SHUFFLE OVER: ALEATORIC ELECTRONIC SCORES FOR PERCUSSION NOTATION REPRESENTING SOUND AND GESTURE

Louise Devenish
University of Western Australia
35 Stirling Highway, Crawley WA

Cat Hope
Monash University Wellington
Road, Clayton VIC

Aaron Wyatt
Monash University Wellington
Road, Clayton VIC

ABSTRACT

This paper provides an overview of the approach and techniques used to represent the music notation of two works by Cat Hope for percussionist Louise Devenish: *Sub Aerial* (2015) and *The Past Is Singing In Our Teeth* (2017). Both works use a unique iteration of the Decibel ScorePlayer iPad Application which offers the facility to randomly determine the order in which a series of slides are presented to the performer. The graphic notation on each slide displays shapes representing non-rhythmic gestures to be drawn on the surface of the instruments using a variety of implements by the performer. An overview of the application as developed for the notation in these works and the graphic design principles with which it complies will be followed by a summary of performance implications as experienced in preparation of their performances that influenced the development of the notation and performance practices.

1. INTRODUCTION

This paper provides an overview of the approach and techniques used to represent the music notation of two works by Cat Hope composed for percussionist Louise Devenish: *Sub Aerial* (2015) and *The Past Is Singing In Our Teeth* (2017).
Sub Aerial was commissioned by The Sound Collectors for a program exploring different approaches to percussive gesture in existing and new repertoire for percussion duo. [1] For solo performer, *The Past is Singing in Our Teeth* was commissioned by Kate MacMillan as part of her exhibition of the same name. The brief required Hope to compose a score based on the objects, sculptures and a series of 'shorthand poems' featuring in the exhibition that the performer would move between.

Both works use performance practices associated with non-pitched percussive objects as inspiration for the notational style. The graphic notation used by Hope is a linear representation of physical gestures such as scrapes, swishes, buzzes, friction and rubbing techniques frequently used by performers to elicit sound from various instruments and objects.

---

[1] *Sub Aerial* was premiered in Melbourne as part of 'New Music Beauty Queen' on 1 April 2015, and subsequently performed in 'Gesture' at the Perth Institute of Contemporary Art on 17 July 2015 (Tura New Music 2015).

Both works use a unique iteration of the Decibel ScorePlayer iPad Application which offers the facility to randomly determine the order in which a series of slides are presented to the performer. The graphic notation on each slide displays shapes representing non-rhythmic gestures to be drawn on the surface of the instruments using a variety of implements by the performer. *Sub Aerial* was the first work that required the application to display notation in this manner, and performances of this work influenced the development of the application, notation and performance practices in subsequent works including *The Past Is Singing In Our Teeth*.

This paper will provide an overview of the application as developed for *Sub Aerial* and the graphic design principles with which it complies. This is followed by a summary of performance implications as experienced in preparation of performances of *Sub Aerial and The Past is Singing in Our Teeth*. Discussion of research findings exploring the unique musical possibilities the application updates affords concludes the paper.

2. CONCEPT

Increased interest in graphic notation has seen a diverse body of recent research discussing the tools available for the composition and performance of digitally created graphic notation. This includes real-time compositional systems (Freeman 2010 and Hajdu 2015), animated notations (Ross Smith 2016), and live coding (Fischer 2015, McClean 2011, Magnusson 2014). This paper explores an aleatoric digital shuffle score developed for a series of percussion works by Cat Hope. Hope's compositions focus on aspects of drone and noise, and her first work for percussion alone, *Sub Aerial,* epitomizes her approach to percussion writing.

Sub Aerial presents the performers with a graphic score that is interpreted through a range of performance gestures on surfaces and with objects prescribed by the composer including portable a.m. radios and horsewhips. The score consists of a range of drawings made using the Illustrator design software that explore linear and pointillist illustrations. Of the 30 images presented to the performers over the course of the piece, 12 images are unique. The other 18 images are duplications in red and blue. 6 cards combine both colours, and are performed as 'duos' within the larger structure of the piece, as illustrated by the card image reproduced in Figure 1. Whilst a hard copy of the cards is provided to the performers to facilitate rehearsal, the

piece cannot be accurately performed from this set, as coordination of these duo slides would be almost impossible. As is common to many of Hope's compositions, the hard copy scores are intended not only for musicological study, but also for performers to see all the parts in a way not possible in the electronic score player (Hope, Wyatt and Vickery 2015b).
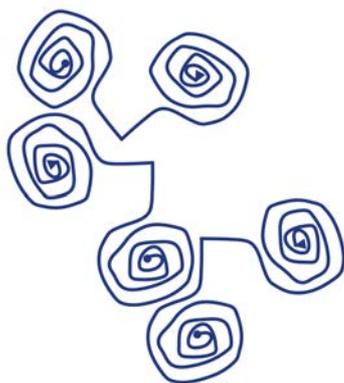
Figure 1: An example of a slide from *Sub Aerial*. Note that each line has either an arrowhead or a circle at its end, indicating the start and end points respectively.

