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The Possibilities of Novel Formal Structures through Computer Controlled Live Performance

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ABSTRACT

Computer controlled performance opens a range of novel structural possibilities. This paper explores the mechanisms and ramifications of this approach, and its potential to expand the repertoire of formal structures available to the composer.

Traditional and computer coordinated performance models are compared. Modes of computer control, permutation, transformation and generation are discussed and their implications are evaluated.

The range of implications of this approach to the performance environment are given together with illustrations from the author's own work.

1. INTRODUCTION

The advent of computing provided a platform for controlling musical performance in a manner far more rapidly, seamlessly and interactively than previous media. James Hollan identifies two key features that distinguish computer interfaces from previous forms of representation:

> they provide the most plastic representational medium we have ever known, and they enable novel forms of communication. (…) This plasticity in combination with the dynamic character of computation makes possible new interactive representations and forms of communication that are impossible in other media [12].

This paper examines the scope of the structural possibilities that computer control of live performance implies and permits.

In a traditional acoustic performance model (Figure 1.), coordination of the performance is, in the first case, determined by the composer who provides materials which incorporate both events to be performed and a tempo/metric framework for their synchronization. Coordination of the actual performance is managed by the performers alone, through visual cues and auditory feedback.

This is not to diminish the crucial role played by performers who, in addition to their technical and interpretive skills, draw their own experience and judgments (still far more complex than any computer) into the equation. As John Zorn states in regard to the role of the performers of his work *Cobra* (1984): they "bring in their own private perceptions, past experiences, instrumental techniques, and interpersonal attitudes" [4].

Computer coordination of live musical performance (Figure 1.) allows for the control and synchronisation of

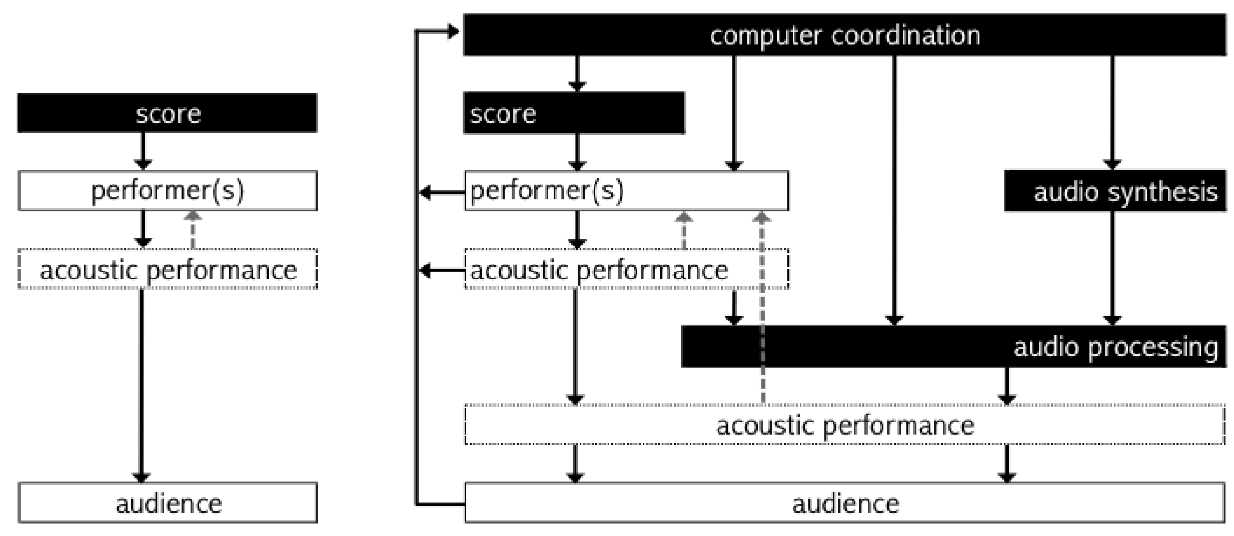

Figure 1. Traditional "Classical" acoustic performance model (left) and the Computer controlled performance model (right).

the score and the temporal framework, in addition to the generation of electronic sounds and electronic transformation of both the acoustically and electronically generated sounds. The computer-generated clicktrack creates the opportunity not only to independently control the tempi of multiple performers, but also to transmit formal (for example nonlinear selection of score materials) and performance (such as articulation, dynamics and so forth) parameters in real-time.

