one domain or the other. Elizabeth Martin proposed the idea of the ‘Y-Condition’ as ‘the middle position of music and architecture when translating one to another (Martin, 1994), however my interest lies in the Y-Condition as applied to the creative process and built or modelled
manifestations of music. Instead of playing on the paradigm of ‘architecture as frozen music (von Goethe, 1832)’, my research is concerned with ‘architecture (or, more appropriately, spatial design) as frozen process’.

Whilst significant work has been done on the computational mapping and translation of ‘music into architecture’ this work has principally involved the translation of extant bodies of music. Christensen and Schnabel (2008) translate a collection of 48 of Bach’s fugues into the spatial dimension as ‘a family of forms, aiding comparison and improving the depth of analysis possible’. Explorations by Ferschin et al. (2001) and the built work of Steven Holl in the Stretto House all provide a spatial foundation founded on the music of deceased composers. Music-architecture practitioner Jan Henrik Hansen activates the process by involving composition and playing for some of his ‘musical sculpture’ works (Hansen, 2015), however the act of making spatial elements is given precedence over the act of making music in many cases. For this research, the musician-architect is at the centre of the research as the agent for the active generation of drum music through live (studio) performance.

The founding principal is that the musical outcome of improvised performance is musical data. These data can form the ‘sole building material’ for a ‘data representation architecture that comes from the combination of architecture (design discipline), data (basic information/raw material), and representation (set of organized signs used to express data) (Levy, 2003). The Musical Instrument Digital Interface (MIDI) format provides the data foundation for the research through the recording of hundreds of improvisations on a Roland TD20 digital drum kit in MIDI format using the Reaper Digital Audio Workstation (DAW). MIDI data is exported and translated into Microsoft Excel (.csv) format for purposes of spatialization.

The principal measurable parameters of a drum performance on the digital drum kit are as follows:

- **Drum notes**: These include digital sensor pads that emulate an acoustic drum kit and sound like a snare drum, hi-hats, bass drum, tom toms and cymbals;
- **Drum events over a timeline**: The selective placement of drum notes over a timeline
- **Drum Tempo**: the temporal foundation of a performance, measured in beats per minute (BPM);
- **Velocity**: the force at which the drum pad is struck;
- **Note Duration**: the duration of the note, measured in seconds.

The complexities of this temporal, metrical, timbral and dynamical improvised play have been spatialized through a series of Rhino3D™ Grasshopper™ definitions that translate MIDI parameters into the spatial dimension as notation (Ham, 2017) and representations in CAAD environments and Virtual Environments (Ham et al., 2017). These translations act to continue the creative process from the domain of music into the spatial domain, thus constitute a series of improvisations and compositional processes in themselves. This continuum of performance to notation to representation provides the foundation of an inter-disciplinary practice that integrates the creative practices of music and architecture. Drum improvisations, performed by the author as a musician in the musical domain, are brought into the spatial domain wherein spatial aesthetic and analytical design decisions are made by the author, as an architect. Parametricism allows complete flexibility in representations, so that lengths, heights, ratios and relationships between elements can be manipulated within GH to produce a wide range of spatial outcomes. Figure 1 illustrates four ways of translating and spatializing drum data as a 3D Delaunay lattice structures (image 1 left), panels (image 2), tunnel (image 3) and column forms (image 4 right).
4. Spatial Representation of 100 Drum Solos

The methodology for this project involves the performance of a large number of improvisations on the digital drum kit by the author. In the initial exercise, one hundred 60-second drum improvisations were performed across three categories that are reflective of contemporary performance practice: playing drum beats with improvised ‘fills’ (short breakouts from the beat structure), free form drum solos and drumming along to a three-part piece of guitar music (300 total improvisations). The 100 BPM template is representative of mid-range tempo structure whilst one minute improvisations allow enough time for the drummer to initiate a start and finish section and to evolve a theme or idea. The process of mass improvisation is intended to allow the definition of a personal lexicon of drumming patterns and phrases as a ‘polyrhythmic idiolect (Gander, 2017)’ or lexicon of ‘referents.’ A referent, in the context of drumming, is a pattern, phrase or ‘riffs’ that is drawn upon in improvisational situations (Pressing, 1987) as ‘tacit-knowing-in-action (Schön, 1983).’ In performing this exercise, I am also mindful of the way in which a previous iteration informs the outcome of subsequent iterations. As Fischer (2008) states: ‘Two different designers cannot be expected to design in the same way, nor can one designer be expected to design in the same way repeatedly (the same applies to learners and learning).’ From this, one would expect elements of repetition and development of referent patterns and phrases over the course of the research, and for new learning and evolution of nuances and modifications to patterns and phrases to occur.

Figure 2, below, illustrates the representation of drum data as a ‘tunnel’ form (left) and ‘column’ form (right). In the tunnel form, drums are arranged in order from the bass drum (bottom) tom toms, snare (middle), cymbals and hi-hats (far end). The time duration of the drum solo is represented as a series of arcs rotating clockwise. When drums are played during a solo, data points are created along these arcs, with the ‘bumps’ radiating out from the arcs representing the velocity at which the note is played (i.e. how hard the drum skin is struck). To provide a thickness to the solid, note durations of each note played at certain velocities are represented as extensions of the velocity ‘bump’. The column form translates this definition, with drums arranged vertically. The ‘form’ of the drum solo is provided by placing a lofted surface over the data points in GH.

