THE 3-D SCORE

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ABSTRACT

This paper examines attempts by composers to transcend the two-dimensional constraints of the printed page in musical notation. The author reviews how material depth in printed media has been explored to help create new structural forms and two of the author's works which feature real-time, three-dimensional scores are examined. Incumbent technical limitations and constraints of multidimensional notational schemas are discussed and the author concludes by arguing that the reading *through* of a notational schema affords a new spatial ontology for the works represented.

1. INTRODUCTION

In many respects, music notation can be regarded as a multi-dimensional construct that has evolved to facilitate communication of an increasingly complex and polyvalent musical language. The use of neumes, for example, while perfectly satisfactory for prescribing the pitch contours of plainchant does not suffice, nor is it intended, to convey complex rhythmic structure. Thus, the dimensionality of notational schemas is extended through the addition of new symbols such as time signatures and tuplets as musical language evolves.

Despite the growing complexity of musical notation, it has nevertheless always been bound by the constraints of the medium upon which it is inscribed. With the transition from parchment to paper in the mid-15th century, for example, the use of ancillary decoration becomes less pronounced.[1] The growing use of screen-based scores is also not without limitations with screen resolution, use of color, and speed of animation all representing constraints affecting communication with performers. [2] Whether paper or screen-based, both mediums have been jointly bound by the two-dimensional surface of the display. With the growing use of 3-D technologies in printing, imaging, immersive projection, and augmented reality systems it therefore seems natural to consider the creative potential of multidimensional notational schema. Such an appraisal, however, needs to be framed in the broader context of efforts to transcend the materiality of the printed surface.

[1] While there are obvious economic causes at play, the materiality of paper ultimately did not lend itself as well to the use of colored inks. [1]

2. TRANSCENDING THE PAGE

While the discovery of perspective in the 14th century allowed painters to more realistically depict depth on a two-dimensional surface, it was not until the mid-to-late 19th century with the development of photography and stereoscopic images that a more convincing illusion of depth was able to be conveyed to a viewer. Through the use of stereoscopic viewers to project phase shifted, and sometimes color corrected images to individual eyes, see Figure 1, early stereographic images created an overwhelming sense of presence for the viewer as was noted by early enthusiast Oliver Wendell Holmes in 1859 - "The first effect of looking at a good photograph through the stereoscope is a surprise such as no painting ever produced. The mind feels its way into the very depths of the picture. The scraggy branches of a tree in the foreground run out at us as if they would scratch our eyes out. The elbow of a figure stands forth as to make us almost uncomfortable." [3]

Figure 1. The Brewster stereoscope (left) and the Holmes stereoscope (right). Two early examples of stereoscopes from the late 19th century.

The desire to immerse the viewer in a scene, which played no small role in the early appeal of the medium, [4] has continued to be a driving force in the development of stereoscopic imagery today. This is most obviously notable in virtual reality or immersive systems such as the Oculus Rift [5] or, to a somewhat lesser extent, in the increasing popularity of 360 photos.

The illusion of depth that stereoscopic images create fundamentally represents an effort to embed more information about an image than can be ordinarily represented on a two-dimensional surface. Stereoscopic images, thus by their very nature, represent an effort to transcend the two-dimensional materiality of the page.

Many innovations in musical notation may similarly be framed in part as an effort to transcend the material constraints of the printed page. The use of colored ink in a number of scores of Baude Cordier and other composers from the Mannerist school of the 15th century to more clearly delineate rhythmic layers offers an early example, see Figure 2.

Figure 2. Detail from the score for Baude Cordier's (1380-1440) *Belle, Bonne, Sage* in which red colored notes denote rhythmic modification.

The use of screens to display musical scores also present many opportunities to transcend the constraints of paper-based scores with generative processes, animation, and extended graphical schema providing rich material for musical exploration. [2] To what extent, though, has material depth provided opportunities for creative exploration and the development of unique musical forms?

3. THE MATERIALITY OF DEPTH

Unlike visual art-forms in which the illusion of depth is typically motivated by a desire to immerse a spectator in a scene, notational depth in music notations and representations is most commonly driven by a desire to embed additional layers of information in a notational schema. There are, however, deeper ontological motivations behind these explorations which will be touched upon later in this paper.

