3. Classifying Nonlinear Structures

While the previous discussion opens up a hypothetical space for nonlinear structure between linear structures and formlessness, it does not address the range of nonlinear structures that might occupy this space. Assuming that a work has fulfilled the criteria to be classed as nonlinear, it is proposed that further classification may be applied in regard to three continuums:

- the temporal orientation of the work;

- the degree to which the work may be contextualised by the presence of narrative musical elements; and

- the degree to which the work contains materials referring to connotations beyond its own borders.

This chapter addresses these three classifications of nonlinear structure, and situates the existing terminology for such nonlinear works within this framework, exploring specific representative exemplar works.

3.1. The Temporal Continuum

If nonlinear structures must contain discrete and noncontingent substructures, it follows that these substructures may be temporally arranged in the same horizontal and vertical modes as linear substructures.

Gordon Fitzell in his PhD *Time-Consciousness and Form in Nonlinear Music,* argues that nonlinearity between substructures can exist in three temporal organisational modes: Adjacent – in which distinct substructures occur in succession; Overlapping – in which distinct substructures extend into the boundary of another substructure, but are not temporally encompassed by another distinct substructure; and Polyphonic – in which a substructure is either concurrently present or falls within the boundary of a another distinct substructure (2004 pp. 113-134).

Because of potential confusion between other possible meanings, the terms adjacent and polyphonic will in this dissertation be referred to, in accordance with their structural implications, as sequential and multilinear respectively (see Figure 15). These two states, equivalent to the notion of vertical and horizontal structural organization, form the poles of the first continuum for classifying nonlinear structures.

Sequential

Overlapping

Multilinear

Figure 15: Nonlinear Temporal states (Adapted from Fitzell 2004 p. 133).
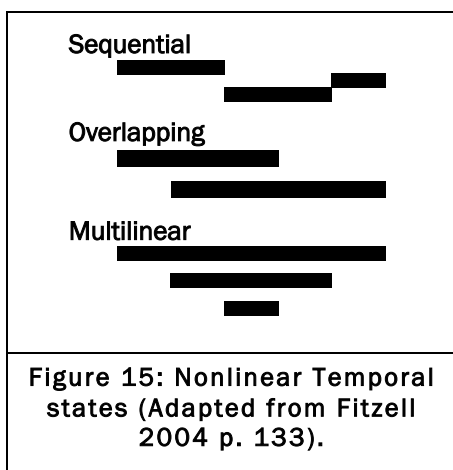
The temporal continuum is bounded by sequential nonlinearity (requiring the presence of continuity within, and discontinuity between, adjacent substructure) and multilinearity (requiring the presence of distinct non-unifiable musical streams). Structures may fall between these two polarities depending on the degree to which blocks of discreet but unified material overlap with one another.

In the literature, the classification of nonlinear formal structures according to their temporal organisation has given rise to a varied nomenclature. These designations may be represented upon the temporal continuum on the basis of their sequential, multilinear or overlapping characteristics. Table 5 indicates the principal temporal orientation associated with the most commonly used nonlinear structural models; it also distinguishes between works that are determinate, performed from a fixed score and those that are indeterminate, performed from a mobile score.

		Sequential	Overlapping	Multilinear
Determinate		Block Form		
		Montage		
		Mosaic Form		
			Multilayered/Superposition	
			Palimpsest	
Indeterminate			Moment Form Mobile Form Polyvalent Form Open Work	

Table 5: Terms for nonlinear structures referring to their temporal organisation arranged according to the continuum of temporal organisation.

3.1.1. Block, Montage and Mosaic Form

"Block", "Montage" and "Mosaic" are used almost interchangeably to designate structures that exhibit strictly sequential and non-developmental substructures comprising parametrically divergent musical materials. The term Block Form is very

strongly associated with Stravinsky[33], but is also used to refer to similar formal structures by composers as diverse as Harrison Birtwistle, Salvatore Sciarrino, Tōru Takemitsu and John Zorn[34]. As its wide usage suggests, Block Form is probably the most accepted designation for this class of sequential nonlinear structure. The term itself is perhaps not particularly descriptive, but does at least carry some of the monolithic sense of discrete, discontinuous sonic structures.

