# 5. The Spectrogram as a Tool for Analysis of Nonlinear Structures

As the chief characteristic of nonlinear structure is disjunction between and conjunction within musical substructures, the analytical techniques associated with works foregrounding parametrical manipulation are particularly pertinent. The techniques of *Sound Mass* composition are focused almost exclusively on broad multi-parametrical manipulation of abstract textures and therefore provide mechanisms for the objective evaluation of conjunction and disjunction within a composition. Techniques of composers such as Xenakis, Ligeti and Penderecki afford a useful entry point into the discussion of nonlinearity between compositional substructures.
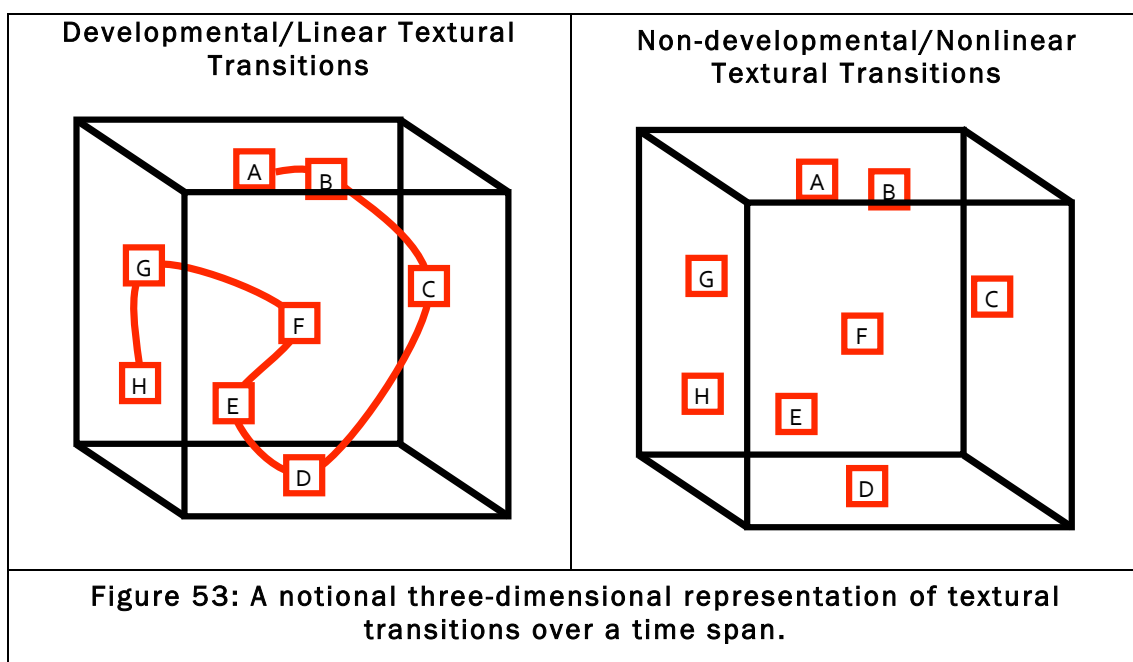
Danuta Mirka's analysis of the timbre system of Krzysztof Penderecki reveals that the composer dealt with the creation of texture by plotting textural shifts on a parameter "rosette" (Mirka 2000) (see Figure 52). Use of the rosette allowed Penderecki to distinguish and plot textural "states" that formed the basis of the structure of his Sound Mass works such as *Threnody for the Victims of Hiroshima* (1960).

Figure 52: The "Rosette of Penderecki's basic system" from (Mirka 2000 p. 4).
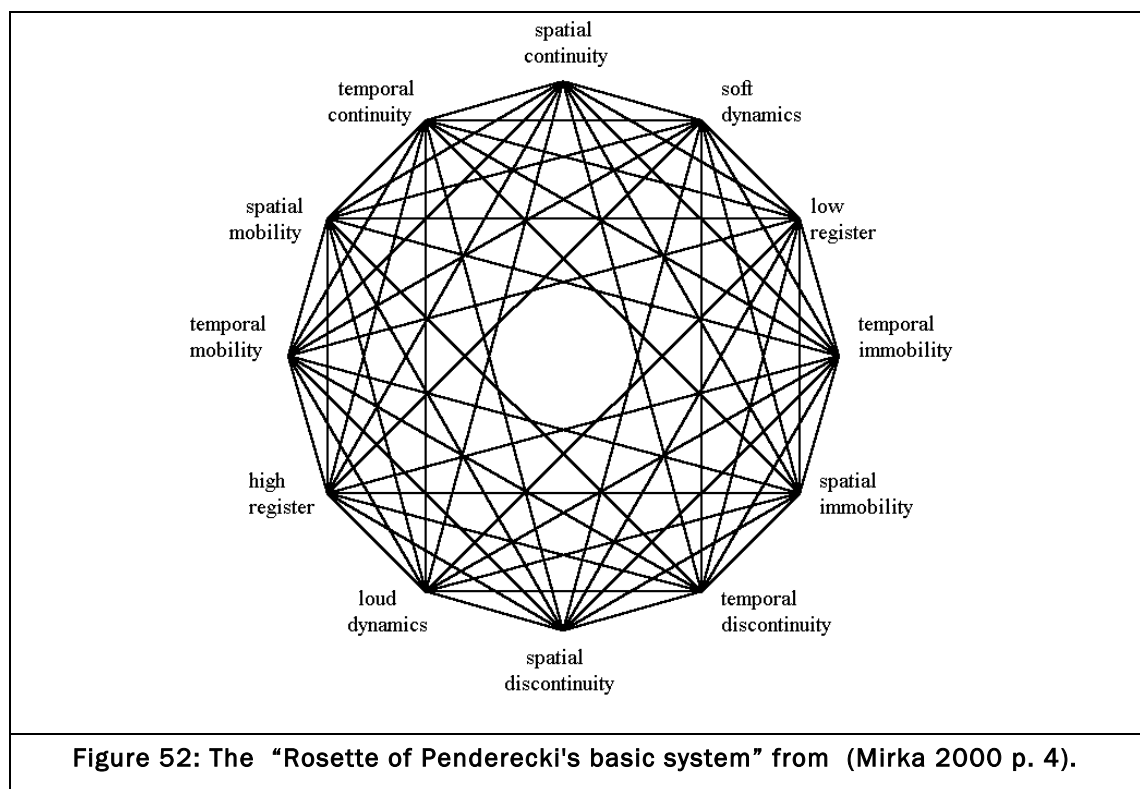
The rosette concept permits some broad generalisations about the presence of continuity and discontinuity between sub-sections within a composition. It is bounded by parametrical continuums: high register/low register, temporal continuity/discontinuity and so on, "A combination of their terms generates an inventory of elementary syntactical units in Penderecki's sonoristic style" (Mirka, D. 2000 p. 3).

By expanding this process and plotting the transitions between textural states over time, it is possible to expose the level of disjunction occurring between sub-structures. In this approach, works in which substructures transition continuously from one textural state to the next would be considered developmental and linear, whereas works in which substructures transition discontinuously, by shifting directly from one textural state to a contrasting state would be considered non-developmental and nonlinear.

The representation of texture as a multidimensional parameter-space allows for a clearer illustration of this method for evaluating the presence of nonlinearity in a musical work. In Figure 53, three dimensions are represented to schematically represent this method (for example relative pitch, duration and dynamics). In reality, such a system would need to evaluate transitions in numerous dimensions (timbre, tempo, style and so on) to fully take into account the degree of discontinuity between one textural state and the next.

Developmental/Linear Textural Transitions	Non-developmental/Nonlinear Textural Transitions

Figure 53: A notional three-dimensional representation of textural transitions over a time span.

The recognition of discrete substructures is crucial to nonlinearity because, in many cases, the overarching narrative structure found in developmental forms is either minimised or completely dispensed with in nonlinear works.

This chapter explores the spectrogram as an analytical tool for nonlinear structures. The spectrogram represents duration and pitch/timbre spatially, and amplitude through colour intensity. These parameters include four of the five "form-bearing" parameters listed by McAdams (1989 p. 195). The spectrogram does not provide any evidence of referentiality and is limited in the degree to which it can indicate narrative aspects of a composition. In multilinear works, the listener is exercising sophisticated perceptual acuities to differentiate simultaneous streams of music that are often not apparent in the spectrograms visual representation. For this reason the spectrogram is ill suited to the analysis of such works. However, it is a useful tool for visualizing parametrical disjunction, the primary source of nonlinearity in sequential musical structures. Four contrasting sequential nonlinear works will be examined using this technique with the purpose of establishing the efficacy of the spectrogram as an analytical tool.

5.1. Sequential Non-referential Nonlinearity: Stravinsky's Symphonies of Wind Instruments (1920).

Stravinsky's *Symphonies of Wind Instruments* is a complex work combining many features that might normally create unity, such as: tonality/modality, a small range

of related tempi, a timbral pallet limited to woodwind and brass instruments and melodic materials that are for the most part typical of his "Russian" period. Despite these features, the work plainly establishes discontinuity between its component substructures to a degree that strongly implies a nonlinear Block Form construction.

Symphonies has been, and continues to be, frequently analysed[95], perhaps partly on account of Stravinsky's own intriguing description of the "cut and paste" (Cross) manner in which elements were "adumbrated", post-completion, into the work.

> The music was finished in an abbreviated score (...) but a few days later I added two adumbrative bits of chorale to the body of the piece.
> (Stravinsky and Craft 1972 p. 39)

The challenge of analyzing the work was also laid by the composer's comments (as related to Nicholas Nabokov) in regard to the compositional procedures employed in his *Oedipus Rex* (1927).

> "Here, see, I cut off the fugue with a pair of scissors". And he clipped the air with his fingers "I introduced this short harp phrase like two bars of an accompaniment. Then the horns go on with their fugue as if nothing has happened. I repeat it at regular intervals, here and here again.
> (Nabokov 1951 p. 152)

The numerous analytical interpretations of the work reveal much about the ideological shift in musical analysis away from the desire to reveal an underlying formal unity. Edward Cone's groundbreaking investigation already identifies the discontinuities in the work caused by what he terms "stratification".

> By stratification I mean the separation in musical space of ideas - or better, of musical areas-juxtaposed in time; the interruption is the mark of this separation. Since the musical areas are usually incomplete and often fragmentary, stratification sets up a tension between successive time segments. When the action in one area is suspended, the listener looks forward to its eventual resumption and completion; meanwhile action in another has begun, which in turn will demand fulfillment after its own suspension. (Cone 1962 p. 19)

Nevertheless, he concludes that the work achieves an overall unity through "interlock", and finally "synthesis" of the musical material. Kramer, similarly notes the non-linearity of the middleground structures[96], while finding continuity in the foreground through "motivic, harmonic, and voice-leading consistency" and "a

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[95] See Cone 1962, Somfai 1972, Straus 1982, Hasty 1986, Kramer 1978 and 1988, Yin 1990, Walsh 1996, Taruskin 1996, Rehding 1998, van den Toorn 1998 and Horlacher 2001

[96] Kramer suggests the middleground discontinuities constitute what Stockhausen terms "Moment" Form: "albeit an early and impure example." (Kramer 1981 p. 548)

linear stepwise progression descending in the bass and circular in the treble" governing the background relations (Kramer 1981 p. 553).

Redhing, on the other hand, focuses on Stravinsky's technique of "interpolation" which he describes as:

> a foreign body breaking up the predominant material, and it therefore provides the basis for a 'logic of discontinuity', as a non-linear kind of coherence, central to the understanding of the form of Symphonies.
>
> (Rehding 1998 p. 48)

Redhing's identification of a "non-linear kind of coherence" in *Symphonies,* points towards the conception of an aesthetic of formal balance through disjunction and contrast. An aesthetic in which the structural balance of the work relies upon the tension between the components of its patchwork of blocks, rather than upon continuity and developmental momentum. In this regard Cross draws the analogy between *Symphonies* and Picasso's Analytical Cubist period:

> Certainly the way in which blocks of music are interrupted, shear off or fracture, gives a rough character to the work which is shared by Picasso's *Nude*. (Cross 1998 p. 282)

The source of the dual interpretation of continuity and discontinuity in *Symphonies* is evident in the opening 13 bars (figure 54). The first six bars, starkly scored for accented, fortissimo, high register flutes and clarinets with a piano pedal of trumpets and horns, alternates with tenuto, soft tutti chords with all of the instruments playing in their mid to low ranges. Stravinsky clearly differentiates these opening blocks by articulation, orchestration, dynamic and register and yet, the second block beginning in bar 7 is none other than one of the composer's "adumbrations" of the chorale, a germ that will grow to dominate the final section of the work, providing the "interlock", and "synthesis" suggested by Cone.

Figure 54: Metric Modulation at Figure 6 of Stravinsky's *Symphonies of Wind Instruments* (Score Excerpt © 1920 Boosey and Hawkes).

Although Somfai's "attempt to reveal 'organic continuity'" has been criticised (Rehding p. 39), his documentation of the close parallels between the orchestration of *Symphonies* and its sectional structure reveals an important source of perceptual demarcation between the blocks. Figure 55 shows Somfai's schematisation of the orchestration and therefore timbral shifts between the substructures of *Symphonies*.

The final element in *Symphonies*' enigmatic puzzle, is the over-arching tempo structure of the work, based on metric modulations of a fixed ♩ = 72 pulse, which give rise to the related tempi of ♩. = 108 (72 multiplied by $^3/_2$) and ♩ = 144 (72 multiplied by 2).

The subtle interconnections of the tempi in the work allow Stravinsky to perceptibly "change gear" (see Figure 54), maintaining a degree of forward momentum, while simultaneously creating enough disturbance to signal the initiation of new principal formal divisions.[97]

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[97] *Symphonies of Wind Instruments* comprises two layers of formal division: higher order substructures generally marked by tempo changes and comprising a lower order arrangement of sequential nonlinear blocks.

Figure 55: Mapping of orchestration to sectional structure of Symphonies of Wind Instruments from Somfai 1972 p. 379.
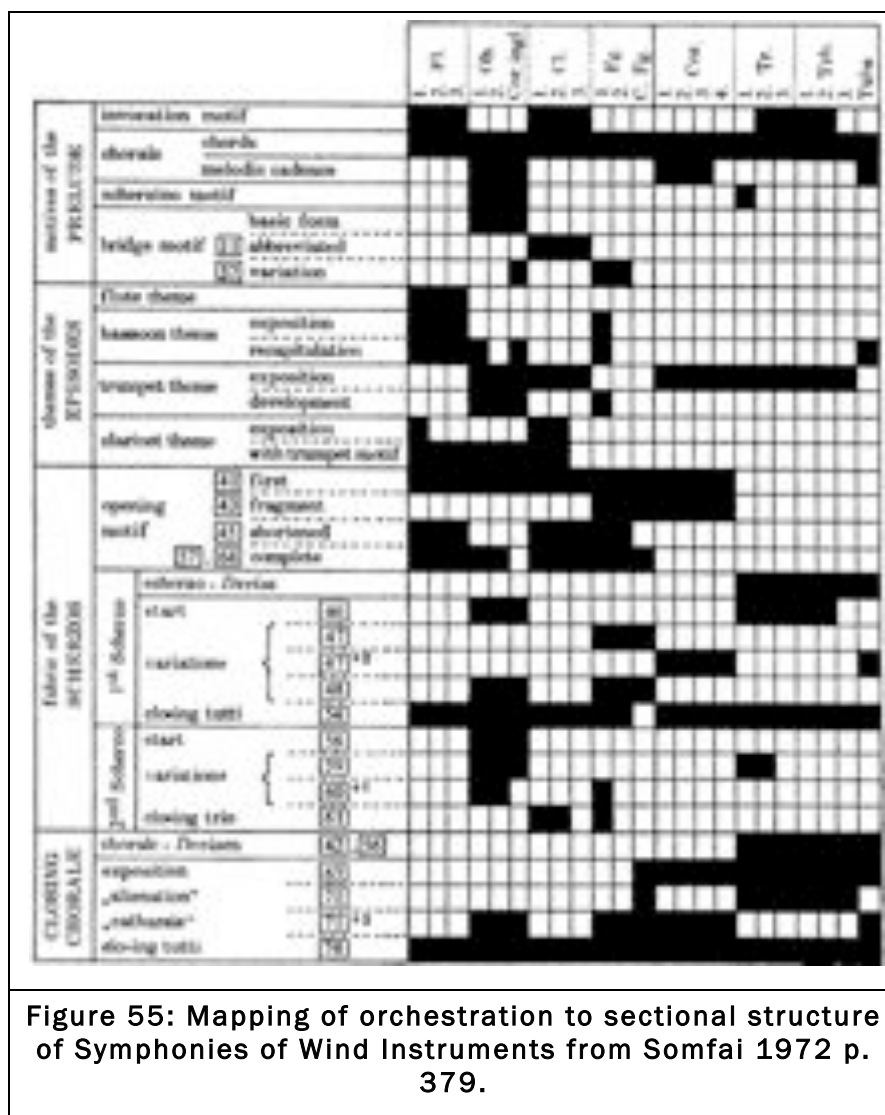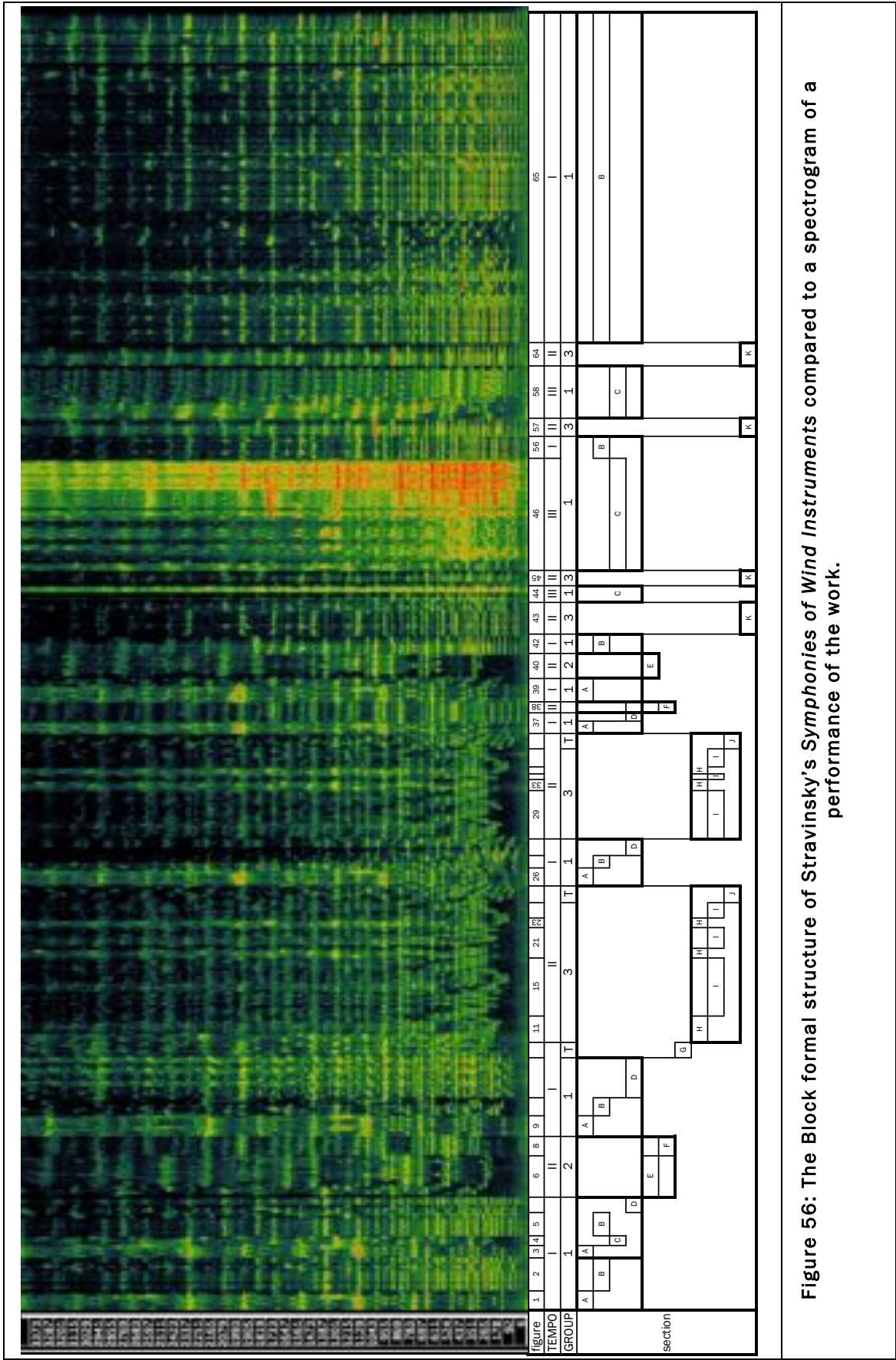
Figure 56 illustrates an analysis of the formal structure for *Symphonies* based on a synthesis of the work of Kramer, Rehding and Yin in relation to a Spectrogram[98] of a performance of the work. The spectrogram renders visible the frequency and intensity of sounds in the work and as such can provide a rough indication of register, dynamic and to a certain extent, orchestration of the blocks that comprise *Symphonies*.

Symphonies reliance upon the parameters of register, dynamic and orchestration to differentiate middle-level block forms is clearly visible in Figure 56. The proposed structure of the work comprises three large-scale formal divisions marked 1, 2 and 3 each further subdivided into middleground blocks: 1: A, B, C, D, 2: E, F and 3: H, I, J, K, and a transitional section: G. In this view the formal structure unfolds in three

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[98] The Spectrograms in this dissertation were created using Chris Cannam's *Sonic Visualiser* software distributed by Queen Mary, University of London.

strands. The beginning to figure 36 in the score, introduces all three large-scale formal divisions contrasted over relatively long spans; a truncated repetition of the first span in which materials from all three formal divisions alternate rapidly; followed by the concluding, relatively uninterrupted span that leads to the final chorale.

Figure 56: The Block formal structure of Stravinsky's *Symphonies of Wind Instruments* compared to a spectrogram of a performance of the work.

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5.2. Referential Nonlinearity: Pierre Schaeffer's *Étude aux Chemins de Fer* (1948)

Pierre Schaeffer's *Étude aux Chemins de Fer* (1948) is one of the earliest examples of Musique Concrète. It was created from "recordings of six steam locomotives whistling, of trains accelerating, and of wagons passing over points" (Sinker 1997 p. 81) from which 23 samples were chosen and assembled into a short study.

Schaeffer would later define the interpretive strategy for Musique Concrète in terms of "reduced listening" a "listening mode that focuses on the traits of the sound itself, independent of its cause and of its meaning" (Chion 1994 p. 29). Schaeffer states that such listening requires "deliberately forgetting every reference to instrumental causes or pre-existing musical significations. The sounds follow each other, much like the cars of a train, in a linear sequence of sound events (Schaeffer 2004 p. 81). In this early work however, the associations with the sound source cannot be avoided.

Schaeffer conceived of Sound Objects schematically, grouping them into families with associations linking them together:

> It is the object (...) that has something to tell us, and consequently we should use it in assemblage according to its familial relationships and the concordance of its characteristics.   (Slater 2000)

The work is less than three minutes long and therfore, on a formal level, comprises only brief middlelevel relationships, albeit of two different kinds, between the recorded samples. Distinction between the sounds can be made on purely musical terms without reference to their extra-musical associations, through variation in frequency, timbre, rhythmic components. In addition, the ambient sound of reverberation plays an important role in separating the sounds that are "outside" and "inside", as well as the proximity of the sounding object(s).

On the other hand, the 23 distinct recordings that make up *Etude de Chemins de Fer* can be grouped into seven families: Guard Whistle, Accelerating Train, Carriage Interior, Rhythmic Train Rolling, Steam Release, Sharp Metallic sound and Dull Wooden sound. Only the last two could conceivably not be strongly associated to the concept of Railroads.

Figure 57. Shows an analysis of *Étude aux Chemins de* Fer plotted against a spectrogram of the work. The table below the spectrogram shows sequentially numbered sections, the elapsed time, the duration of each subsection and a letter designation for each formal block.
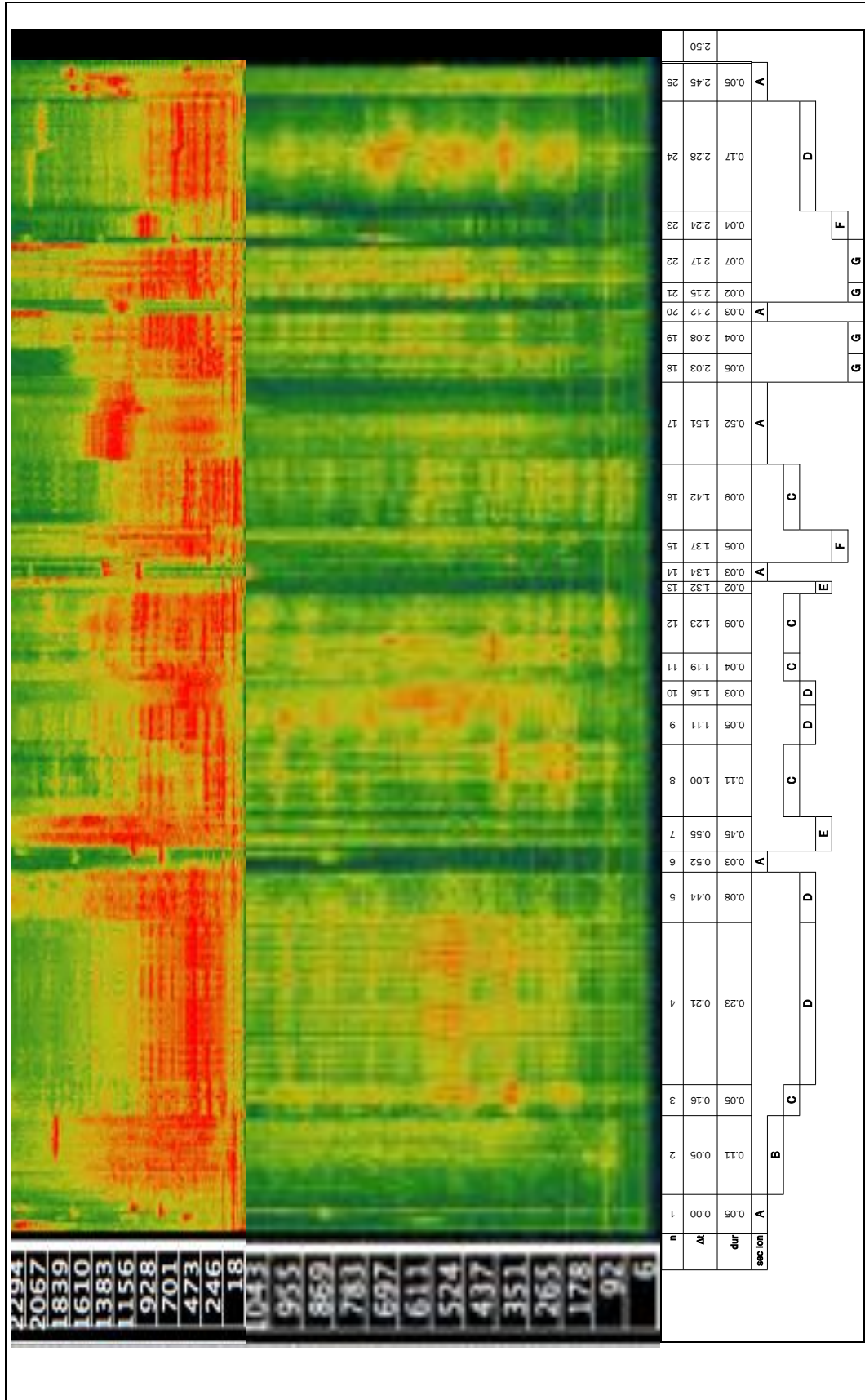
Figure 57: Pierre Schaeffer's Etude Chemins de Fer (1948). Formal structure and comparison to Spectrogram, showing Block Form transitions between materials of varied frequency, timbre and rhythmic content. The seven types of sounds are: A: Guard Whistle, B: Accelerating Train, C: Carriage Interior, D: Rhythmic Train Rolling, E: Steam Release, F: Sharp Metallic Sound; G: Dull Wooden Sound.

5.3. Referential Nonlinearity: James Tenney's Collage #1 "Blue Suede" (1961)

An early example of a nonlinear narrative based on a single source is James Tenney's *Collage #1 "Blue Suede"* (1961). The sonic material is derived exclusively from one source (Holm-Hudson 1997 p. 19) and its provenance is explicit in the title, and more clearly so upon listening to the complete work. However the identity of this "musical object" is not aurally apparent "until one minute and seventeen seconds into the piece, when the distinct timbre of Presley's voice breaks through the more amorphous sonic material" (LeBarron 2002 p. 52)

Elvis Presley recorded Carl Perkins' *Blue Suede Shoes* in 1956 (the same year as the original). It was one of Presley's first recordings on the major label RCA after his early work at Sun Studio (Burke and Griffin 2006 p. 87). The recording is short, slightly less than two minutes and structurally simple: a four bar introduction, an alternating "stop chord" verse and chorus of eight bars each separated by two twelve bar guitar solos, a repeat of the introduction and a twelve bar coda "outro". There is no indication why Tenney chose this particular Presley recording, although it certainly is iconic and as a result it could be expected that many listeners would be familiar with the original.

Collage #1 employs more sophisticated manipulation of the source material than *Etude Chemins de Fer.* Larry Polansky in his liner notes for *James Tenney: Selected Works 1961–1969,* describes "speed changes, reversal, tape head echo, multitracking, splicing, and some filtering" (Polansky 2003) as being evident in the recording. Polansky contends that the "virtuosic" editing does much to establish the "essence" of the "R and B" character of the original, even when the manipulated sounds have been rendered relatively abstract. He observes that "edited phrases seem to fall right around the perceived, implied beats, in much the same way in which a jazz rhythm section and soloist interact around a steady pulse" and yet "intentionally, it never quite finds the "groove" (of steady time divisions)—it is always frustrated by quick silences, aborted beats, and unexpected returns to the beginnings of phrases."

In addition to these nonlinear disruptions in relation to the pulse of the referenced source material, Polansky notes that, in *Collage #1* "the development scheme is "backwards." The source material is not heard until the third section" with

"unrecognizable and highly transmogrified material presented first" (Polansky 2003).