Card and shuffle pieces and the non-linearity embedded within them, are not new in music notation, with notable paper card pieces including Christian Marclay's *Shuffle* (2007) and Erik Griswold's *Stars of Ours* (2014). New computer technologies have, however, enabled sophisticated networked performance and score possibilities, a potential explored by many composers and programmers (see Freeman 2008, Kim-Boyle 2010 and Dannenberg 1996), amongst others. Digital media can provide scores with a range of different interfaces for performers to read from, increased access to the scores and the possibility to experiment with different iterations of a work (Aspary 2011). To that end, the Decibel ScorePlayer provides a unique means through which the compositional goals of *Sub Aerial* and *The Past is Singing in Our Teeth* have been able to be realized (Hope, Wyatt and Vickery 2015).

3. DESIGN CONSTRAINTS AND SOLUTIONS

The Decibel ScorePlayer is an iPad application that enables the display of graphic scores and the timing of aleatoric processes to be synchronized across multiple iPad displays. The player is designed to facilitate the reading of scores featuring predominantly graphic notation (Decibel 2016) and a development application is also maintained by the Decibel new music ensemble,[2]

where new score types are beta-tested before release as part of the commercially available application (Bown 2015). While the development application is where the slide notation for *Sub Aerial* and *The Past is Singing in Our Teeth* began, this is now included in the commercially available ScorePlayer allows anyone with the score file to perform the work.[3]

Display-based scores, such as those presented through the ScorePlayer, have forced composers to contend with a number of design constraints which they do not typically face when working with traditional paper-based media. The relatively low resolution of displays sees a far greater use of linear notations such as those employed in *Sub Aerial* and *The Past is Singing in Our Teeth*, a tendency also reflected in the work of many other composers working with display-based scores such as Ryan Ross-Smith, Lindsay Vickery, Thor Magnusson, and David Kim-Boyle. Conversely, composers operating within this field are able to take advantage of graphic possibilities more easily achieved with digital technologies. For example, the use of colour to more carefully delineate separate parts has been strongly featured in Hope's work in order to more readily distinguish different types of musical gestures.[4] Moreover, through the use of applications such as the Decibel ScorePlayer, colour applications and mappings can easily be transformed over time, a possibility by definition not afforded in fixed media.

The Decibel ScorePlayer offers a range of solutions to what is, perhaps, the key design constraint facing composers creating works intended to be displayed to performers on iPads or other visual displays. As the screen offers a finite size, composers must contend with how new information is to be displayed to performers. While the concept of the page is somewhat of an anachronism, it continues to cast an influential shadow over display methodologies in this regard. In *Sub Aerial* and *The Past is Singing in Our Teeth*, virtual pages or slides are shuffled by the ScorePlayer application and presented to the performer/s in random order. The order that slides are presented, need not necessarily be random, however, marking a particular advantage for applications such as the ScorePlayer in their ability to order images in complex successions (Kim-Boyle 2014).

Shuffling the order of displayed pages is not the only means through which the ScorePlayer application can present new 'slide-based' information to performers. It also offers an advanced scroll-based paradigm, which in

---

its early implementation scrolled a master image, read by all performers, across a vertical line or playhead, as shown in Figure 2. Since this early implementation, the application offers the ability to display individual parts in addition to the master score and has also been extended to allow audio files to be triggered at timed points within a scrolling score. This latter feature has facilitated the performance of a number of works for instrument and tape such as Denis Smalley's *Clarinet Threads* (1985) and Giacinto Scelsi's *Aitsi* (1974) for piano and electronics.
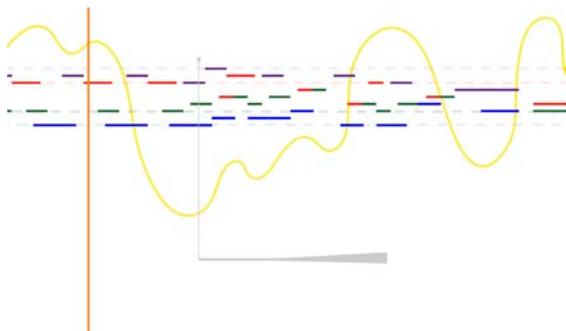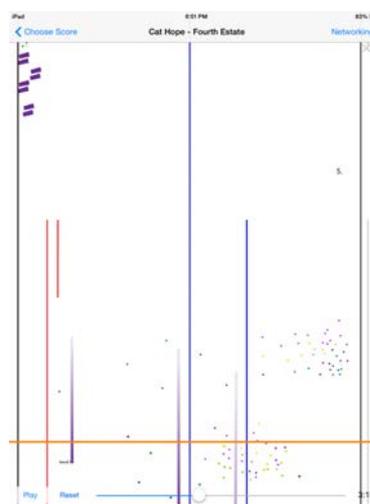