Computer coordination can control many actants in a performance in a manner analogous to the team of players necessary to bring symphony to life. Auditory and visual cues still play an important role in the coordination of the live performance, importantly however, in a computer controlled performance feedback into the system can also be achieved though other means:

- the performers may interact with the computer via hardware interface(s);
- the acoustic performance itself may be used as an interface through computer analysis; and
- the audience may interact with the computer, playing a role in defining the performance.

The performance of music requires extremely fine-grained coordination between events in the order of tens of milliseconds. Computer interoperability allows for the coordination and the requisite rapidity of distribution and interactive analysis that was not previously attainable with performers alone. As such, computer controlled performance potentially permits the conception of formal structures that were previously unrealizable and/or impractical.

2. STRUCTURAL IMPLICATIONS OF COMPUTER COORDINATED PERFORMANCE

The paradigm of the traditional score is that of a continuous scroll, albeit one chopped into segments and arranged sequentially on successive pages for convenience, with the resulting "systems" conventionally read sequentially from left-to-right, top-to-bottom. The rate at which the musical score is read is governed in performance by a synchronised tempo predetermined by the performers. Consequently, the structure of the performed music is, innately linear in character.

Although composers have developed methods to create novel formal structures by subverting the implications of the traditional score with approaches such as mobile musical modules and multiple conductors, they have done so by contravening the conventions of the traditional score. Such approaches are fettered by these conventions, for example: the minimum and maximum length of musical materials presented to the performers and the ability to sequence and coordinate the materials in real-time [18].

The performative, and potentially structural, implications of computer control derive from the nonlinear, hypertextual nature of computational capacities and are musically manifested in three principal organisational procedures: the permutative, generative and transformative.

2.1. Permutation

Computer coordination allows the permutation of musical materials that are presented to performers and the synchronisation of their performance. Permutation of scored materials may involve translocation, insertion, duplication and/or deletion of musical materials. The materials may vary in size from large structural blocks, to sub-structural cells or even individual parameters.

The permutation of large structural blocks of music may be found in traditional paper scores such as Stockhausen's *Momente* (1962-69) and *Mixtur* (1964), however synchronization issues rules out real-time permutation in these works [17].

Although short fragments of a few seconds length, are permutated in the performance of Feldman's *Intermission 6* (1953), the fragments remain isolated "sound objects" rather than functioning at any time as components of a continuous musical passage or discourse. In my works *Antibody* (2009) and *Improbable Games* (2010) sub-structural units are permutated to create novel passages of music in real-time.

Figure 2. Detail from Vickery's *Antibody* (2009) showing permutated "cells".

The independent manipulation of even smaller units, the parameters that are combined to form musical events is also possible in digital media. This approach is exploited in Gerhard Winkler's *Hybrid* series (1991-) [20]. In *Hybrid II*, for example the glissando, string position, bow pressure and dynamics are graphically conveyed to the performer in real-time.

The structural implication of permutation of blocks, cells or parameters in "mobile" forms are the same as those identified by Boulez in Stravinsky's *The Rite of Spring* (1913) [2], namely that synchronous permutation of all parts simultaneously results in "vertical" changes in the performed materials, and asynchronous permutation of the parts, given that they are sufficiently distinct, results in "horizontal" or layered changes. (See Figure 4.)

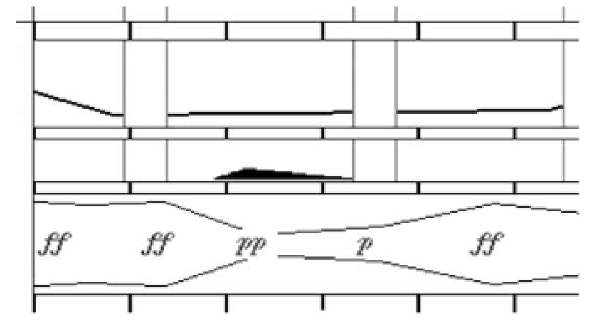

Figure 3. Detail from Winkler's *Hybrid II* for viola and interactive live electronics (1996/2001), showing graphs representing (from the top) string position, bow pressure and dynamics [19].