Polansky's discussion of the work identifies four sections as shown in Table 16:

A.	Almost exclusively slowed-down tape transformations of the instrumental background, particularly the drums, omitting the voice._x000D_ Tape head echo is used to produce a rich, sustained, phase-shifted processing on the low, complex sonorities. The quick splicing and primarily monaural texture clarifies the rhythmic movement.
B.	Introduces some beautiful higher-pitched timbres over the low bass. These sounds seem to be the results of various filterings, reversals, editings, and speed increases (in various combinations) of the higher-pitched sounds on the recording. They have a grainy quality that might suggest that they are actually lower-pitched sounds played at a higher speed, maybe even those of the first section. There is a complex contrapuntal relationship (high/low) developed during this section, and it is developed for about 15 seconds longer than the first. Near the end (the last ten seconds or so), a marked increase in density and tempo occurs, as well as an obvious crescendo, leading into the third section.
C.	Quick splices of more or less unadulterated voice, but the transition is mediated by the crescendo and by the fact that the accompanying instrumental sounds are spliced, of course, in conjunction with the voice. Many of the quick splices, it seems, are slightly dovetailed (on separate tracks) and so the effect is one of quick, seamless shifts of attention.
D.	The low sounds from the first section, and shortly after, the higher sounds from the second, join in. The last minute and a quarter or so of the piece is a three part contrapuntal "jam" of the three textures, and it may well be that the material used in this section is identical to all the "component" material used previously, giving the piece a characteristically economical and transparent form
Table 16: Larry Polansky's analysis of the four Sections in James Tenney: Collage #1: "Blue Suede" (Polansky 2003)	

The spectrogram of *Collage #1* (figure 58) supports Polansky's analysis, and also suggests the presence of further subsections within these four principal divisions. The first "A" section is divided in half by a rising bass sonority. The B section consists of three interactions of similar structures (comprising three high frequency complexes followed by a lower frequency complex), before the passage of increased intensity before section C, mention by Polansky. The C section has an eight second introduction consisting of extremely rapid and sped up fragments, before settling into an extended passage of more recognizable fragments, mostly at their normal pitch. The fourth section initially combines sections A and C, before material from B enters 36 seconds later. A coda is provided by manipulating Presley's final chord to create an ambiguous I-V "imperfect" cadence as the conclusion.
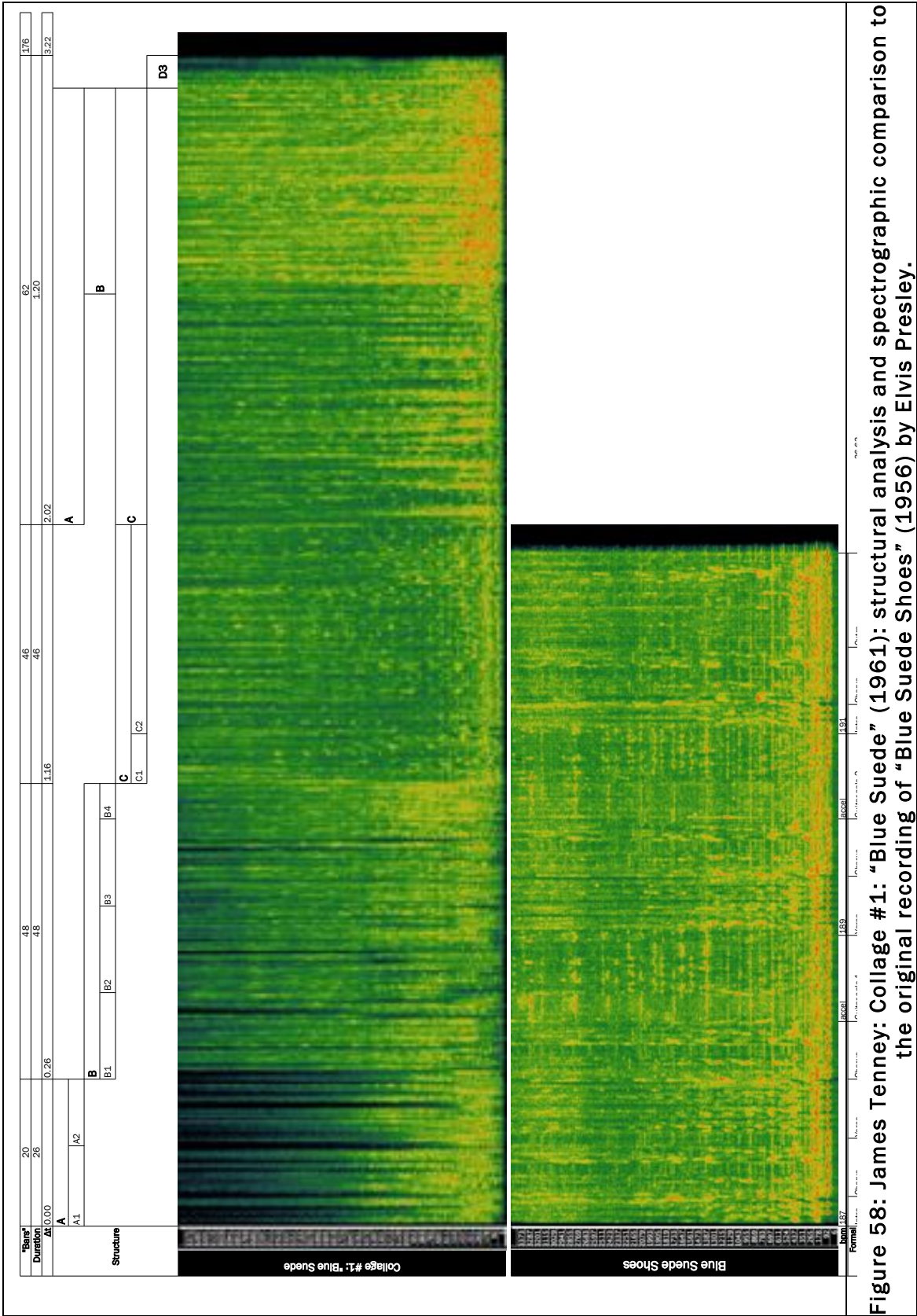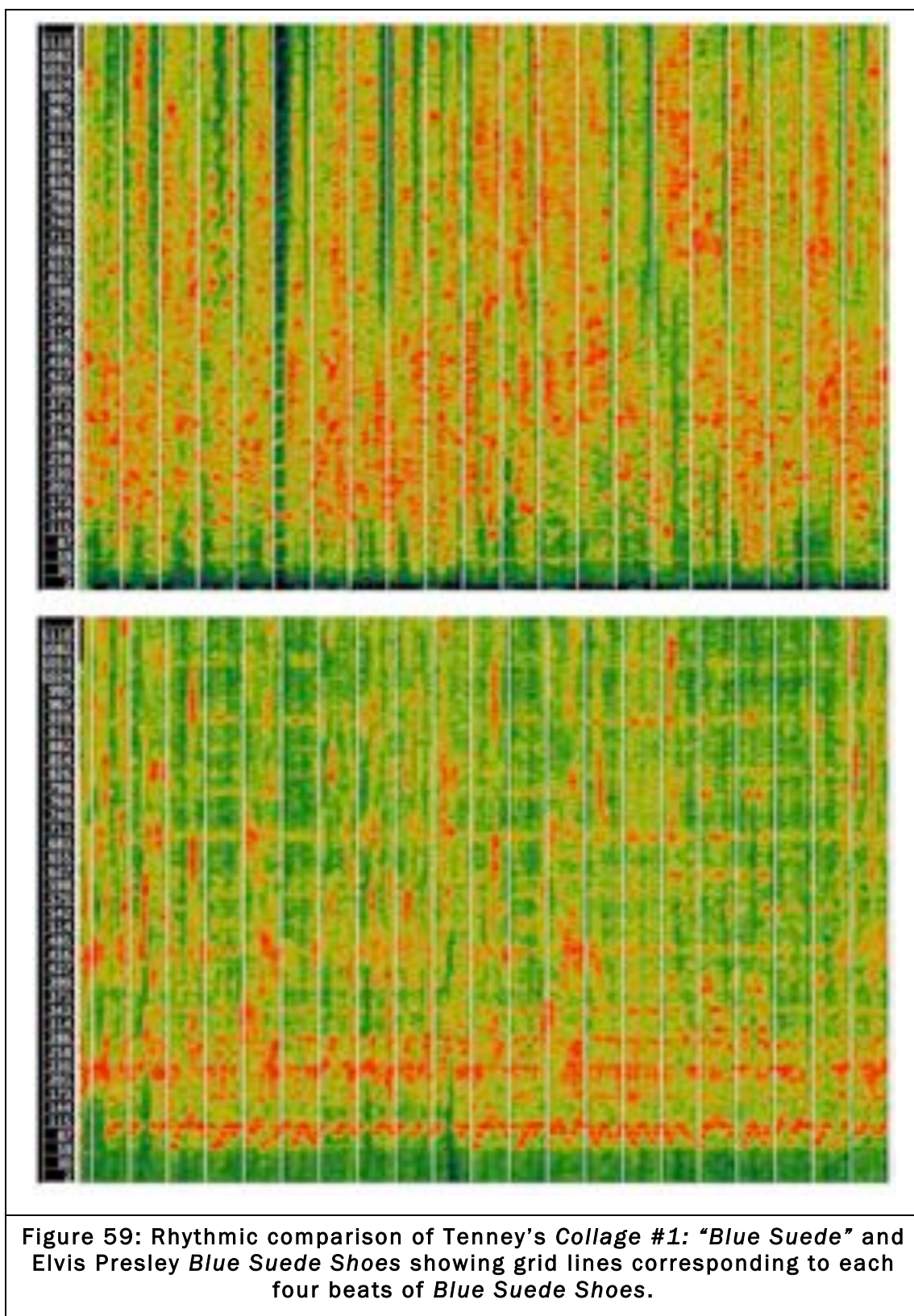
Figure 58: James Tenney: Collage #1: "Blue Suede" (1961): structural analysis and spectrographic comparison to the original recording of "Blue Suede Shoes" (1956) by Elvis Presley.

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The table above the two spectrograms shows: "bar numbers" based on the duration of a bar in the original source recording of *Blue Suede Shoes*; the absolute duration of each subsection; the elapsed time; and the works formal divisions designated by a letter designation for each formal block and a letter and number for each subdivision of a block.

Polansky's comments regarding "perceived, implied beats" are also explored in the figure through comparison to a spectrogram of the Presley recording. The first issue here is the tempo of the original recording: Although the tempo begins at 187 beats per minute, there is an increase in tempo of 2 bpm during each of the two guitar solos. From this point of view, without knowing what portion of the recording Tenney was manipulating at particular point it is perhaps difficult to exactly follow his adherence to the original tempo.

By overlaying a grid marking each bar of the original recording it is possible to get a general indication of concurrence between the two pieces. The passage shown in Figure 59 does appear to indicate that, like Stravinsky, Tenney provided coherence to his work by reference to the tempo of Presley's recording: possibly by trimming his tape splices to a uniform length or a multiple of the length of tape equivalent to one beat at 187, 189 or 191 bpm. The correspondence is close enough to allow both recordings to be represented in bars of $^4/_4$ as shown in the following figure.

Figure 59: Rhythmic comparison of Tenney's *Collage #1: "Blue Suede"* and Elvis Presley *Blue Suede Shoes* showing grid lines corresponding to each four beats of *Blue Suede Shoes*.

Polansky's final contention that the A and B material from the first two sections might have been reused in the final span is difficult to confirm. There do not appear to be any obvious correspondences between the sections as shown by the spectrogram. But even a slight alteration, for example through filtering, would tend

to obscure any similarities. What can be said with certainty is that the final section is significantly longer in duration than either A or B and, since there are no apparent repetitions, the material used in the final section is most likely not to be identical to the first statement of A or B.

As an exemplar of nonlinear narrative *Collage #1* clearly utilizes the strategy of reference to a well-known musical "object". Tenney combines readily recognizable snatches of the Presley classic in combination with highly abstracted treatments of the original material. Similarly, the underlying pulse drawn from Presley's recording, and apparently implied by Tenney's work, provides the opportunity for the creation of a highly disjunctive form of referentiality. The work consists of three disjunct blocks followed by a final section overlaying all of the previous material, however its sense of nonlinearity arises principally from its relation to a referent "musical object".

5.4. Narrative Nonlinearity: Karlheinz Stockhausen's *Klavierstück IX* (1961)

Although not listed by Coenen (1994) as one of Stockhausen's compositional paradigms, the exploration of the "crossing over" of structural components that outline a readily audible narrative contour is common to several of the composer's works beginning with his earliest acknowledged composition *Kreuzspiel* (1951).

> In *Kreuzspiel*, a dramatic process of registral cross-over of musical material is played out. The registral cross-over occurs as a result of the deployment of material on the piano in an X-like shape - starting at the extreme ends of the keyboard, moving to include the middle register and then out again to its extremes. In the second section the material is deployed in the inversion of that structure (a diamond shape) and its 'interversion' (a combination of the X-like shape and the diamond) in the final section.   (Vickery 2000 p. 19)

Stockhausen's *Klavierstück IX* (1961) is a particularly clear example of the "crossing over" technique operating at a formal level. *Klavierstück IX* comprises three narrative contours, but unlike *Kreuzspiel,* they are textural rather than linear. The first two narrative contours also occur, for the most part, in successive alternations rather than appearing simultaneously.

The work is clearly unified through use of the Fibonacci series, and like the Stravinsky and Tenney examples proportionally related tempi (160/60/120 bear the proportions 8/3/2). Kramer even claims Fibonacci proportions to be perceivable and predictable (Kramer 1988 p. 315). In 1990, Clarke and Krumhansl

tested this claim and indeed found that "the listeners were quite veridical in judging the relative durations of the segments" (Clarke 1990 p. 236). More importantly to this discussion, their experiments showed that "there was considerable agreement between listeners in the placement and relative strength of boundaries" (p. 225) created through the disjunction of alternations between the Contour 1 and Contour 2 material. Furthermore, they discovered that the ability of listeners to "indicate the original location of individual segments in relation to the whole piece" was strong (Ibid. p. 231). These findings suggest the presence both of the ability to detect disjunction and to sense temporal succession in a work where, as Kramer's definition of "Multiple Time" suggests, the underlying linearity "is sufficiently straightforward and perceptible that we can understand a reordering of it" (Kramer 1981 p. 545).

Figure 60 aligns a score-based analysis of *Klavierstück IX* with a spectrogram of a recording of the work. The Contour 1 material (A1-7) is clearly visible due to its fixed pitch and narrative contour of diminishing amplitude. The gradual reduction of the colour (intensity) of the overtones of the chord, gives these substructure a uniformly triangular shape. The intervening Contour 2 material (B-E) is visibly contrasted in its diversity of pitch and amplitude. The concluding section F, characterised by high-pitched figures is also identifiable.

The use of the spectrogram to illustrate formal divisions in these examples of nonlinearity effectively captures the audible parametrical disjunctions between their substructures. Each of the chosen works comprises sequential substructures.
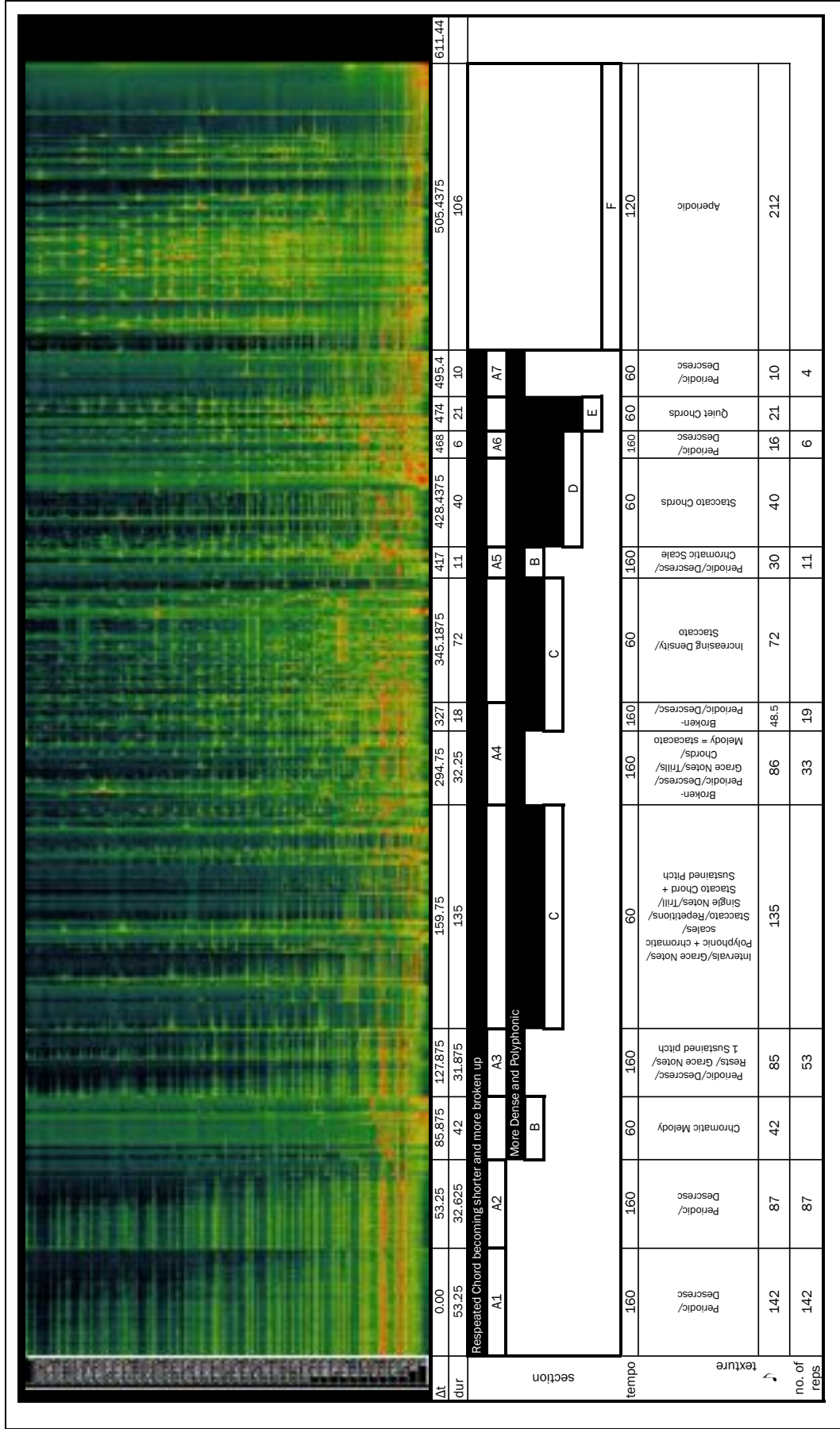
Δt	0.00	53.25	85.875	127.875	159.75	294.75	327	345.1875	417	428.4375	468	474	495.4	505.4375	611.44
dur	53.25	32.625	42	31.875	135	32.25	18	72	11	40	6	21	10	106	
section	A1	A2	A3		C	A4		C	A5	D	A6	E	A7	F	
	Respeated Chord becoming shorter and more broken up		More Dense and Polyphonic / B					B							
tempo	160	160	60	160	60	160	160	60	160	60	160	60	60	120	
texture	Periodic/Descresc	Periodic/Descresc	Chromatic Melody	Periodic/Descresc/Rests/Grace Notes/1 Sustained pitch	Intervals/Grace Notes/Polyphonic + chromatic scales/Staccato/Repetitions/Single Notes/Trill/Staccato Chord + Sustained Pitch	Broken-Periodic/Descresc/Grace Notes/Trills/Chords/Melody = Stacacato	Broken-Periodic/Descresc/Melody = stacacato	Increasing Density/Staccato	Periodic/Descresc/Chromatic Scale	Staccato Chords	Periodic/Descresc	Quiet Chords	Periodic/Descresc	Aperiodic	
♩	142	87	42	85	135	86	48.5	72	30	40	16	21	10	212	
no. of reps	142	87		53		33	19		11		6		4		

Figure 60: The substructural divisions of Karlheinz Stockhausen: *Klavierstück IX* compared to a spectrogram of a recording of the work.

6. Exploring Nonlinear Formal Models in my Creative Practice

In the creative folio I have set out to explore a range of formal approaches, as well as notational and performative means to generate nonlinear musical structures. Certain lines of enquiry discussed in the previous chapters have been favoured in pursuit of these goals: fixed Block-Form Structures, Mobile "Collage" Form, Multilinearity, Polytemporality, Polystructure and Subtractive structure. Several issues arising from the exploration of nonlinear structure, such as multiple versioning, means of generating disjunction and the implications of referentiality and musical narrative, are also prominently discussed. The exploitation of these procedures has developed through the creation of the folio, resulting in clusters of works exploring particular structural methods and, in some instances, interpenetration and hybridization of these methods.

Where appropriate, the discussion of formal structure in the folio works will be illustrated by spectrograms of performances of the works. As discussed in chapter five, the spectrogram provides a visual summary of the work based on its frequency, duration, timbre and amplitude, and is therefore a useful tool in the discussion of sequential structure in music.

The creative folio consists of 29 works. The works have all been publically performed, some of them numerous times, by a number of individuals and groups and in venues in Australasia, the United States, Europe and Asia. The complete available recordings of the works are collected on the accompanying DVD.

In order to contextualise such a large number of works, the following discussion provides an overview from the perspectives of instrumentation, aspects of the performative models employed, and finally their classification in terms of the categories proposed in chapter three.

The exploration of nonlinear structure is largely independent of stylistic considerations, as has been demonstrated by the range of examples discussed in the previous chapters: including "transcendental" polystylism (Ives), Stravinsky's Russian period, serial composition (Schoenberg), the indeterminate approach of the New York School composers (Cage and Brown), Avant Garde multiple serialism

(Stockhausen), Stochasticism (Xenakis) and Postmodern "hyper-quotation" (Zorn).

The pursuit of the apparently paradoxical goal of nonlinear structure is a preoccupation that appears to have always been central to my compositional interests. In 1989 I wrote in *New Music Articles* magazine, "Collage ideas appeal because they imply a view of time as fragmented, circular and irregular, especially when applied repeatedly to material" (Vickery 1989 p. 7). Attracted to works such as Charles Ives' *Putnam's Camp* (1912), Stravinsky's *Symphonies of Wind Instruments* (1920), Luciano Berio *Sinfonia Movement III* (1969), the visual art works of artist Max Ernst and writers such as Alain Robbe-Grillet and William Burroughs, this predisposition manifested itself in my earliest compositions.

Although this exploration proceeded organically, in retrospect it is possible to discern a range of approaches that together, if sometimes embryonically, outline several of the techniques employed in the nonlinear models that will be discussed. These techniques are summarised in the following table along with earlier examples of my compositions that explore or at least allude to them.

Collage: decontextualisation caused by quotation of materials from existing works;		
Octet for Winds	1986	employed fragments from Mozart's Serenade in C Minor KV 388 'Nacht Musique', "chosen for their chromatic content or interesting shape" (Vickery 1986b) as seeds from which to develop musical material in a rhizomatic manner – in that the fragments are treated as starting, ending or central points in the musical fabric.
Erasure (Étrécissement): decontextualisation caused by the removal of material;		
Blackpool Tower: Elegy for John Lennon	1988	"a completely unique form of collage where two pieces are theoretically playing throughout the piece, but are "mixed" in the manner of someone controlling volume faders on a mixing desk in such a way that each piece seems to merge to the background, or foreground, while never quite dominating, or disappearing from the texture" (Mustard 2005 p. 34).
Block-Form: non-developmental sequentially ordered but disjunct musical material;		
stairways of sleep	1989	"original material using the techniques I had developed for the collage works" (Vickery 1989 p. 8).
Multilinearity: the horizontal splintering of musical texture through multiple distinct linear continuities;		
Twilight's Last Gleamings	1986	Four players alternately perform their notation (a characteristic American patriotic song) as written or "supply their own durations" (to "blend into the texture") (Vickery 1986c).

Polytempo: the horizontal splintering of musical texture through multiple tempi;		
a-synchronous au privave	1989	"The 'head' and solos are cut-ups of Charlie Parker's original (Au-Privave) and there is an obbligato violin part ("double stop glissandi as slowly as possible") that, rather like the 'druids who know, see and hear nothing' in Ives' The Unanswered Question' remains aloof throughout the performance" (Vickery 1989).
Polystructure: the horizontal splintering of musical material through multiple distinct developmental continuities;		
Solar/Lunar Music	1992	"the form of the lower plane is the same as that of the upper plane in reverse, and the form of each determines the way in which they interact" (Vickery 1992).
Table 17: Nonlinear Structural Techniques in early works by the author.		

Similarly, the performative techniques developed during this early period (see Table 18), assembled a number of approaches that would become key to the emergence of the performative model, involving computer-based coordination of performers, used in the most complex and ambitious of the folio works. Alternatives to the sequential left to right convention for delivering musical material to performers via a score, have been crucial to the development of nonlinearity both as an article of ideology and a practical necessity, as was shown in chapter four. In my own work the incorporation of alternative performative models has also played a key role.

This performative model, employing computer coordination of interactivity, audio processing, sample playback, scored materials and performers (through click-tracks and audio cues), has allowed for unprecedented precision and control of mobile musical structures. In addition to eleven of my own compositions, this model has allowed precise reconstructions of "pre-digital" works, as well as new works by my contemporaries.[99]

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[99] Percy Grainger (*Free Music No. 1* (1936)), Earle Brown (*December 1952* (1954)), John Cage (*Radio Music* (1956)), Karlheinz Stockhausen (*Klavierstück XI* (1956), *Adieu* (1966) and *Pole* (1969)), Mauricio Kagel (*Prima Vista* (1962-3)), Alvin Lucier (S*till and Moving Lines in Families of Parabolas No. 1* (1972), *in memorial stuart marshall* (1993) and *Ever Present* (2002)), Denis Smalley (*Threads* (1985)), Thomas Meadowcroft (*Pretty Lightweight* (2001)), Cat Hope (*Wolf at Harp* (2010), *Kuklinski's Dream* (2010), *In the Cut* (2010), *Kingdom Come* (2009), *Cruel and Usual* (2011), *Longing* (2011)), Christopher de Groot (*Agerasia* (2011)) and Julian Day (*Beginning to Collapse* (2011)).

Improvisation		
manual of improvisation	1986	"a collection of progressive exercises exploring aspects of PITCH and RHYTHM without the use of notation" (Vickery 1986a).
A-Synchronous Scores		
Savoy Trifle	1988	Each player is instructed to play "as fast as possible" simulation the "fast forward" button on a CD player (Vickery 1988).
Audio processing		
Dice Game	1995	"The processes involved are used to reinforce the work's structure - emphasizing the changes between sections and, to some degree, the sub-sections within them" (Vickery 2002 p. 117).
Interactivity		
27matrix	1995	"An improvising soloist provides the raw MIDI data that is transformed by MAX in real time into various structures. 27matrix combined live improvisation with the sort of formal processes that I had been using in my music between 1990 and 1995" (Ibid).
Audio cues		
Rendez-vous: an opera noir	2001	"The necessity to synchronize the live musicians with the video (via a click-track) also lends a strange inevitability to the work. From the audience's point of view the music is unfolding freely and naturally and yet is able to coincide with disconcerting accuracy with the video, adding to the sense that the events being witnessed are part of an elaborate plan" (Vickery and Wilson 2002 p. 4).
Table 18: Performative Techniques in early works by the author.		

Amid the pantheon of current stylistic approaches, my own work sits between, and is in dialogue with, chamber music of the "Postmodern of Resistance"[100] - works concerned with continuing the exploratory Modernist project; the work of Free-Improvisers[101]; and the "microsound"[102], glitch and noise based approach of post-electronica laptop artists.

A recent article in the New York Times states that "instead of waiting for established ensembles to give them a hearing, (young composers) have built an alternative musical universe" (Kozinn 2011). My own stance on the performance and raison d'etre of my work is aligned to this ideology: a fact reflected in the number of works in the creative folio written for performance by myself or groups with which I perform, such as Magnetic Pig, HEDKIKR and Decibel.

Despite this preference for the "band" paradigm – in which "the composer (is) a performing member of an ensemble" (Davidson 2001 p. 3), the creative folio

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[100] "a postmodern of resistance (...) arises as a counter-practice not only to the official culture of modernism but also to the 'false normativity' of a reactionary postmodernism" (Foster 1983 p. xii). And a "postmodernism which seeks to deconstruct modernism and resist the status quo" (Ibid. xi)
[101] LeBaron has drawn the connection between Surrealism and the "automatic" ideology of Free-Improvisation (LeBaron 2002). This is the connection in my work too, stemming from the influence of the techniques of Andre Breton, Max Ernst and others.
[102] See Roads 2004 and Thomson 2004

encompasses a range, both in size and diversity, of forces from solo works to chamber orchestra of fifteen players.

The solo works have in general been constructed in such a way that they are capable of performance by any monophonic instrument. Only *Hey Jazz Fans!* (Alto Saxophone) and two works written for disklavier, *Reconstruction of a Shifting Path* and *questions written on sheets of glass*, have specific instrumentation. The recordings collected on the accompanying DVD demonstrate a variety of instruments performing the solo works,

Works from the *delicious ironies* series may also be performed by multiple instruments. The ensemble works range from two to seven players and in addition to western orchestral instruments, explore the timbre of the theorbo (a baroque lute), sarons from the Sundanese gamelan and the Hungarian cimbalom. *Transit of Venus* and *The Talking Board* are also capable of exploration by a range of instruments.

The chamber orchestra works necessarily focus on a more orchestral approach based on the timbral contrast between families of wind, brass, string, percussion and keyboard instruments. The specific instrumentation of *parallel trajectories* is open however, and the recordings on the accompanying DVD demonstrate a range of orchestrations of this work. Table 19 summarises the folio by instrumentation.

Solo Works		
As Viewed from Above	2001	monophonic instrument and computer (stereo)
Splice	2002	instrument and computer (stereo)
Hey Jazz Fans!	2003	alto saxophone and computer (stereo)
corridors, stairways night and day	2009	monophonic instrument and computer (quad)
delineate 1	2010	monophonic instrument and computer (stereo)
echo-transform 1	2010	monophonic instrument and computer (stereo)
partikulator	2011	monophonic instrument and computer (stereo)
Reconstruction of a Shifting Path	2011	pianist, computer and disklavier
questions written on sheets of glass	2011	monophonic instrument, computer and disklavier
delicious ironies 1	2001	instrument(s) and sampler (stereo)
delicious ironies 2	2002	Instrument(s) and computer (stereo)
delicious ironies 3	2007	Instrument(s) and computer (stereo)
Ensemble Works		
between the lines	2002	tenor saxophone and drums
interXection	2002	drums, microphone and ring modulator (stereo)
offRamp	2002	tenor saxophone and drums
Kreuz des Suedens	2003	violin and cello

Whorl	2004	saxophone, celeste, percussion and computer
particle + wave	2004	saxophone, 2 sundanese gamelan instruments and computer (stereo)
zwitschern	2005	clarinet, violin and theorbo and computer
Transit of Venus	2009	three monophonic instruments and computer (quad)
improbable games	2010	alto flute, clarinet, cello and computer (quad)
Hunting Pack	2011	cello, keyboard and cimbalom and computer (quad)
The Talking Board	2011	four instruments and computer (quad)
entropology	2002	violin, alto saxophone, double bass, vibraphone and piano
Exit Points	2003	soprano saxophone, violin, viola, double bass, piano
antibody	2009	alto flute, clarinet, viola, cello and computer (quad)
ghosts of departed quantities	2010	bass flute, bass clarinet, cello, piano and computer (quad)
shifting planes	2005	clarinet, harp, theorbo and string quartet
Night Fragments	2011	mezzo-soprano, alto flute, clarinet, cello, keyboard and computer (quad)
Chamber Orchestra Works		
still life with visitations	2002	15 players
Parallel Trajectories	2003	15 players
TECTONIC	2007	15 players and computer (quad)
Eraflage	2007	11 players and computer (stereo)

Table 19: Categorisation of the creative folio by instrumentation.

The computer is an integral component of the majority of the works in the creative folio. The progression of increasing involvement of the computer in the works, first as a means of timbral and temporal manipulation and later, additionally, as a means of coordination of the performers, provides one indicative demarcation between the three principal approaches to the performance of nonlinear works explored in the creative folio. The traditional performative model employing paper-scores and acoustic instruments spans only the years 2002-3. The use of the computer as a means of timbral and temporal manipulation is most evident in the works from 2001 to 2007. The development of a computer coordinated performance model, in which the computer assumes control of the notated elements of the score (via the screen-score) and coordination of the performers via visual or auditory cues, spans the final period of composition from 2007 until 2011. The evolution of this approach will be examined in greater detail in the discussion of individual works. Table 20 summarises the folio by performative model.

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Traditional Performative Model (2002-2003)
Score

interXection	2002
Exit Points	2003
Kreuz des Suedens	2003
shifting planes	2005
still life with visitations	2002

Score (with improvisation)

entropology	2002
offRamp	2002
between the lines	2002

Multilinear Score

Parallel Trajectories	2003

Computer Interactivity (2001-2007)
Improvisation and computer interactivity

As Viewed from Above	2001
delicious ironies 2	2002
Splice	2002
partikulator	2011

Mobile Score with improvisation and computer interactivity

delicious ironies 1	2001
Hey Jazz Fans!	2003
delicious ironies 3	2007

Mobile Score with Computer Coordinated Polytemporality

particle + wave	2004
Whorl	2004
zwitschern	2005
Eraflage	2007
TECTONIC	2007

Computer Coordinated Performative Model (2009-2011)

Segmented Screenscore

Hunting Pack	2011
Night Fragments	2011

Permutative Realtime Screenscore

antibody	2009
improbable games	2010
Reconstruction of a Shifting Path	2011
questions written on sheets of glass	2011

Scrolling Realtime Screenscore

delineate 1	2010

Permutative Scrolling Realtime Screenscore

Transit of Venus	2009
corridors, stairways night and day	2009
echo-transform 1	2010
ghosts of departed quantities	2010
The Talking Board	2011

Table 20: Categorisation of the Creative Folio by Performative Model.

The creative folio works may also be considered from the standpoint of their classification according to the temporal, narrative and referential categories proposed in chapter three. Table 21 lists the examples of sequential and multilinear nonlinearity chronologically and indicates the presence of narrative and referential qualities possessed by the works.

Sequential

Title	Year		
As Viewed from Above	2001	**Narrative**	
delicious ironies 1	2001		**Referential**
delicious ironies 2	2002		**Referential**
entropology	2002		**Referential**
interXection	2002		
offRamp	2002		**Referential**
Splice	2002		
Still-life with visitations	2002		
Exit Points	2003		
Hey Jazz Fans!	2003	**Narrative**	**Referential**

Kreuz des Suedens	2003	
shifting planes	2005	
delicious ironies 3	2007	
antibody	2009	Narrative
echo-transform 1	2010	Narrative
ghosts of departed quantities	2010	Narrative
improbable games	2010	
partikulator	2011	
Reconstruction of a Shifting Path	2011	
questions written on sheets of glass	2011	

Multilinear

Title	Year	
between the lines	2002	
Parallel Trajectories	2003	
particle + wave	2004	
Whorl	2004	
zwitschern	2005	
TECTONIC	2007	
Eraflage	2007	Narrative
Transit of Venus	2009	Narrative
corridors, stairways night and day	2009	Narrative
delineate 1	2010	Narrative
Hunting Pack	2011	
Night Fragments	2011	
The Talking Board	2011	

Table 21: Chronological categorisation of the Creative Folio by sequential and multilinear nonlinearity, with indications of additional narrative and referential qualities.

Intertextual connections, both implicit and explicit, exist between many of the works in the folio. These are partly accounted for by a quirk of my own musical language: that since 1990 I have investigated the possibilities of generating the same formal structure based upon a nine digit "cypher": 5 3 2 2 1 4 4 5 1[103] in as a diverse manner of instantiations as possible (See Figure 61). I have used this numerical sequence in numerous works to generate details from individual pitch and durational values to the overall temporal proportions of the work. This last fact is of

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[103] For a discussion of this practice see Mustard 2005.

particular consequence with regard to the creative folio, as several of the works share the same formal divisions and proportions.

5	3	2	2	1	4

Figure 61: Formal and Proportional Divisions determined by the nine digit "cypher": 5 3 2 2 1 4 4 5 1
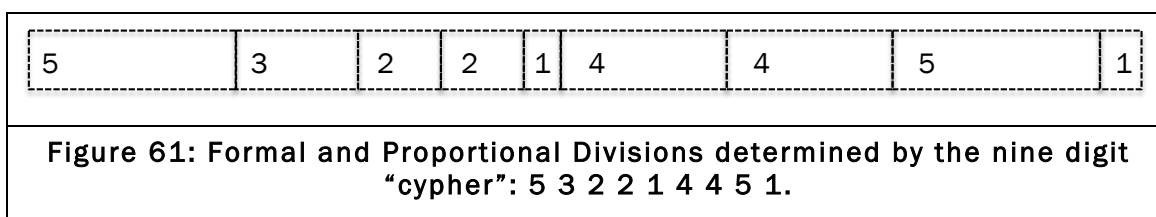
This approach was first employed in my work *stairways of sleep* (1989) in order to create a Block-Form structure from "original material using the techniques I had developed for the collage works" (Vickery 1989 p. 8). The continuing use of this "cypher" has been the result of a perverse and excessive pursuit of the goal, in the manner of the "work-in-progress" (Eco 1989 p. 19), to generate the greatest possible variation of material from the re-casting of the same proportions. This notion is also explored in the *delicious ironies* series (1991-2010) and *splice* (2002) in a more "automatic" manner, in that the computer generated components of the works share precisely the same structure in terms of durational proportions, from the formal level to the duration of individual samples. In the *delicious ironies* series the sound samples from which the computer component is generated, are altered from work to work, and in *splice*, the computer draws its samples from a live improvisation; the audio content of the computer component is varied in each performance.

The works *Kreuz des Suedens* (2003), *Delicious Ironies (KDS)* (2007) and *Improbable Games* (2010) constitute in some respects a more explicit example of a "work-in-progress" in that they are all based on reworkings of precisely the same musical materials.