Figure 2: A still from the score for Hope's *Wall Drawing* (2014) as it appears in the Decibel ScorePlayer scrolling mode. This work is for string quartet, theremin and electronics.

In addition to simple left-right scrolling, the ScorePlayer application has afforded a range of other unique possibilities for updating and refreshing displayed information. Techniques such as interrupted scrolling, involving the change of direction and/or random start and end points, tiling (where single images are joined) and the shuffle to scroll. The shuffle to scroll method, which involves the ScorePlayer randomly choosing the order of parts from separate image files to form a single image that passes by the playhead, was first explored in Cat Hope's *Fourth Estate* (2014) for piano, as shown below in Figure 3. While *Fourth Estate* appears as a single, scrolling score, it is in fact made up of seven individual images designed to join seamlessly together in any order. Each time the score file is opened, it arranges materials in a different order. *Sub Aerial* and *The Past is Singing in Our Teeth* make use of this function, but do not use the scrolling mechanism.

While the use of shuffling, scrolling or other animation techniques provides a means through which new information can be displayed to performers, this raises technical challenges of how aleatoric or discretely timed processes can be coordinated across multiple displays. Many composers avoid the problem through having performer/s read a score from a single master display. The Decibel ScorePlayer, however, affords a unique solution in this regard as it allows coordination of such processes to be synchronized over a network. In works such as *Sub Aerial*, for example, the shuffling of slides can be coordinated such that the appearance of particular slides is synchronised, or so that particular

musical choices regarding parameters such as dynamics can be more tightly controlled. Performance is also facilitated through features such as 'countdown' bars (see Figure 10), where players can see how much time has expired and how much remains for each card, and 'slide' bars, which indicate how much of the score has been displayed and how much remains. The 'countdown' bar feature is particularly useful in the performance of installation-style works such as *The Past is Singing in Our Teeth,* where the presence of a score on a music stand disrupts the aesthetic of the work. The 'countdown' bar enables the performer to place the score at a discreet distance while still being easily see how much time remains from a distance. In the premiere of *The Past is Singing in Our Teeth,* the score was placed discreetly above the doorway to the room.

Figure 3: A still taken from the score for Hope's *Fourth Estate* (2014) as it appears in the Decibel ScorePlayer. Note how the scroll is now up and down, rather than right to left.

4. IMPLEMENTATION

The first iteration of the card shuffling idea ultimately adopted in *Sub Aerial* was a slideshow style score where the sequence of pages displayed was manually controlled by swiping left or right on the screen. While this was mostly used as a means of turning pages on traditionally notated scores, it was also used for music that required a click track supplied as either an audio file within the score itself, or managed via a separate system synched to the ScorePlayer via Open Sound Control (OSC) (Open Sound Control n.d.). Lindsay Vickery's 2011 work *Night Fragments* was the first work whose score was adapted for a January 2015 performance using this style of score. It featured automated page turns synchronized to a click track, where each performer had a different tempo (Wyatt 2013).

This original code provided a basis for the development of the shuffling slide iteration of the player, and a new rendering module, (FlashCards.m), was created. The extant code lacked any randomisation of slide order or duration as required by the work. There was also no mechanism to make sure that certain transitions were synched; whenever a duo slide was displayed, both iPads needed to show the same card in the same orientation, with the same dynamics, for the same amount of time. To do this, a card order was first generated on one iPad (referred to as the master iPad) that was designated as the server, and the locations of any duo cards were sent out to the other iPads (referred to as slave iPads) over the network - in the case of *Sub Aerial*, just one other iPad. Other iPads could then create their own random order for any intervening cards.

So that as much code as possible could be reused, the following function was defined:

```
–                              (NSMutableArray
*)generateCardOrderWithDuos:(BOOL)enableDuos
fromTime:(NSInteger)startTime
toTime:(NSInteger)endTime
```

The function returns an array containing a list of shuffled cards for the defined duration. Each entry in the array is an array of integers which defines the parameters for each card: its start time, the index of the image that should be used, its duration in seconds, the dynamic to be used, and the orientation (0 indicates the card should be presented as is, 1 indicates it should be rotated 180 degrees.) Because the function allows for the inclusion of duo cards to be set as a parameter, as well as allowing for defined start and end times within the work, it can be used by both the master iPad to generate an entire set of cards (including duo cards), and by the slave iPads to fill in the remaining gaps between duo cards.