Perhaps the most well known early example in which the materiality of depth plays an integral role in defining musical structures are those works of John Cage which involved the use of transparencies, the most famous of which include the *Variations II* (1961), *III* (1962), *IV* (1963), and *VI* (1966); *Fontana Mix* (1958), *Music Walk* (1958) and *Cartridge Music* (1960). In each of these works musical structures emerge from the superimposition of preprinted transparencies and printed sheets, see Figure 3.

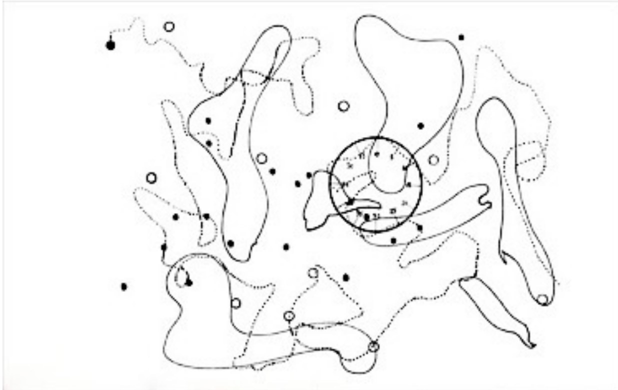

Figure 3. A performance score for Cage's *Cartridge Music* (1960). The score is created by superimposing four transparencies on one of up to twenty pre-printed sheets.

Musical form in these works is an emergent result of an aleatoric process, a sonic assemblage or composite of discrete individual prescriptive actions. [6, 7] While Cage's interest in the use of transparent media for musical composition appears to have come to a close in the 1960s, the potentiality of depth for creating unique forms continued to be explored in his lesser known visual art works built from plexiglass such as, for example, *Not Wanting to Say Anything About Marcel* (1969), see Figure 4, in which randomly chosen words and letters are distribued across parallel sheets of plexiglass according to the results of a three-coin toss. [8]

Figure 4. *Not Wanting to Say Anything About Marcel* (1969).

The influence of Cage's use of superimposed transparencies was felt more strongly in Japan where, as is well known Cage spent considerable time in the 1960s, more so than in Europe or North America. In Toshi Ichiyanagi's *Music for Piano No. 7* (1961), for example, the performer is provided with ten pre-printed sheets with three options for arranging them to form a performance score. The third option requires the performer to – "3. Accumulate ten sheets freely in a row. So each sheet is read only in part. The performer may change the order or turn the score upside down in the same position to continue the piece." [9]

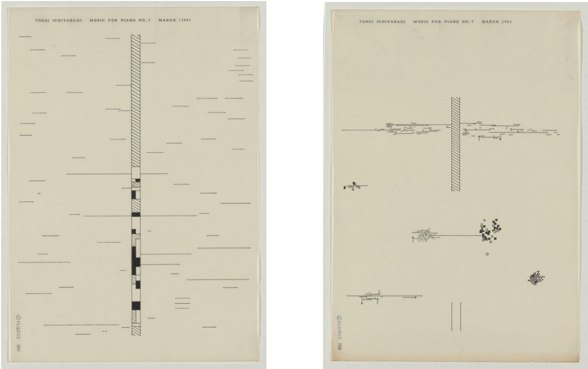

Figure 5. Two pages from preparatory material of *Music for Piano No. 7* (1961) by Toshio Ichiyanagi.

Each of the ten sheets available for the performer employs graphic notation often featuring a long thin rectangular prism which bisects the page and is filled and surrounded by various shadings, lines, circles and squares which in turn designate pitches, pitch ranges and various harmonics to be performed. The random accumulation of sheets naturally creates potential musical structures which unfold as the pianist reads *through* the sheets.

The creation of musical structure through material depth also plays a fundamental role in Toru Takemitsu's *Corona* (1962). The score for this work, designed in collaboration with graphic designer Kôhei Sugiura, [10] exists in two versions, one for solo piano and the other for string orchestra. It consists of five cards and transparencies printed in different colors which may be interlocked in configurations of the performer's choosing to form a performance score, [10, 11] see Figure 6. Both versions of the work present performers with a great deal of freedom although Takemitsu does provide detailed instructions on how the graphic shapes and symbols are to be interpreted.