The vertical and horizontal structural implications of the permutation of audio that is digitally derived are identical to those pertaining to scored materials. However, the source of the sounds may strongly bear on the sense of formal structure that arises, especially in the case that the materials are referential to existing, familiar sources, or derived from processed acoustic sounds from the performance itself. In the first case, familiar sound sources carry their own signification: a ten second burst of a sample from Beethoven or Elvis will sound more isolated in the context of the average minute performance, for example, than a ten second burst of white noise.

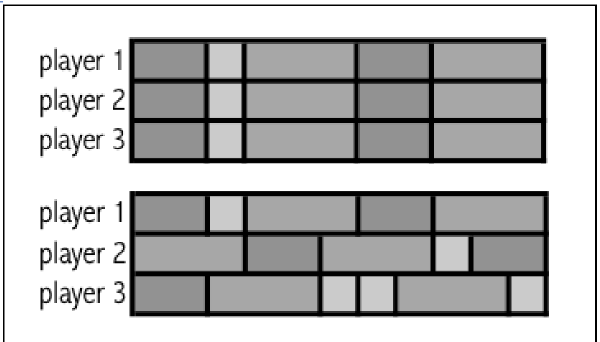

Figure 4. Synchronous "vertical' permutation (top), A-synchronous "horizontal" permutation (bottom).

The permutation of processed live acoustic sound, likewise may be closely bound in the mind of the listener to the instruments that produced them in the recent past. Structurally, live processing may act quite independently of the source sounds, following an opposing trajectory that reinforces, cancels or is in counterpoint with those of the live performer.

2.2. Transformative

Transformation differs from permutation in that it acts upon an "original" object to which alterations occur over time. In this sense transformation is related to the musical concept of development, as permutation is related to "concatenation" or "block" forms [7]. The notion of development is expanded by digital transformation in that the alterations need not be predetermined: they may act uniquely on the materials in each performance.

Transformations may be applied graphically to a digital score altering how it is to be performed. The transformative screen-score is the digital descendant of Stockhausen's *Refrain* (1959), a work in which the paper score is overlaid by a mobile clear plastic strip that modifies whatever the material is below it a structural approach he referred to as "Variable Form" [7].

Figure 5: Excerpt from Kim-Boyle's *tunings* (2006), showing "real-time blurring and other distortion techniques" used to transform the score [14].

In David Kim-Boyle's *tunings* (2006) for cello and computer, "real-time blurring and other distortion techniques" are employed to reveal only portions of an underlying score. Boyle states that the work is modeled on "the idea of an old-fashioned radio tuning into different stations, sometimes pausing, often moving on" [14]. In this Open Work [9], Kim-Boyle refers to a range of musical materials, amongst them Bach's second Cello Suite. The reference to this work extends the "tuning" metaphor, drawing on the performer's own memory and familiarity with this core repertoire work.

My work *Transit of Venus* (2009), utilises a transformative real-time score, live sound processing and independent click tracks to control a guided-improvisation by the players. The score-player for *Transit of Venus* separates the functions of the traditional score, where performance indications are normally vertically unified.

This configuration allows temporal independence to be established between parameters such as texture, pitch, dynamics and articulation. The graphical-score component of the score-player displays a continuum of transformations from silence to free improvisation to be is followed by each performer.

Although transformation occurs over time and is therefore principally a "horizontal" technique, it may contribute important structural distinction according to how it is deployed through the distinction between "vertical" application to all actants in the work, or "horizontal" application to independent layers within the performance.