While the function generates random durations for most of the cards, it intervenes at the end to avoid a situation where a final card may be displayed more briefly than the minimum desired duration of the work. It does this by first extending the length of the final card to fill in the remaining time. If this leads to a display time of more than twice the minimum value it then splits this time in two and allocates one more randomly selected card to the list. In this way, there are no unexpectedly quick transitions that would disrupt the flow of the work.

The FlashCards module was created from the very start to be flexible enough to allow a number of different scores based on the same concept to be implemented. As with previous modules, preferences for each score are contained within an XML file in the score file (itself a zip file with its extension modified to .dsz. This file contains all of the resources required for the score.) The preferences file used for *Sub Aerial* is shown below:

```xml
<?xml version="1.0" encoding="UTF–8"?>
<!DOCTYPE cards SYSTEM "cards.dtd">
<cards>
      <quantity>13</quantity>
      <upsidedown>yes</upsidedown>
      <timer>
        <mindisplay>20</mindisplay>
        <maxdisplay>40</maxdisplay>
        <style>graphical</style>
      </timer>
      <dynamics>
        <dynamic>Soft</dynamic>
        <dynamic>Loud</dynamic>
        <dynamic>Varying dynamic</dynamic>
        <dynamic>Very soft</dynamic>
        <dynamic>Very loud</dynamic>
      </dynamics>
      <duo>
        <quantity>8</quantity>
        <filename>Duo_1.png</filename>
      </duo>
</cards>
```

Figure 4. The XML preferences file used to define the parameters for the first iteration of the shuffling slide score.

Most of the possible options that can be defined for such a score are shown in Figure 4. The <timer> section defines the minimum and maximum duration that a card should be displayed, as well as defining the style of the timer displayed to the performer. The graphical option presents a depleting bar that represents the time remaining for the current card. A numerical option to display a countdown timer was also defined from the outset, but was not initially implemented in the code. It has since been added and is available as an option in the current version of the ScorePlayer. Further, use of the graphical option in *Sub Aerial* was deemed more practical and easier to see for a percussion work, as iPads or music are often placed behind a large setup. The dynamics are supplied as text in *Sub Aerial*, but they may also be supplied as a set of images by inserting the line "<graphical>yes</graphical>" into the <dynamics> section.

The parameters relating to the cards are contained in the duo section and in the top level of the schema. If the <duo> section is omitted, duo cards are not used, and there are no sections of the work that are synchronized between the networked iPads. If it is, the quantity of cards and the base filename should be given using the standard naming convention of the ScorePlayer: that is, that the set of images to be used are named filename_1.png (or .jpg), filename_2.png and so on. The probability that a duo card should be selected can also be defined using the optional <probability> tag. If omitted, the default probability is 0.25.

The top level of the schema has tags that define the quantity of normal (non-duo) cards. If individual parts are specified in the opus.xml file, these parts should all have the same number of cards that can be displayed. The <upsidedown> tag defines whether cards can be

rotated 180 degrees for display, and the <allowrepeats> tag defines whether cards can be repeated before all of the cards in the deck have been used at least once. If omitted, the default for both of these options is no. The full document type definition for the preferences file can be found below:

```
<!ELEMENT cards (quantity, upsidedown?,
    allowrepeats?, timer, dynamics, duo?,
    order?, fadetime?)>
<!ELEMENT timer (mindisplay, maxdisplay,
    style?)>
<!ELEMENT dynamics (graphical?, dynamic+)>
<!ELEMENT duo (quantity, filename,
    probability)>
<!ELEMENT order (change+)>
<!ELEMENT quantitiy (#PCDATA)>
<!ELEMENT upsidedown (#PCDATA)>
<!ELEMENT allowrepeats (#PCDATA)>
<!ELEMENT fadetime (#PCDATA)>
<!ELEMENT mindisplay (#PCDATA)>
<!ELEMENT maxdisplay (#PCDATA)>
<!ELEMENT style (#PCDATA)>
<!ELEMENT graphical (#PCDATA)>
<!ELEMENT dynamic (#PCDATA)>
<!ELEMENT filename (#PCDATA)>
<!ELEMENT probability (#PCDATA)>
<!ELEMENT change (#PCDATA)>
```

Figure 5. The Document Type Definition (DTD) that describes the format of the XML preferences file used for a shuffling slide style score.