There is also a noteworthy connection between the works *offRamp* and *Exit Points*, and *between the lines* and *Parallel Trajectories*. These works are examples of investigation of essentially the same concept and musical materials in the context of improvisation (*offRamp* and *between the lines)* and notation (*Exit Points* and *Parallel Trajectories*). Again this follows a practice established in my work as early as *vo* (1990), in which materials were first explored in an improvisational setting and then later notated.

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[104] The delicious ironies series, offRamp, Splice, Still-life with visitations, Exit Points, Kreuz des Suedens, shifting planes, between the lines, Parallel Trajectories, particle + wave, Whorl, zwitschern, Hunting Pack and Night Fragments.

The tension between a desire for spontaneity and freedom on one hand and control of structural elements on the other is one of the defining features of my music.

> I'm interested in structure and freedom at the same time and so these mobile forms try to address both tendencies. In some way, perhaps, it also solves, or at least sidesteps, the desire to leave the composition open. The 'finished' work includes so many possible pathways or realisations; this approach avoids having to fix the composition in one particular form.

(Vickery in Hope 2008)

6.1. Block-Form: "Cypher" Works

The block-form works from the creative folio derive nonlinearity from disjunction between and conjunction within, sequential sections of parametrically divergent material. In each of the formal divisions, proportions are derived from the numerical "cypher" 5 3 2 2 1 4 4 5 1, and therefore comprise five contrasting blocks of musical material. One of the areas of investigation in this process is the means through which parametrical divergence is achieved. Table 22 shows the principal methods of parametrical divergence for these works.

section	1	2	3	4	5
still life with visitations					
Tempo	42				
Time Signature	4/4				
Dynamic	*pp*				
Texture	ensemble arpeggio	brass pulse/ wind gliss	sustained chords timbral fingerings	pointillist	distributed pointillist
offRamp					
Tempo	180 bpm	90 bpm	60 bpm	45 bpm	36 bpm
Time Signature	9/4				
Dynamic	Free				
Texture	points improv	trills improv	groups of 3 improv	groups of 4 improv	groups of 5 improv
Exit Points					
Tempo	150 bpm	75 bpm	50 bpm	37.5 bpm	30 bpm
Time Signature	3/4				
Dynamic	*f*	*mf/f-ppp*	*mp*	*pp*	*ppp*
Texture	tutti unison	viola/saxophone	violin	double bass	arpeggios and chords (piano)
Kreuz des Suedens					
Tempo	54 bpm	94 bpm	48 bpm	81 bpm	54 bpm
Time Signature	9/16	9/16	12/8	4/4	3/4
Dynamic	*f-p*	*pp-ff*	*ppp-f*	*mp*	*ppp-fff*
Texture	heterogeny unison	rhythmically articulated chords	melody and harmonics	melody and arpeggios	heterogeny unison

Shifting Planes					
Tempo	free	120 bpm	90 bpm	60 bpm	15-120 bpm
Time Signature	free	4/4	9/16, 4/4	9/8	9/4, '9/8, '9/16
Dynamic	*ppp*	*mf*	*f*	*pp*	*pppp-ff*
Texture	Descending/ascending glissandi	pitches groups by instrument	arpeggios	sparse and diffused	accel/rall. accumulating horizontal pulse

Table 22: Categorisation of Block Form works indicating principal methods of parametrical divergence.

6.1.1.*Shifting Planes (2005)*

Shifting Planes exhibits perhaps the most unambiguous example of the "cypher" process. The work explores the disjunction between the horizontal and vertical aspects of musical organization. It begins with horizontal planes of pitched-rhythms that coalesce into a rhythmic matrix of harmonies. The planes then break from the horizontal, cutting through the matrix diagonally to create arpeggios, and finally lining up vertically to create chords. This process allows the same materials to be exploited both rhythmically and melodically. The tension created through the search for a middle ground between the horizontal and vertical planes results in glissandi that form an increasingly important part in the musical texture.

Figure 62 shows a schematic representation of the formal structure of *Shifting Planes* in conjunction with a spectrogram of a performance of the work. The spectrogram confirms the presence of parametrical disjunction marking the block-form sections of the work. The schematic precisely illustrates the proportions of the "cypher" structure; slight divergences from the tempi indicated in the score, give rise to minor distortions to the temporal proportions of the work.
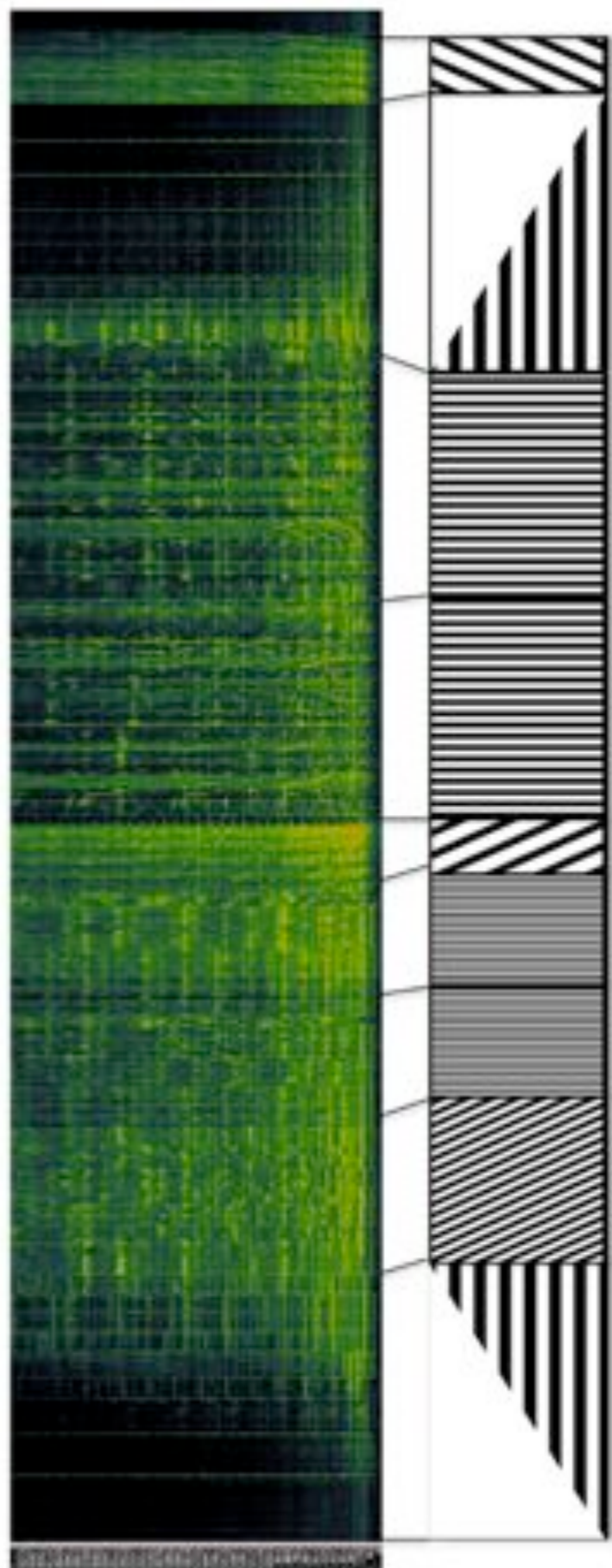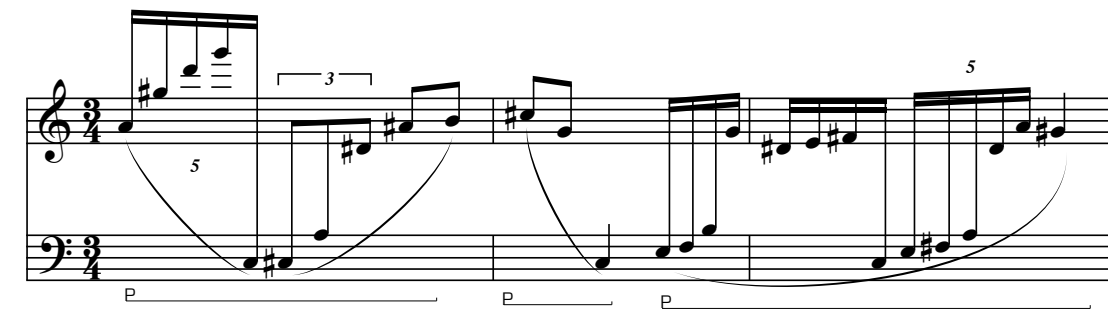
Figure 62: Schematic representation of disjunction engendered by divergence in horizontal and vertical aspects of musical texture in *Shifting Planes* compared to a spectrogram of a performance of the work.

6.1.2.offRamp (2002) and Exit Points (2003)

Both *offRamp* and *Exit Points* explore tempo as the principal means of creating disjunction between sections. At the heart of both *works* is a nine beat melodic kernel with beat subdivisions based on the numeric cypher. The melody contains every beat subdivision from one to five (See Figure 63). The melodic kernel is treated as a loop that is "phased", beginning a beat later with each appearance. In this manner the same material is heard from a different perspective in each section, in both its physical and temporal orientations.

Figure 63: The nine beat melodic kernel of offRamp (bar 1) and Exit Points (bars 7-9).

The five contrasting tempi are derived from these subdivisions. The tempo implied by each subdivision of the first beat of each "phase" of the melody provides an "exit point" or "off ramp" into the varied tempi of the work's substructures as illustrated in Figure 64.

♩ = 180 bpm   5 beats = 36 bpm

♩ = 144 bpm   4 beats = 36 bpm

♩ = 108 bpm   3 beats = 36 bpm

♩ = 72 bpm   2 beats = 36 bpm

♩ = 36 bpm   1 beat = 36 bpm

Figure 64: Tempi derived from the first beat of each phase of the melodic Kernel in *offRamp* and *Exit Points*.
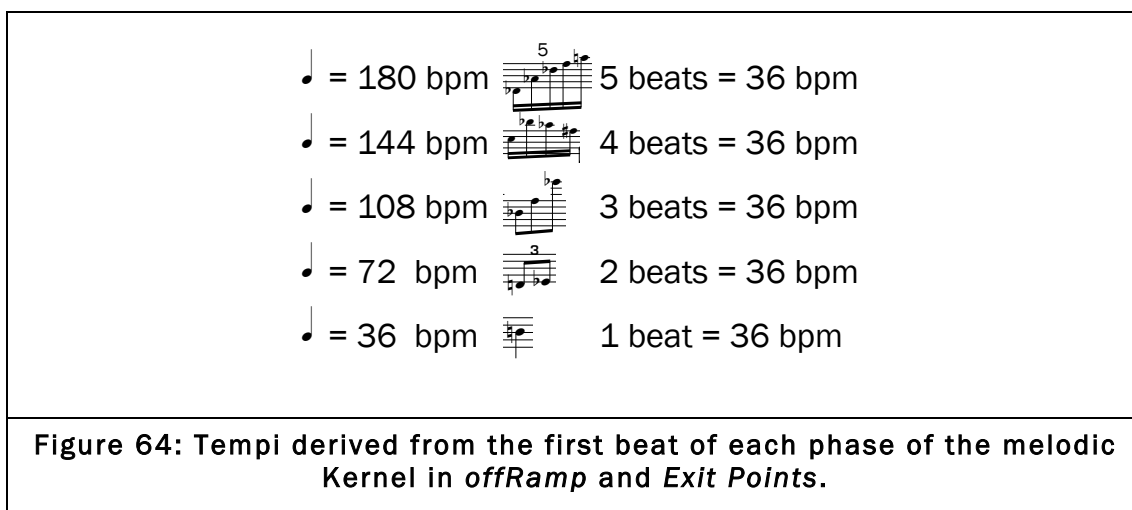
The resulting structure emerges as a consequence of metric modulations between the tempo of each section. Figure 65 illustrates the block-form structure of *offRamp* and *Exit Points,* showing the tempo of each section and the metric modulation relationship between each section. The schematic is compared to a spectrogram of a performance of *Exit Points.* Again temporal proportions are slightly distorted in the performance: in particular the slow tempi are elongated and the fast tempi are compressed.

Figure 65: Schematic Representation of Tempo disjunction between sections of *offRamp* and *Exit Points,* compared to a spectrogram of a performance of *Exit Points.*
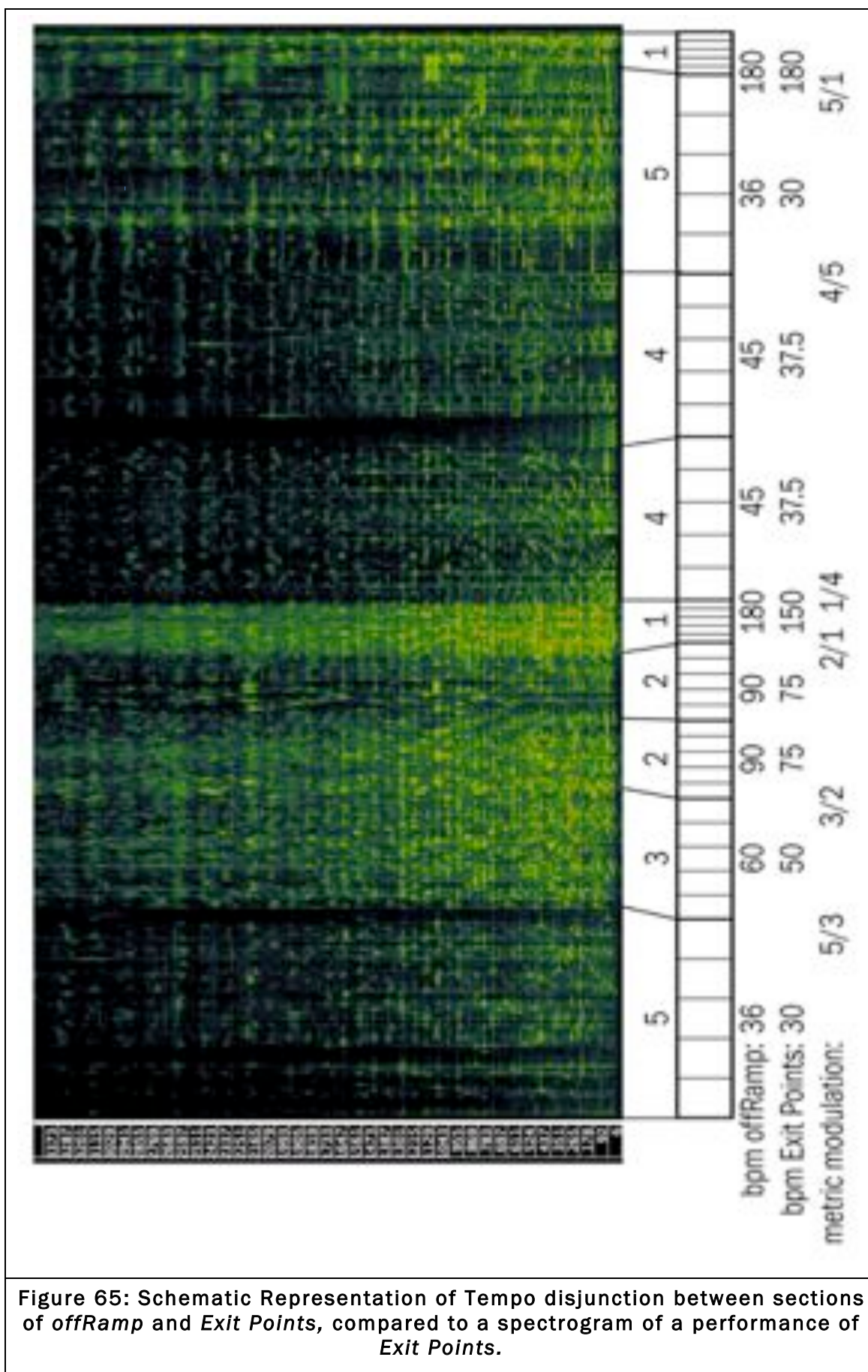
6.1.3. *Still-life with Visitations* (2002)*, Kreuz des Suedens* (2003) *and Night Fragments* (2011)

These three works employ the same "cypher" procedures to generate their musical materials, however the degree of differentiation between the independent materials is less marked than in the works previously discussed. For this reason, they provide an interesting example showing that relatively weaker disjunction between substructures also engenders a relatively weaker sense of nonlinearity.

Still-life with Visitations comprises a static textural foundation upon which various kinds of musical events manifest themselves: a kind of sound-painting moving in time. The 'visitations' are comprised of related musical material that is modally transfigured and usually moving at a different tempo. They were intended to suggest openings or recollections of other times/configurations, in a manner similar to Stockhausen's "Einschub" (Maconie 2005 p. 195) technique.

The work has a uniform meter and slow tempo (mm. 42), upon which harmonic material, forming the textural foundation, is stretched both by transposition to create denser sonorities and temporally to produce diverse rhythmic material that does not reinforce the underlying pulse. The "visitations" are differentiated from the foundation by their contrasting rhythmic unison. This procedure relies less heavily on the disjunction of multiple parameters, and arguably results in something other than a sense of "block form" structure: a multilinear texture in which a continuous form upon which contrasting blocks of material are superimposed.

Kreuz des Suedens on the other hand comprises five movements with an average length of two minutes each. The movements are contrasted from one another in a similar manner to the other "cypher works". However, the contrasts are perhaps more contextualized by the division of the work into movements and the consequent expectation that they will be contrasted. This is reinforced by presence of a text, spoken alternately by the performers before each movement (see Figure 66), the five lines of which provide the titles for each of the movements. Although each individual movement also comprises cypher-proportioned substructures, the compositional disjunction employed between them is also weaker: compromised by an overriding necessity for contrast from movement to movement, rather than from substructure to substructure.

Kreuz des Suedens	Southern Cross
Nächte, die dich steinigen	nights that stone you
Die sterne stuerzen herabauf ihrem licht	the stars tumble down on their light
Du stehst in ihrem hagel	you stand in their hail
Keiner trifft dich	none of them gets you
Doch es schmerztals traefen alle	but it hurts as if they all did

Figure 66: Reiner Kunze's Poem *Kreuz des Suedens* and its English translation.

Like *Kreuz des Suedens*, *Night Fragments* is a multi-movement work responding to a text. The work is a nine-movement song cycle based on nine poems by the non-existent Belgian Surrealist Poet Françilon Daniels[105]. The movements correspond in proportional duration and texture to the "cypher" structure. However, like *Kreuz des Suedens*, disjunction between the movements is contextualised by the programmatic implications of the texts and by the individuated movement structure.

The work was in part an exploration of the possibilities afforded by the computer coordinated performance model, which I had first employed in *Transit of Venus*. In *Night Fragments*, the segmented screen-score, audio processing, spatialisation, mixing and temporal coordination through independent click-tracks, is centralised in the computer, allowing for the exploitation of convergences of the formal implications of these elements to the millisecond.

Figure 67 shows the application of the "cypher" structure to the nine movements of *Night Fragments*.

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[105] Françilon Daniels was a fictional poet invented by me for a high school literature essay in 1981. *Night Fragments* was a personal celebration of the thirtieth anniversary of her invention. The program note for the premier of the work claimed that the author created the texts "using a variant of the Surrealist paranoiac-critical method" called ""écriture de sommeil": noting thoughts at the twilight between sleep and wakefulness" (Vickery 2011). This last claim was in reality a factual description of their provenance.

Movement	1	2	3	4	5	6	7	8	9
Cypher Structure	5	3	2	2	1	4	4	5	1
	[some other world or time]	[invisible net]	[faded back into static]	[red wolf]	[a man stands on the wing]	[resting underwater]	[slowly filling with keys]	[the surface remains unmoved]	[night flowers]

Figure 67: The cypher structure and titles of the nine movements of *Night Fragments.*

The block-form "cypher works" from the folio engage with a strictly sequential and fixed form of nonlinearity. These issues led, in particular to the development of more expansive means of establishing structural nonlinearity through referentiality in the "Collage" and openness in the Mobile form works.

6.2. Collage and Mobile Models

The Collage and Mobile Form works in the folio augment the principals of the Block-form cypher works in a variety of ways. Broadly-speaking, these works are temporally sequential, but vary from the Block-Form "cypher" works by, for example, their degree of structural complexity and interactivity, diversity of materials, and/or indeterminacy and openness of structure.

These works are collages, in some cases in the referential manner explored by Berio in *Sinfonia* and Zorn in his *Naked City* pieces such as *Speedfreaks*, but also in the sense that they explore the self-referential temporal re-ordering of material that the listener hears live from the player's performance.

Table 23 categorises the Collage works according to the materials, presence of a score or category of score, the manner of transformation that is applied to the materials and the emergent formal structure.

entropology	
Materials	Charlie Parker: Parker's Mood
Score	Traditional linear score with some improvisational passages
Transformation	Interval multiplication, temporal manipulation and verticalisation of horizontal lines
Formal structure	Based on the lead-line of Parker's Mood

As Viewed from Above	
Materials	Samples of a sixteen line text
Transformation	Manipulation of tempo/pitch and down-sampling
Formal structure	Playback of the text is interrupted by the performer. The text samples are manipulated by data drawn from a spectral analysis of the soloist's performance

delicious ironies 1	
Materials	Genre related samples
Transformation	Manipulation of tempo/pitch
Formal structure	The computer generates a block-form "cypher" structure articulated by changes in the types of samples played and the density of playback.

delicious ironies 2	
Materials	Instrument related samples
Transformation	Manipulation of tempo/pitch
Formal structure	The computer generates a block-form "cypher" structure articulated by changes in the types of samples played and the density of playback.

Splice	
Materials	The improviser's live performance
Transformation	Manipulation of tempo/pitch
Formal structure	The computer generates a block-form "cypher" structure articulated by changes in the samples of the soloist's performance played and the density of playback.

Hey Jazz Fans!	
Materials	Charlie Parker's Yardbird Suite as performed by Bob Dorough
Score	Guide score indicating interactive cues
Transformation	Manipulation of tempo/pitch
Formal structure	Samples from Yardbird Suite are cued interactively by the performer, using cue notes detected by spectral analysis to determine the samples performed.

delicious ironies 3	
Materials	Samples from existing works by the composer
Score	Score fragments from existing works by the composer
Transformation	Manipulation of tempo/pitch and live audio processing
Formal structure	The computer generates a block-form "cypher" structure articulated by changes in the types of samples played, the density of playback and the form of audio processing employed.

Table 23: Categorisation of Creative folio Collage works by materials, score, transformation and emergent formal structure.

6.2.1. *entropology (2002) and Hey Jazz Fans! (2003)*

The interest in re-exploring and recontextualising the music of Charlie Parker is a theme that has run through my music, and includes the works *Savoy Trifle* (1986), *A-Synchronous Au-Privave* (1989) and *Chase the Bird* (1991). These two works continue that preoccupation. In *Entropology*, reflecting on the fact that for almost all of us Parker's legacy has come only from recordings, I set about trying to transform

a written transcription of the work *Parker's Mood*, through the distorting mirror of simulated LP record and CD-like glitches - blips, scratches, hung notes, failing motors and so on. Figure 68 shows one of these passages, the "slide" section, simulating the slowing down of a record player through expansion note and rest durations, gradual downward transposition and glissandi.

Figure 68: The "Slide" section emulation of a record-player in *Entropology.*

Figure 69: An example of Interval Expansion and temporal manipulation in *Entropology.*

In addition to temporal stretching, the single line of Parker's transcribed solo was subjected to a process of interval expansion, similar to that employed by Stockhausen in his work *Mantra* (1970) (see Maconie 2005 p. 331). Figure 69 shows an example of both of these techniques from the score.

Entropology was constructed in an unusual manner. The original Parker solo was transcribed onto a sequencer and then pitch was manipulated to create multiple transformed versions. This material was then temporally altered by applying radical accelerandi and ralentandi to the MIDI file. The altered file was then recorded into a second sequencer, at a fixed tempo of 120 bpm. This resulted in "written out" tempo changes notated in terms of note elongations and compressions, allowing the scoring of simulated polytemporal textures. The resulting materials were then "collaged" into a structure, quite removed from the original source.

Entropology is more independent of its referent material than my earlier Parker-based works, in that the distortions are more severe, rendering the source material more obscure. Figure 70 shows the formal structure of *Entropology* in conjunction with a spectrogram of a performance of the work. The section titles are taken from the score and reflect the reference to simulated LP record and CD-like glitches, mentioned above. The "piano glitch solo", the sudden loss of speed in the "double-bass gliss. solo", the "slide" section and the two groove sections – in which soloists are accompanied by a repeating "locked-groove" accompaniment are all examples of the nonlinear fragmentations employed in this work.

Figure 70: The formal divisions in _Entropology_, compared to a spectrogram of a performance of the work.

In *Hey Jazz Fans!*, notes on the Alto Sax are mapped via the MAX/MSP object fiddle~ (Puckett et al 1998) to a set of short samples from a scat-style vocal version of Parker's *Yardbird Suite* as sung by Bob Dorough (See Figure 71). The motive for this work arrived many years ago when a friend gave me a record called *Devil May Care* featuring Dorough singing banal lyrics to every note of Parker's legendary solo from the LP *Bird Symbols*.
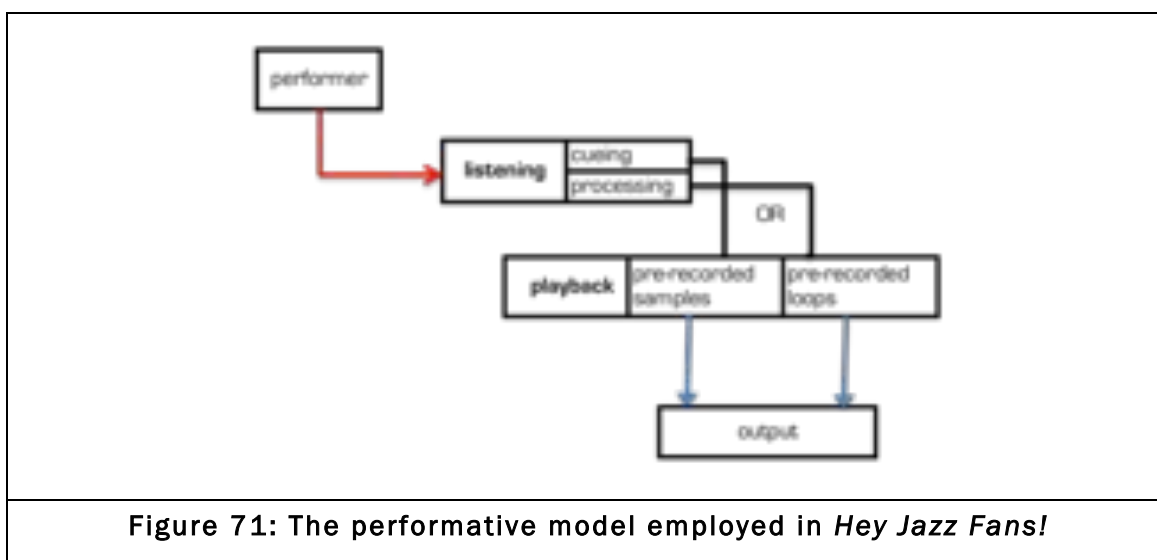
Figure 71: The performative model employed in *Hey Jazz Fans!*

In *Hey Jazz Fans!* the soloist is able to deconstruct Dorough's cover by playing notes from the original Parker solo. The content of the soloist's improvisation is free in all respects apart from that fact that the soloist should utilise the rhythms and shapes of Parker's original solo wherever possible. However they may be altered, deformed or modified in tempo, timbre or pitch at the performer's discretion.

The soloist shapes the formal structure of the work using two contrasting modes of interaction. The modes are selected by playing particular pitches: Low 'Bb' chooses RHYTHM LOOP MODE and second register 'B' chooses SAMPLE PLAYBACK MODE. The 'look-up' rate at which the live performance is monitored by the computer can also be varied by playing cue notes: A second register 'D' selects a FAST SAMPLE look-up rate of 326 milliseconds (the same length as one beat of the sampled BeBop tune: MM. 184); second register 'Eb' selects a MEDIUM SAMPLE look-up rate of 1304 (every 4 beats); and second register 'E' selects a SLOW SAMPLE look-up rate of 5217 (every 16 beats).

Figure 72 shows and excerpt from the guide score for *Hey Jazz Fans!*, showing the five "control notes" and the first two cue notes followed by a transcription of the sample from Dorough's cover that results when that note is played.
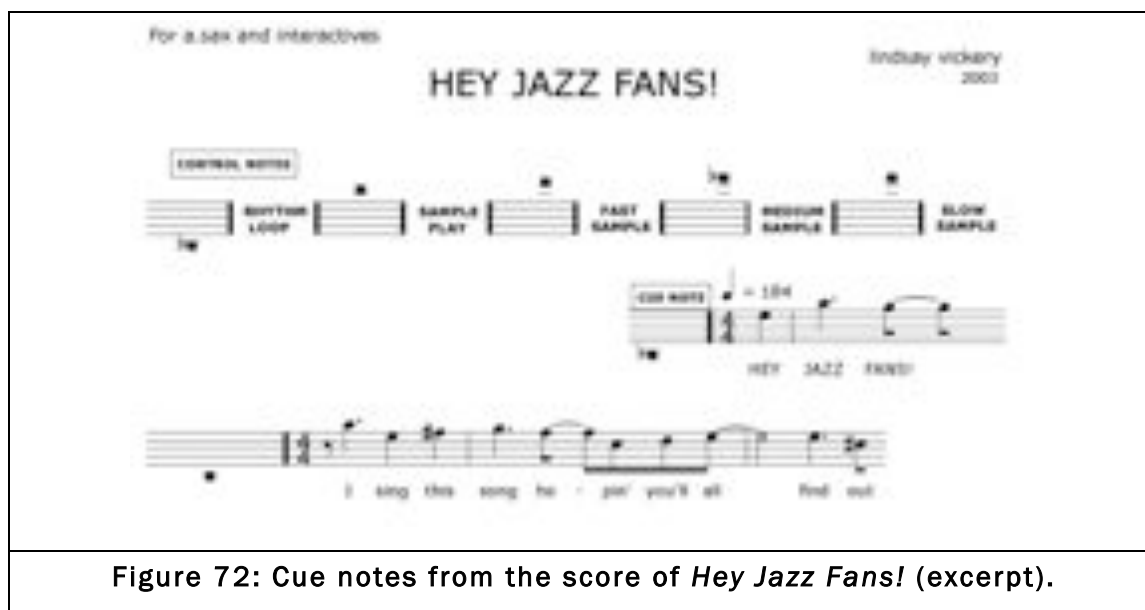
Figure 72: Cue notes from the score of *Hey Jazz Fans!* (excerpt).

The structure of the work is determined interactively by the choices of the performer. The transitions from RHYTHM LOOP MODE to SAMPLE PLAY mode are particularly significant in terms referential and parametrical disjunction. In the SAMPLE PLAY mode samples are cued by every detected pitch, and therefore the density of the texture is also greatly influenced by changes in the look-up rate. In RHYTHM LOOP MODE, samples of the accompaniment (without the lead line) of different lengths are played back as a loop. The speed and frequency of the loop playback is controlled by the pitch of the latest detected saxophone note. Higher pitches cause the loop to glissando proportionally upwards in frequency and lower pitches cause the loop to glissando proportionally downwards in frequency, creating a digital version of the "faulty record-player motor" referenced in *Entropology*.

This range of modes of interaction between the performer and the software, allow for an open structure in which each instantiation of the work may vary significantly in length and form. Figure 73 shows spectrograms of three versions of the work, illustrating the range of possible formal outcomes (and durations) that may arise from a particular performance.

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Figure 73: Spectrograms of three performances of *Hey Jazz Fans!* illustrating the range of possible formal outcomes of the work.
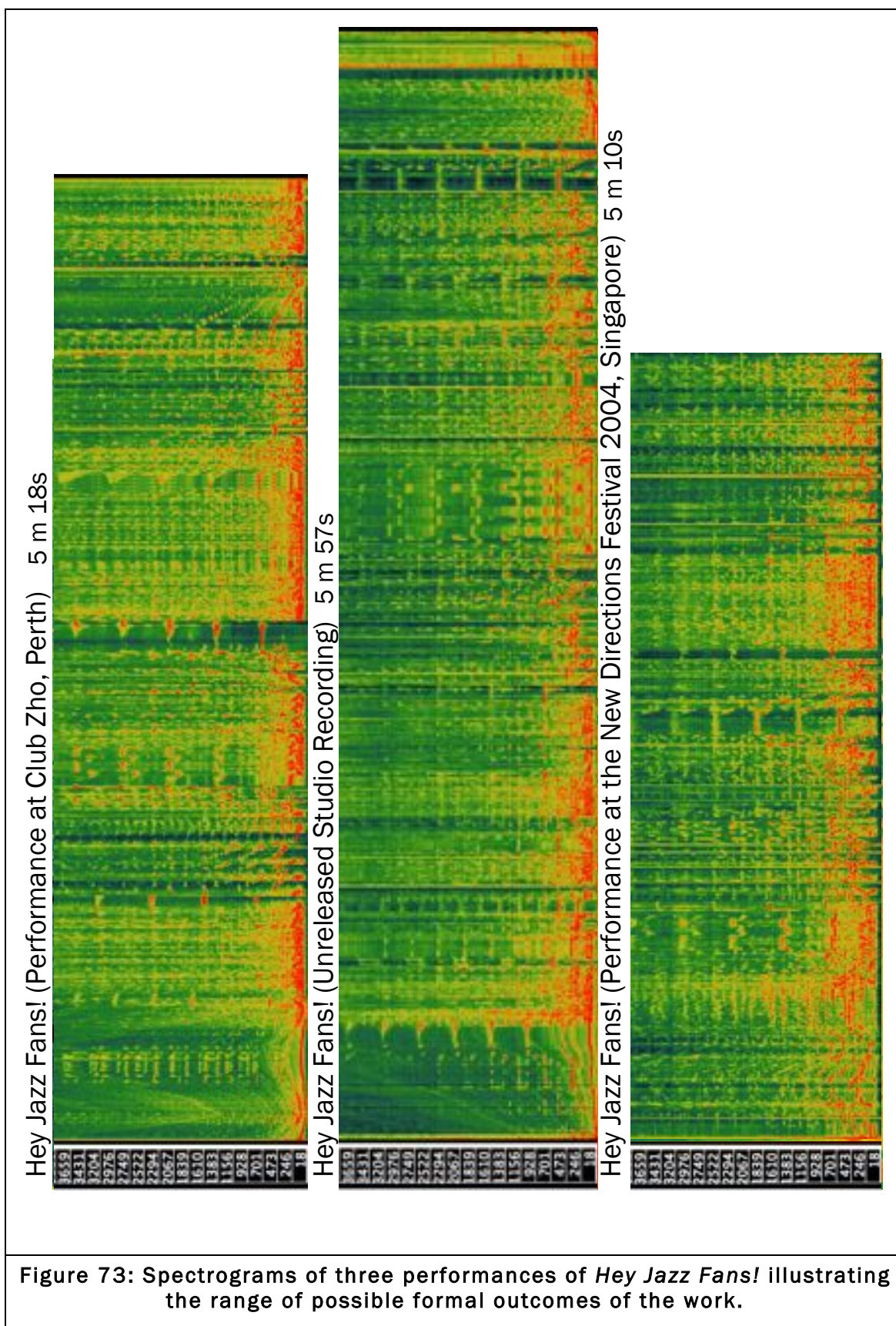
6.2.2. *<as viewed from above>* (2001)

<as viewed from above> drew its inspiration from the Postmodern literary structure the 'hypertext rhizome' (Žižek, 2000 pp.37). In particular the notion of the hypertext rhizome as a dramatic paradigm developed by MIT professor Janet Murray. She coined the term 'Violence Hub' to designate hypertextural works in which a central event is examined from different perspectives.