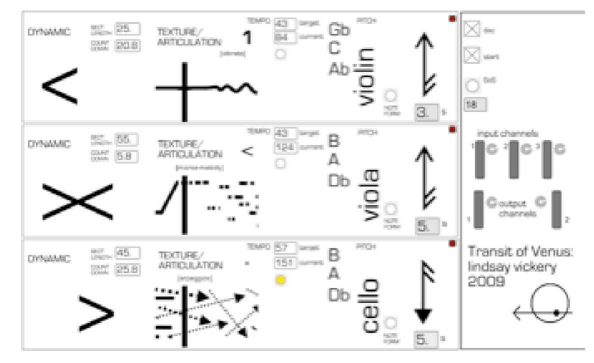

Figure 6: Screen-shot from Vickery's *Transit of Venus* (2009)

2.3. Generative

Algorithmic or interactive generative processes may be employed to construct components of a digital score in real-time. This approach opens broad range of structural possibilities often linked to a narrative or dramatic concept.

In the broad sense permutation and transformation may both be viewed as having generative characteristics. The distinction here is the complete absence of any "object" prior to the performance in generative works. Although algorithmic processes may be predetermine in a generative work, the outcome, in the form of a score or sonic product is completely undefined prior to the performance. For this reason, this form of "dynamic scoring" is sometimes euphemistically referred to as "extreme sight reading" [11].

For example in Polish composer Marek Chołoniewski's *Passage* (2001) a conductor directs a silent performance of hand gestures by the performers, which are measured by changes in luminosity measured by light sensitive resistors mounted on their music stands. The recorded gestural data in turn generates a scrolling score that is subsequently performed by the ensemble [5].

Similarly, Cat Hope's *Possible Stories of Harry Power* (2010) explores a concept not unlike the children's game "Chinese Whispers". Specifically in this case, the fabrication of mythologies around the life of the Australian folk hero, the bushranger Ned Kelly. Three instruments representing the Kelly, his mentor Harry Power, and Kelly's mother, read their pitch and volume from a projected graphical score. Each instrumental line is depicted in a different colour in what are essentially four a maps both of the pitch, duration and timbre of each line and the versions of the recorded movements of Power, Kelly and his mother in relation to each other in time.

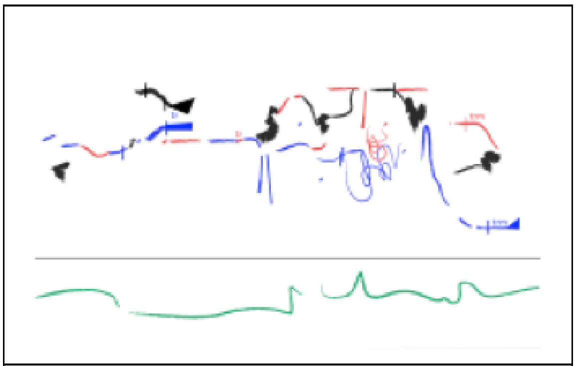

Figure 7: Section 1 of Hope's *Possible Stories of Harry Power*: the initial graphical notation score presented to the musicians.

In performance, the first "map" (Figure 8.) is played and simultaneously rendered by the computer into a second map incorporating the computer (and performer's) errors, this second map is then played and the process is repeated, recasting the score into a third map incorporating yet another layer of "Chinese whispers" style elaboration. The final section returns again to the composer's rendering of yet another version of the intertwining trajectories of the three characters (Figure 9.).

The computer patch, created in Max/MSP by Kynan Tan, "listens" and "retells" the performer's reading in an analogy to oral transmission. The three performers are recorded via contact microphones, the computer analyses the instruments' pitch, inverts them and then renders them proportionally in three contrasting colours as the next portion of the score. As such, *Harry Power,* casts the computer's generative potential in a narrative role, taking advantage of the inaccuracies in the