The term Montage was borrowed from film theory where it was first used to describe the cutting together of non-continuous sequences of film. It carries some baggage in the sense that film montage theory focuses specifically on the technique's ability to imply connection and meaning between discontinuous scenes (via "The Kuleshov Effect"[35]), whereas music has the capacity for levels of abstraction that minimise this consequence. Perhaps that most apposite use of the term is in the description of musical works comprising sequences of referential material such as quotations or samples. Nicholas Slonimsky describes the techniques of Musique Concrète in this way as early as 1966 (p. 83). Anne LeBaron identifies Montage as "the more time-oriented form of collage" (LeBaron 2002 pp. 53).

The term Mosaic Form is generally used in reference to works by Messiaen[36], which exhibit parametrically divergent musical materials in sequence. The term is perhaps misleading in that it might suggest simultaneous, two-dimensional proliferation rather than sequential, one-dimensional extension, however it was Messiaen's

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[33] Stravinsky's compositional approach was described in terms of block form as early as 1919, *before* the composition of *Symphonies of Wind Instruments*. (Henry, L. (1919). Igor Stravinsky, The Musical Times Vol. 60, No. 916 (Jun. 1, 1919), pp. 268-272)

[34] See for Birtwistle: *Verses for Ensembles* (1969) (Beard 2001 pp. 29-30, Adlington 2006 p. 121), Sciarrino: *Piano Sonata V* (1994) (Fitzell 2004 pp. 43-44), Takemitsu: *Archipelago S.* (1993) (Koozin 2002 p. 32, Zorn: *For Your Eyes Only* (1989) (Strickland 1991 pp. 124-140), *Cat O' Nine Tails* (1989) (Brackett 2010 p. 59).

[35] Lev Kuleshov conducted an experiment in the 1920s in which a close-up of the impassive face of a well-known actor was intercut with images of a plate of soup, then a coffin and finally a young girl playing. The discovery that audiences inferred meaning and connection between the unconnected scenes, projecting feelings onto the expressionless face (in fact many claimed to be touched by his fine acting) was named The Kuleshov Effect (See Nelmes 2003 p. 394).

[36] While Stravinsky's work was undoubtedly an influence on Messiaen (Healey 2008 p. 183), his Mosaic form might also be seen as a logical consequence of his experimentation with more complex sectional forms extrapolated from refrain and rondo forms (Keym 2008 p. 190).

preferred designation, and denotes in particular the religious significance of stained-glass mosaic in Roman Catholic Cathedrals.[37]

Referring to Stravinsky's *Symphonies of Wind Instruments*, Jonathan Cross states that in Block Form "each block, once defined, remains unchanged; there is no sense of directed (linear) motion through it" (Cross 1998 p. 10). Stravinsky's development of block form is one of the touchstones of nonlinear formal structure providing what Rehding describes as "the basis for a 'logic of discontinuity', as a non-linear kind of coherence" (Rehding 1998 p. 48). Similarly, Cross identifies Block form as a crucial break with the dominant principal of linear development, typified by Sonata Form (Cross 1998 p. 10).

Andriessen and Schonberger referring to Stravinsky's *Symphonies,* describe a musical montage[38] as comprised of "short, continually-returning fragments each with their own identity, abruptly alternated with contrasting structures, every one of which can be defined by a limited number of characteristics (2006 p. 162).

Stravinsky's *Symphonies of Wind Instruments* (1920)[39] is comprised of musical substructures, distinguished by parametrical discontinuity in register, orchestration, dynamic, articulation and occasionally tempo. Figure 12 shows three of these substructures from the first thirteen measures of the work.

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[37] "interlacing its temporal blocks, like the rose window of a cathedral with its flamboyant invisible colours" Messiaen 1966 Preface.

[38] Andriessen and Schonberger, actually trace the emergence of Montage technique back to theatre practice where it had the sense "to give form by means of assembling parts" (2006 p. 161)

[39] This work will be discussed in detail in the following chapter.

Figure 16: Parametrically disjunctive "Block" substructures in Stravinsky: *Symphonies of Wind Instruments* (1920) Bars 1-13 (notated in c). (Score excerpt © 1920 Boosey and Hawkes).