As future development adds more features to the score type, additional sections in the XML schema may need to be defined. Any additions, however, will be mindful of the need to maintain backwards compatibility with extant score files. None of the current tags will be redefined, however, and any default behaviours will remain as they are.

5. PERFORMANCE

For both works, interpretation of the cards begins with instrument choices. A number of suggestions are included with the score for *Sub Aerial*, however the performers are encouraged to expand on these. As the instrumentation choice for each card is open, interpretation of the cards began with a series of workshop sessions sought to create a collection of instruments and objects that could successfully execute gestures shown on a number of cards. Each performance utilized different materials based on available resources, shown in Table 1. The instruments and objects selected were chosen for their ability to produce very soft sounds similar in timbre to the required radio static option provided, so as to 'create an ethereal sound world of transmission' (Hope 2015), and their ability for these sounds to be executed via tracing gestures on either horizontal or vertical planes. This allowed some flexibility in performance, as sounds could be chosen both in response to any given card and in response to the sounds played before it.

A series of experiments using the hard copy paper version of each card facilitated exploration of each gesture with compatible instruments and objects over different durations. Access to a hard copy of the cards provides an advantage during the early rehearsal process, as it allowed manually testing of every combination of two cards against all of the instrumental sounds without having to limit explorations to the timeframe selected by the ScorePlayer. Eliminating the possibility that a particular combination may not appear in the digital version ensured that all of the possible combinations could be explored early in the rehearsal process. Supporting the digital score with a hard copy score is advantageous when rehearsal time is limited and improved the effectiveness of the early workshops by facilitating a thorough and methodical approach of testing sounds against different cards.

These workshops showed that certain sound-gesture combinations were more effective than others, and that certain notation produced more effective sonic results. In *Sub Aerial*, as each collection of instruments for each performance is different, a specific performance practice must be developed in rehearsals.

Performance 1	Performance 2
Metal baking trays with rice	Metal baking trays with rice
Bass drum with superball mallet, rute, soft scrubbing brush	Bass drum with superball mallet, rute, soft scrubbing brush
AM radio	AM radio
Sandpaper (4 different grades) played with knitting needs, dreadlocks, toothbrush	Sandpaper (4 different grades) played with knitting needs, dreadlocks, toothbrush
Textured wallpaper	Textured wallpaper
Felt-tip marker on paper	Felt-tip marker on paper
Snare drum	Toy wooden ducks
Ceramic bowls	Toy Buzzy Bee
Small metal mixing bowl	Toy spinning top
Paper, torn	Thin plastic bag
Soft sandpaper blocks	Cellophane
Blackboard with chalk	Bubble wrap
	Tissue paper
	Small gong
	Bamboo switches
	Leather horsewhip

Table 1. Instrumentation of *Sub Aerial*

The discoveries made during the workshop process of *Sub Aerial* facilitated a much faster development process for *The Past is Singing in Our Teeth,* as various notational and performance challenges had been overcome. The point of departure for the notation and the instrumentation was defined by Kate McMillan as she developed her exhibition of the same name, reversing the process. Even in the early stages of rehearsals for this work, the gesture followed the notation, not the reverse.

The score for *The Past is Singing in Our Teeth* was completed by Hope prior to rehearsals, before either the performer or composer had sighted the final version of the instrument. The instrument was a sculpture designed by Kate McMillan as one component of her exhibition of the same name, and the walls and floor of the surrounding room. The sculpture, shown in Figure 6 below, comprised a metal 'tree' hung with various natural and created objects developed by McMillan including bronze clenches, gourds, guitar strings, hagstones, children's milk teeth and chains. The assembly of the objects and their placement on the 'tree' was left to the performer to decide based on ease of sounding each item.


Figure 6. McMillan's sculpture performed in the premiere of *The Past is Singing in Our Teeth*. Photography by Lesley Ranzoni.

4.1 Interpreting the cards

In both works, each card presents the performer with a unique score activity. Like other graphically notated percussion works by Hope, these cards have a fixed start and end point, and are not open to completely free interpretation. The gestures have a clearly defined direction and movement and a fixed time during which they must be performed.

Figure 7 shows the simplest of graphical shapes appears in *Sub Aerial* as a large, filled circle representing a single soft sound on either a bass drum or gong allowed to decay naturally, 'drawn' or executed once, or multiple times in any given time period. This type of graphical shape is unusual in Hope's work, which usually feature long lines over extended durations with a focus on glissandi. There are two primary performative choices to be made for all other cards in both works: method of interpretation (the image can be drawn literally or abstractly interpreted), and duration. Additionally, the thickness of the lines or circles offers further interpretative choice with regard to complexity of timbre selected.
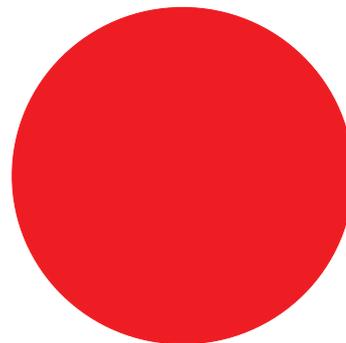

Figure 7: A sample card from *Sub Aerial*.