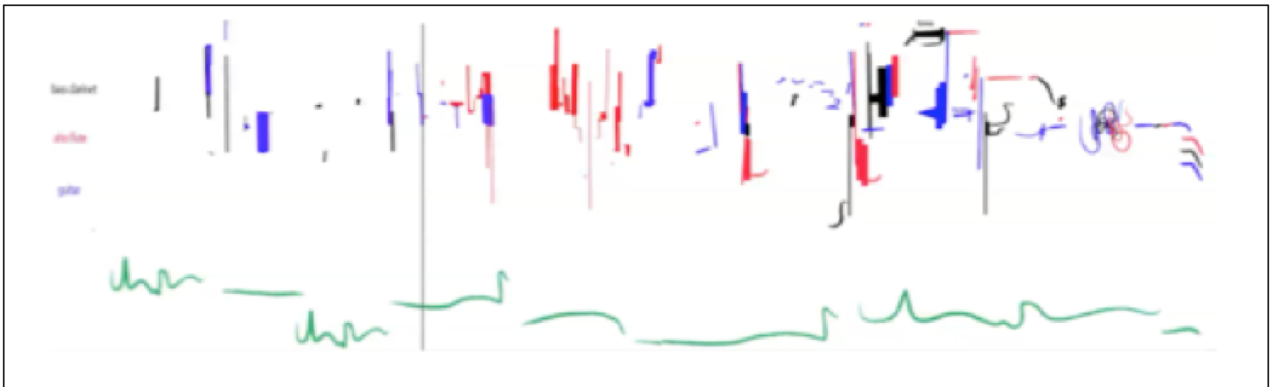

Figure 8. The final 3 sections of *Possible Stories of Harry Power,* showing the computer renderings of the performer's realization of section 1 and 2 and the final graphically notated section.

computer's transcription, to enact an analogy to the transformation of oral transmission of narrative.

Interaction with a generative model may also take place directly with the algorithmic processes themselves as is the case with "live coding", an approach that "involves writing and modifying computer programs that generate music in real-time. Often this music making activity occurs in a live performance situation with the code source projected for the audience" [3].

The structural implications of generative approaches are particularly open-ended: Choloniewski's work is gestural and performative, Hope's programmatic and the live coding approach is in some respects narrative and performative. It might be expected that many other paradigms will be explored as this practice (and technology) matures.

3. FORMAL IMPLICATIONS

A sense of structure is derived from changes in continuity and discontinuity in materials, processes and transformations evident in the sonic outcomes arising from a particular performance model. In the traditional classical model the sense of structure derives principally from the score, with a relatively minor contribution drawn from the performers' interpretation and interaction. Computer coordination allows a radical redistribution of the relationships between the performers, the score, the digital components and the audience. Structural decisions may arise from any actant in the performance model and may be the result of interaction and improvisation as well as predetermination. In Jason Freeman's *Glimmer* (2004) for chamber orchestra and audience participation, for example, the audience influences the unfolding composition "by waving four-inch battery-operated LED light sticks back and forth" in front of video cameras' [11].

Computer coordination allows for greater distinction between voices and layers in a musical work through expansion of timbral, dynamic, spatial and temporal qualities both "vertically" and "horizontally".

Sampling provides a pathway to unprecedented referentiality to sound objects outside the performance model. Networking and telepresence expand the potential of these possibilities beyond the specific environment of the performance model. Perhaps these possibilites will someday allow for the realization of Anthony Braxton's "orchestral musics" conceived "to be performed simultaneously in different cities, (if perhaps not "on different planets and even in different galaxies" [1].

3.1. Multiple versions

In *The Open Work*, Umberto Eco theorised the possibility of the "work in movement" permitting "numerous different personal interventions" [10]. The Computer coordinated performance provides just such a possibility, allowing for the existence a precise, unique but variable, multi-versioned work, in which each performance renders a new outcome.

3.2. Immancence

Computer coordination reduces the cognitive load on the performer. The manipulation of musical materials and the provision of coordination for their performance reduces non-musical decision-making, and potentially allows the performer give greater focus to their performance. It is also possible to apply structure to materials that are freely improvised, placing the performer(s) in an environment where the only consideration is the "performed moment". George Lewis the composer of the *Voyager* (1987), an "interactive musical environment that privileges