Stravinsky's development of Block Form occurred immediately following his period working with the *Ballet Russes.* Its genesis may have been the result of his experience of creating music for non-developmental dance tableaux, of collaborating with Picasso during his Cubist phase[40], or his own experiments with related smaller scale techniques such as rhythmic cells, rapid block development (Boulez 1991) and rhythmic offset (Code 2007).

3.1.2. Mobile, Polyvalent and Moment Form and The Open Work

In the 1950s the concept of Block Form was expanded by the ability to permutate the blocks of musical material. The practice of introducing nonlinearity to the process of performing a work developed almost simultaneously in the works of Morton Feldman *Intermission 6* (1953), Earle Brown *Folio and Four Systems* (1954) and Stockhausen *Klavierstück XI* (1956). This new development was named "Mobile Form" by Earle Brown (borrowing the term from the sculptor Alexander Calder (Selz, 1966 p. 72), "Polyvalent Form"[41] by Stockhausen (Coenen 1994 p.

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[40] Several authors have noted the connection between Cubism and Stravinsky's development of Block Form. Watkins sees the as *3 Pieces for String Quartet* (1914) "a virtual demonstration piece, ad reductio for cubist premises" (1994 p. 255), Taruskin describes Stravinsky's "deliberately disjointed productions of the war years" (1996 p. 1452) as comparable to Analytical Cubism; and Cross compares Picasso's work from 1910 to the composer's Block Form work Symphonies of Wind Instruments, "whose 'images' are constituted by such ideas as familiar folk-like melodies, the chorale fragments, a fanfare, and so on, but these are glimpsed through their interaction, only to be reabsorbed into the music's overall spatial/temporal flux" (1998 p. 21).

[41] There is much confusion in the literature about the interpretation of Stockhausen's terms Polyvalent Form and Variable Form. While either term might appear satisfactory for the description of

218) and "The Open Work", or more precisely "The Work in Motion"[42] by Umberto Eco (1989 p. 19).