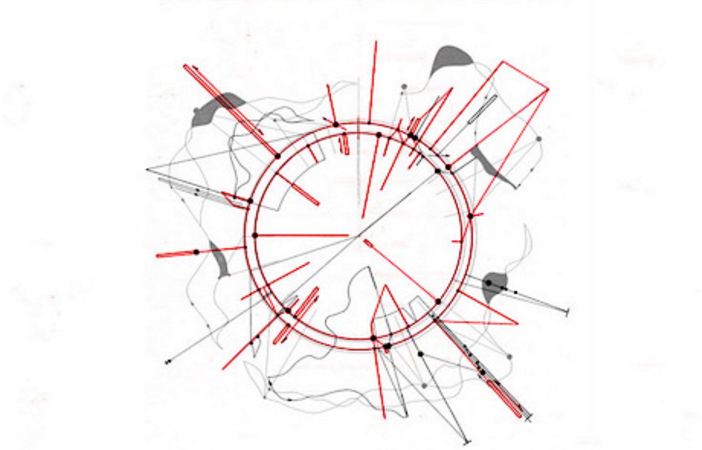

Figure 6. A performance score for the Takemitsu's *Corona* (1962) for solo piano.

Like arrangement number three of Ichiyanagi's *Music for Piano No. 7*, and Cage's *Cartridge Music* the performance score for *Corona* constrains prescriptive information to a single "page". This is also a notable feature of many works featuring scores created in real-time as discussed in [12] where the concept of a page turn is an obvious anachronism.

Notational depth is also a feature of Kenneth Gaburo's *Lingua II: Maledetto* (1967-8) and Herbert Brün's *Mutatis Mutandi* (1976) the scores for each of which are constructed from complex superimpositions of words, letters, and other graphical shapes, see Figure 7.

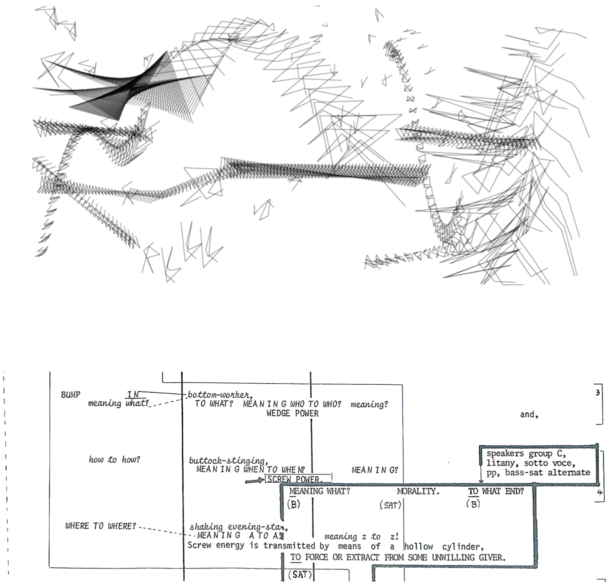

Figure 7. Score excerpts from Herbert Brün's *Mutatis Mutandis* (top), and Kenneth Gaburo's *Lingua II* (bottom) both of which employ complex graphic superimpositions to create musical structure.

In each of these works the performer is not afforded the flexibility to create their own multi-layered score from the superimposition of pre-composed pages or transparencies. Nevertheless, the printed superimposition of graphical and typographical shapes presents similar authorial intentions and interpretive challenges. Of these, Brün has written – "The interpreter, now, is to construct, by thought and imagination, HIS version of a structure that might leave the traces which the graphic displays. The interpreter is not asked to reconstruct my computer program, the structured process that actually generated the graphics. Rather he is asked to construct the structured process by which HE would like to have generated the graphics." [13] The notational complexity of Brün's work with its overt layering of graphical planes, naturally encourages performers to read *through* the score in addition to a more accustomed reading *across*. The multi-dimensionality of the notational structure is also foregrounded in Gaburo's work for seven virtuoso speakers with simultaneity and overlapping of vocal enunciations mirrored in notational depth and textual superimposition.