> The proliferation of interconnected files is an attempt to answer the perennial and ultimately unanswerable question of why this incident happened. These violence hub stories do not have a single solution like the adventure maze or a refusal of solution like post-modern stories; instead they combine a clear sense of story structure with a multiplicity of meaningful plots. The navigation of the labyrinth is like pacing the floor; a physical manifestation of trying to come to terms with the trauma; it represents the mind's repeated efforts to keep returning to a shocking event in an effort to absorb it and finally, get past it.
>
> (Murray 1997 p. 135-6)

Žižek identifies the potency of this novel formal structure in Lacanian terms as referring to the "trauma of some impossible Real which forever resists its symbolization (all these narratives are ultimately just so many failures to cope with this trauma)" (Žižek 2000 p.38). *<as viewed from above>* attempts to sonically reproduce a formal structure of this type.

At the heart of *<as viewed from above>* is a short text. The software 'listens' to the live performance of an acoustic instrument, as a trigger for proceeding through the samples of a text. Each line of text is recorded as a separate sound file. The computer can choose to replay and manipulate any previously chosen sound file of text, but is constantly narrowing its own number of text choices. In effect the patch left to its own devices will choose to 'obsess' over - in this case repeating and deforming - an ever diminishing group of samples. The live performance 'distracts' this process and forces it to act upon new material until all of the samples have been exhausted. The text used in the work is shown in Figure 74.

head like a map too much detail as viewed from above this map that gets you lost lines that can't join too far too far since when did breathing become so important not enough numbers not enough detail these lines superimposed all these lines tangled turning around wrong wrong again time so much of it these moments can't all mean something another failed attempt at detachment

Figure 74: The text from *<as viewed from above>*.

The MAX/MSP frequency analysis object fiddle~ forms the bridge between the live performer and the computer. This object is used to approximately map the current frequency and amplitude of sounds from the performer and also to estimate the beginnings of phrases based on amplitude changes. The performative model for the work is shown in Figure 75.
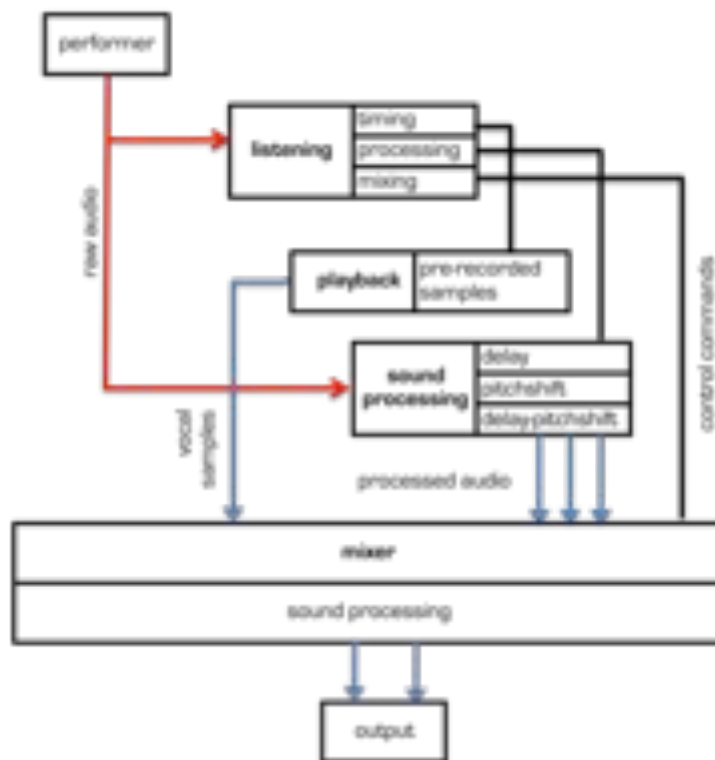
Figure 75: The performative model employed in *<as viewed from above>*.

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The information gathered from the fiddle~ object is processed in three distinct layers. Layer one cues text samples based on the beginnings of the live performer's phrases. It also manages the samples so that the texts do not play simultaneously and have appropriate pauses between groups of lines of text. Layer two manipulates the samples that have been played up until that point. It uses frequency and amplitude information as well as information pertaining to the amount of activity in the live part to change playback speed, assign loops and loop lengths and pan the samples. The final layer creates an overall mix between the live performance, the expanding text and the manipulated text and processes the result using comb filters and reverbs.

The order of emergence of the lines of text is fixed. Its theoretical model, referencing a "psychological" paradigm of "obsession" in the moment and moving forward is an example of the investigation of a cognitive, rather than explicitly musical, type of formal structure.

The formal structure of *<as viewed from above>*, in terms of total duration and the duration of interstitial spaces between the emergence of each new line of text is determined by interaction between the performer and the software. Figure 76 shows spectrograms of four performances of the work, indicating the divergence in formal structure texture and duration achievable.
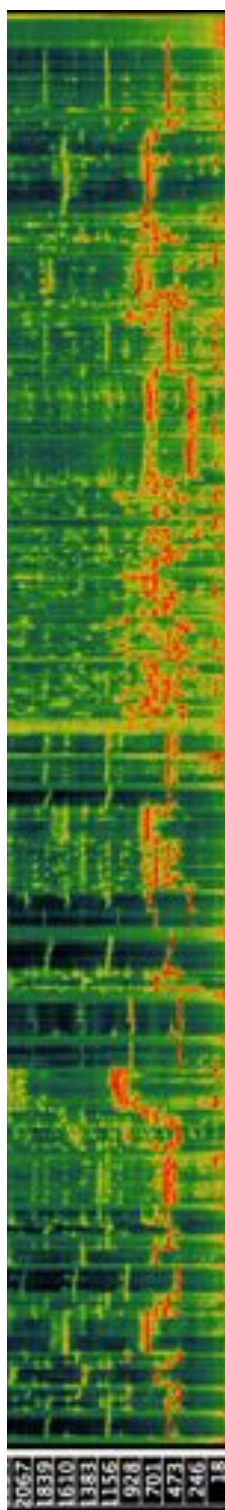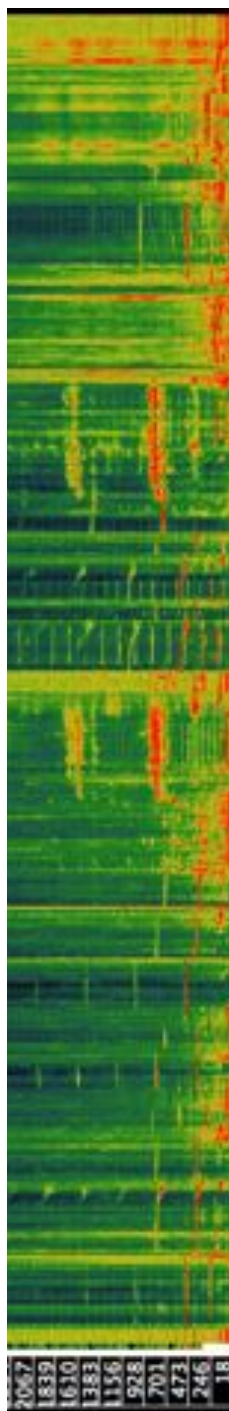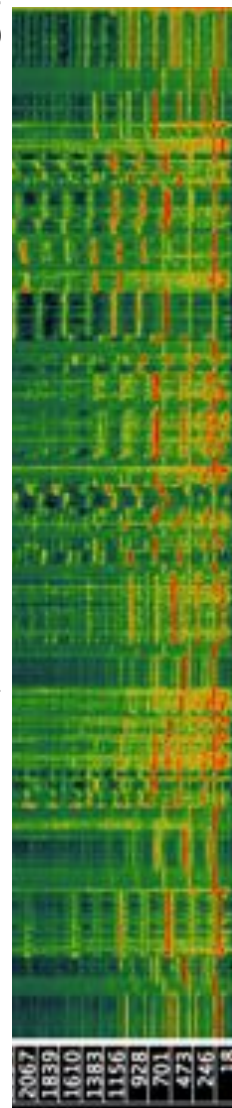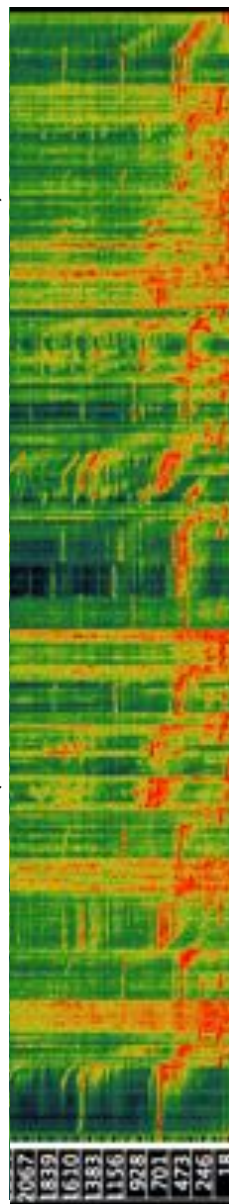
Figure 76: Spectrograms of four performances of *<as viewed from above>* illustrating the range of possible formal outcomes of the work.

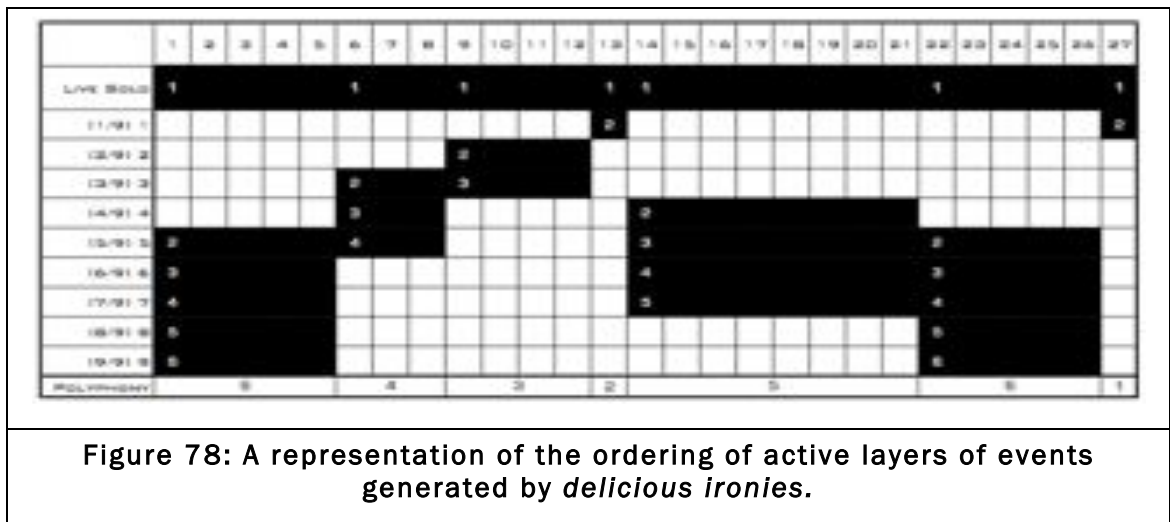### 6.2.3.*Delicious Ironies (2001) and Splice (2002)*

Delicious Ironies was created as a vehicle to provide an extremely unpredictable and provocative sonic environment for the solo improviser. The intention was to use sound samples that were pertinent to the soloist, but also volatile and erratic enough to inspire an interesting improvised response in the moment.

The stream of samples that accompany the improvisor in *Delicious Ironies* is created by nine layers of event-generating objects. The fastest object sends cues at nine times the speed of the slowest (See Figure 77). Events sent from the objects are mapped to different aspects of sample playback: i.e. sample choice, playback speed, duration, volume, loop, pan and portamento amount.

Figure 77: A representation of the polytemporal generation of events in *delicious ironies.*
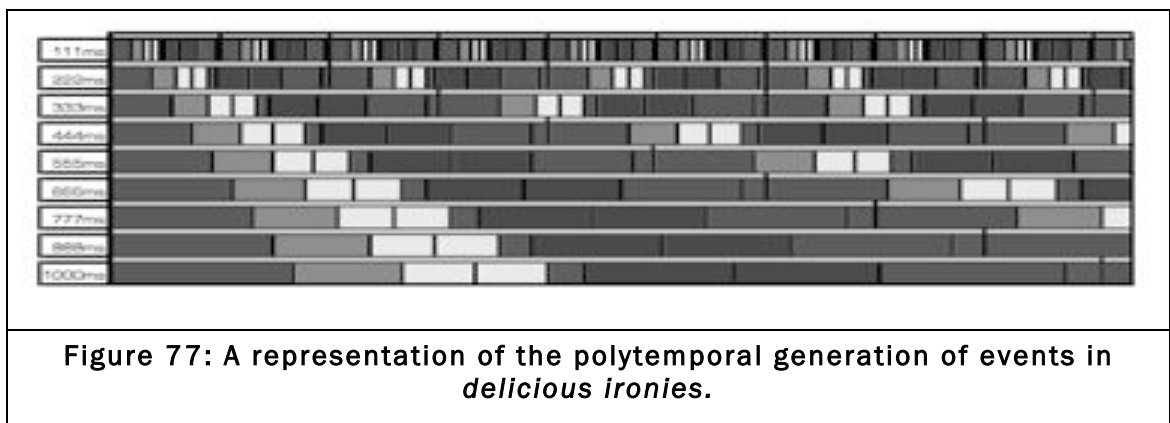
Despite the fact that the events are 'played' by the computer in exactly the same temporal framework each time, the altered sample set generates an utterly different sounding piece each time. The computer's utterances act to prompt the live soloist and, in the best circumstances, the two form an amalgam in performance. However, despite it sometimes sounding to the contrary, the performer cannot influence the computer performance in any way.

In order to shape a formal structure from the continuous polytemporal cuing, not all of the nine event generating objects are activated at all times. The changes in activation patterns follow the "cypher" pattern discussed in the previous section. At the beginning five layers are active, followed by 3, 2, 2, 1, 4, 4, 5, and then 1 layer with the length of activation time proportional to the number of active layers. (For example the section with five active layers is five times longer than the section with one active layer) (See Figure 78).

Figure 78: A representation of the ordering of active layers of events generated by *delicious ironies.*

The changes in texture generated by these activation patterns are the principal means of creating disjunction between substructures in the work. In this sense the *Delicious Ironies* series works are all "cypher works" with the same formal divisions as the works discussed under the heading "Block Form".

There are three "series" of *Delicious Ironies* works:

- Series one: for sampler cued via MIDI from a computer running Max/MSP

- Series two: for a computer running Max/MSP accessing samples on its hard-disk

- Series three: for a computer running Max/MSP accessing samples on its hard-disk, and processing the sounds of the samples and of the performer.

Series one focused on narratively related samples, for example, from film noir, boxing movies and record glitches. Series two did not provide any score and used samples derived from extended techniques made by the performers themselves: for example guitar and Sichuan opera percussion instruments. Series three explored the deconstruction of my own pieces *Kreuz des Suedens*, *Cyphers of the Obscure Gods* with the addition of a mobile score (See Figure 72), improvisations by my group *shmil*, the work of others: Earle Brown's *December 1952* and improvisations by bassist Dr. Ian Woo.

In *Delicious Ironies a* sense of immanence in the performer is encouraged by specifically instructing that the performers to not listen to the computer component prior to the performance. Series one and three of provide a mobile score as an additional source of stimulus for the performer.

In *Delicious Ironies (noir)*, the source of the text was taken from a pre-existing dance-theatre work of mine *noir* (2000). The text was constructed by dividing the page into four columns and then flowing the words vertically around the columns. The performer, reading the text in the traditional left to right manner, is presented with a "cut-up"[106] version of the text from *noir*. In regard to interpretation of the mobile score, the performance instructions state,

> Apart from non-text vocal noises – i.e. screams, grunts, wolf-whistles, moans or other bodily sounds - only use the suggested text. You may, however choose to read it down the column across the columns or in diagonal lines - whatever. The text should be read using a variety of Film-Noir voices: i.e. the femme fatale; the squeaky secretary; the down'n'out detective; the dumb mechanic; the sadistic crime boss; the nice girl he orta marry if he was that kinda guy; the pleading weak henchman; the cynical policeman who wants him to just keep out trouble; heavy breathing behind a curtain; the gunshot victim gurgling to death; etc etc. It is not necessary to make sense as long as it has character.   (Vickery 2002)

The example in Figure 79 shows the order in which the text was performed by Melissa Madden Gray in the opening of the recording of *Delicious Ironies (noir)* collected on the creative folio CD2 (Collage). She chose to begin the work reading left to right sequentially across the two pages of text, alternating between taking one or two vertical lines at a time and sometimes overlapping the text by reading lines that were spoken in a different context in the previous pass: for example "the stake-out They say" in the first pass and "They say there's some" in the second pass.

Figure 79: The pathway taken by the vocal performer in the Creative Folio recording of Delicious Ironies (noir).
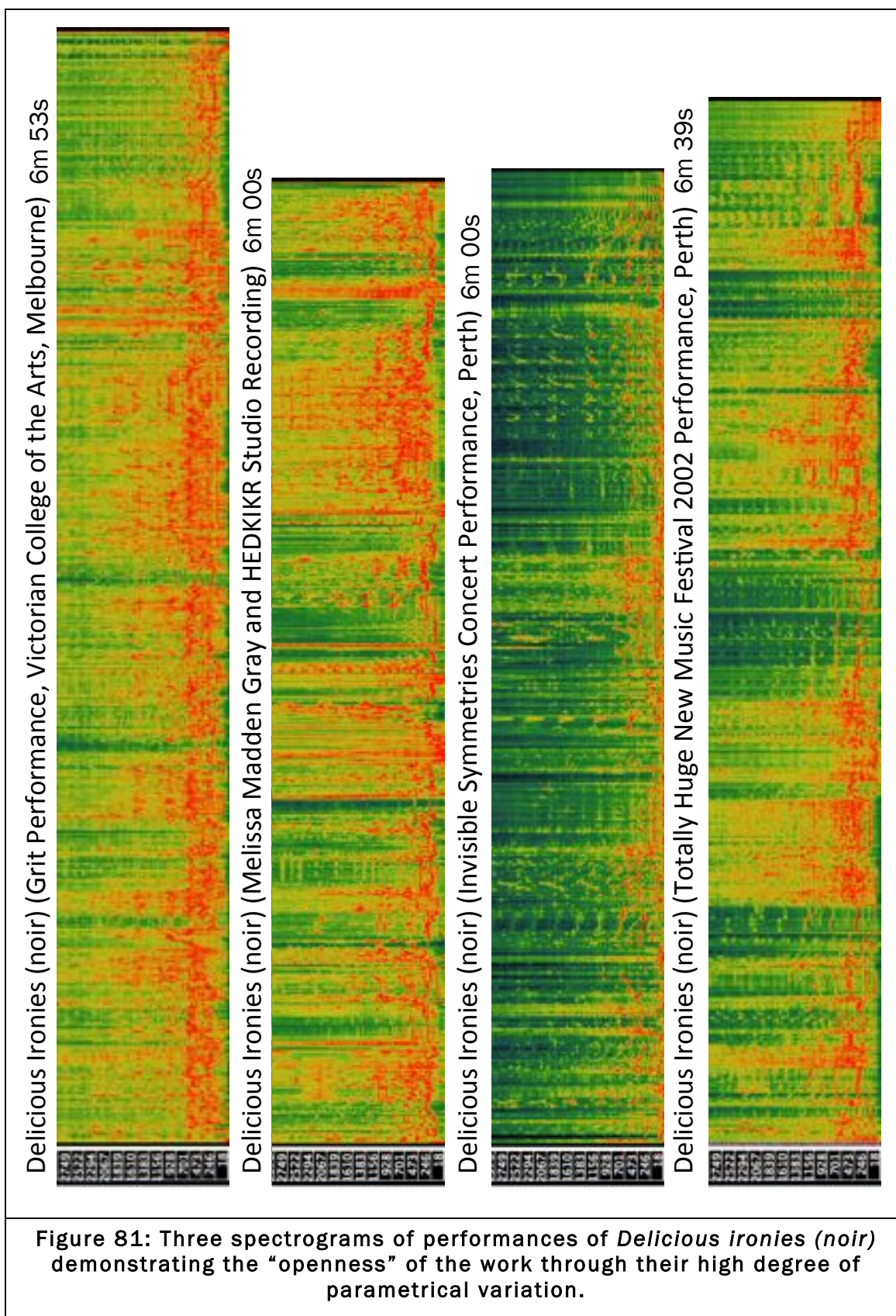
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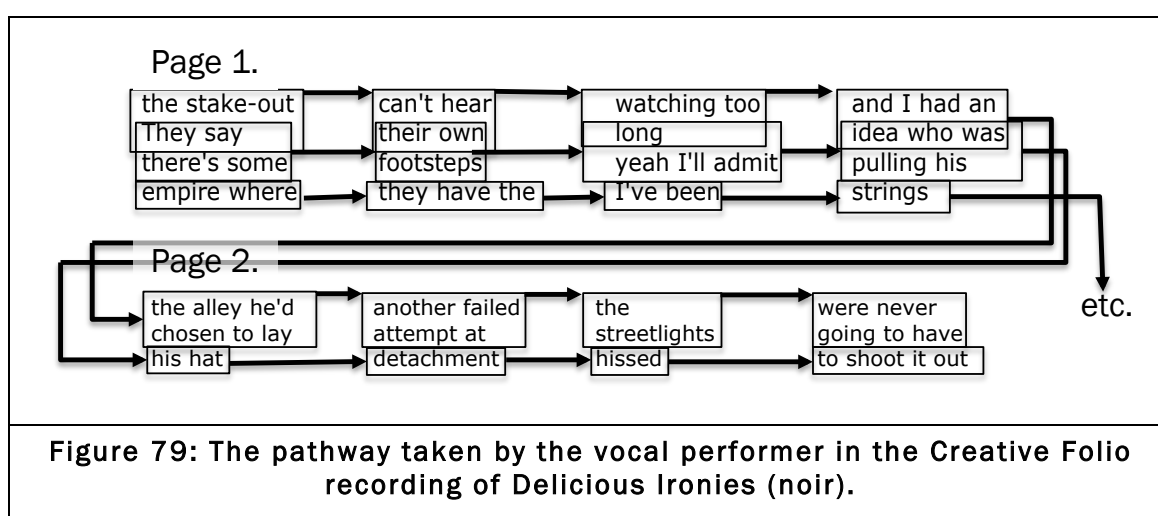
[106] The "cut-up technique", a method of physically permutating pre-existing texts was invented by Brion Gysin and popularised by Beat writer William Burroughs (Gysin and Weiss 2002 p. xii)
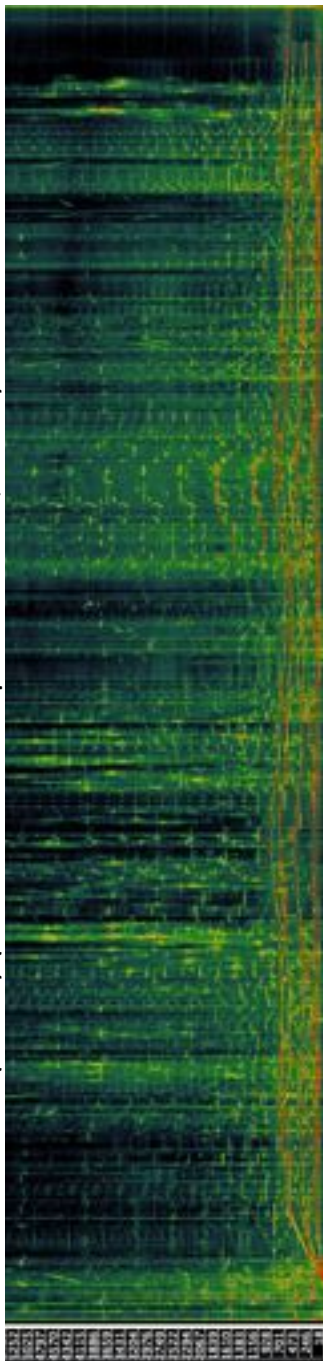
Similarly, in the work *Delicious Ironies (KDS)*, the performers are presented with a notated mobile score, this time comprising deconstructed elements of my work *Kreuz des Suedens* as shown in Figure 80. In performance, the violin and cello players signal each other to indicate a transition to another of the eight possible fragments. The electronic component of the work is analogously comprised of samples from a performance of the linear version of *Kreuz des Suedens*, that are assembled in performance by the computer.

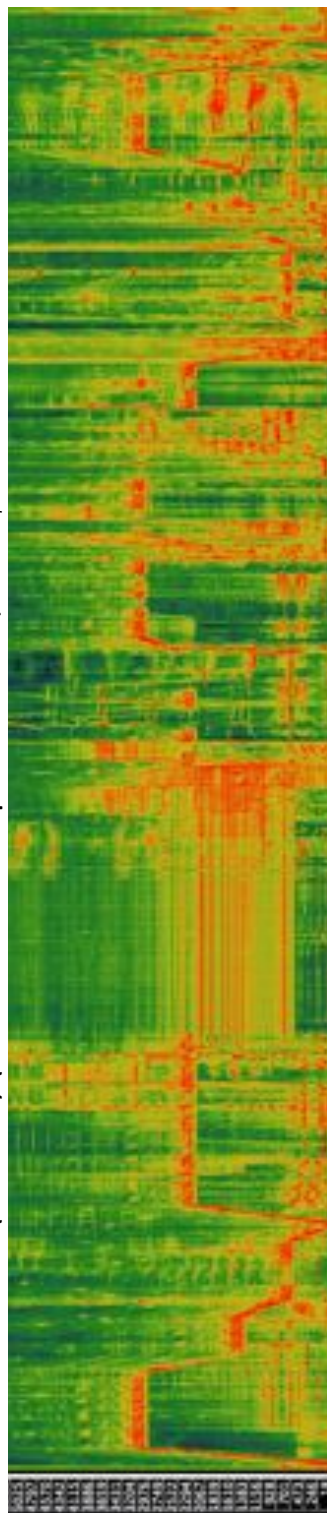Figure 80: The deconstructed mobile score for *Delicious ironies 3 (KDS)*.

Figure 81 shows spectrograms of four performances of the same work, *Delicious Ironies (noir)* from series one and Figure 82 shows spectrograms of performances of three different works *Delicious Ironies (anak²)*, *Delicious Ironies (Dr Woo)* and *Delicious Ironies (shmil)*. The performances of *Delicious Ironies (noir)* were made over a period of five years and feature contrasting instrumentations. They indicate the "openness" of the work through the high degree of parametrical variation that may arise from different instantiations. In contrast, the three versions of *Delicious Ironies* shown in Figure 82 were all recorded in the same performance. The works contrast in the instrumentation of the solo part, the nature and provenance of the samples employed and the audio processing applied to both the solo and the computer components. They again indicate the "openness" of the work through multiple versioning of the same structure.

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Figure 81: Three spectrograms of performances of *Delicious ironies (noir)* demonstrating the "openness" of the work through their high degree of parametrical variation.
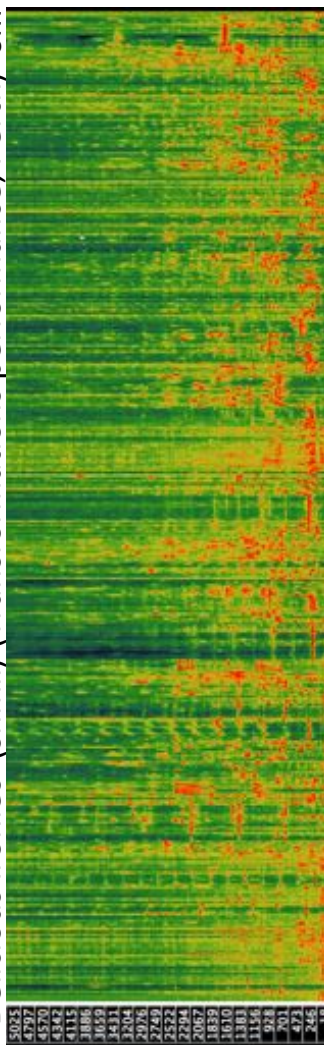
Figure 82: Three spectrograms of performances of three different *Delicious ironies* works from the same concert illustrating multiple versioning of the same structure.

Splice employs synchronised live sampling of the soloist to impose a formal structure on a live improvisation. It is an example of an encoded 'meta-music' - a compositional map that is without contents until a live performer adds them. The soloist's sounds may be stretched, altered in pitch, echoed or recorded only to re-emerge later - techniques similar for example to those found in a conventional notated composition – with the exception that they occur in realtime. Splice sculpts all sounds into the same structure regardless of whether they are melodic, noise or even silence, generating a novel instantiation of its structure in each performance.

The performative model for the work is simple and typical of works of this type: a live soloist; a microphone recording the soloist's performance; a computer processing the recorded audio in real-time; and speakers projecting the soloist's performance and the processed audio. The final component of this arrangement is the soloists' interaction with the computer's manipulation of their own performance (See Figure 83).


Figure 83: The performative model employed in *Splice.*
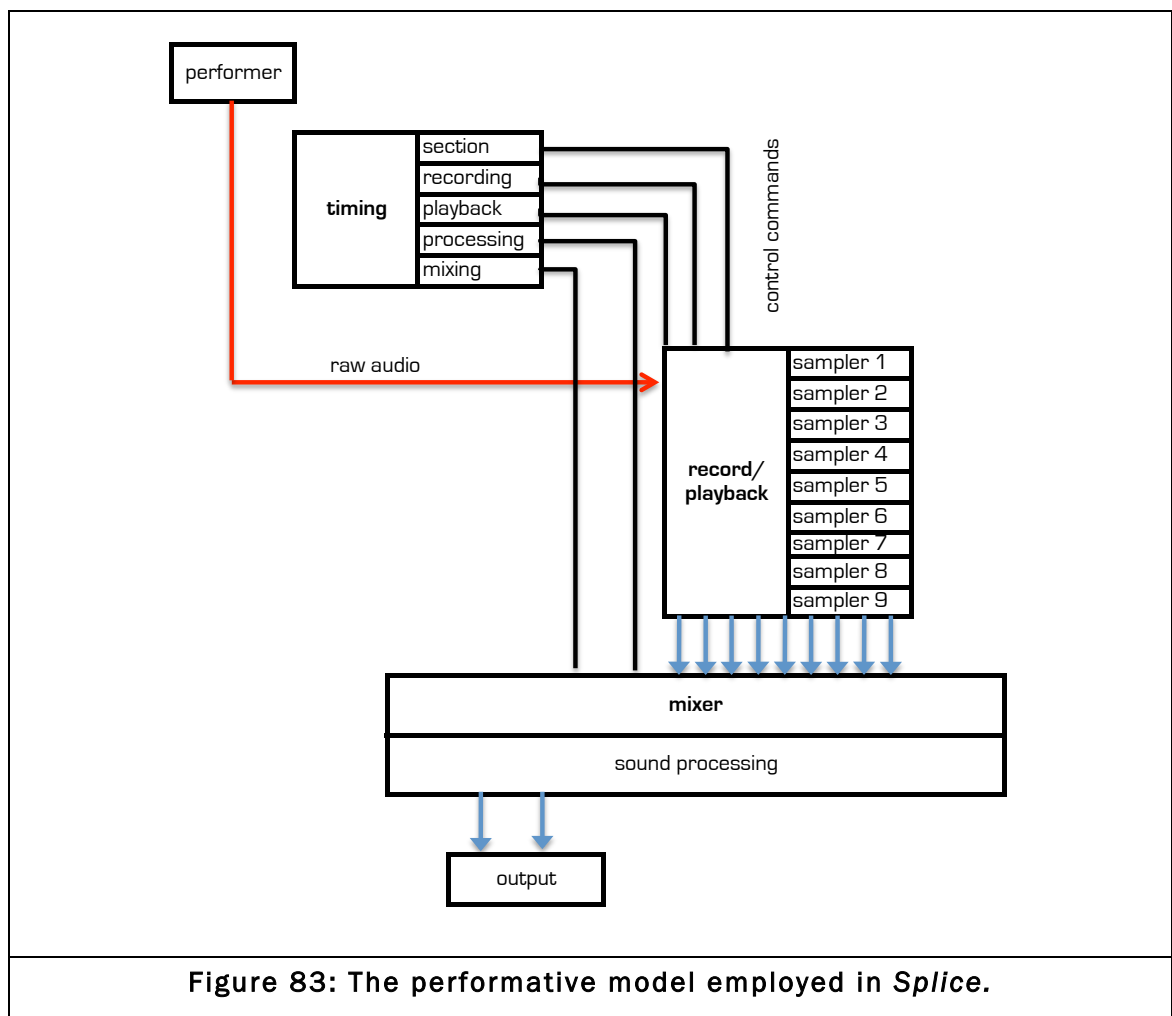
Splice's formal strategy is to record, manipulate and playback live audio from a soloist's improvisation, creating a structure that is based upon elements typical of musical works, such as those noted by Dannenberg and Hu:

> repetition at different time scales (of) elements of the music (that) are repeated or transformed' 'the transfer of these elements within a composition, forming relationships and therefore structure.