In Table 5 these three terms are represented as spanning the "Sequential" and "Overlapping" categories of the temporal continuum. Because the formal arrangement of any particular instantiation of a Mobile work is indeterminate, it is not necessarily possible to predict whether mobile structures will be performed successively or simultaneously.
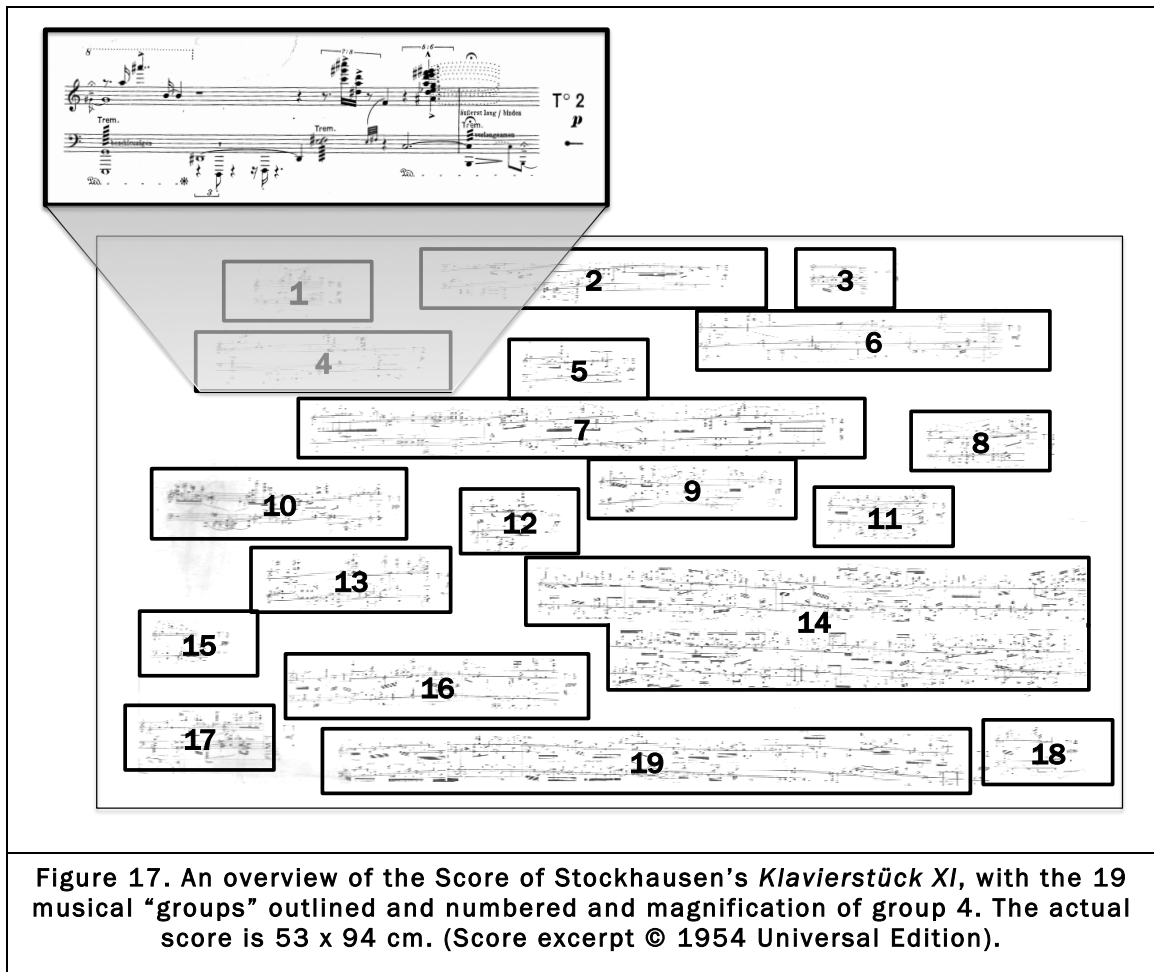
A composer may expressly forbid successive or simultaneous realisations of a mobile structure; indeed it may be physically impossible to perform more than one structure at a time. In the example by Earle Brown discussed in Chapter 2, both sequential and overlapping arrangements are likely, even encouraged to occur. Stockhausen's *Klavierstück XI*, on the other hand is an example of sequential mobile (or polyvalent) form, written for a single pianist. It is scored on a single page and comprises 19 musical passages or "groups", each followed by three indications detailing the tempo, dynamic and articulation that must be applied to the group that is performed next:

> At the end of the first group, the performer reads the tempo, dynamic and attack indications that follow, and looks at random to any other group, which he then plays in accordance with the latter indications.   (Stockhausen 1954)

An overview of the score is shown in Figure 17, with the 19 groups outlined and numbered to indicate their topography on the page. "Group 4" has been magnified as an example of the character of the groups. The tempo, dynamic and articulation instructions to be applied to the next group are visible to the immediate right of the stave.

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works in which subsections can be re-ordered, Stockhausen (according to both Coenen (1994 p. 18) and Kohl (1990 p. 176)) intends Variable Form to refer to structures formed with "indeterminacy of performance" (such as *Refrain* (1959) – in which a transparent plastic "refrain" is pinned into the centre of the score and may affect different parts of the score depending on its orientation and *Zyklus* (1959) – which features somewhat ambiguous notation and the possibility of starting (and consequently) ending on a different page of its spiral-bound score. Polyvalent Form, on the other hand, refers to works such as *Klavierstück XI* (1956) and *Mixtur* (1964) that are comprised of discrete musical sections that may be reordered in performance.

[42] Eco identifies three forms of openness in the work of art: "Openness of interpretation" (*"in which there are no established codes for their interpretation"* (Williams 2001)); "Openness of the Semantic content" (in which ambiguity of meaning is caused by semantics issues); and "The Work in Movement" ("the possibility of numerous different personal interventions, but (...) not an amorphous invitation to indiscriminate participation" (Eco 1989 p. 19).

Figure 17. An overview of the Score of Stockhausen's *Klavierstück XI*, with the 19 musical "groups" outlined and numbered and magnification of group 4. The actual score is 53 x 94 cm. (Score excerpt © 1954 Universal Edition).