Multi-dimensional notational structures, especially those exploring depth, naturally push the boundaries of what can be represented on a two-dimensional surface. It is perhaps not surprising then that composers such as Cage and Gaburo moved on to explore multidimensional multimedia forms in works such as Cage's *Musicircus* (1967), *Roaratorio* (1979) or Gaburo's *My, My, My, What a Wonderful Fall!* (1974) after having largely exhausted the musical possibilities of notational depth on printed media, [2] while contemporary artists such as Marc Berghaus [15] and Martin Daske [16] have developed three-dimensional sculptural scores as a means of exploring the use of depth in creating unique musical forms. Before closing this section, it is also worth acknowledging a body of concrete poetry by poets such as Jackson MacLow, bp Nichol, and Augusto de Campos whose work was fundamentally invested in exploring the relationships between typographical structure and literary expression. [17]

4. 3-D SCORES

Not surprisingly, with the rapid evolution of computer processing power and the parallel development of programming languages for real-time graphic display and processing such as Jitter, Processing, and OpenFrameworks, the use of transparencies, slides and other media suited to representing multiple layers of notation has ostensibly ceased. In the author's own creative work, Jitter has been a core tool that has afforded exploration of the potential of 3-D notations. As of writing, two of the author's works, with another in development, have featured 3-D scores. In each of these works, the score is generated live and employs a unique graphical schema.

4.1 point studies no. 2 (2013)

point studies no. 2, for any two pitched instruments, presents performers with a series of colored nodes randomly distributed across a three-dimensional grid. [3] The color and relative size of a node denotes the pitch and intensity respectively of a note to be performed. Performers are free to determine the sequence of pitches performed by choosing various pathways through the nodes, which are connected by thin lines according to their alignment, see Figure 8. A "multi-player" computer-generated interpretation of the score, consisting of sine tones, accompanies the performer's interpretation.

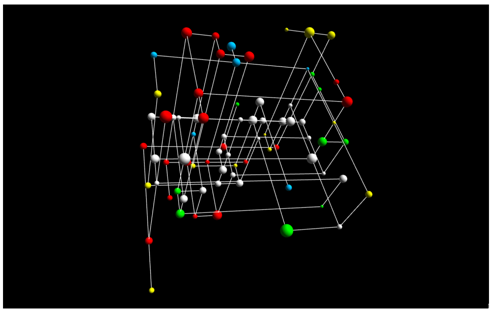

Figure 8. Screen capture of the score for *point studies no. 2* (2013) for any two pitched instruments and computer.

The score for *point studies no. 2* is generated live at the start of each performance but once generated, the pitches, their intensities, and the possible navigational pathways between them remains fixed. No position within the grid of nodes is privileged, however, as the performers are free to choose their starting node and respective pathways through the score. In order to facilitate legibility of the full distribution of pitches, a virtual camera moves around, in-and-out of the score.[4] The illusion of depth within the score is created by distributing nodes in three dimensions where mapping in the z-dimension is achieved by adjustments of scale and lighting. Like any three-dimensional object presented on a two-dimensional surface, occlusion of background layers presents a challenge difficult to overcome. To that end, the author is exploring how augmented reality systems might offer opportunities for performers to physically engage with a score by integrating choreographed movement around the virtual score within the interpretation.

4.2 16:16 (2016)

16:16 (2016) for prepared piano four hands, presents a different approach to the use of three-dimensional notation and is the first work of the author's to explore the use of stereoscopic imagery. While, the work has some superficial similarities to *point studies no. 2* in that colored nodes are used to represent pitched events, *16:16* extends the graphical schema considerably and presents the performers with a more complex range of possibilities in interpretation.

In *16:16*, nodes represent various pitched events with color denoting a different type of preparation material (red⟶screw, green⟶rubber, blue⟶plastic, yellow⟶metal, white⟶wood). To facilitate interpretation, it has proven helpful for small colored adhesive labels to be applied to the piano keys, see Figure 9a. Nodes are randomly distributed on a rectangular grid which contains various numbers within certain squares indicating the number of times a note is to be repeated, see Figure 9b. During the work, nodes rise and fall from the fixed grid

[2] Curiously, Jim O'Rourke's 2006 recording of Takemitsu's *Corona*, also foregrounds multidimensionality through juxtaposing two different performances of the work. [14]

[3] A score excerpt is available for viewing at <http://www.davidkimboyle.net/point-studies-no-2-2013.html>.

[4] This virtual camera corresponds to the OpenGL camera which looks upon a scene to be rendered within the Jitter environment in which the work is programmed.

with one of the pianists interpreting those that rise and the other those that fall. Such nodes are said to be activated and are the only nodes eligible for performance by either player.