This representation of digital drumming reflects the ‘liquid architectures’ of Marcos Novak (Novak, 2007) however the intention is to balance a readability and interpretation of the drum solo with the exploration of new ways to generate novel spatial forms that reflect the polyrhythmic complexity of the drum solo itself. The same drum solo is represented as tunnel (left) and column (right) forms in Figure 2, below. The more ‘full’ the form is, the more drums have been played across the timeline, with time in the
tunnel form arcing 180 degrees, and 360 degrees for the column form. Figure 2 illustrates a solo with a dominant usage of the bass drum, minimal tom-tom usage and high velocity hi-hat hits later on in the solo. Tunnel forms reveal a different information set than column forms, and each form can be adjusted parametrically to accentuate different parameters and reveal further insights into the improvisation. Through training, one can intuit elements of this musical structure into the spatial forms and gain understandings of the meaning of the spatialization.

![Figure 2: Digital Drum data as Spatial Forms (tunnel form to left and column form to right).](image)

When the complete set of 100 drum solos are brought together as ‘tunnel forms’ (Figure 3) and Delaunay Lattice Forms (Figure 4), the form, shape and patterns of the drummers ‘polyrhythmic idiolect’ emerge in the spatial domain. Lofting provides a draped surface over the data points including velocity and note duration and, when the architect’s imagination is engaged and parameters are adjusted appropriately, graceful 3D objects emerge that are easily imaginable as massing options for a bridge or tunnel structure. As drummer and architect, these forms are not just the outcome of a parametric process, but have a personal meaning as the definition of my drumming style manifested in spatial form. The key here is the engagement in a design process that provides a line of continuity from the musical domain into the spatial domain. This Xenakian approach has much potential for further development, with the potential to continue into digital fabrication and realization at 1:1 scale.

The removal of the 3-dimensional spatialization of velocity and note duration of Delaunay lattices in Figure 1 (left) affords the emergence of a complex set of patterns of the 100 drum solo improvisations. The Delaunay GH script seeks to find the nearest data point to form a triangle. This triangulation particularly highlights areas within the drum solo timeline comprised of clusters of fast repeated notes, open spaces in the solo and deformations of the square lattice outline brought about by decisions not to play certain drums until mid-way through the drum solo. Whilst the lattice structures could be easily imagined as a set of design studies for façade structures, the focus at this stage is to provide a spatial manifestation of a large data set that is otherwise unavailable from recorded sounds or traditional notation and complements current research on Music Information Retrieval and music visualization techniques (Hunt et al., 2017).
Figure 3: Spatialization of 100 drum solos as tunnel forms.

Figure 4: Representation of 100 drum solos as 2D Delaunay Lattices.
The final spatialization reported in this paper is the composite 3D spatial representation of the improvised drum composition ‘Layered Relationships’. This piece was composed by the overlay of six polyrhythmic drum-based improvisations, with each layer purposefully referencing the previous to form a ‘wall of sound’. For this composition, a range of synthesized Virtual Instruments were used as a way of transforming the digital drum kit away from traditional drum sounds to include sampled environmental sounds, keyboards and other experimental sound sources. This sonic exploration by the musician-architect is complemented by explorations in the spatial domain so that the initial improvisations push boundaries in both domains. The result is a highly complex spatial layering that reflects the polyrhythmic complexity of the drum performance. This spatialization of multi-layered polyrhythms illustrates the potential of the parametric spatialization method outlined above and the potential for creative outcomes in both the musical and spatial domains.

Figure 5: Composite spatialization of the ‘Layered Relationships’ drum composition

5. Conclusions and Further Research
This research provides an insight into a larger creative practice PhD that explores the nexus between music and architecture/spatial design. The key to this research is the active engagement of the practitioner in both the musical and spatial domain, with the process of musical improvisation as providing
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This pathway- from the domain of music into the domain of spatial design affords opportunities for creative representations of music- as data. Whilst the eternal reference that ‘architecture is frozen music’ attributed to von Goethe (1832) casts a shadow over this research, it is contended that architecture is, in fact, architecture- and music is music. But between these domains, lies a pathway of creative practice- a ‘musico-spatial design’ creative practice wherein practitioners skilled in both music and architecture can explore the scope of their own work, taking from each domain as appropriate to provide affordance (Norman, 2002) to their understandings of their own practice.

From this initial stage of reflection and analysis, arises opportunities for a new creative practice that merges and integrates music and architecture and redefines Elizabeth Martin’s “Y-Condition” as the intersection of practice and process, and not the intersection of musico-architectural form or product. Whilst the research presented here is based on drum based improvisation- as music- future research is concentrating on the idea of ‘spatial improvisation’. Spatial improvisation involves the adaptation of digital drum performance to the designerly manipulation of the parametric model for the production of pre-conceived or novel spatial outcomes. These spatial improvisations are being explored in Virtual Reality, with real-time feedback enabled between the musical output and the 3D spatialization. This brings in concepts of ‘re-improvisation’ and feedback loops between improvised drumming, 3D polyrhythmic spatialization in VR and subsequent improvisations in response to spatial output. These explorations are actively seeding a new form of integrated musico-spatial design creative practice that furthers the aspirations of the late, great Iannis Xenakis.

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