(Dannenberg and Hu 2002 p. 44)

This work's structure is organised along the same lines as the *Delicious Ironies* series, but with the recording and playback of a live performance replacing the cuing of pre-recorded samples.

Splice uses nine separate recording and playback modules, each restricted to a different buffer size[107] (See Figure 84). The largest buffer allows for nine seconds of audio to be recorded and the smallest allows for just one second. The synchronisation of the recording and playback by the *splicer* modules is controlled independently according to a predetermined scheduling.

Figure 84: *Splicer* Recording and Playback Modules from *Splice.*
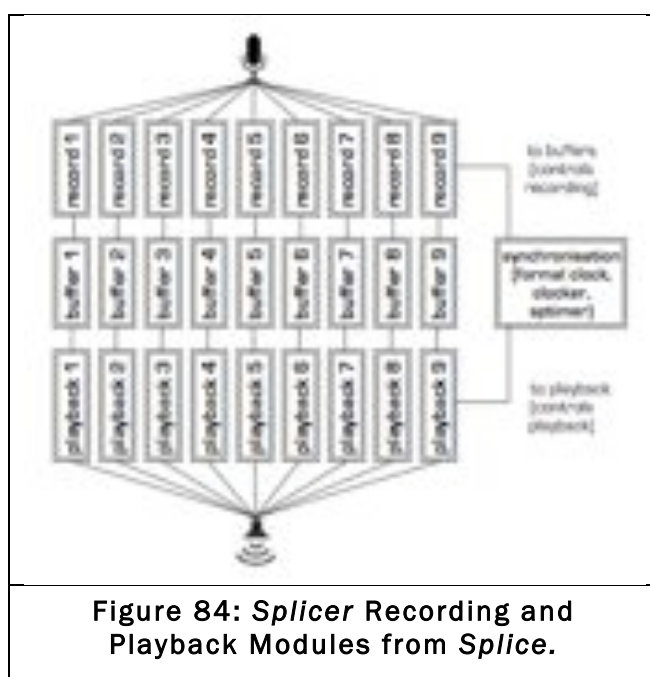
The audio processing in *Splice* creates an emergent formal structure: the same "cypher" structure previously discussed. It is a referential structure, but only in the sense that the sampled materials have been recently played by the live soloist. The structure is articulated principally through changes in the number of polyphonic voices in each section and the average frequency of the sample playback.

As in *Delicious Ironies,* the *splicer* modules do not function simultaneously throughout the entire piece. They are turned on and off according to the work's "formal clock". The activation and deactivation of the *splicer* modules generates changes of density in the overall resultant texture. Differences in the properties of

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[107] Buffer size refers to the maximum duration of audio material that may be stored.

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each *splicer* module and the number of *splicer* modules that are active at any point create changes in polyphony from one section to the next. A schematic of the resulting structure is shown in contrast to a spectrogram of a performance of the work in Figure 85.
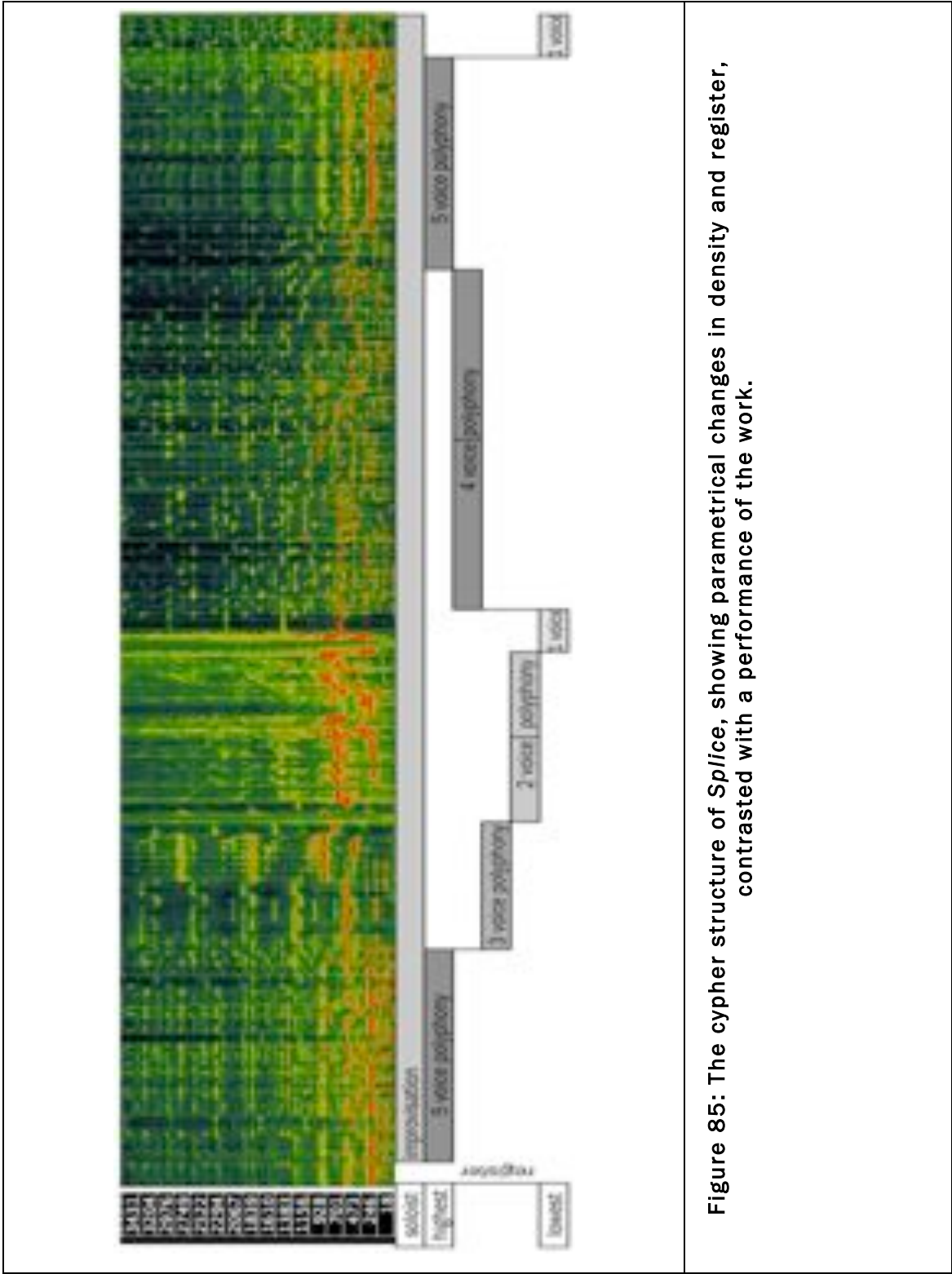

Figure 85: The cypher structure of *Splice*, showing parametrical changes in density and register, contrasted with a performance of the work.

The inherent structure is empty until the introduction of audio from the soloist's performance. The contents of the formal structure are therefore contingent upon the sounds emitted by the soloist[108], and this results in openness of the work in terms of sonic content. The performer's role is dual, in that they provide raw material for the computer, but additionally interact, responding to the computer's audio output. The timing and nature of the computer's processing is not predictable by the performer. However, a timer on the computer screen steps through the 27 units of the work's duration, and gives the performer a general indication of the state of the computer's progress through the structure.

6.3. Permutational Models

The permutationally structured works expand on the collage processes employed in *Hey Jazz Fans!* to generate structure. In these works the free interaction between the performer and the computer found in *Hey Jazz Fans!* is exchanged for more defined structural goals. Computer coordination in these works allows the musical materials that are presented to performers to be permutated or translocated in a synchronised manner, allowing the exploration not only of permutation of blocks of material (as found in *Improbable Games*), but also insertion of cells of material within blocks (as found in *Antibody*). These works also explore the notion of selectively permutating materials, in order to reveal contrasts between passages of permutated materials and sequential passages (*Improbable Games*) and fixed structural axes and permutated interstitial materials (*reconstruction of a shifting path*). Screen grabs of the screen-scores for several of these works are collected on the accompanying DVD. Table 24 categorises the Permutational Structure works from the folio by materials, score, transformation and emergent formal structure.

antibody	
Erasure	Measures from five nine-bar passages of music are gradually translocated during the performance.
Score	Permutating and translocating screen score. Players are synchronised by click-track.
Transformation	Live audio processing
Formal structure	Indeterminate sequential nonlinear structure with a narrative contour implied by continuously increasing translocation.

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[108] *Splice* has been performed with a solo saxophone, guitar, toy instruments, voice and drums.

Improbable Games (2010)	
Materials	Three contrasting sections from Kreuz des Suedens
Score	Permutating notated score. Players are synchronised by click-track in tutti passages.
Transformation	Tempo/pitch and live audio processing
Formal structure	A formal structure is generated by computer permutation of the score and manipulation of the audio processing parameters.

reconstruction of a shifting path	
Materials	Five contrasting musical passages and materials for improvisation based upon the passages.
Transformation	Generation of related materials through MIDI triggering
Formal structure	A formal structure is articulated by the computer, comprising temporally fixed structural materials and indeterminate interstitial passages.

Partikulator	
Materials	The improviser's live performance
Transformation	Live audio processing
Formal structure	A formal structure is generated by computer manipulation of the audio processing parameters.

questions written on sheets of glass	
Materials	Spectral analysis of the improviser's live performance
Transformation	Temporal manipulation and verticalisation of horizontal lines
Formal structure	A formal structure is generated by computer manipulation of the distribution of data from the spectral analysis to the disklavier.

Table 24: Categorisation of Creative folio Permutational Structure works by materials, score, transformation and emergent formal structure.
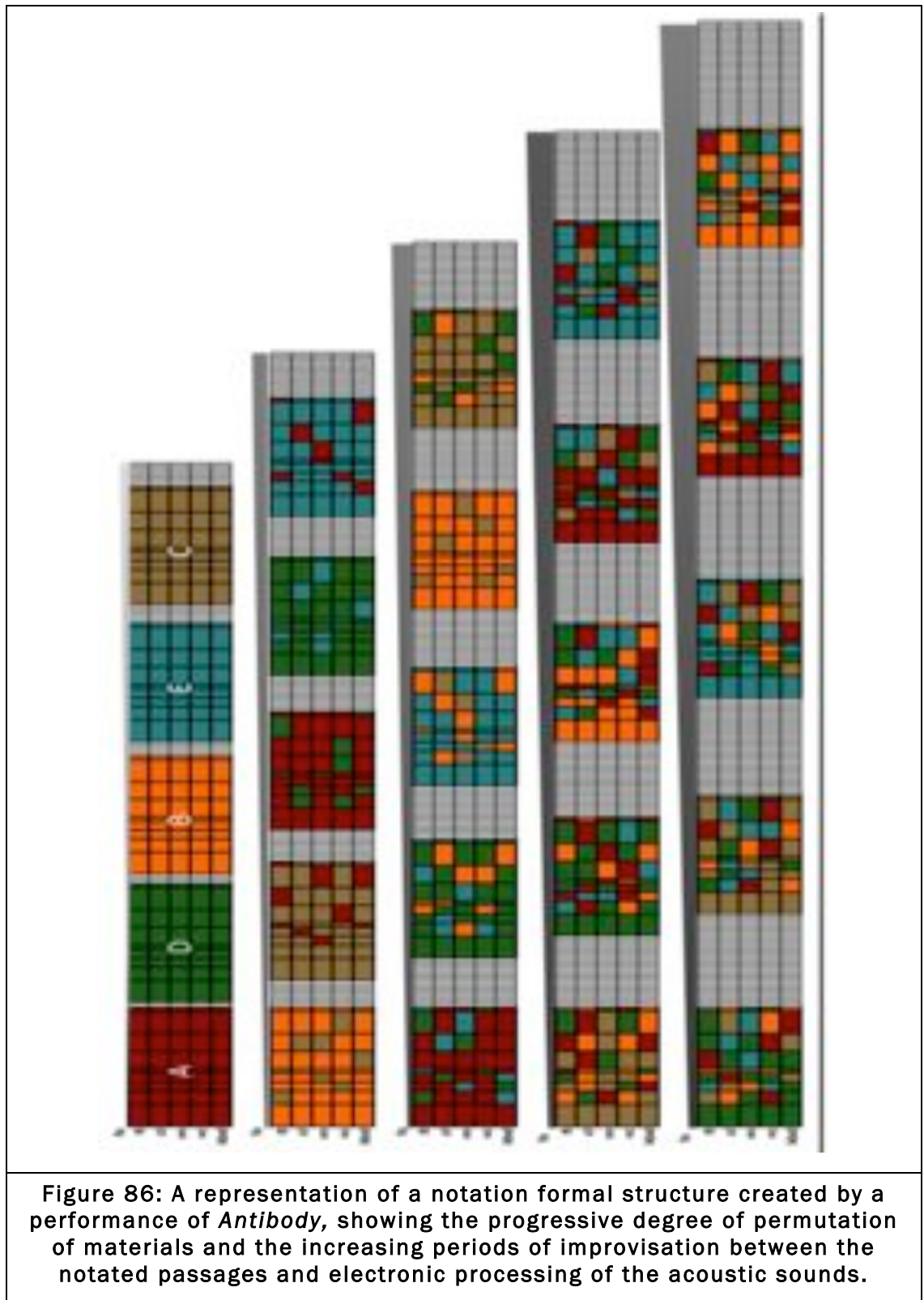
6.3.1.*Antibody (2010)*

Antibody employs a permutative score to explore a formal structure based on the principle of mutation, for example: the processes of deletion, duplication, insertion and translocation. The performers are presented with one of five cells [A through E] comprising nine measures of score with a distinct tempo and texture. They perform the music synchronously with the aid of a coordinated clicktrack. At the end of each cell there is a break during which the performers are instructed to improvise a transition from the material they have just played to the next cell presented by the computer. The interstitial periods between each cell increase in length throughout the work.

The musical cells are permutated to create a cycle with substructures of indeterminate order. The work comprises five cycles of the permutated cells. In the first cycle of the work, the five cells are played in an order chosen algorithmically by the computer, but with each nine-measure span remaining homogenous and unmodified. In the second cycle the five cells are permutated again, but this time
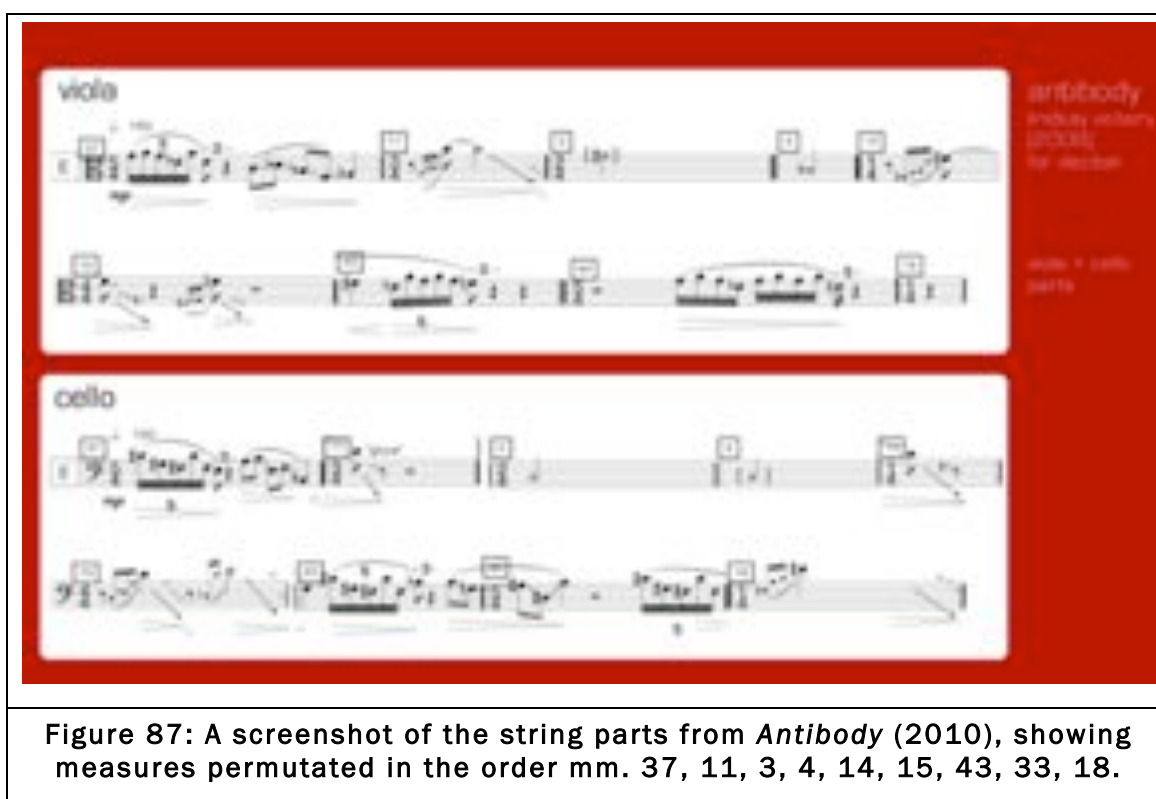
with some measures from another cell inserted. In the subsequent cycles the inserted measures are drawn from the two, three and finally four other cells. By the final section the five cells have completely interpenetrated one another, as shown schematically in Figure 86.

Figure 86: A representation of a notation formal structure created by a performance of *Antibody,* showing the progressive degree of permutation of materials and the increasing periods of improvisation between the notated passages and electronic processing of the acoustic sounds.

The contrasting, but proportionally related tempi of the five cells, (mm. 30, 60, 90, 120 and 150), mean that measures are performed at a new tempo when they are inserted into a different cell, in a manner similar to *Exit Points*. As a consequence they are continuously transformed each time they are played.

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 is increased throughout the duration of the work.

Three computers, displaying the scores for alto flute and clarinet, viola and cello and keyboard, are networked together to provide synchrony between the evolving scores. Figure 87 shows a screenshot of the viola and cello parts. The translocation of the materials is indicated by the non-sequential bar numbers.


Figure 87: A screenshot of the string parts from *Antibody* (2010), showing measures permutated in the order mm. 37, 11, 3, 4, 14, 15, 43, 33, 18.

Antibody achieves the kind of sectional mobility found in Block Form works such as Earle Brown's *Event-Synergy II* (1967) and sub-motivic mutation pioneered by Debussy in *Jeux* (1912). However, through the use of the screenscore, these processes result in the real-time reordering of the work in each performance. These processes are documented in a video on the accompanying DVD.

6.3.2. *echo-transform 1 (2010)*

echo transform combines the improvisation and sampling procedures of *Splice,* with a graphically notated and permutated scrolling screen-score. The score (shown in Figure 88.), indicates relative pitch and duration, and is interpreted by the performer in semi-improvisatory fashion as it scrolls across the computer screen.

Figure 88: The complete graphical scrolling score for *Echo-transform*.

As in *Splice*, the sampling process is visually 'opaque' to the performer (there is no visual sign that it is taking place and it is not notated in the score). However, due to the increased consistency of the process, (the computer will always reliably sample

the same portions of the performance), the players can begin, through repeated rehearsal, to recognize aspects of the process aurally.

In *echo-transform,* the score is "permutated" in the sense that it can jump from section to section in any order. The sections also scroll at a range of different speeds. There are five mobile sections in *echo-transform* and an introductory and closing section. Each mobile section uses only 1, 2, 3, 4 or 5 "notes", however the actual kind of sound that is rendered as a "note" is not specified. In is intended that the performer create a new combination of sounds each time the score appears, and if appropriate, links their note choice to the previous section. Electronic processing is linked to each section so that the sound environment for each section is similar whenever it is played. The score is presented to the performer on screen, with two staves that alternate allowing the performer to see what section will occur next as shown in Figure 89.
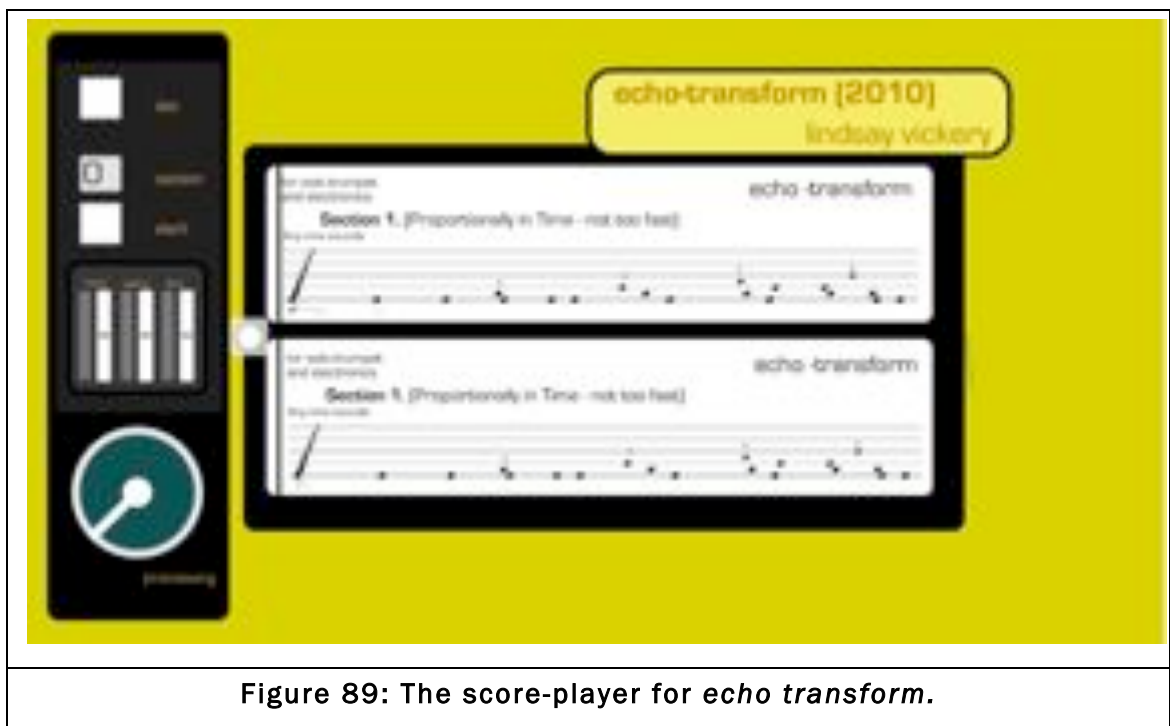
Figure 89: The score-player for *echo transform.*

Figure 90 shows a spectrogram of the work indicating a significant degree of parametrical disjunction occurring between clearly defined sections. The structure of *echo-transform* is indeterminate and consists of 27 sections that occur only once each, but in any sequence. A variety of audio processing arrangements, linked to each of the sections, reinforces the differentiation between them. There is some multilinear overlapping of structure created by elements of the live performance that remain captured in sampled loops.
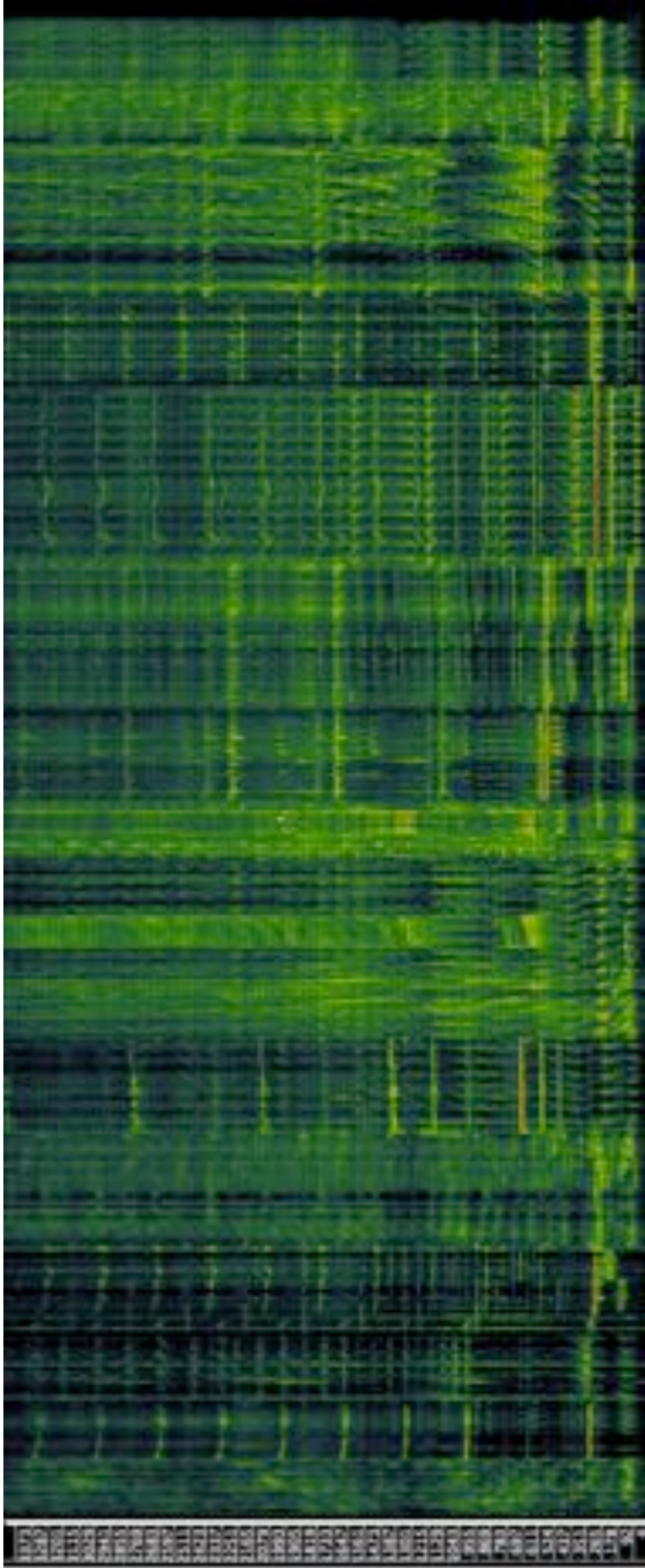
Figure 90: A spectrogram illustrating the parametrical disjunction occurring between clearly defined sections in *Echo Transform*.

6.3.3.*Improbable Games (2010) and Reconstruction of a Shifting Path (2011)*

Improbable Games explores the distinction between passages of notated, pulsed synchronous material and semi-improvisatory, unpulsed asynchronous material. The synchronous materials comprise 27 bars of notated score derived from the work *Kreuz des Suedens*, divided into three segments of nine, ten and eight bars respectively, that are contrasting in tempo, register dynamic and texture. The asynchronous passages consist of the same 27 bars presented individually to the performers in indeterminate order. Figure 91 shows a screenshot of the screenscore of *Improbable Games.* The performers are expected to explore this fragmented material over a period of time (between 1 and 27 seconds) indicated by the left to right movement of a scroll-bar below the fragment.
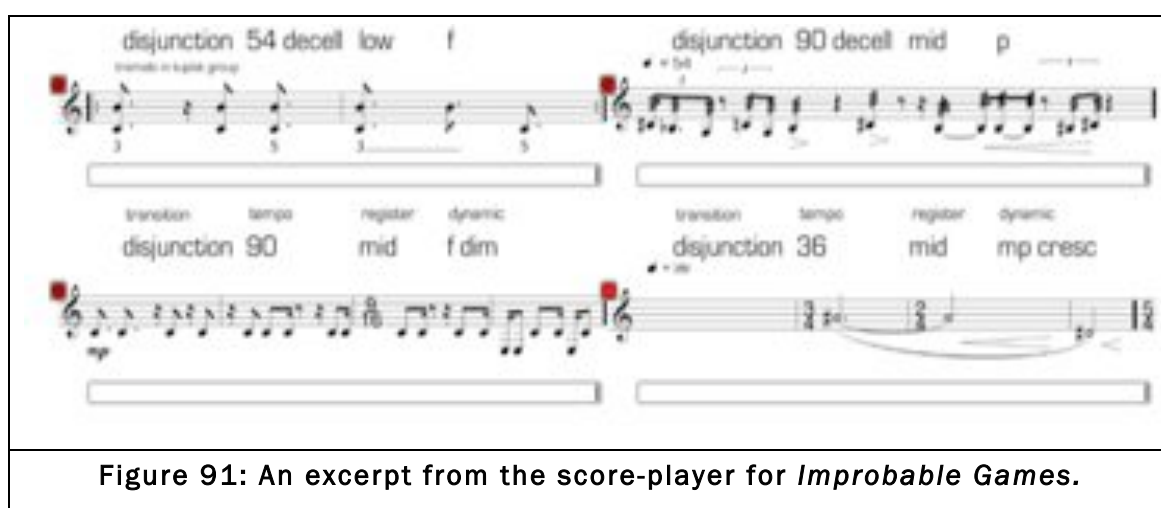
Figure 91: An excerpt from the score-player for *Improbable Games.*

The synchronous passages emerge from this asynchronous texture as a "full-screen" linear score, together with a clicktrack to coordinate the performers. The actual iteration of the formal structure is altered in each performance. The piece concludes when all three synchronous passages and all 27 asynchronous passages have been performed. A schematic representation of a possible instantiation of the formal structure of *Improbable Games* is shown in Figure 92. These processes are documented in a video on the accompanying DVD.
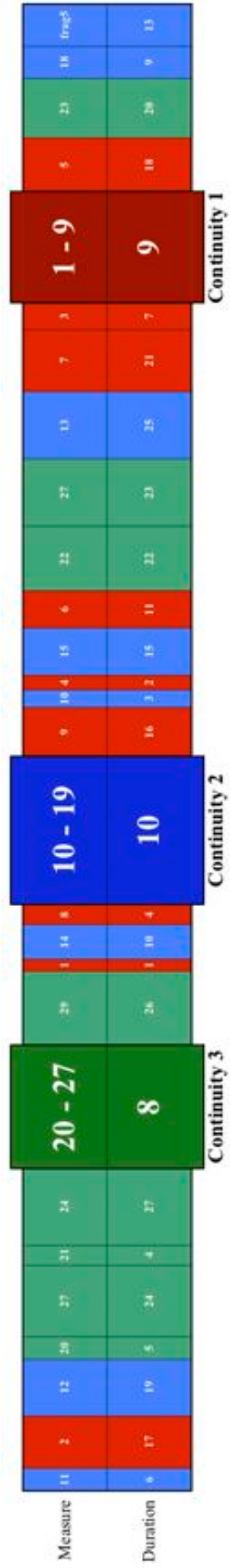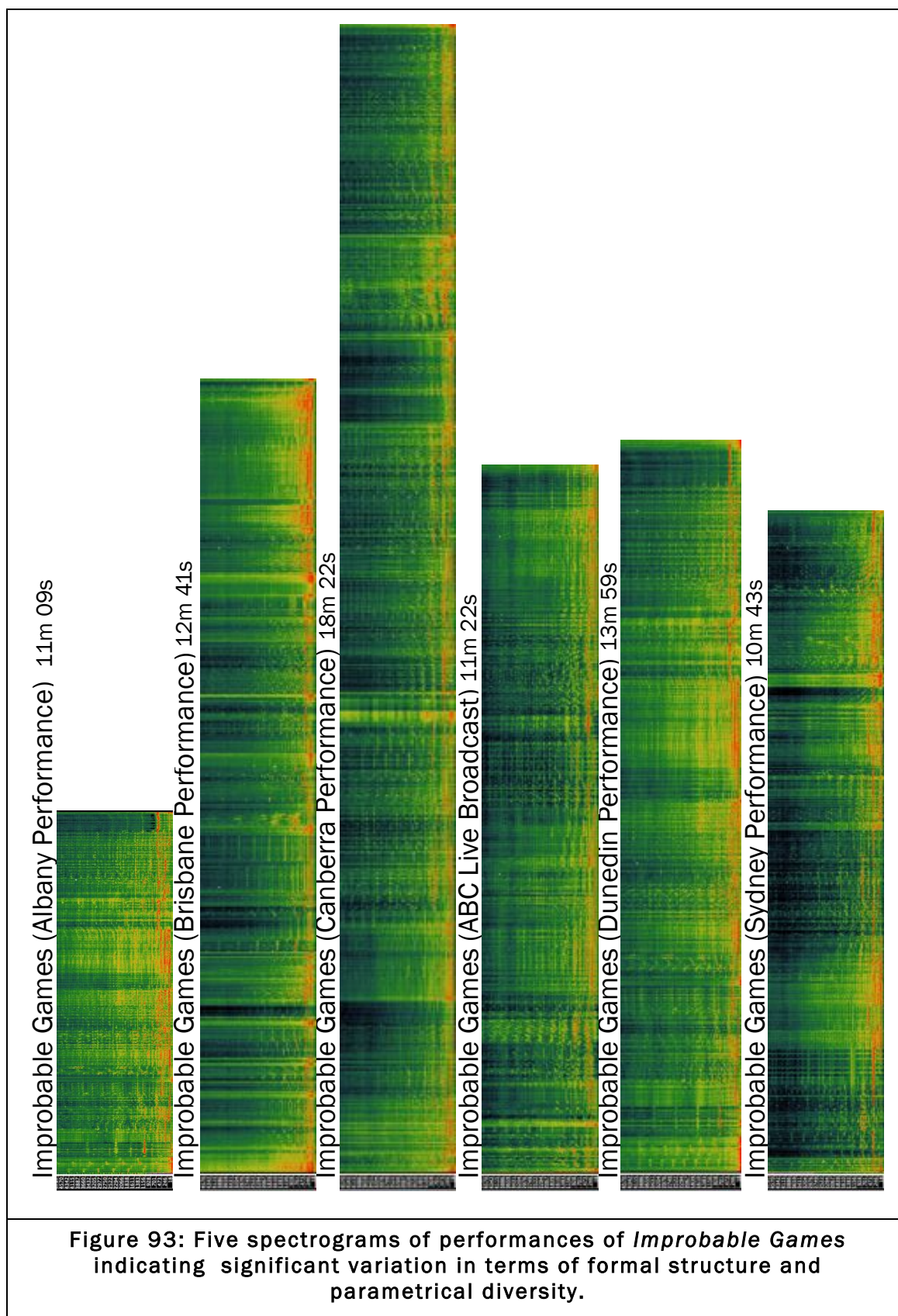
Figure 92: Schematic representation of a possible instantiation of the formal structure of *Improbable Games*.