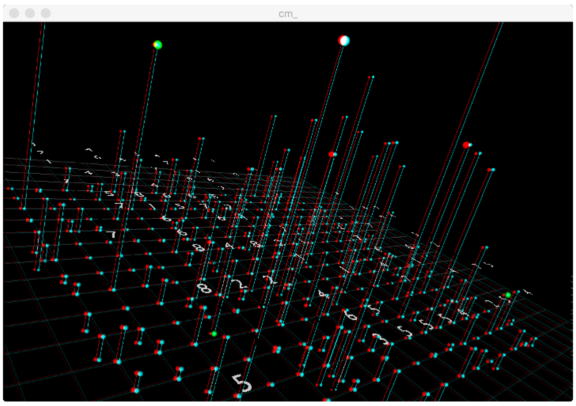

Figure 9. a) Colored adhesives applied to piano keys to facilitate score interpretation (top), b) Screen capture from the anaglyphic score for *16:16* (2016) for prepared piano four-hands (bottom).

Like *point studies no. 2*, the virtual camera through which the displayed score for *16:16* is presented to the performers moves in three-dimensional space which not only facilitates legibility but also helps reveal and occlude particular segments of the score. The real innovation of *16:16*, however, is that it is presented as a stereoscopic, anaglyph image requiring each of the performers to wear red-cyan glasses. In an anaglyph, a stereoscopic image is created by physically separating the red and cyan channels of a full-color image. In order to ensure that each eye only receives the filtered image intended for it, red-cyan glasses need to be worn. The further the channels are separated, the greater the illusion of depth that is created. In the Jitter/OpenGL environment within which the score for *16:16* is generated, this is achieved by rendering a scene from two different camera angles each of which is subsequently filtered to display discrete red (left) and cyan (right) channels, see Figure 10.

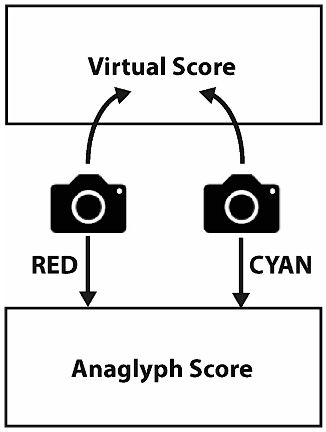

Figure 10. Creating a stereoscopic image in *Jitter*.

Unlike stereoscopic images which require the use of polarized light, or immersive systems which radically constrain interaction with an instrument, the anaglyph image offers a cheap method through which a stereoscopic effect can be created for performers. In *16:16*, it facilitates legibility of the three-dimensional movements of nodes and helps distinguish nodes aligned along nearby axes. The use of an anaglyph image is not, however, without constraints. It is somewhat pointless, for example, to display such imagery to an audience as is often done in concerts featuring works with real-time screen scores unless members of the audience are presented with their own red-cyan glasses. Of more concern, however, is the fact that anaglyph images have a limited color field with which they are effective. [18] While this has not been a tremendous constraint in *16:16* with a color field limited to red-green-blue-yellow-white-black, it still represents a constraint affecting typographical choices.

5. CONCLUDING THOUGHTS AND FUTURE WORK

By promoting a reading *through* rather than just a reading *across* within a notational schema, scores that feature juxtaposition, superimposition, and other three-dimensional techniques help establish a new spatial ontology for the works they afford. [19] Through offering new ways of engaging with space, these works also draw awareness to the activity that takes place within it. Cage strongly hints at this in his discussion with Richard Kostelanetz on *Variations III* where he states – "…We are constantly active; we are never inactive. There is no space in our lives. But there is a greater or lesser number of things going on at the same moment; so that if I'm not doing anything other than listening, the fact that I'm listening is that I'm doing something by listening. That's what *Variations III* is." [20]

This reinvigorated awareness of the social dimension of space was also strongly present in much of the 1950s Japanese avant-garde tradition as represented in the work of Ichiyanagi, Tone and others who explored multidimensional notational schemas. [21] And in some respects, it also hearkens back to what Eco was referring to in his discussion of Baroque poetics where he argues that "…the Baroque work of art…induces the spectator to shift his position continuously in order to see the work in constantly new aspects, as if it were in a state of perpetual transformation." [22]

While many pragmatic issues still need to be addressed, perhaps the area with the most potential for future development in three-dimensional representations are those afforded by immersive and augmented reality systems. Concurrent with that opportunity however, is the challenge of overcoming the isolationist tendencies inherent in most such systems. Nevertheless, the author believes the new spatial ontologies afforded by such systems is rich in aesthetic potential with exciting opportunities for new forms of musical engagement.

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