The notation in *The Past is Singing in Our Teeth* is more complex, as it is based on shorthand symbols used by McMillan in hanging fabrics that form part of the overall exhibition. The shorthand symbols were those created by McMillan's mother when writing notes for household tasks. A number of the shorthand symbols form the graphic shapes that appear in the score in three colours. Each colour represents a different object or sound quality. All blue lines are to 'drawn' on a surface with one hand. All red lines are to be sounded out by 'handling' items in hand, but drawing the shapes in space as you do. Green lines are more traditionally 'percussive' and any lines in green are to be seen as drawing up to a 'stuck' moment.

In both works, the duration of each card is randomly determined by the ScorePlayer. This then influences performative choices surrounding the duration of each gesture within the displayed image. When a card is displayed for a longer period, the performer can decide to execute the image once, or multiple times, at any speed within the given time frame. For example, a detailed gesture could be slowly executed over the entirety of a 60 second period, or very quickly, leaving space at the end of a 60 second period. Further, the same gesture executed over a 15 second period could be much louder, or much larger physically if executed in the air or on the walls or floor of the room. For example, Figures 8 and 9 show an example of a slide that presents a variety of options for this kind of execution.
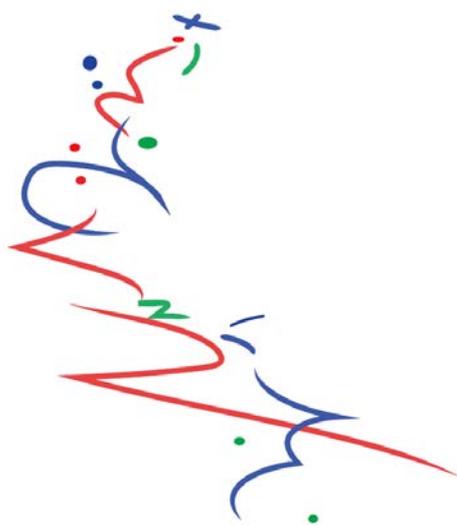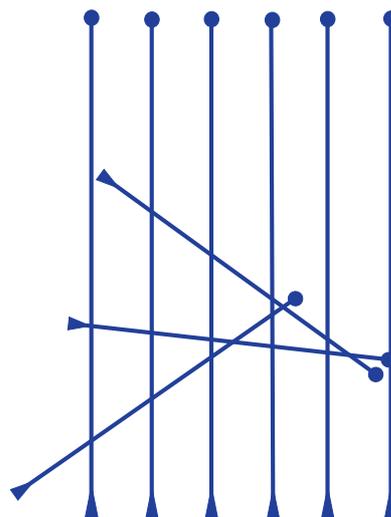

Figure 9: A slide from *Sub Aerial* that presents a variety of interpretation options (appears in either blue or red).

Many of the slides in both works indicate a 'drawing' process, so rather than striking the instruments, the performers would 'draw' on the surface of an instrument. In *The Past is Singing in Our Teeth*, the gestures can be 'drawn' in the air, spatialising the sound produced. On some of the *Sub Aerial* slides, triangles are included as a suggested starting point and direction for the gesture. Others, when combined with particular instruments or objects, allowed for vertical or horizontal execution of the slide. For example, using bamboo switches or items sounded by their movement through air, required vertical 'drawing' of slides. Further, the directionality of the noise produced by the small a.m. radios allowed for further exploration of vertical and horizontal gestures.

During early rehearsals for *Sub Aerial* challenges surrounding the duration of each gesture relative to the chosen sound source, and balance arose. It soon became clear that certain sounds masked others completely, not solely because of volume, but because of timbre. As the sounds selected were chosen for their ability to produce very soft, yet audible sounds similar in timbre to radio static, the majority had a noise-like quality that sonically cancelled out less noise-like sounds. Further, the dynamics chosen by the ScorePlayer weren't always the most musical choice for the card presented - visually the image could indicate a louder gesture, but the indicated dynamic could be very soft. The range of dynamics includes *mf, p, pp, ppp* - so overall, very soft. This was addressed through a change to the ScorePlayer code for *The Past is Singing in Our Teeth*. Instead of choosing the dynamics completely at random, it could make a selection from a range indicated for each slide by the composer in the preferences file.