The work uses a combination of permutation and continuity through the presentation of the materials via a screen-score. The implications of this formal arrangement are both nonlinear in any particular instantiation, and in respect to variation between repeated performances. Figure 93 shows spectrograms of five of the ten recordings of this work and indicates the significant variation between them in terms of formal structure and parametrical diversity.

One potential problem of such an indeterminate "open" approach is that it is possible for one particular instantiation to be less satisfying than another. This concern is, in my opinion, outweighed by the opportunities to explore the materials from numerous perspectives.

Improbable Games (Albany Performance) 11m 09s

Improbable Games (Brisbane Performance) 12m 41s

Improbable Games (Canberra Performance) 18m 22s

Improbable Games (ABC Live Broadcast) 11m 22s

Improbable Games (Dunedin Performance) 13m 59s

Improbable Games (Sydney Performance) 10m 43s

Figure 93: Five spectrograms of performances of *Improbable Games* indicating significant variation in terms of formal structure and parametrical diversity.

Reconstruction of a Shifting Path approaches this issue from another perspective by fixing the positions of the synchronous materials while leaving the interstitial spaces between them open to more improvisatory exploration.

The work places the Yamaha Disklavier in the dual role of performance instrument and electronic trigger. The score, presented to the performer on screen alternates between traditionally notated sections and sections in which materials to explore through improvisation are presented. In both cases a "triggering map" of the keyboard, which is altered from section to section, is also displayed to the pianist. Figure 94 shows a screenshot of one section of the work.

Figure 94: An excerpt from the screen-score of *Reconstruction of a Shifting Path, showing* traditional notation, improvisatory materials and a triggering map of the keyboard for this section of the work.

The temporal structure of *Reconstruction of a Shifting Path* is derived from recursively applying the golden section[109] to the duration of the work, and successive, nested, layers of substructure.

Figure 95 shows the structure of *Reconstruction of a Shifting Path,* where the

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[109] The Golden Section or Mean is defined by the instance where the ratio between the smaller (A) to the larger (B) of two substructures is equal to the ratio of the larger (B) to the sum of the two (A+B). It is approximately 1 : 0.618.
"J. H. Douglas Webster shows many instances of sonata-form structures approximating to the 'Golden Mean' ratio, and some additional examples of strategic events in non-sonata-form movements placed on or near points of 'Golden Section', with composers ranging from Bach to Bartok". (Howat 1977 p. 285)

golden section of the work is marked by section A, the golden section of the passage from the beginning until A is marked by section B, and so on until the fifth level of substructure. Crucial notated formal events are presented to the pianist at these pivotal points. Between these points, the computer indeterminately choses improvisatory material for the pianist to explore according to cues which are determined by proportions of the sixth to tenth level of "golden ratio" substructure.

Figure 95: The structure of *Reconstruction of a Shifting Path* showing nested, layers of substructure proportioned according to the golden section.

6.3.4. *Partikulator (2011) and questions written on sheets of glass (2011)*

Partikulator and *questions written on sheets of glass* are both works created for an improvising soloist. *Partikulator* combines the permutative audio processing methodology of *Echo-Transform* with the desire to stimulate an improvisation through unexpected sonic outcomes explored in *Splice*. It evolved from similar modules that I had devised for improvised noise performances in the group *Candied Limbs* with bass player Cat Hope. The structure consists of 27 combinations of audio processing techniques, each of a different duration, that are permutated, appearing only once in any performance of the work. Unlike *Splice* and *Echo Transform* the soloist is instructed which of the combinations of audio processing techniques are in play, allowing for interaction on a visual basis.

questions written on sheets of glass employs a similar strategy of permutation, but in this case the soloist's performance is analysed and then rendered in a number of contrasting ways on a Yamaha Disklavier. The work was inspired in part by the "speaking piano" of German composer Peter Ablinger (Ablinger 2009), a process by which spoken text is analysed into its component partials, amplitudes and durations and undergoes "analogue resynthesis" through realisation via MIDI on a computer controlled piano. Likewise, *questions written on sheets of glass* makes a realtime analysis of the soloists performance and then employs elements of pitch, duration and amplitude information derived from the performer to generate a range of textures on a Disklavier. Like *partikulator*, this permutation of textures process is open ended and defined only by pre-specifying the duration of the work.

6.4. Multilinear Models

Conceptually the multiple-perspective narrative can be seen as the obverse of the kind of single pathway non-linearity that characterizes sequential nonlinearity. Rather than consisting of a single path that may alter course at any junction, multiple-perspective non-linearity requires a number of paths with distinct identities that function simultaneously yet independently. A single path may include surprising jumps or juxtapositions that the performer (and consequently listener) is forced to accept with a kind of existential contingency. In contrast, the co-existence of potentially competing possible lines in a multilinear work creates an ambiguity, undermining the certitude of any chosen line and introducing a realisation of the absence of the lines not taken.

Consequently multilinear works are capable of creating tension through the incongruity of the perspectives presented. A recent example of the ambiguity multiple-perspective can create is found in Figgis' film *Timecode* (2000) which presents the events of the same 90 minutes to its audience on a split screen from four different cameras' perspectives. Through refraining from directing the audience to a single point of view, Figgis achieves a level of moral ambiguity highly unusual in mainstream cinema. In one sequence on four screens we simultaneously see pivotal action that can be summarised by the two narrative threads in Table 25.

1ˢᵗ Narrative Thread	2ⁿᵈ Narrative Thread
Two women in a car fight over the younger woman's fidelity. (She is an aspiring film-actress)	A Film Director at a film studio pathetically drinks and fights over the phone with his ex-lover
The younger woman angrily leaves the car for an interview at the studio	The younger woman leaves the car and arrives at the Studio reception
It is revealed the older woman has placed a bug in her lover's purse.	Inside the Studio the younger woman meets the Director,
The older woman listens remotely via the surveillance device. Her reactions reveal she cannot distinguish between the dialogue from the film screening and the real conversation	The Director takes the younger woman to a screening where she immediately flirts with him. He does not resist her advances. She leaves the purse at the front of the theatre they retire to the back of the theatre.
The older woman listens in anguish to sounds of love-making via her lover's bugged purse.	In the Screening's 'film-within-a-film' a couple begin to noisily make love. In reality the director and the woman also make love at the back of the theatre.

Table 25: Multilinear Narrative sequences in Mike Figgis' *Time Code.*

In the particularly ambiguous climax of this sequence we see what the older woman only hears – the abandoned handbag in a screening theatre that is screening rushes of love-making scenes from a movie, we also see that the soundtrack masks the real sound of the director and the unfaithful lover's actual sexual encounter. The ability to view the events from the point of view of each principal character has the strange effect of rendering us neutral or ambiguous in our sympathies and our position in regard to the morality of each character's actions.

One of the motivations for the investigation of these possibilities in a compositional context was the fact that no matter how detailed the plan for a composition, there always remain decisions to be made at the notation stage, that cause the music to take one particular path rather than countless others. Multilinearity provides a framework in which some of these pathways remain open for exploration with each performance.

6.4.1.*Between the Lines (2002) and Parallel Trajectories (2003)*

In the works *Between the Lines* and *Parallel Trajectories* a means was sought to allow synchronisation of independent lines. In comparison to other artforms, the temporal organization of music is arguably more dependent on the coordination of very fine temporal increments. The form of Multilinearity explored in these two works provides a model for music, especially in the case that the vertical synchronisation of lines is crucial, that allows for the possibility of retaining synchronisation between paths even when they are not audible.

The two works are closely related: *Between the Lines* explored this technique from an improvisational standpoint and *Parallel Trajectories* from a fully notated perspective.

In *Between the Lines*, the performers are provided with a score comprising three simultaneous alternative pathways. The performer must, at particular nodal points in the work, choose to perform one of the three lines, to improvise or to remain silent. The three lines are distinguished by density, register and function: line one is arpeggiac, line two melodic and line three underpins harmonic movement. The work was written for the duo HEDKIKR, comprising tenor saxophone and drums. The score excerpt in Figure 96, shows two upper staves in which the lines to be played by the saxophone are notated, and a lower stave in which all three lines are notated for the drummer.

Figure 96: The multilinear score of *Between the Lines* (bars 1-3).

Parallel Trajectories extrapolates the same idea for an ensemble of "readers". In total there are fourteen lines of musical material and each of the players is provided with four of the lines. At 'nodal points' marked in the score, each player must change from their current line to a different one or choose to remain silent until the next 'node'. The resulting combinations of lines, in all probability quite different from one performance to the next, create altered musical contexts and textures. This circumstance causes the players to make other decisions, based on the choices of their colleagues, about their function in the texture (for example, whether they are leading the ensemble or supporting another line) and the execution of their part (for example, what kind of articulation or dynamic to employ). Focused listening is required to successfully transform this potential music into actuality.

In addition to the structural decisions, it is considerably more difficult to maintain synchronization with the other parts than in a linear work, since there are no reliable fixed musical landmarks to orientate the performer. Figure 97 is a schematic representation of the possible pathways taken by performers traversing the score.
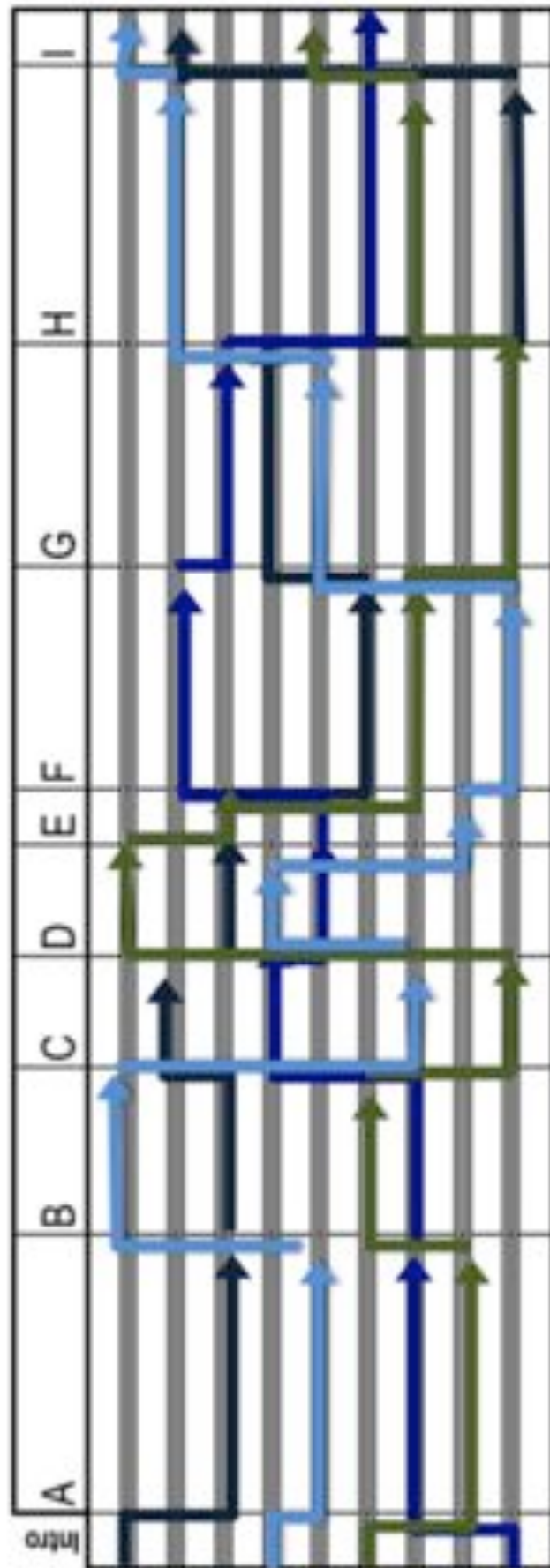
Figure 97: Schematic representation of the possible pathways taken by performers traversing the score of *Parallel Trajectories*.

6.4.2. *Tectonic (2007)*

Tectonic employs a mobile score, in which five notated textures – C (chord), R (rhythm), H (harmony), M (melody) and P (polyphony) - are performed independently by four instrumental groups: wind, string, percussion and keyboard. The mobile score layout for the string players in *Tectonic* is shown in Figure 98.
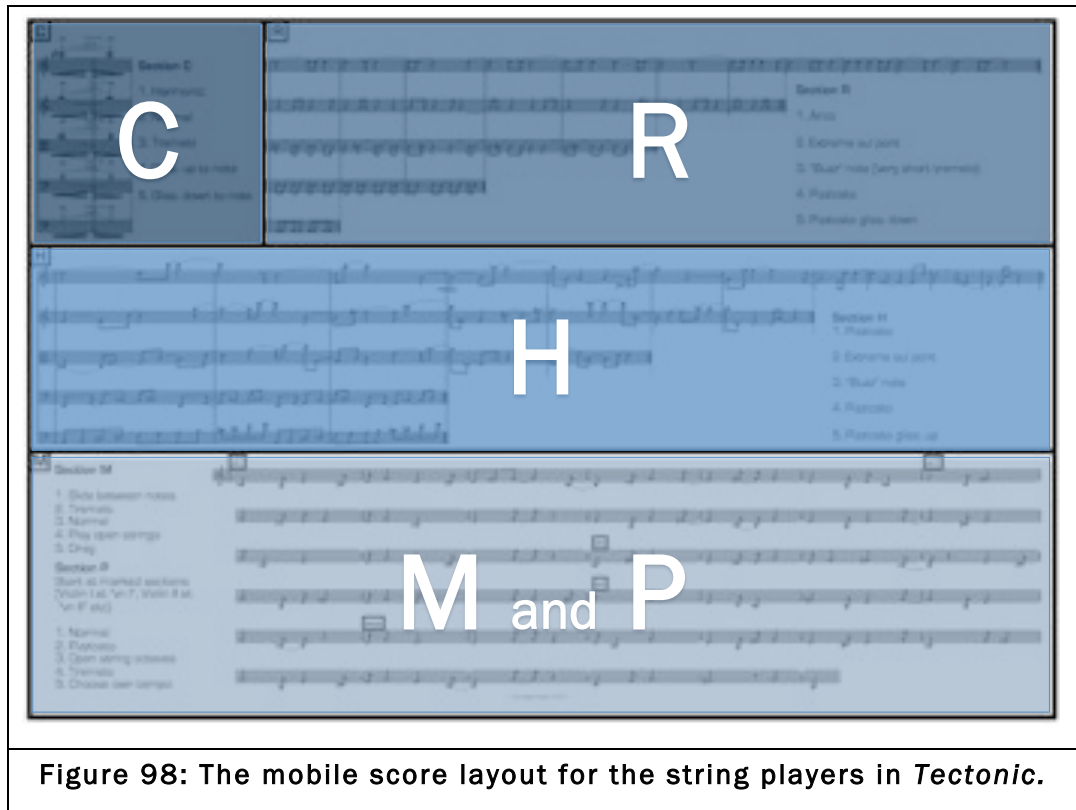
Figure 98: The mobile score layout for the string players in *Tectonic.*

Coordination of this indeterminate structure is maintained by a computer that directs each instrumental group which of the notated textures to play and the tempo (between mm. 27 and mm. 135) at which to play it. The computer generated metronome pulses may accelerate, decelerate or remain constant throughout the performance of each texture.

Figure 99 is a representation of an example performance of Tectonic, showing the order of material performed and the changes in tempo taking place during the performance.
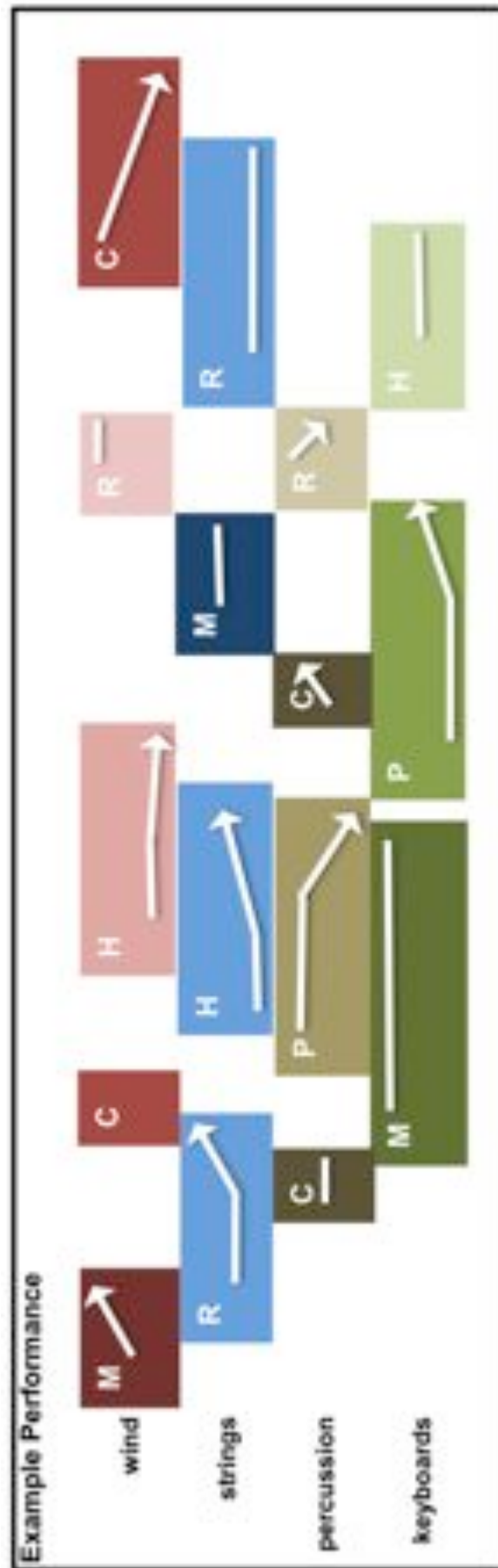
Figure 99: A schematic representation of the formal structure of *Tectonic*.

Figure 100 shows a spectrogram of a performance of *Tectonic,* clearly indicating the presence of multiple and divergent blocks of texture. The important role played by audio processing is also evident in the contrasts in high frequency transformations of the live performers between sections. The polytemporal aspects of the structure are not visible at this level of magnification, but the presence of overlapping textural blocks is partially captured by the spectrogram. Both elements are clearly audible in the recording.
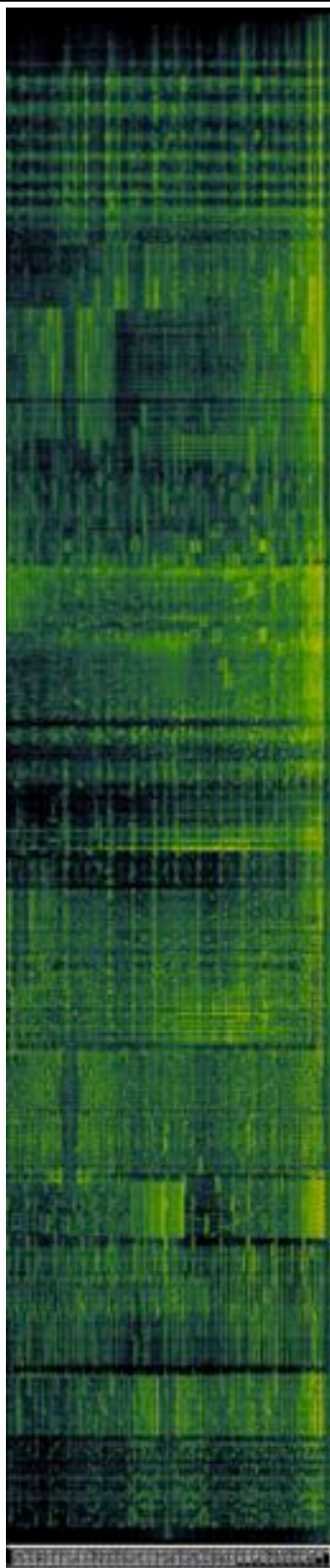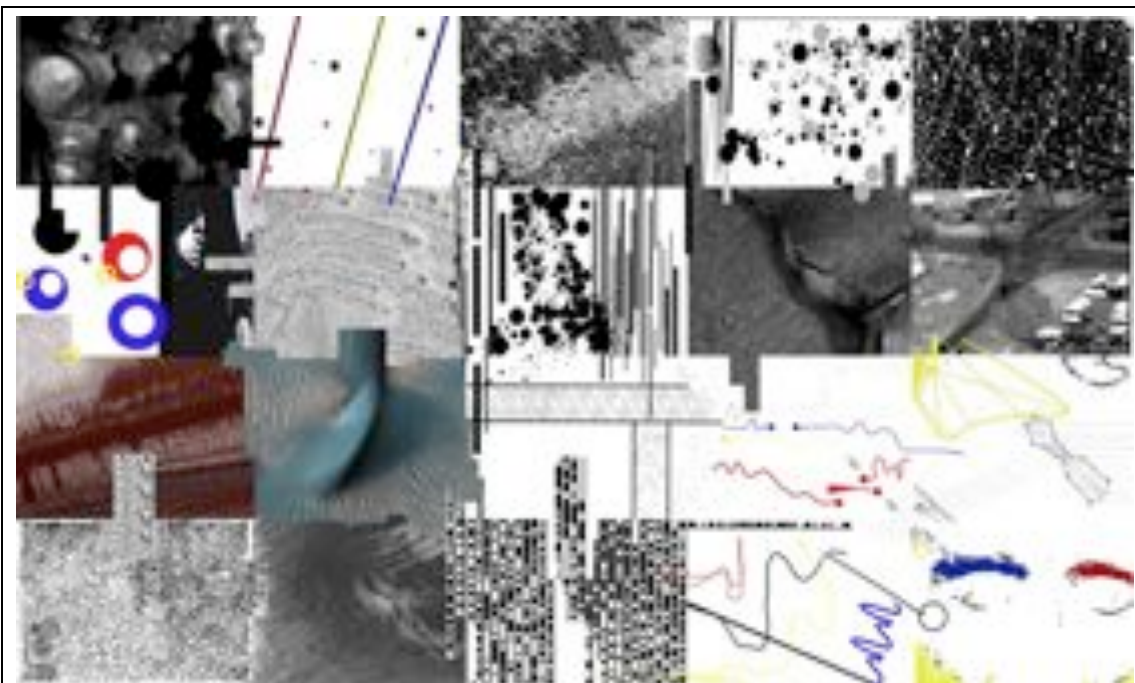
Figure 100: A spectrogram of a performance of *Tectonic* indicating the presence of multiple divergent block of texture.

6.4.3. *The Talking Board (2011)*

The Talking Board was created in collaboration with composer Cat Hope. The work utilises a graphical score-collage of twenty images provided by Hope and myself, shown in Figure 101.


Figure 101: The graphical score for *The Talking Board.*

The four performers realize the work by interpreting the components of the score that are framed by a "planchet"[110]: a circle, colour coded to correspond to each instrument, that also moves freely around the score. The graphical score is also continuously repositioned during the performance, moving smoothly in the vertical and horizontal dimensions and also jumping to particular new positions. Figure 102 is a representation of the relationship between the mobile score and the visible score that appears on the performer's screen (shown here as the opaque rectangle in the lower right-hand corner). The visible portion of the mobile screen is continuously repositioned during the performance.

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[110] The term is taken from the designation of the heart-shaped piece of wood used on a Ouija Board (or Talking Board) to indicate the supposed responses of "spirits".

Figure 102: A representation of the relationship between the mobile score and the visible score that appears on the performer's screen (shown here as the opaque rectangle in the lower right-hand corner). The visible portion of the mobile screen is continuously repositioned during the performance.
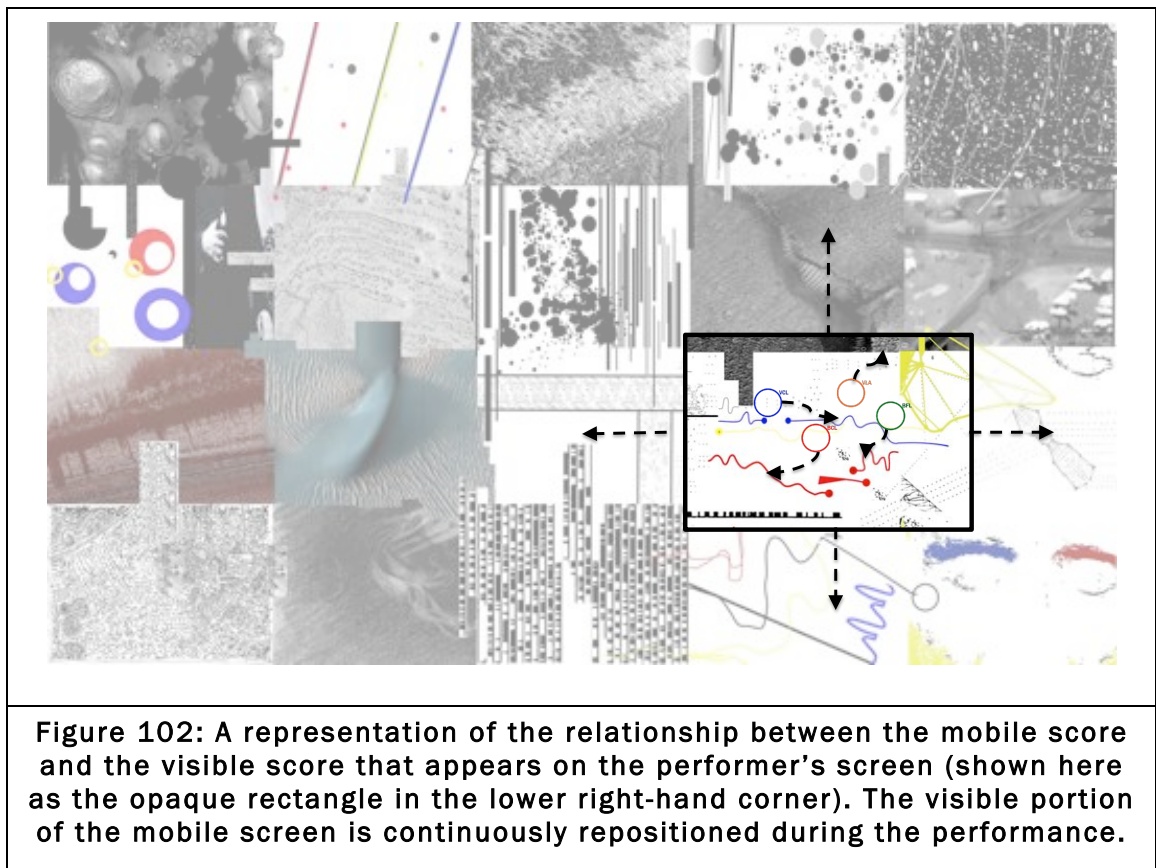
I programmed the trajectories of the planchets so that their movements are indeterminate, but permutate between a range of contrasting behaviors: wander – in which the movement of the four planchets are completely independent; follow – in which three planchets mirror the trajectory of the remaining planchet; and converge in which three planchets converge on the (moving) position of the remaining planchet. In addition to these behaviours, each planchet is programmed to grow in size at indeterminate points in the performance, indicating that the corresponding performer should take a more soloistic role. These behaviours are illustrated in Figure 103. These processes are documented in a video on the accompanying DVD.

Figure 103: A graphical representation of the behaviours of "planchets" in *The Talking Board.*
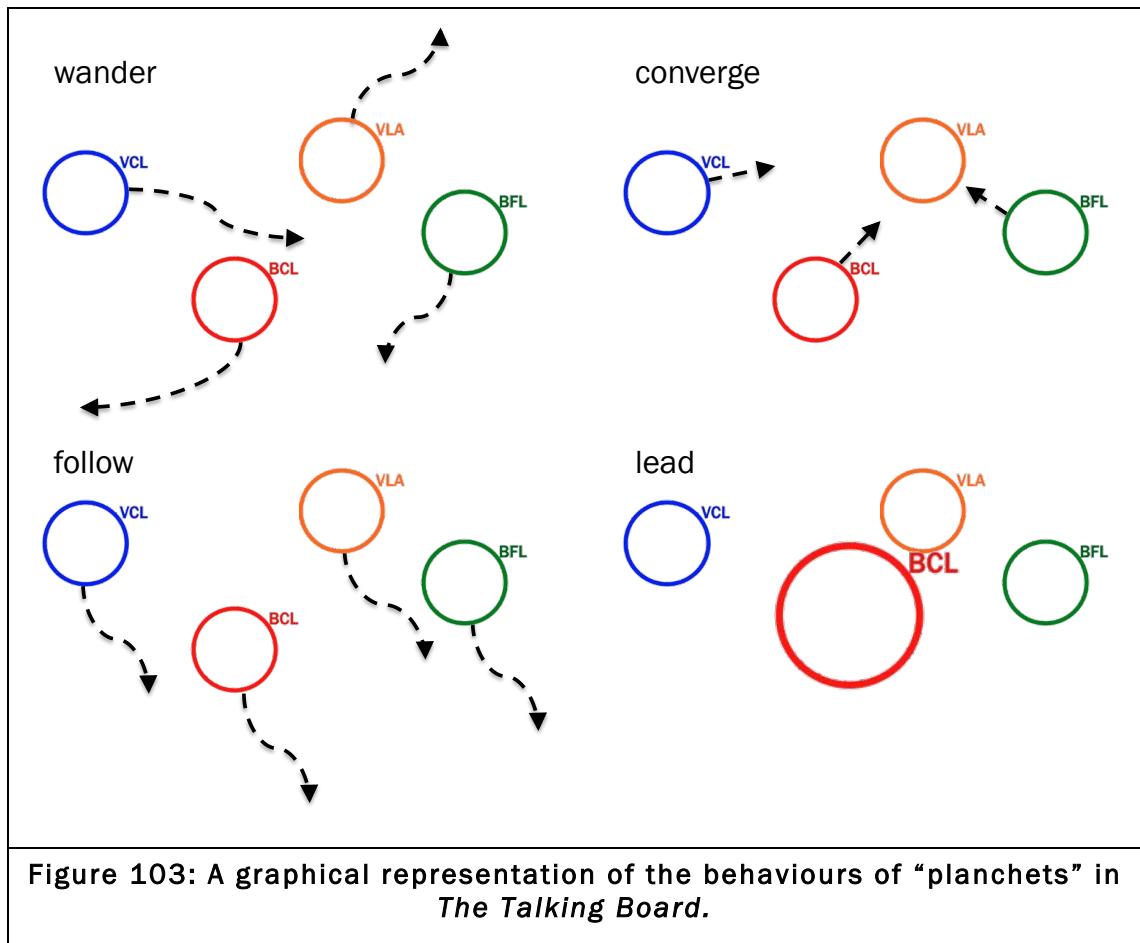
The movement of the score and the behaviours of the planchets define the formal structure of the work. Importantly, since the score employs asemic graphical notation, the players are left to interpret the symbols how they will. The result of this circumstance is that, in a live performance, players tend to move towards a consensus in terms of means of interpretation, creating a gradual transformation towards greater parametrical unity of texture in each new notational environment presented by the computer. Therefore, the structural outcome of any particular instantiation of the work is extremely indeterminate, relying as it does upon indeterminate trajectories both of the score and the planchets, as well as each performer's interpretations of and group interactions to, the large number and diversity of the graphical images.

6.5. Polytemporal Models

Tempo is one of the least explored musical parameters in live performance. Fred Lerdahl's claim that "simultaneous tempos (…) produce independent organizations competing for attention" rather than a fused "hierarchy of strong and weak beats" (Lerdhal 1992 p. 106), suggests that independent manipulation of tempo might

potentially be employed as a means of generating disjunction between musical substructures.

In performance, each additional player greatly decreases the ability to change tempo. Accurate continuous changes in tempo (i.e. accelerando and rallentando) are generally regarded as non-specific commands (i.e. we are not trained to rallentando over a particular, exact duration). These understandings are embedded in our musical perception to a high degree (Bregman 1990 143-164). Even in electronic music, where tempo variations *can* be precise, they often cause a perception in the listener of separate streams of sound rather than elements of a composite texture. This mirrors the way in which timbres are unpicked perceptually by the listener and attributed to different sources.

The polytempo works detailed in Table 26 explore the independent manipulation of tempo as their principal formal distinction.

interXection	
Polytemporality	Notational and microphone positioning parameters determined by nine related but independent tempi
Score	Traditional linear score
Transformation	Processing by a ring modulator is altered by continuous changes in microphone position notated in the score.
Formal structure	Sequential Block structure derived from the most prominent layer of parametrical change: mallet type or instrument type.

Whorl	
Polytemporality	Three instruments perform five related but independent tempi connected by accelerandi and rallentandi. The rate of tempo change is independently varied for each instrument
Score	Mobile Score, tempo, dynamic and formal structure are indicated to performers by independent headphones.
Formal structure	Sequential Block structure derived from the most prominent layer of parametrical change: pitch set.

| particle + wave	
Polytemporality	Three instruments perform five related but independent tempi connected by accelerandi and rallentandi. The rate of tempo change is independently varied for each instrument
Score	Traditional linear score, tempo, dynamic and formal structure are indicated to performers by independent headphones.
Formal structure	Sequential Block structure derived from the most prominent layer of parametrical change: pitch set.