Robert Morgan has noted with regard to Stockhausen's investigations of mobile form, that "the episodic character of these pieces, arising from the transposable nature of their elements, seems to have led inevitably to an erosion of the logic within the system" (Morgan 1975 p. 9). The focus on immanent temporal experience, "in which the concentration is on the Now - on each Now" (Stockhausen 1964 p. 199), in turn led Stockhausen to formulate "Moment" Form.

Moment Form

Stockhausen defined a "Moment" as follows:

> When certain characteristics remain constant for a while – in musical terms, when sounds occupy a particular region, a certain register, or stay within a particular dynamic, or maintain a certain average speed – then a moment is going on: these constant characteristics determine the moment. And when these characteristics all of a sudden change, a new moment begins. If they change very slowly, the new moment comes into existence while the present moment is still continuing. The degree of change is a quality that can be composed as well as the characteristic of the music that is actually changing.

> (Stockhausen in Maconie 1990 p. 63)

This approach was first manifested in the composer's work *Kontakte* (Contacts 1958-60) (Wörner 1973 p. 46). The discrete nature of each "moment" gives rise to structures in which each one "simply gives way to the next, with no implication of linear development or necessity" (Morgan 1975 p. 8). In this sense Stockhausen's "Moment" describes the same discrete and non-contingent characteristics necessary for the emergence of nonlinear events, and the assemblage of Moments into "Moment Form" gives rise to the same non-compressible, indeterminate structures described in Chapter 1. Moment Form captures the essential qualities of nonlinear structure (particularly sequential structure) and therefore can (and has been) retroactively employed to discuss earlier works especially Debussy's *Jeux,* (1912) and Stravinsky's *Symphonies.*[43]

Figure 18a schematically represents the modular arrangement of "moments" in Stockhausen's *Momente* (Moments) (1962- 64/69). The moments are arranged in a branching structure and designated by the letters M: *Melodie* (melody), K: *Klang* (sound), and D: *Dauer* (duration) (Emmerson 2007 p. 46). Stockhausen's conception is rather like a visual mobile.[44] Maconie has also noted the similarity between Stockhausen's sketches for *Momente* and the "Halle-Jakobson structured classifications of speech sounds" derived from communication theory (Maconie 1990 p. 130).

Figure 18b shows the path taken through the structure in a particular instantiation, the *Europe Version* recording of 1972 (Stockhausen 1993). Although the moments are mobile within the branching structure, at least notionally from performance to performance, they are not mobile in realtime in the same manner as *Klavierstück XI.*

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[43] See Debussy: Pasler 1982 p. 68 and Albaugh 2004 p. 3; Stravinsky: Kramer 1978 p. 184, Cross 1998 pp. 60-63.

[44] Compare the "arborescent" schematic of *Momente* to that of Brown's *Calder Piece* (1966), Figure 37 p. 84.