Figure 8. A slide from *The Past is Singing in Our Teeth* based on McMillan's shorthand symbols.
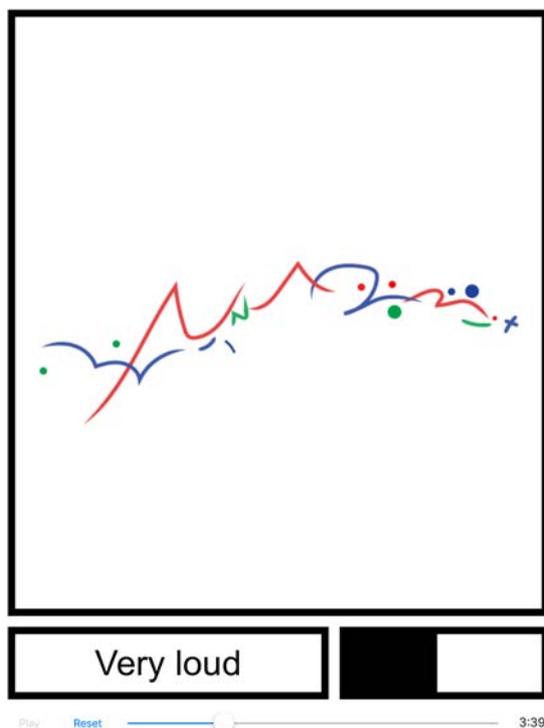
Figure 10: How *The Past is Singing in Our Teeth* slides look in the Decibel ScorePlayer on the iPad. Note the dynamic on the left, the countdown bar on the right and the time elapsed for the entire piece on the bottom right. The line along the bottom in pale blue shows where the slide is in relation to the duration of the piece. This slide can be displayed either vertically or horizontally for performance.

4.2 Limitations of the ScorePlayer

As noted, one of the features of the ScorePlayer is its ability to network multiple iPads for performance of ensemble works. However, an early version of *Sub Aerial* that allowed for random selection of cards at varied durations frequently resulted in both iPads changing from one card to another simultaneously, limiting the variety of sonic material presented. This caused problems with balance as described above, and as a result of workshops with the performers, was addressed from a coding perspective. Here, access to a hard copy version of the score prevented any disruption from the interpretation process as the coding was developed. It enabled the performers to try different ideas at different speeds, and lay all the cards out to compare them. The score as presented on the score player can only show one slide at a time, in a prescribed order. The performer can scroll through the slides using the slide bar at the bottom of the screen as seen in Figure 10. The ScorePlayer does, however, provide the opportunity for musicians to interactively influence the evolution of the piece so that each performance is a unique realisation. Each iteration of the piece is unique when the piece is chosen from the ScorePlayer menu.

While the choice of slides and dynamics was originally coded to be entirely random, there is certainly the possibility of extending the code in the future to add further conditions on the selection criteria. Already, an option has been added to allow for a fixed order, as was required by Hope's subsequent percussion solo work *Tone Being* (2016). Further to this though, in the same way that duo slides are co-ordinated between the networked iPads, code could be developed to allow for other concurrences or to avoid them entirely. Synchronization of dynamics to the selected card or to other members of the ensemble could be a particularly useful addition. Different weighted probabilities could also be added to the card selections, either independent of the proceeding card or related to the proceeding card, the latter lending a more defined structure to the work through the use of Markov chains. The images themselves are designed so that they can work in order, and have no preferred links to each other. In fact, they're designed to each be as different as possible. All the possible options above would need to be specified within the XML file that contains the preferences for the score, requiring both an update to the document type definition for the score type, and updated parsing code.

The ScorePlayer could be further improved if players could annotate the score to remind them of ideas for the abstract graphic scores, a function available in other network scores, such as Georg Hajdu's Quintet.net project (Hajdu and Didkovsky 2009). Given the touch screen capability of the iPad, this could be a likely future development.

6. CONCLUSION

The implementation of 'shuffle-based' scores within the Decibel ScorePlayer extends the functionality of the application in exciting new ways, with the ability to synchronise and coordinate images and transitions across multiple displays. This offers a unique solution to some of the challenges involved with ensemble-based playing. It further addresses the limitations of the generic ScorePlayer score - a linear model that scrolls from left to right. As musicologist Matthew Lorenzon points out, 'the use of graphic scores is not always about introducing greater uncertainty and scope for interpretation into a work, but is a way of creating scores that demand the same fidelity from the performer as any notated score' (Lorenzon 2015). The approach taken by the performers to this work supports this view. Development of the ScorePlayer throughout the rehearsal process enabled coordination issues surrounding repetition, dynamic range and rate of change to be addressed by minor changes to coding. This in turn ensured that the slides displayed by the ScorePlayer, while shuffled at random, produced a fluent, performable score that could be effectively and musically realised in performance. The shuffle function in the ScorePlayer offers a new means of representing graphical notation, and has significant potential for

further development and use by composers of indeterminate and/or generative notation.