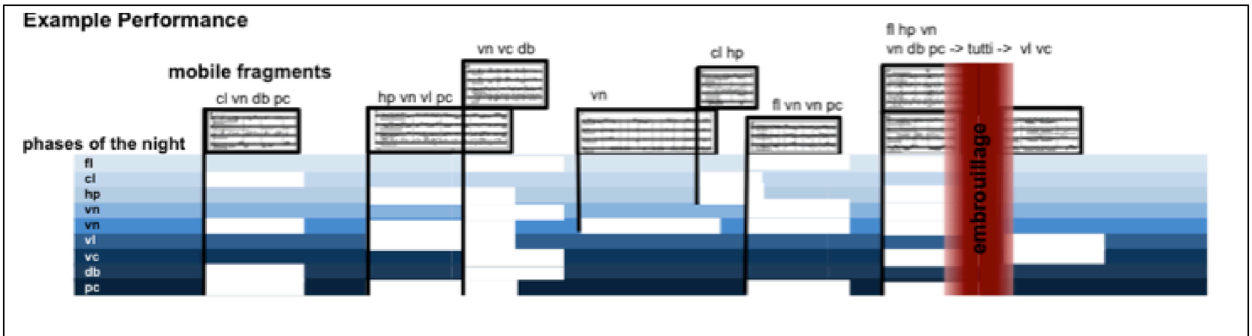

Figure 9. Representation of the formal structure of Vickery éraflage (2007)

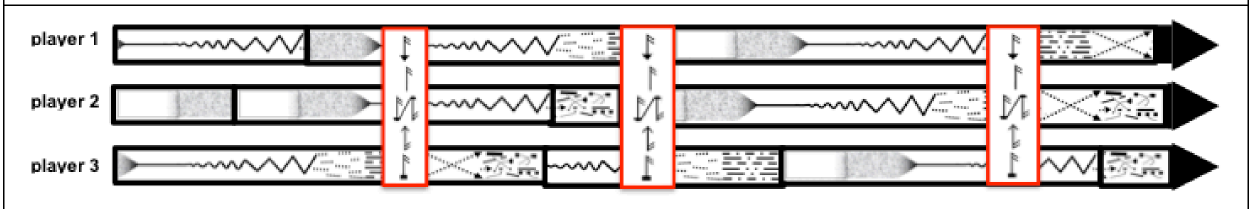

Figure 10. Representation of the formal structure of Vickery's Transit of Venus (2009)

improvisation" states "with no built-in hierarchy of human leader/computer follower—no "veto" buttons, footpedals or physical cues—all communication between the system and the improvisor takes place sonically" [16]. Other systems specifically designed for improvised performance include those of Lawrence Casserley and Evan Parker [4] and William Hsu and John Butcher [13].

In this environment the performer might be potentially capable of playing in an "immanent" state, what Deleuze defines as "a pure stream of a-subjective consciousness, a pre-reflexive impersonal consciousness, a qualitative duration of consciousness without a self" [8].

3.3. Poly-structure

Permutative, generative and transformative strategies can be independently employed a single work through computer coordination. The combination of formal structures in a single work leads to structural polyphony – poly-structure.

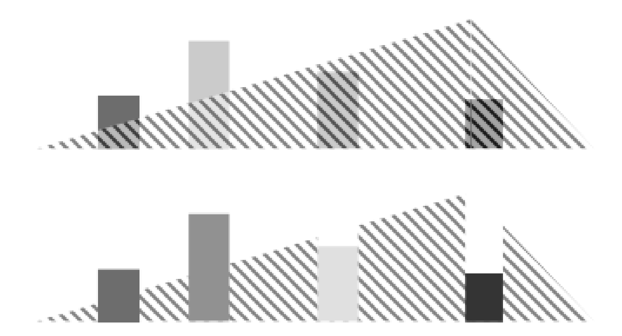

Figure 11. Representation of poly-structure (top) and interleaved poly-structure (bottom)

In my work *Éraflage* (2007) two formal structures co-exist: one a continuous loop of 27 bars at a constant tempo, that is performed throughout the work and the other a "mobile" collage of 12 musical fragments with five varied tempi. At indeterminate junctures the computer instructs between two and four players via headphones to disengage from the continuous texture, and to perform one of the fragments. The performers are coordinated both in their performance of the fragment and in their return to the continuous texture via click-track. This gives rise to a poly-structure comprising a dynamic permutative collage and a static looping continuum.