Figure 18 a. The modular arrangement of "moments" in Stockhausen's *Momente* (1962 – 1964/1969), b. The path taken through the structure in a particular instantiation, the *Europe Version* recording of 1972.
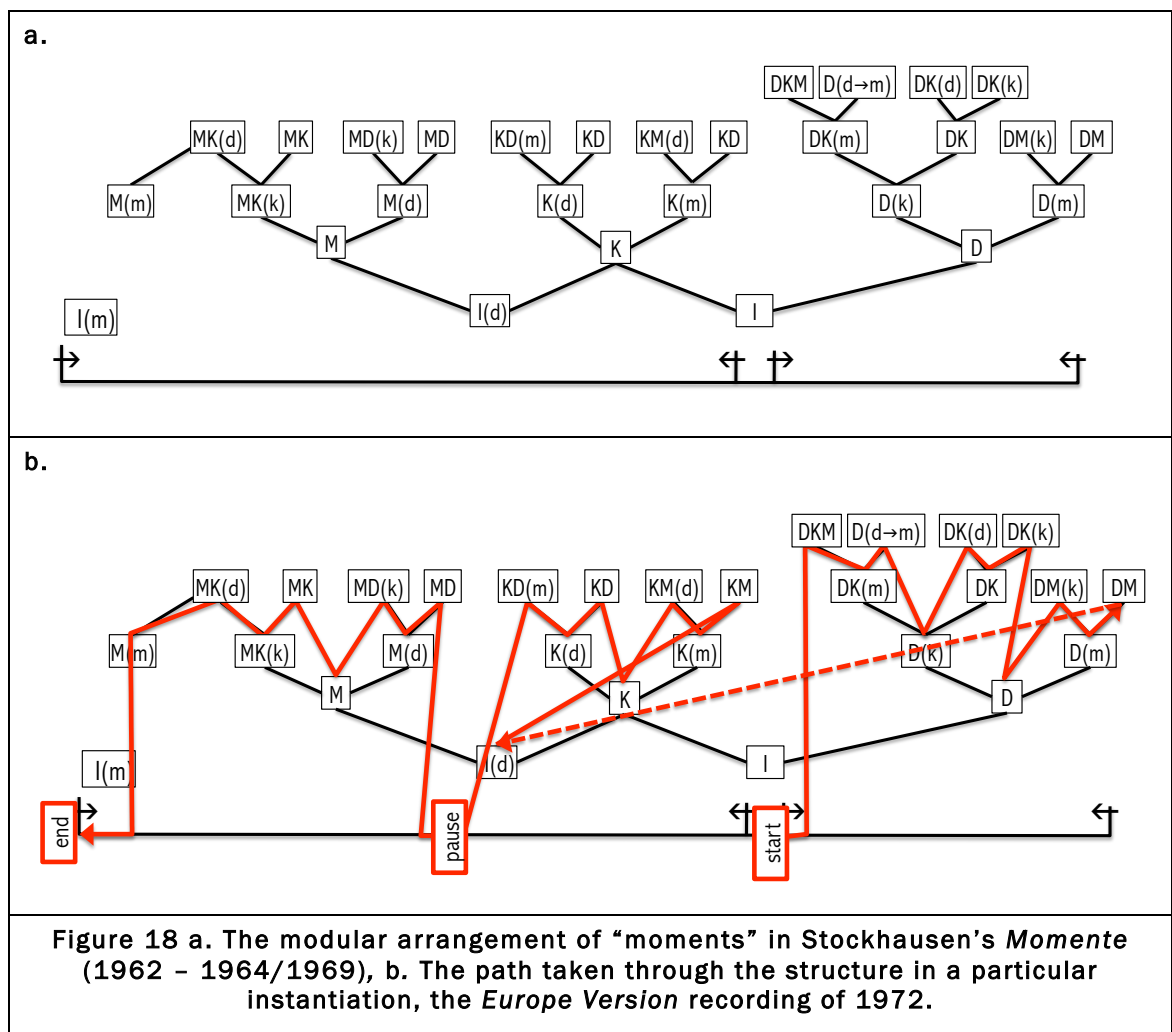
The following account of an early performance of Stockhausen's *Momente* (1962-69) shows the imperative for pre-ordering of the orchestral parts.

> Stockhausen expects the performer to vary the order of movements at will, and even provides for passages from one movement to be inserted into its neighbors. For each concert the score may be re-arranged, in accordance with certain instructions; the extracts or "inserts" may be glued into certain slits in the score, and their duration and volume are varied depending on the context, as indicated by a long list of rules on each sheet. Then the parts are prepared in whatever order has been selected for the particular concert.
>
> (McElheran 1965 p. 37)

The account of the 1965 performance by McElheran, mentions "extracts or inserts", another nonlinear structural innovation by Stockhausen, that he termed the "Einschub" (Insert). The technique involved the interpolation into a Moment, of material that had already been heard (memory) or of what will be heard (anticipation) in a preceding or successive Moment. Maconie describes them as

materials "discovered during the process of composition and attached to the finished work even though they are unaccounted for in the composer's original master plan"(Maconie 2005 p. 195). In Figure 19 the Inserts from Moment KM from *Momente* are outlined with dashed lines.

Figure 19. Moment KM from Stockhausen's *Momente* (Europe Version 1972) from (Stockhausen 1993). The Inserts are outlined with dashed lines. (Score excerpt © 1972 Stockhausen Verlag).