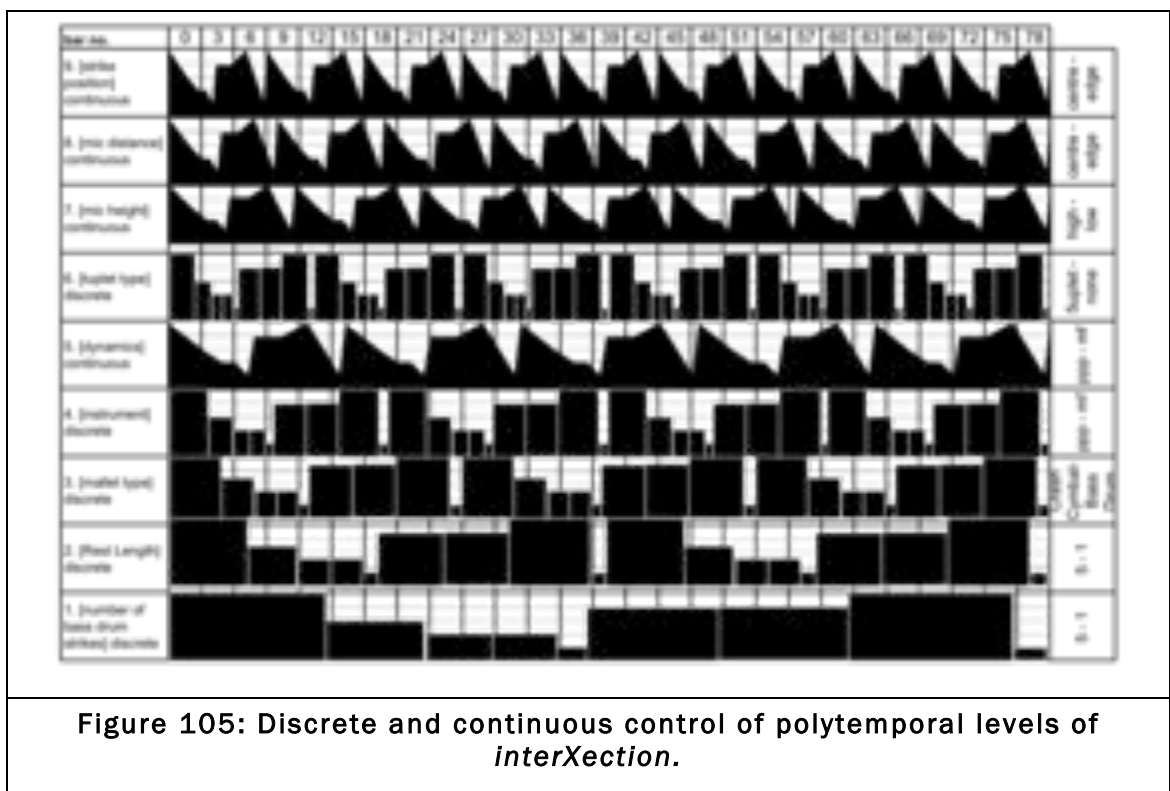| zwitschern	
Polytemporality	Three instruments perform five related but independent tempi connected by accelerandi and rallentandi. The rate of tempo change is independently varied for each instrument
Score	Mobile Score, tempo, dynamic and formal structure are indicated to performers by independent headphones.
Formal structure	Sequential Block structure derived from the most prominent layer of parametrical change: pitch set.

Transit of Venus	
Polytemporality	Three instruments perform five related but independent tempi connected by accelerandi and rallentandi. The rate of tempo change is independently varied for each instrument
Score	Permutated, scrolling real-time score, tempo is indicated to performers by independent headphones. The structure is interrupted by passages of short textural events.
Transformation	live audio processing
Formal structure	Indeterminate structure generated by computer

delineate 1	
Polytemporality	The soloists performance is recorded simultaneously recorded and simultaneously played back increasingly slowly (and lower in pitch)
Score	Scrolling graphical real-time score
Formal structure	Narrative contour created by increasingly complex performance materials

Hunting Pack	
Polytemporality	A number of tempo relationships are explored: the simultaneous performance of prime number relationship tempi, independent acceleration and deceleration of each player and microrhythm – the separation of the players by tiny time intervals.
Score	linear segmented screen-score
Transformation	live audio processing
Formal structure	Sequential Block structure derived from changes to the configuration of polytemporal relationships.

Table 26: Categorisation of the Creative Folio Polytemporal works indicating forms of Polytemporality, score type, transformation type and Formal Structure.

6.5.1. *interXection (2002)*

In *interXection*, the same polytemporal cypher structure employed by *Delicious Ironies* and *Splice* is used to determine a number of parameters including the percussionist's tempo, roll speed, instrument, mallet type, accent, dynamics, rest, note length and strike position on the current instrument, as well as the vertical and horizontal coordinates of the microphonist's microphone in relation to the percussionist's current instrument. This microphone part, essentially notating two 'vectors', resembles the graphic interface for automation for Pro-tools© effects inserts. The score excerpt in Figure 104 shows the opening of the work,

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Figure 104: InterXection (bar 1-2) showing microphone position indications.
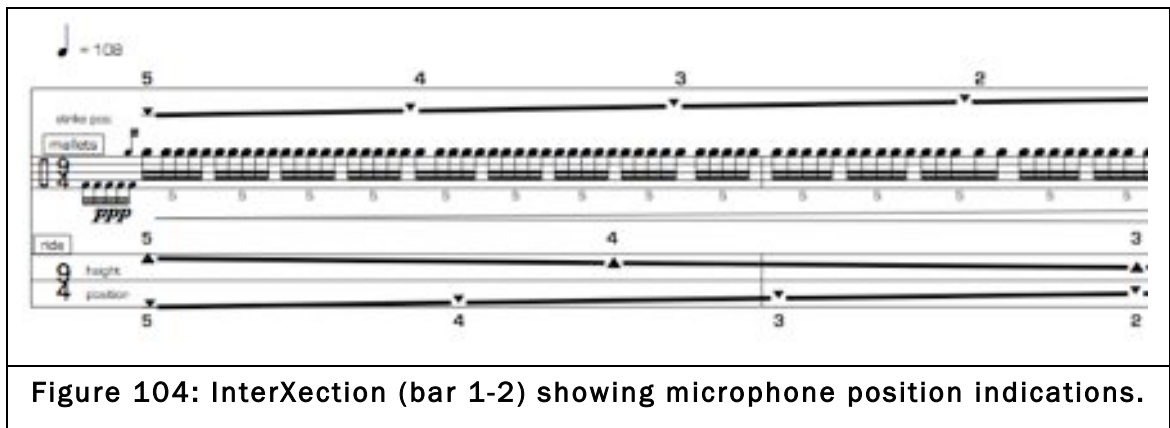
InterXection notates the polytemporal processes of the computer components of *Delicious Ironies* and *Splice*. Importantly however the polytemporal levels control individual parameters that are fused together by the performer through the score, resulting in a conjunctive surface. The polytemporal levels manipulated both in a discrete and a continuous manner as illustrated in Figure 105.

Figure 105: Discrete and continuous control of polytemporal levels of *interXection*.

6.5.2. *Whorl (2003), particle + wave (2004) and zwitschern (2005)*

These three works were "studies" designed to develop and explore a methodology to control multiple tempi for live performers. Several questions had been raised by previous investigations of polytemporal structure such as *entropology*, *Delicious Ironies, Exit Points* and *interXection*. These works attempted to resolve issues such as: the factors determining whether simultaneous tempi are discerned as a fused

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texture or as separate lines; whether particular melodic or textural features draw attention to a particular line/tempo giving it primacy over other lines; and how the sense of pulse impacted by simultaneous continuous changes in tempo.

Like *Delicious Ironies* and *interXection,* multiple proportionally related tempi determine different parameters in these three works. Nine tempi are assigned to three parameters of each of the three instruments. Figure 106 show the relationships between these tempi, the absolute length of a beat in milliseconds and the parameter that is linked to each tempo.

whorl	ratio	TEMPO rate (ms)	ratio	PITCH rate (ms)	ratio	DYNAMIC rate (ms)
soprano saxophone	1/6	5832	1/7	6804	1/1	40824
celeste	1/9	4536	1/2	20412	1/4	10206
percussion	1/3	13608	1/5	8165	1/8	5103

particle+wave	ratio	TEMPO rate (ms)	ratio	PITCH rate (ms)	ratio	DYNAMIC rate (ms)
soprano saxophone	1/3	4536	1/9	1512	1/4	3402
saron 1	1/2	6804	1/8	1701	1/5	2721
saron 2	1/1	13608	1/7	1944	1/6	2268

zwitschern	ratio	TEMPO rate (ms)	ratio	PITCH rate (ms)	ratio	DYNAMIC rate (ms)
violin	1/9	4536	1/2	20412	1/4	10206
clarinet	1/6	6804	1/7	5832	1/1	40824
theorbo	1/3	13608	1/5	8165	1/8	5103

Figure 106: Tempo to parameter assignment in the works *whorl*, *particle+wave* and *zwitschern*.

In each of the works, the players receive a clicktrack (with five tempi and connecting accelerandi and rallentandi), independent of the other players, as well as instructions on what dynamic, musical material and pitch set to play. Variations in tempo, pitch set and dynamics cycle through a pattern of fixed and continuous changes as illustrated in Figure 107.

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Whorl and *particle + wave*

Zwitschern

Figure 107: Graphs of the tempo cycles from *Whorl, particle+wave* and *Zwitschern*.
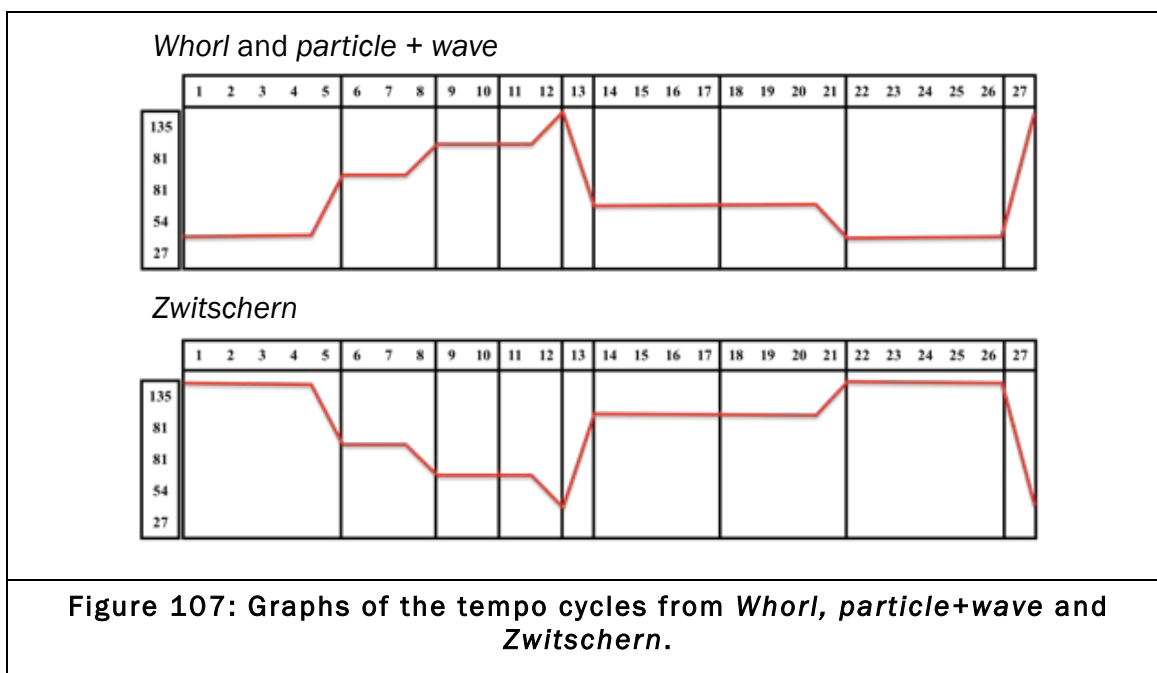
The changing beat patterns of the three players in *Whorl, particle+wave* and *Zwitschern* are illustrated in Figure 108.

Whorl

Zwitschern

Figure 108: Graphical renderings of the three simultaneous click-tracks for *Whorl* and *Zwitschern*. (images taken from soundfiles of the click-tracks).

This arrangement creates an unusual set of conditions for the performers in which their listening skills are divided between synchronization with the computer generated clicktrack and 'ensemble' playing through listening to the other players. In rehearsal this initially results in a split focus – players tend to concentrate more on one task than the other. (Arguably this split focus also occurs to a degree when music with a unified tempo is first rehearsed.)

The conclusion drawn to the questions of textural fusion in polytemporal works was that the individual lines must be extremely simple in order to be differentiated. As a result, the scores for the three works are progressively less complex as shown in Figure 109.

Figure 109: Excerpts from the scores of *Whorl, particle+wave* and *Zwitschern*.

Whorl employs five sections with different textures articulated through five varied pitch sets, the sections in *particle+wave* are only differentiated by the number of pitches and rhythmic variation, and in *Zwitschern* the sections are only differentiated by pitch.

6.5.3. *Transit of Venus (2009)*

Transit of Venus utilises a nonlinear score, live sound processing and independent clicktracks to control a quasi-improvised performance by the players. In addition to following the tempo of their individual clicktrack, each player must also follow a mobile set of symbols that dictate the evolution of the dynamics, changes in the

texture, the pitch class resources that they should use to realize the score, and finally the period of time over which these changes should occur. These processes are documented in a video on the accompanying DVD.

Transit of Venus was the first of my works to employ a scrolling score that is realised by the performer as the graphics reach a vertical line – or "playhead". This concept was later developed into the "Decibel Scoreplayer" for Max/MSP and iPad, as a means for synchronising the performance of graphical scores, unpulsed and/or continuously evolving music.

Figure 110 shows a screen shot of the mobile score.
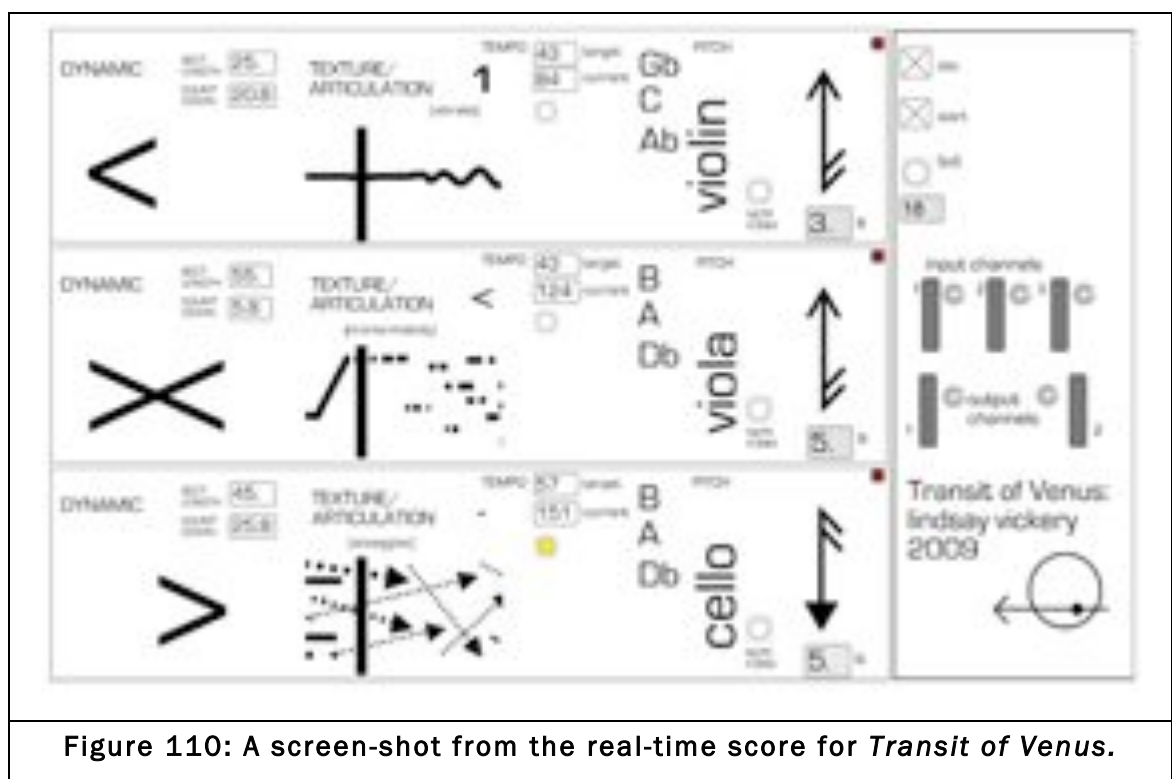
Figure 110: A screen-shot from the real-time score for *Transit of Venus.*

The textures indicated, are arranged in a developmental continuum from silence through to free improvisation as illustrated in Figure 111. The intention here was to provide a clear developmental narrative contour, allowing for the permutations (in order and tempo) of each the independent part to be heard more clearly.

Figure 111: The development continuum of musical textures employed in *Transit of Venus.*
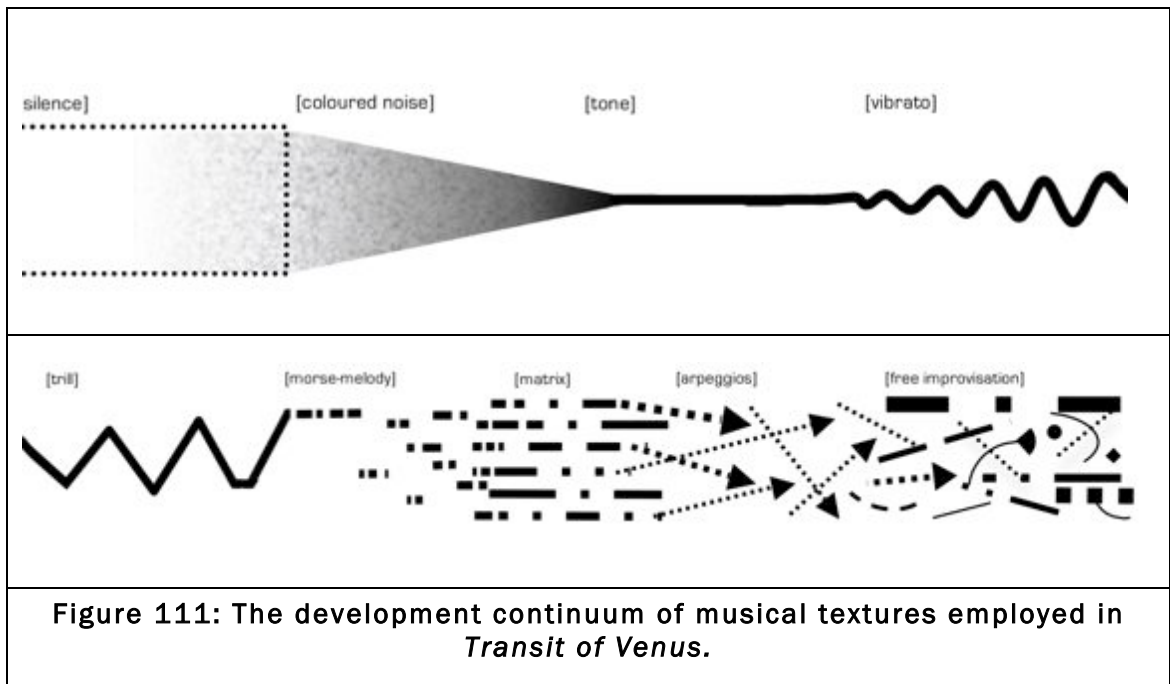
Unlike the three works previously discussed, the tempi of the performers in *Transit of Venus* bear a number of different relationships: periods of relative independence from one another; periods where tempi converge; and others where they are brought into tempo unison.

The graphical arrangement of the score-player for *Transit of Venus* atomises and separates the functions of the traditional score, where performance indications are normally unified vertically. This configuration allows permutational independence to be established between parameters such as texture, pitch, dynamics and articulation. Each parameter is controlled in an asynchronous and nonlinear manner, creating the potential for a very large number of possible realisations of the work. In this way, the work's configuration of information is only made possible through the computer medium.

The work alternates between two principal modes. The first presents a scrolling continuum of musical textures (Figure 111). For example, if the performer is playing a single tone and receives the indication add vibrato, they should transition from the first texture to the second continuously over the indicated time-period.

The second is a free 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, shown in Figure 112, that appear for short periods (between two and five seconds) on the right of the screen.
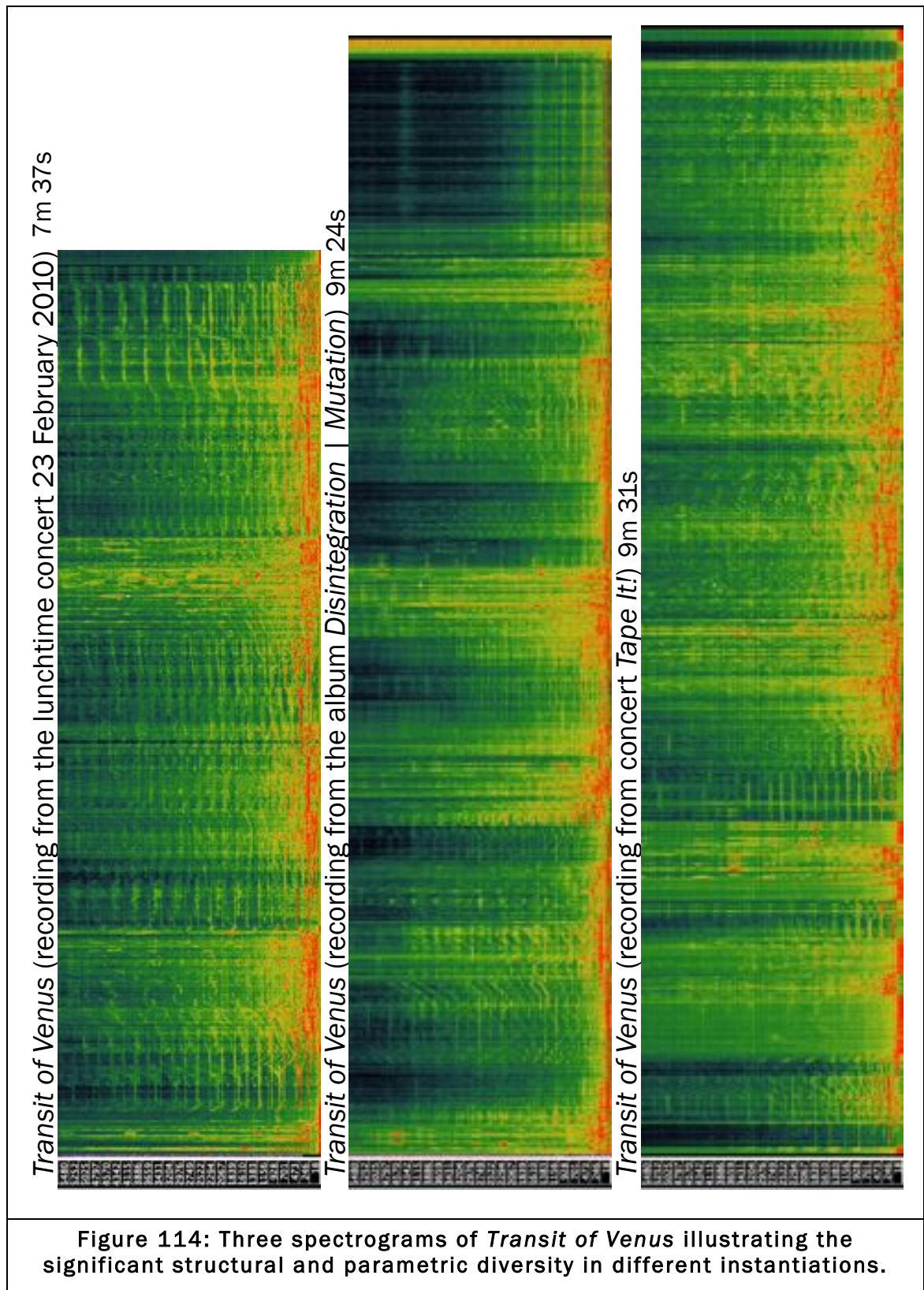
[symbol]	Lowest Note	[symbol]	Highest Note	[symbol]	Distorted Note
[symbol]	Ghost Note	[symbol]	Glissando between all notes		

Figure 112: Note-form indications from *Transit of Venus.*

Figure 113 is a notional representation of the structure of a performance of *Transit of Venus*, showing the independent order of texture continuum material presented to players and synchronous interruptions by free sections throughout the work. *Transit of Venus* is a nonlinear work, in that the tempo, and scroll-rate of the continuums is variable in each performance and each performer moves in and out of synchrony in relation to the other two.

Figure 113: A notional schematic representation of the formal structure of *Transit of Venus.*
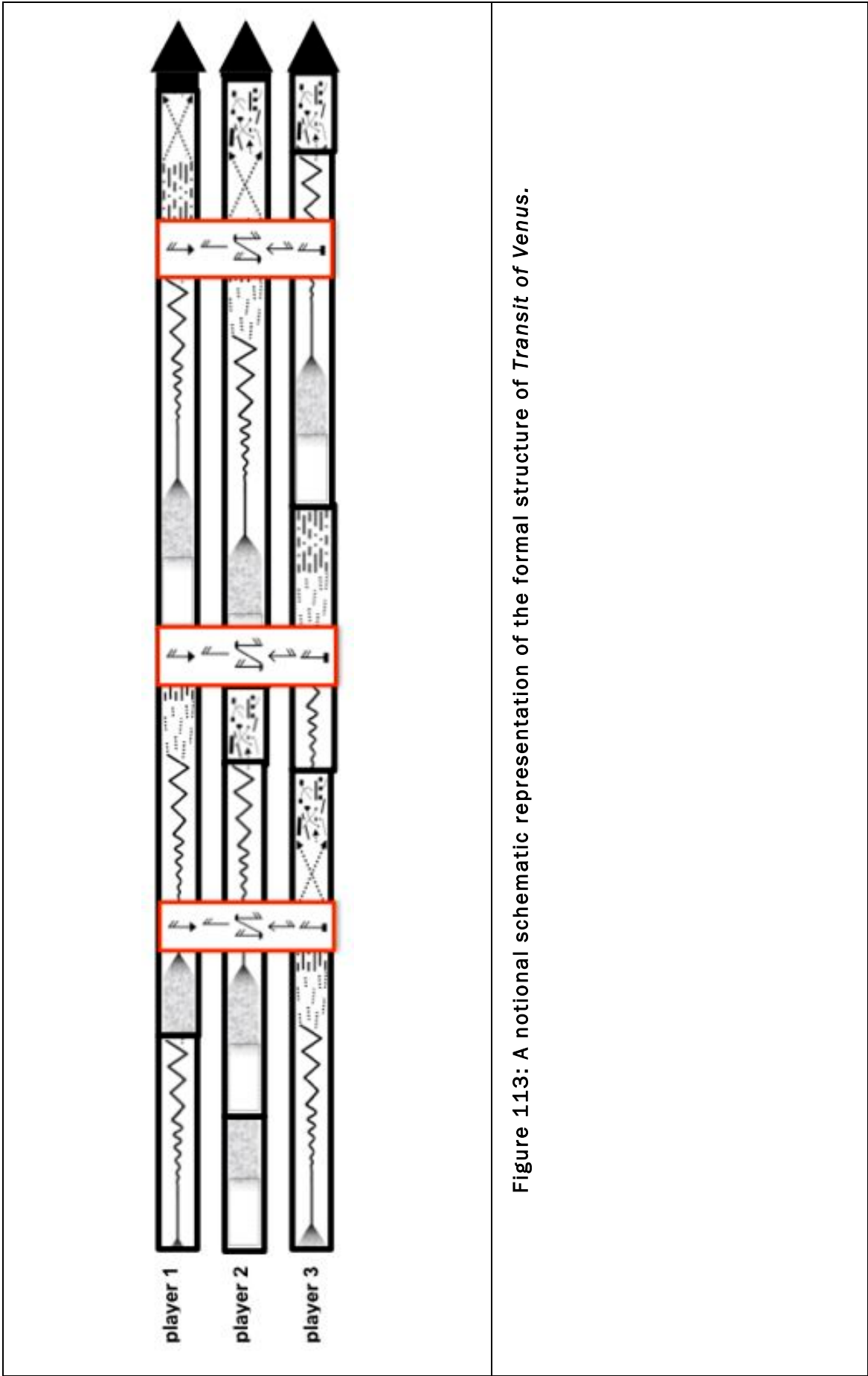
In Figure 114, spectrograms of three performances of *Transit of Venus* show the variability of structure and duration in successive instantiations of the work.

Figure 114: Three spectrograms of *Transit of Venus* illustrating the significant structural and parametric diversity in different instantiations.

6.5.4.*delineate 1 (2010)*

Delineate is a solo work in which the performer reads a continuously scrolling score, with a developmental narrative quality of increasing complexity. As the work progresses, the soloist's performance is recorded and simultaneously played back at an increasingly slower rate and therefore lower pitch. At the beginning of each new section, another recording and decelerating playback is added until the final section. In the final improvised section, a seven-note polyphonic accompaniment is created by suddenly playing the recorded sound-files back at random times and with glissandi created by fluctuating playback speeds. Figure 115 shows a schematic representation of the formal structure of *delineate.*

Figure 115: A schematic representation of the formal structure of *delineate.*
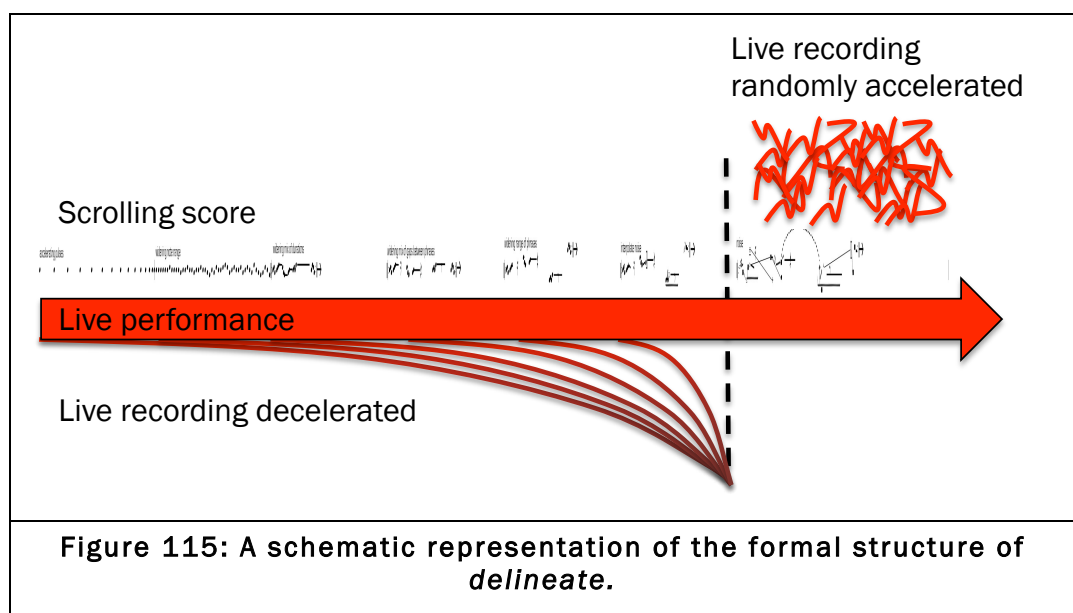
6.5.5.*Hunting Pack (2011)*

If *Transit of Venus* extrapolates the polytemporal concepts explored in *Whorl*, *particle+wave* and *Zwitschern* in the direction of greater indeterminacy of structure, *Hunting Pack* takes the opposite path, using these concepts to generate a fixed block-form "cypher" work. The formal divisions in *Hunting Pack* are principally marked by changes in the temporal relationship between the three players. Figure 116 shows the range of approaches to polytemporality explored in this work.

Section	5	3	2	1	4	5	1
Cello	Microrhythm (120/90/45/60/120/40)	90	60	Accel. 4.25-60	Continuous tempo change 360/288/216/144/72	Microrhythm (120/90/45/60/120/40)	Rall. 60-4.25
Cimbalom	Microrhythm (120/90/45/60/120/40)	120	80	Accel. 9.5-80	Continuous tempo change 360/288/216/144/72	Microrhythm (120/90/45/60/120/40)	Rall.80-9.5
Keyboard	Microrhythm (120/90/45/60/120/40)	210	100	Accel. 16-100	Continuous tempo change 360/288/216/144/72	Microrhythm (120/90/45/60/120/40)	Rall. 100-16

Figure 116: Diverse forms of polytemporality as a structural determinant in *Hunting Pack*.

Sections two and three cast the three instruments in different, but proportionally related tempi: Section Three at 90/120/210 bpm with the ratios 3/4/7 and Section Two at 60/80/100 bpm with the ratios 3/4/5. Section one simultaneously accelerates or decelerates the three instruments at different rates: Cello from 4.25 to 60 bpm, Cimbalom from 9.5 to 80 bpm and Cimbalom from 16 to 100 bpm. In section four the three instruments accelerate and decelerate continuously between a maximum tempo of tempi 360 and a minimum tempo of 72 bpm. The variations in the pattern of tempo changes between the instruments are shown in Figure 117.

Continuous tempo change order									
Cello	360	216	144	144	72	288	288	360	216
Cimbalom	144	72	288	288	360	216	360	216	144
Keyboard	288	360	216	360	216	144	144	72	288

Figure 117: Variations in the pattern of tempo changes between the instruments in*Hunting Pack.*

Finally, the opening section explores micro-rhythm through the displacement of each instrument by a small durational value. The click-tracks synchronizing the players are displaced by small values allowing the performance of extremely rapid and intricate patterns. When combined with the small intervallic compass between the instruments in the section of a major third, this technique results in perceptual fusion due to Temporal Continuity and Pitch Proximity[111] of the three parts. This process is similar to the fusion of the two manuals of the harpsichord into a single perceptual unit in Ligeti's *Continuum* (1968) (Cambouropoulos 2008). The displacement of the down beats of each performer is illustrated in Figure 118.

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[111] *Principle of Temporal Continuity:* 'In order to evoke strong auditory streams, use continuous or recurring rather than brief or intermittent sound sources (Huron, 2001, p. 12). *"Pitch Proximity Principle:* The coherence of an auditory stream is maintained by close pitch proximity in successive tones within the stream" (Ibid p. 24).