Poly-structures may also be interleaved by alternating sections that are based on distinct formal principals. My work *Transit of Venus* is an example of such a structure. The work alternates between two principal modes. The first presents a scrolling continuum of musical textures to the performers, the second is a improvisatory section during which the continuum and the metronomic click are suspended for all three performers. During these periods each performer follows the note-form indications that appear for short periods on the right of the screen (See Figure 6).

3.4. Subtractive structures

Poly-structures are additive in nature allowing the accretion of formally distinct material. The converse process – removing structural material – is also facilitated by computer coordination. Precise real-time excisions of material provide a novel structural approach.

An example of the potential of this tactic is my work *ghosts of departed quantities* (2010) that explores the paradox of "the devil's staircase", in which the proportional removal of material is repeated successively leading to the formation of an increasing number of fragments of decreasing size. The sonogram in Figure 13. shows the progressively increasing number and decreasing size of "holes" cut into the both the electronic and acoustic components of the performance.

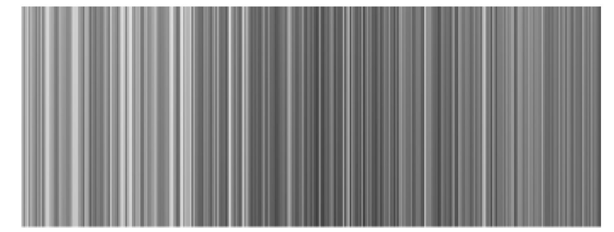

Figure 12: Condensed Sonogram of a 12 minute performance of Vickery's *Ghosts of Departed Quantities* (2010)

3.5. Substructural organisational procedures

Computer coordination may also act upon materials at the sub-structural level, allowing permutation, transformation and generation of material from within musical structures. In my work *Antibody,* for example a formal structure based on biological principles of mutation is explored. In this work, five contrasting blocks of musical material, each nine measures long with a distinct tempo and texture, are progressively "mutated" by translocating a greater number of cells between them to create increasingly hybrid arrangements. The order in which the five blocks appear is also permutated continuously.

Between the iteration of each block are interstitial spaces during which the players are instructed to improvise on the material they have just performed and link it to the next block. The length of these unscored sections is increased by one beat completion of each block.

Digital processing of the acoustic instruments provides a final level of transformation. Each player is separately recorded and processed and the degree and rate of processing grows throughout the work.

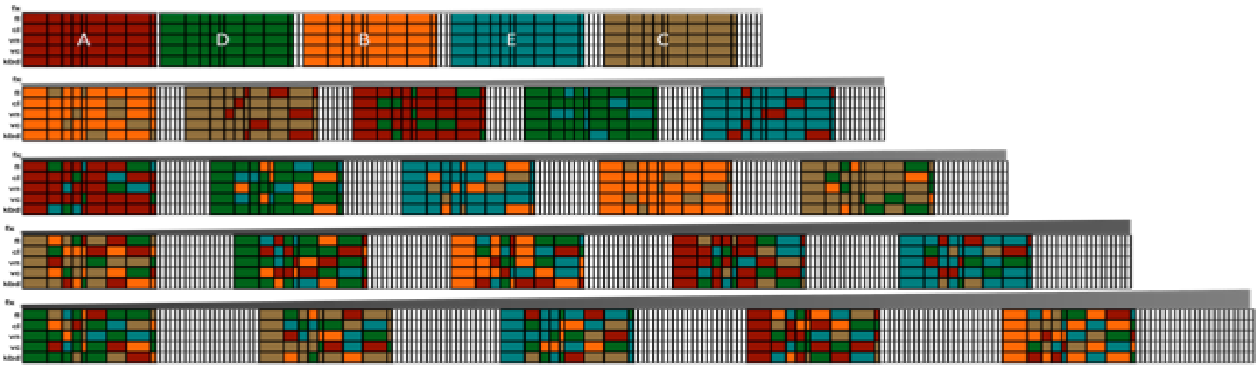

Figure 13. Representation of the "mutational" formal structure of Lindsay Vickery Antibody (2010)

4. CONCLUSION

The invention of the paper score provided composers with unprecedented control over the coordination of large musical forces and structures. However, in the last fifty years many composers have pushed the capabilities of the paper score to their logical limits.