6.1 Acknowledgments

7. REFERENCES

Aspary, W. 2011. Digital Media: Technological and Social Challenges of the Interactive World. London: Scarecrow Press (p. 211).

Bown, O. & Loke, L. 2015. Musify Gamify: Contemporary Perspectives on Gamified Music and Musified Games. Sydney: University of Sydney. (p. 55).
Dannenberg, R. B. 1996. Extending Music Notation Through Programming. Computer Music in Context 13(2): 63–76.

Decibel. 2016. Decibel ScorePlayer on the App Store. Available: http://itunes.apple.com.au/app/decibel-scoreplayer/id622591851 [Accessed 15 February, 2016].
Freeman, J. 2008. Extreme Sight-Reading, Mediated Expression, and Audience Participation: Real-Time Music Notation in Live Performance. Computer Music Journal 32(3) (pp. 25–41).
Freeman, J., & Colella, A. (2010). Tools for real-time music notation. *Contemporary Music Review*, 29(1) (pp. 101-113).
Hadju, G. 2015. Dynamic Notation – a Solution to the Conundrum o Non-standard Music Practice. *Proceedings of TENOR, First International Conference on Technologies for Music Notation and Representation 2015,* Institut de Recherche en Musicologie, IReMus *Paris, France, May 2015* (p. 241-248).

Fischer, C.M. 2015. Understanding Animated Notation. Proceedings of the First International Conference on Technologies for Music Notation and Representation, TENOR 28-30 May, 2015 Université Paris-Sorbonne / Ircam Paris (pp. 31-38).
Hajdu, G. and Didkovsky, N. 2009. On the Evolution of Music Notation in Network Music Environments. Contemporary Music Review 28(4): p. 403.
Hope, C., Vickery, L. & Wyatt, A. 2015. "The Decibel ScorePlayer - New Developments and improved Functionality." Texas, USA: *Proceedings of the International Computer Music Conference* (pp. 314-317).
Hope, C., Wyatt, A. & Vickery, L. 2015. The Decibel ScorePlayer - A digital tool for reading graphic notation. *Proceedings of TENOR, First International Conference on Technologies for Music Notation and Representation 2015,* Institut de Recherche en

Musicologie, IReMus *Paris, France, May 2015* (pp. 59-70).
Hope, C. 2015. *Sub Aerial* [score].
Kim-Boyle, D. 2010. Real-Time Score Generation for Extensible Open Forms. Contemporary Music Review 29(1): 3–15. Kinsler, V. and Carpenter, R. H. S. 1995. Saccadic E.
Kim-Boyle, D. 2014. The Visual Design of Real-Time Scores. *Organised Sound*, 19(3) (pp. 286-294).
Lorenzon, M. 2015. Partial Durations: Sound Collectors: New Music Beauty Queen, April 7. http://partialdurations.com/2015/04/07/the-sound-collectors-new-music-beauty-queen/ [Accessed 27 February 2016].

Magnusson, T. 2014. Herding cats: Observing live coding in the wild. *Computer Music Journal*, 38(1) (pp. 8-16).
McLean, A, Wiggin, G. 2011. *Texture: Visual notation for live coding of pattern*. Ann Arbor, MI: Michigan Publishing, University of Michigan Library
Open Sound Control. Center For New Music and Audio Technology (CNMAT), UC Berkeley. Open Sound Control specifications http://opensoundcontrol.org/spec-1_0 [Accessed January 25, 2016].

Ross-Smith, R. 2016. [Study No. 50][Notational Becoming] [Speculations] *Proceedings of the Second International Conference on Technologies for Music Notation and Representation*, *Cambridge, UK, May 2016. Cambridge, UK, May 2016* (pp. 98-104).

Tura New Music. 2015. 'Concert 2 Gesture: The Sound Collectors' [online]. Available: http://www.tura.com.au/tura-program/scale-variable-2015/concert-2-gesture-the-sound-collectors/ [Accessed 12 February 2016].
Vickery, L., James, S., Devenish, L., (2017). 'Expanded Percussion Notation in Recent Works by Cat Hope, Stuart James and Lindsay Vickery', *Contemporary Music Review,* 36: 1-2
Wyatt, A. et al. 2013 "Animated Music Notation on the iPad (Or: Music stands just weren't designed to support laptops)". Perth, WA: *Proceedings of the 2013 ICMC Conference* (pp. 201-207).