Figure 118: "Micro-rhythmic" variations in the openning section of *Hunting Pack.*
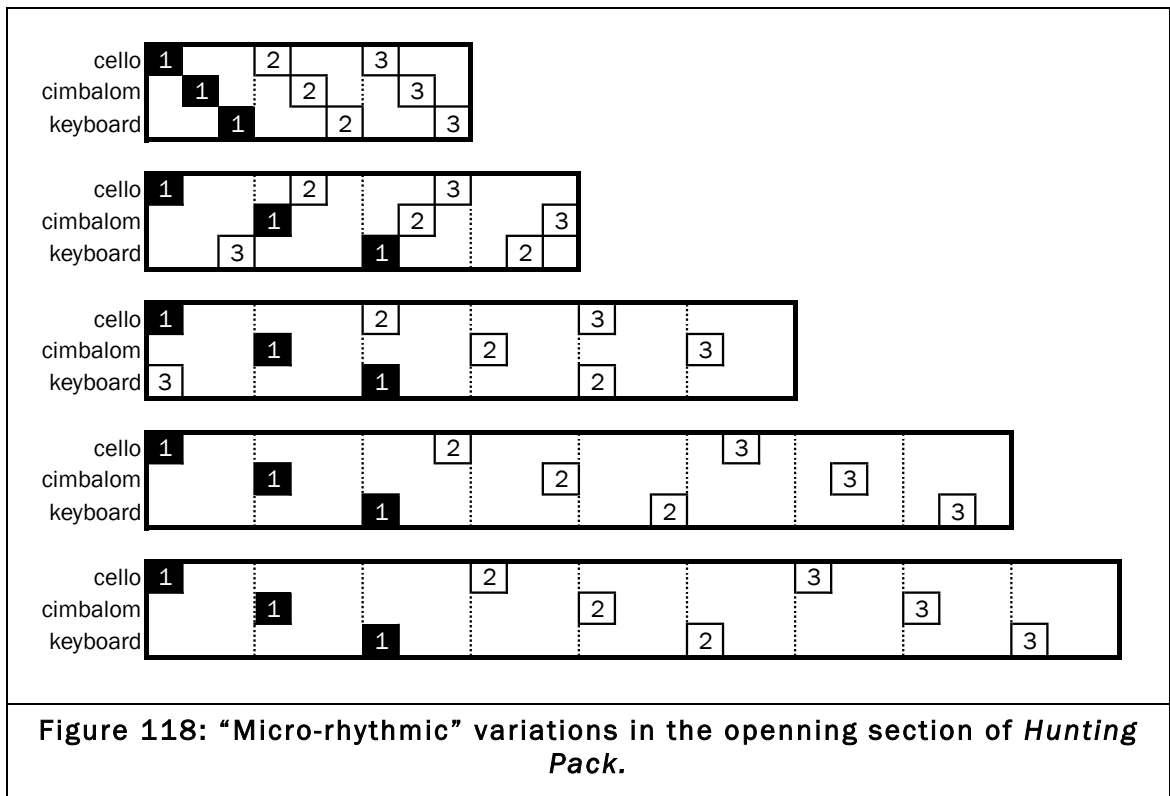
Huron states that in order to retain the perception of continuity, "intermittent sounds should be separated by no more than roughly 800 ms of silence" (Huron, 2001, p. 12). The attacks of the instruments in this section of *Hunting Pack* fall between 133 and 666 ms.

Disjunction between the subsections of this work are achieved through alterations in the polytemporal relationships between the three parts, ranging from apparent perceptual fusion in the section five of the cypher substructures, to an intermediate state in which the instruments retain fixed proportional relationships to one another in the cypher sections two and three, to a partial lack of fusion where the instruments are accelerating or decelerating together but at different rates in the cypher one sections, and finally to a complete independence in cypher section four.

6.6. Polystructural Models

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. Details of the two works exploring this structure are shown in Table 27.

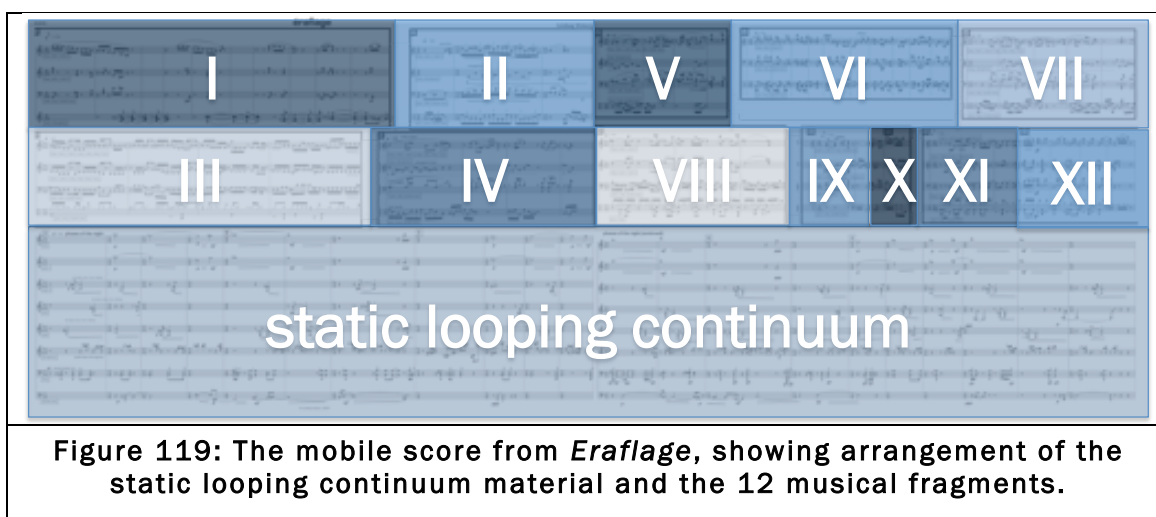| Eraflage	
Polystructure	a) slow-moving continuous texture and b) twelve musical fragments distinct in tempo, harmonic complexity and texture.
Score	Mobile score comprising one cycling continuous passage and ten contrasting fragments.
Formal structure	permutative collage and a static looping continuum.

corridors, stairways night and day	
Polystructure	a) Performance of a permutated scrolling score and b) a sample of a continuous cycling texture.
Score	Permutated scrolling score
Transformation	live audio processing
Formal structure	Indeterminate nonlinear polystructure

Table 27: Categorisation of the Creative Folio Polystructural works indicating forms of Polystructure, score type, transformation type and Formal Structure.

6.6.1.*Éraflage (2007) and corridors, stairways night and day (2009)*

In *Éraflage* two formal structures co-exist: one a continuous static-textured 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. The mobile paper score for the work comprises the "full score" (shown in Figure 119), including the "static looping continuum" (called "phases of the night") and the twelve fragments.

Figure 119: The mobile score from *Eraflage*, showing arrangement of the static looping continuum material and the 12 musical fragments.

In performance, the computer coordinates the path of each individual player. 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 players are coordinated both in the tempo of their performance of

the fragment and in their return to the continuous texture via clicktrack. This gives rise to a polystructure comprising a dynamic permutative collage and a static looping continuum. A schematic representation of this structure is shown in Figure 120.
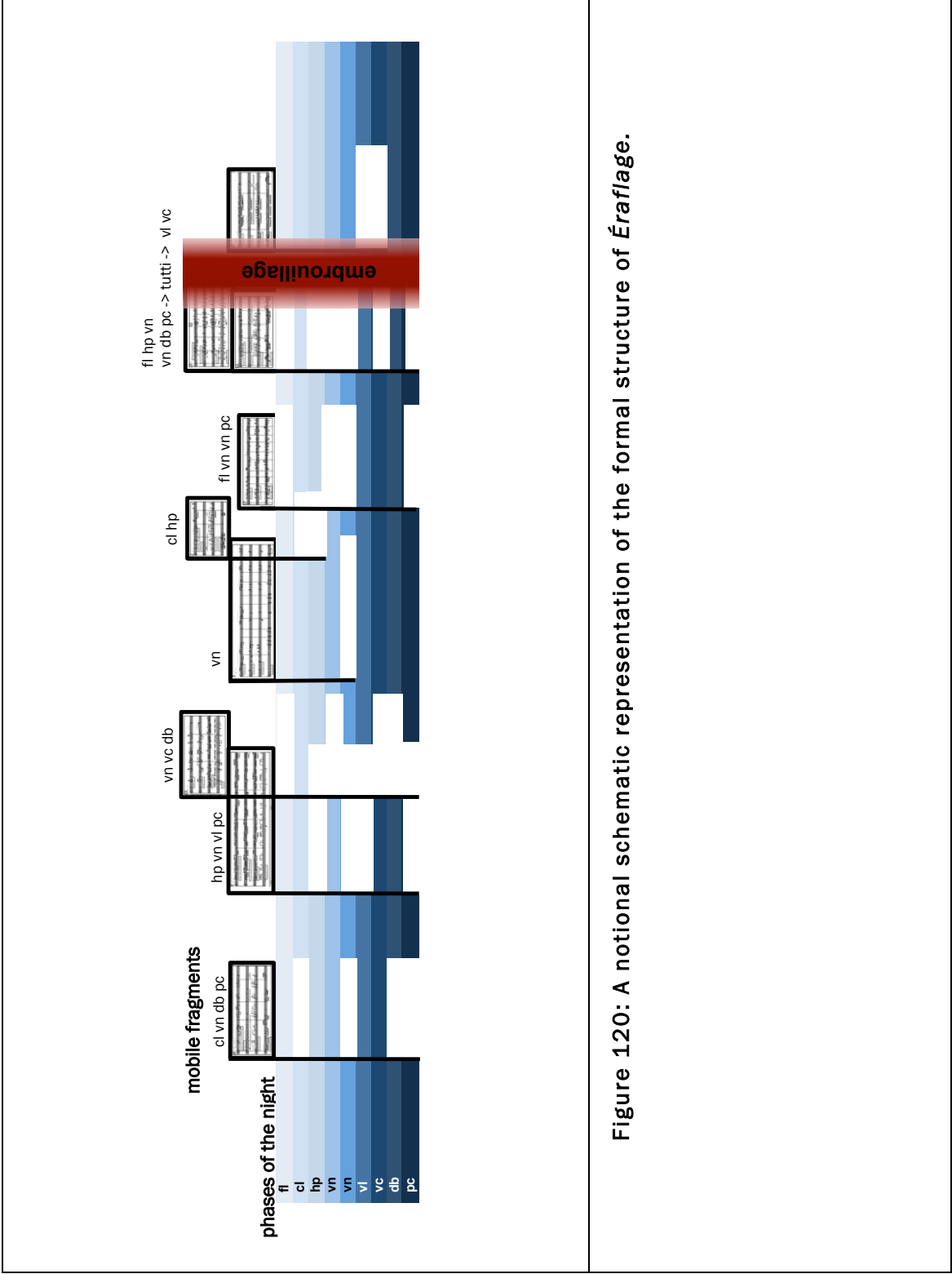

Figure 120: A notional schematic representation of the formal structure of *Éraflage.*

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The structure of the work is indeterminate and is generated differently with each performance.

In *Éraflage's* "sibling" work, *corridors, stairways, night and day,* the exploration of different materials by the soloist evokes a journey through an imaginary space: the "corridors" and "stairways" of the title. This imaginary space is also (figuratively) in motion: revolving through figurative a "night" and a "day" state, depicted by changing cycles of effects processing.

The work was inspired by Max Ernst's painting *Day and Night* (1942), which portrays a nocturnal landscape strewn with windows (or canvases) depicting the same landscape in the daylight.

The performer is shown contrasting types of scored material. The continuum employed in *Transit of Venus* is interpreted by the performer to indicate an evolving range of improvised textures. Five varied forms of notated melodic material also appear at indeterminate times during the work.

Audio from the live performance is processed throughout the work. The audio processing completes one cycle through a period of harmonisation and pitch shifting (day), and reverbs and delays (night). The start-point in the cycle is varied for each performance. During the "reverbs and delays" processing cycle, samples of the static looping continuum from *Éraflage*, "phases of the night" are also played by the computer. Figure 121 is a schematic representation of the formal structure of *corridors, stairways, night and day*.
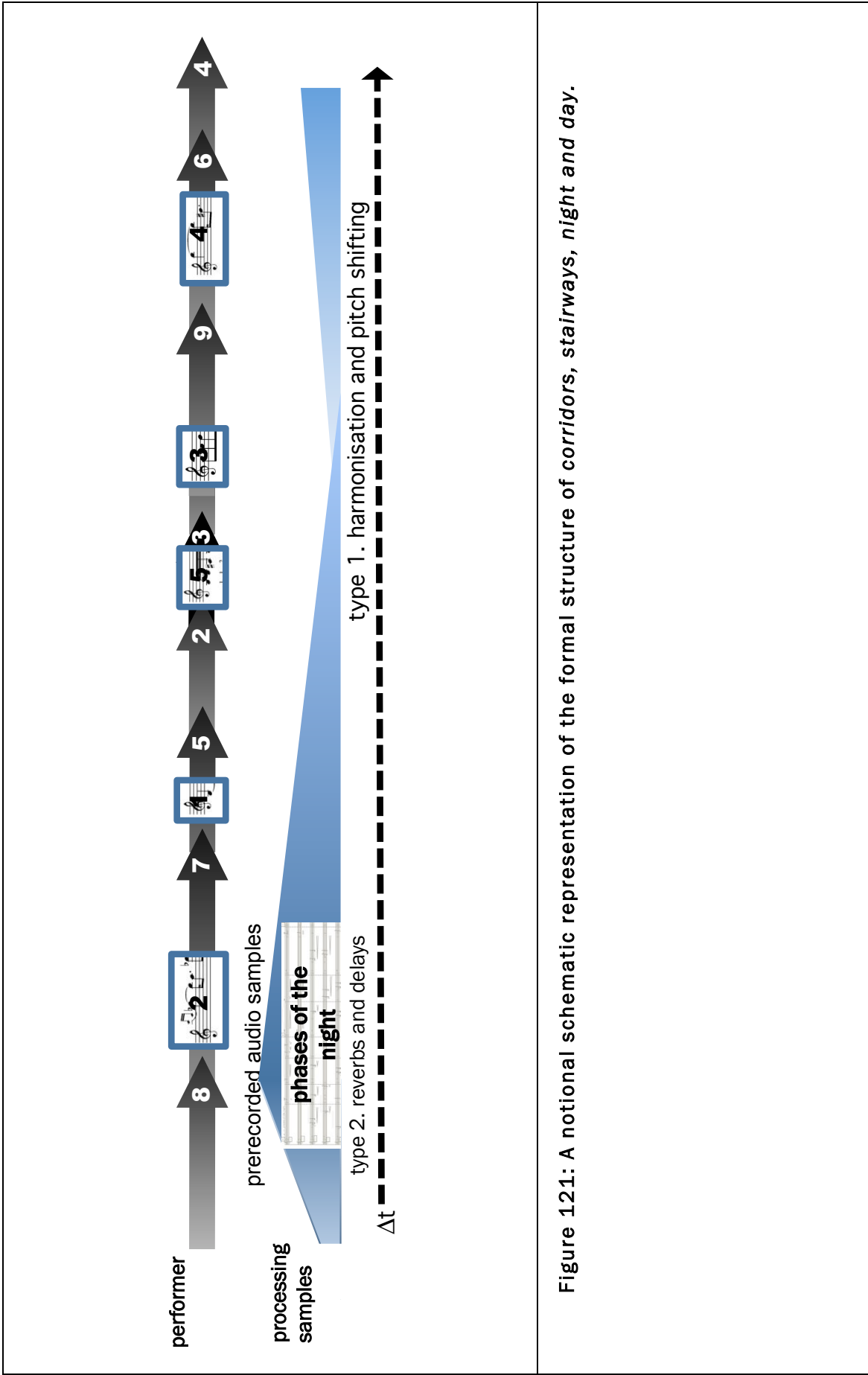
Figure 121: A notional schematic representation of the formal structure of *corridors, stairways, night and day.*

In this sense, *corridors, stairways, night and day* operates as a solo performer analogy to the work *Éraflage*, and shares its polystructural methodology.

6.7. Subtractive Models

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

6.7.1. *ghosts of departed quantities (2010)*

ghosts of departed quantities 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 work takes title from George Berkeley's *The Analyst* (1734): "And what are these same evanescent Increments? They are neither finite Quantities nor Quantities infinitely small, nor yet nothing. May we not call them the Ghosts of departed Quantities?" (2002 [1734] p. 18).

The four performers - bass flute, bass clarinet, cello and piano - are presented with a networked, graphically notated, permutated and scrolling score as shown in Figure 122.
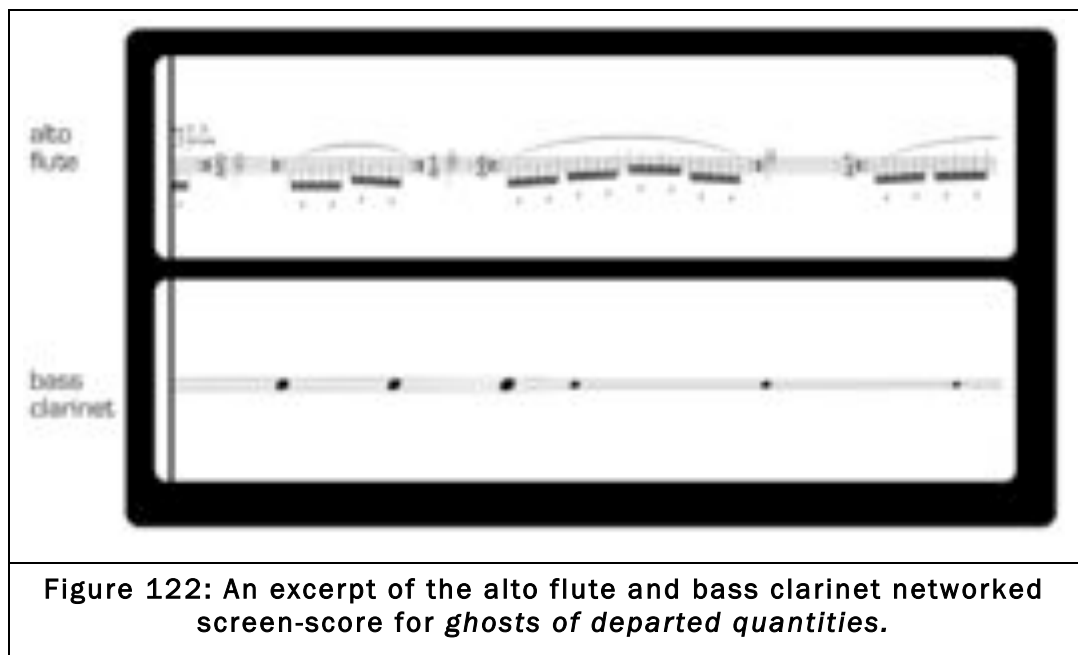

Figure 122: An excerpt of the alto flute and bass clarinet networked screen-score for *ghosts of departed quantities.*

The graphical score comprises six sections each with a pitch set of 1, 2, 3, 5, 7 or 9 pitches, derived from the harmonic series of Bb (Figure 123).
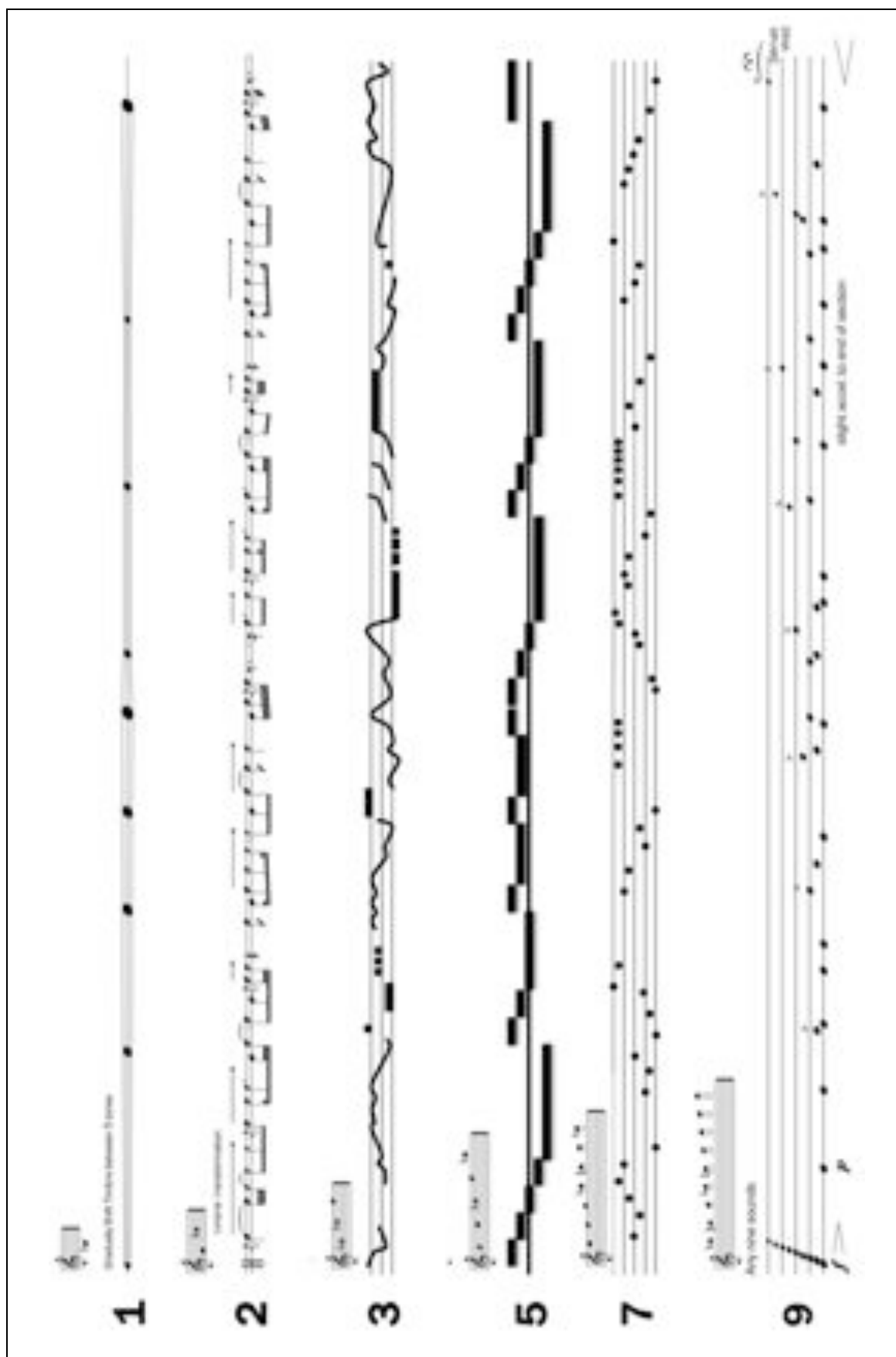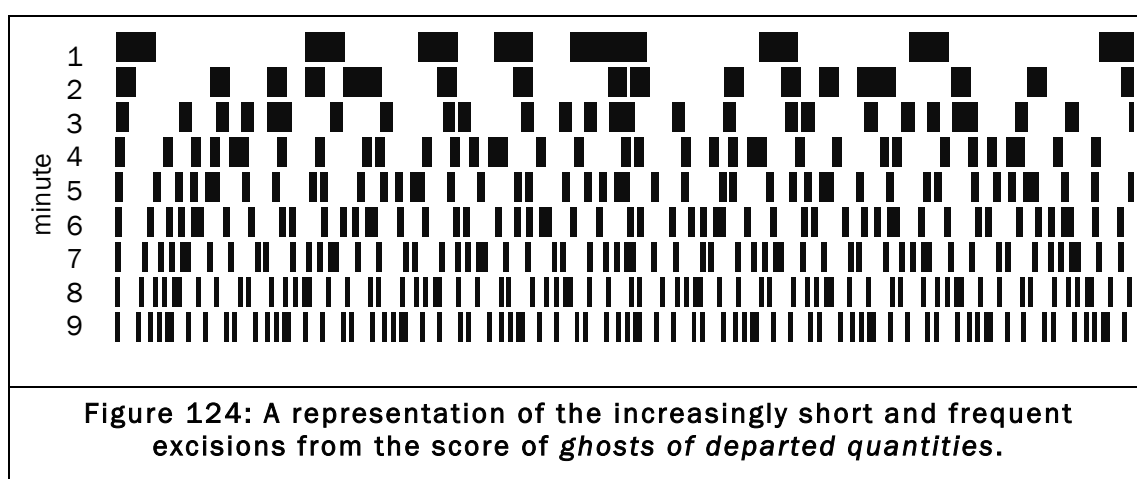
**Figure 123: The graphical score materials for the bass flute part of *ghosts of departed quantities*.**

The performers read the nota[tion]
is implied by five different
permutated by the computer.

alto flute

The work progresses in 60-s
withdrawn from the screen fo

bass clarinet

The progression of this process is illustrated in Figure 124.

minute
1
2
3
4
5
6
7
8
9

Figure 124: A representation of the increasingly short and frequent excisions from the score of *ghosts of departed quantities*.

These processes are documented in a video on the accompanying DVD.

A sonogram of the resultant structure of the work is shown in Figure 125. The increasingly fine-grained gaps cut into the work as it progresses are clearly visible. The opening and closing sections of the work are magnified to demonstrate the change in grain of the work over time.

Figure 125: A sonogram of a performance of *ghosts of departed quantities*. The opening and closing sections of the work are magnified to demonstrate the change in grain of the work over time.
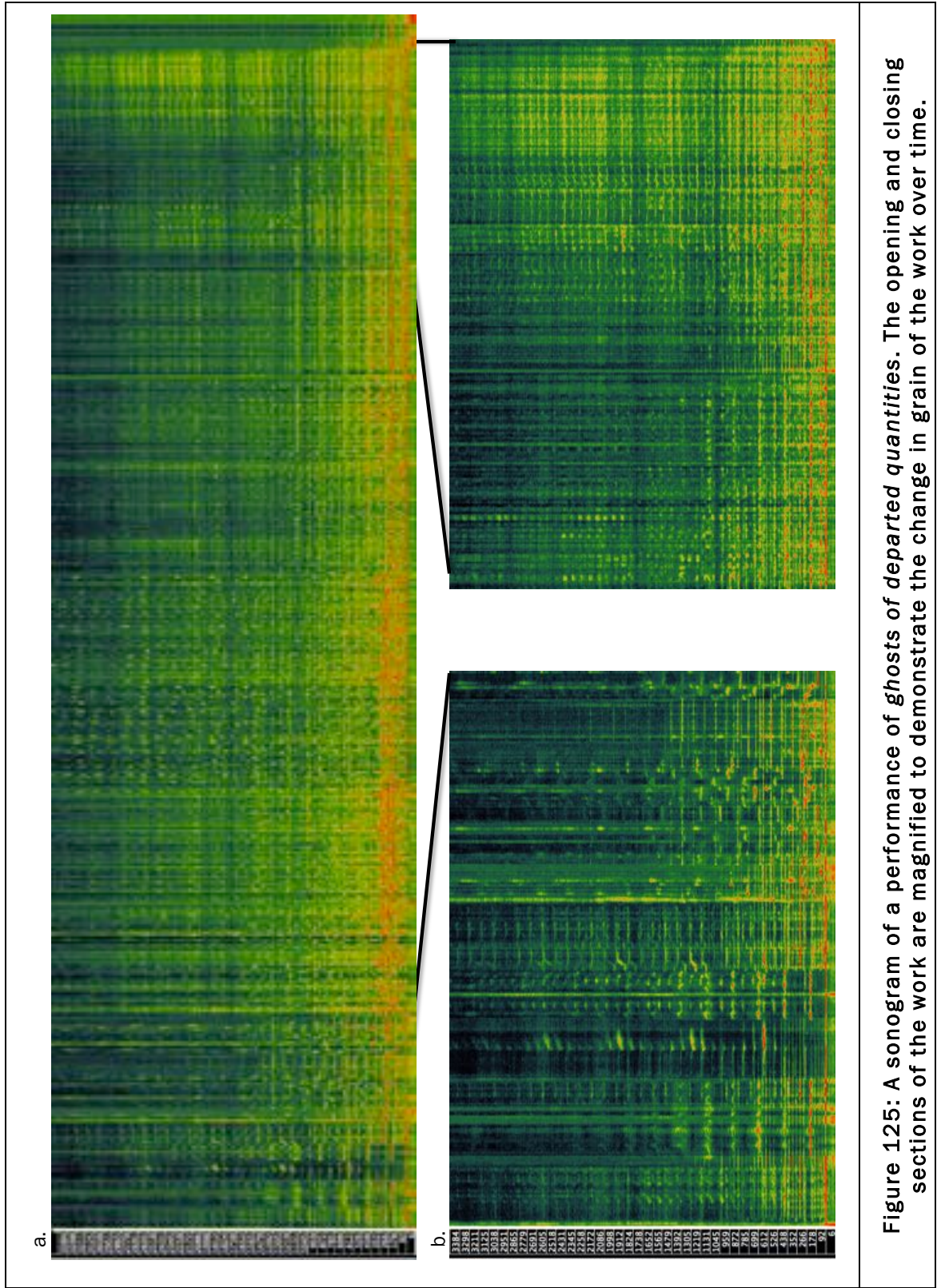
6.8. The Development of Concepts in the Creative Folio

Figure 125 categorises all of the works in the creative folio upon a timeline showing their year of creation and in columns according to their principal structural determinant: Block Form, Collage, Permutation, Polytempo, Multilinear, Polystructure and Subtractive Structure. The works are also categorised according to the principal source of their structure: a fixed score (dark grey), computer interaction (light grey) and computer control (white). The figure summarises and contextualizes the detailed discussion of connections between the works, demonstrating the lines of enquiry that underpinned their development both within and across categories (as indicated by arrows).

It is clear from Figure 126 that the exploration of these ideas expanded in two stages (2001-2006 and 2007-2011), this is perhaps a reflection of the directions that the theoretical research was taking during those periods. The first period was primarily focused upon interaction and nonlinear narrative; whereas the second period sought to resolve the more fundamental issues of identification of the conditions that give rise to of nonlinearity in music, and to classify the categories of nonlinearity that were implied by this definition.

It is apparent that a key concern influencing the direction of research was the development of computer-based methods for manipulating and coordinating structure. This thread runs from the *Delicious Ironies* works, to the Polytemporal studies (*Whorl*, *particle+wave* and *zwitschern*), then to *Transit of Venus* where it is combined with the computer-controlled screen-score and thereafter informs all of the other means of structural organization.

It is evident from the increasing diversity and complexity of structural approaches throughout the folio that, as Žižek claims, "technology and ideology are inextricably intertwined" (2000 p. 39): the development of the computer coordinated performative model has greatly broadened the scope and precision of the possible realisations of nonlinear structural ideas.
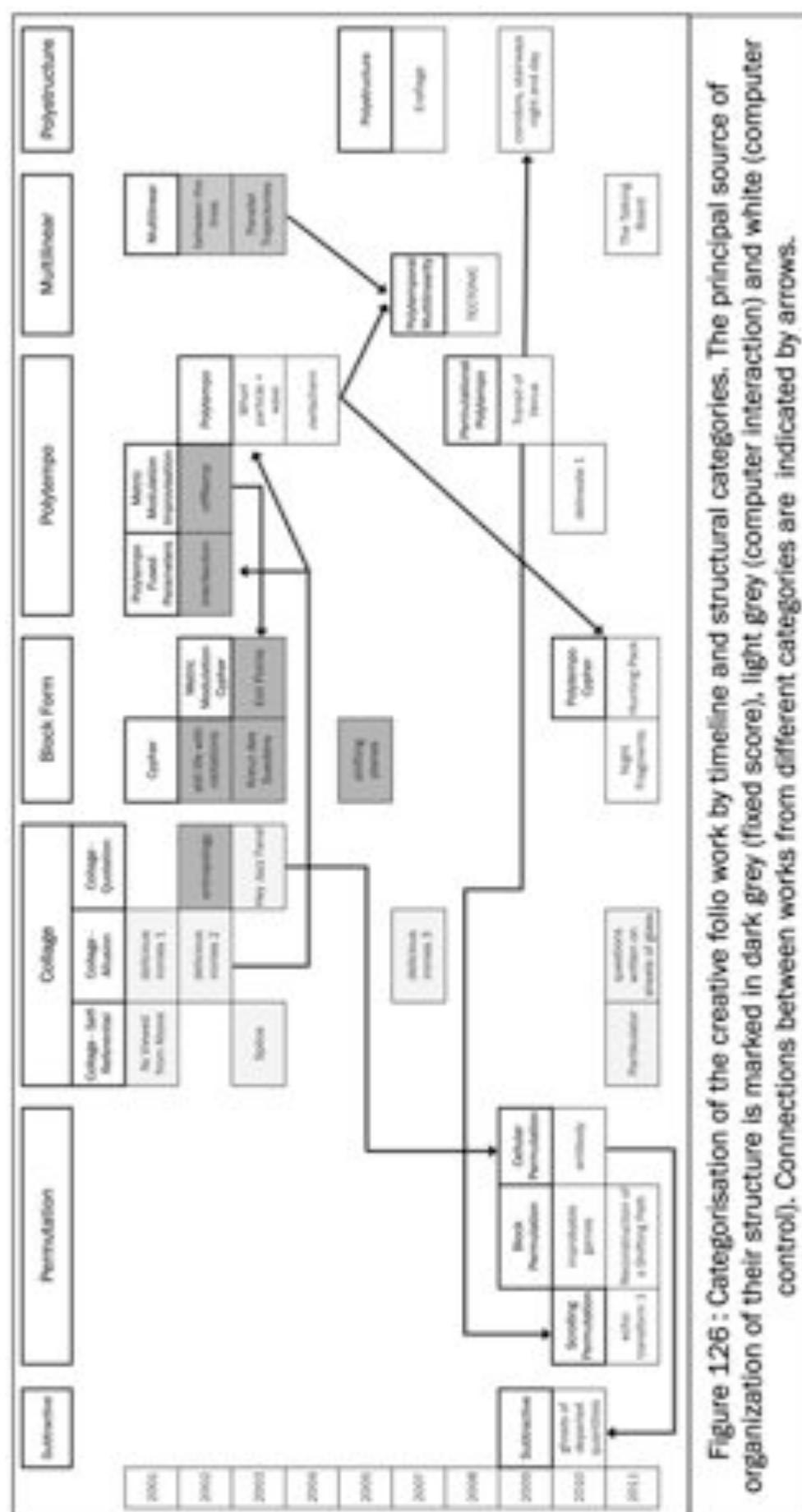
Figure 126 : Categorisation of the creative folio work by timeline and structural categories. The principal source of organization of their structure is marked in dark grey (fixed score), light grey (computer interaction) and white (computer control). Connections between works from different categories are indicated by arrows.