Use of the computer as a source of coordination of musical forces provides a new step forward in furthering the development of musical organization and structure. Computer coordination allows for:

- the synchronisation and interaction of performance elements such as the score, performer(s), audio synthesis, acoustic performance, audio processing and audience;
- the permutation, transformation and generation of these elements;
- the instantiation of multiple versions of works;
- the formation of new formal paradigms such as poly-structure, subtractive structures, substructural organisational procedures.

Although the exploitation of this medium is in its early stages, the advantages in terms of exploring novel structural approaches are difficult to deny.

5. REFERENCES

[1] Adler, D. R., (2007). Anthony Braxton: True Mathematics, Jazz Times, May 2007. Available [on-line] at http://jazztimes.com/articles/18704-anthony-braxton-true-mathematics

[2] Boulez, P. (1991). "Stravinsky Remains", in Stocktakings from an Apprenticeship, Oxford University Press. pp. 55-110

[3] Brown, A. R., and Sorensen, A. C., (2009) *Interacting with generative music through live coding.* Contemporary Music Review, 28(1) pp. 17-29.

[4] Casserley, L. (1998). A Digital Signal Processing Instrument for Improvised Music - Journal of Electroacoustic Music, Vol 11, pp. 25–29.

[5] Chołoniewski, M., (2001). "Passage", Interactive Octet for Instruments and Computer, http://www.studiomch.art.pl/

[6] Cobussen, M., (2002). *Deconstruction in Music*, Interactive PhD Dissertation, Department of Art and Culture Studies, Erasmus University Rotterdam, The Netherlands. Available [on-line] at <http://www.cobussen.com/navbar/intro1.htm>

[7] Coenen, A., (1994). "Stockhausen's Paradigm: A Survey of His Theories." Perspectives of New Music 32, no. 2: 200-25 p. 218

[8] Deleuze, G., (2001). Pure Immanence: Essays on A Life, Zone Books: Brooklyn p. 29

[9] Eco, U. (1989). The Open Work. Cambridge, Massachusetts

[10] Eco, U. (1989). The Open Work. Cambridge, Massachusetts p.19)

[11] Freeman, J., (2008). Extreme sight-reading, mediated expression, and audience participation: Real-time music notation in live performance. Computer Music Journal, 32(3), 25–41.

[12] Hollan, J. D., (1999). Human-computer interaction. In R. A. Wilson and F. C. Keil, editors, Encyclopedia of the Cognitive Sciences. 379-381, MIT Press, 1999. p. 379

[13] Hsu, W., (2005). Using timbre in a computer-based improvisation system. In Proceedings of the ICMC Barcelona, Spain,

[14] Kim-Boyle, D., (2006). "Real-time generation of Open-Form Scores", Proceedings of Digital Art Week Symposium, Zürich: Die Eidenössische Technische Hochschule (ETH)

[15] Kim-Boyle, D., (2010). Real-time Score Generation for Extensible Open Forms, Contemporary Music Review, 29: 1, p. 9

[16] Lewis, G. E., (2000). Too Many Notes: Computers, Complexity and Culture in Voyager, in Leonardo Music Journal, Vol. 10, pp. 33–39, 2000 p. 36

[17] Vickery, L. (2010). Increasing the mobility of Stockhausen's mobile scores, Musicological Society of Australia, University of Otago, Dunedin

[18] Vickery, L. (2010). Mobile Scores and Click-Tracks: Teaching Old Dogs, Proceedings of the Australasian Computer Music Conference, Australian National University, Canberra

[19] Vickery, L. and Hope, C., (2010). The Aesthetics of the Screen-Score, Proceedings of CreateWorld 2010, Griffith University, Queensland

[20] Winkler, G., (2010) 'The Real-Time-Score: Nucleus and Fluid Opus', Contemporary Music Review, 29: 1, pp 89-100

[21] Ibid. p. 93