Although the term Moment Form is perhaps rather branded by its strong association with Stockhausen, its usage has become quite widespread both amongst theorists and the diverse array of composers that they relate it to, who include Ives, Messiaen, Peter Maxwell Davies, Harrison Birtwistle, George Rochberg, Joseph Schwantner, Anthony Braxton, Iannis Xenakis, John Adams and Mauricio Kagel.[45]

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[45] See Kramer 1978 (Ives: *Putnam's Camp* (1908), William Bolcom: *Frescoes* (1971), George Rochberg: *Third String Quartet* (1971)), Radano 1993 p. 129 (Anthony Braxton: *Composition No. 1* (1968), Attinello 2002 p. 264 (Mauricio Kagel: *Anagrama* (1957–8)), Albaugh 2004 (Joseph Schwantner: *Aftertones of Infinity* (1978)), Adlington 2006 p. 142 (Harrison Birtwistle: *Carmen Arcadiae Mechanicae Perpetuum* (1978)), Sholl 2008 p. 195 (Messiaen: *Cantéyodjayâ* (1959)) and Jones 2009 p. xviii (Xenakis: *ST/4* (1962), John Adams: *John's Book of Alleged Dances* (1994)).

3.1.3.Multilayered Form, Superposition and the Palimpsest

Multilinearity is a term employed for nonlinear formal structures in which there are two or more simultaneous, independent streams of discrete musical material. In particular, the multiple streams must in their affect be resistant to compression into any overarching unifying framework.

The term Multilinear gained widespread currency after its appearance in Deleuze and Guattari's *A Thousand Plateaus: Capitalism and Schizophrenia* (1987), where it is described as "a system that dismantles, disrupts, dislocates: a system abounding in new media" (p. 296) and a system in which "everything happens at once" (p. 328). In particular they draw attention to the destabilised sense of linear time created by multilinearity through "deterritorialisation" an effect that promotes temporal relativity over temporal hierarchy, casting the multiple lines adrift, abandoning "points, coordinates and measure, like a drunken boat that melds with a line or draws a plane of consistency" (p. 296).

The term Multilinearity has been most quickly adopted in narrative studies and new media.[46] In music its use is not yet widespread.[47] The atemporal affect of multilinearity, alluded to by Deleuze and Guattari, has led several music commentators (and composers) to resort to the use of spatial analogies.[48]

> It is indicative of a new compositional orientation that Varese himself largely relied upon spatial terms in discussing his own music, describing his compositional procedures with such words as "collision" and "penetration." He often remarked that he conceived of his musical materials as "objects," as "sound masses" to be manipulated in the manner of a sculptor constructing a mobile. (Morgan 1980 p. 534)

The term, "spatial music" appears to have been introduced by Robert Morgan, who adapted the ideas of literary theorist Joseph Frank.[49] Morgan's discussion of spatial form in Ives again reflects its strongly atemporal qualities, stating that it seeks to "negate time as a primary mode of musical expression and experience" and is

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[46] See Landow 1992 pp. 66-67, Aarseth1997 p. 43, Hawkes, Law and Murphy 2000 p. 16, Bolter 2001 p. 128, Reiser 2002 p.152, Vandendorpe 2009 p. 147 and Hesse-Biber 2010 p. 593.

[47] Capper and Wright describe Ives' "spatially conceived pieces manifested harmonic stasis, circular melodic gestures, a weakened sense of elapsed time, multilinear activity and large-scale reflective structures that defied conventional objectives"(2002 p. 575) and Tofts similarly describes Carl Stalling's compositional approach as a "multilinear system (...) that "dismantles, disrupts, dislocates" (Tofts 2003).

[48] See Morgan 1976 and 1980, LaBelle 2006 p. 192, Iverson 2011, Kramer 1996 p. 76, Salzman 2001 p. 159.

[49] See Frank 1991 [1945].

based on "relationships that are simultaneous, reciprocal, and reflective in nature rather than successive, sequential, and unidirectional" (Morgan 1976 p. 53). The term itself is inadequate in defining temporal relationships; rather it sidesteps the issue by suggesting atemporality - or at least minimization of temporality - without specifically explaining the physical formal structure that gives rise to the sense of atemporality.

At present the most commonly used terms for temporal multilinearity are Multi-layered Form, Superposition and Palimpsest. The first two terms refer to the same technique: stacking divergent materials to create an aggregated texture. Morgan, for example, describes Ives' multilinear works as consisting of "a number of different yet simultaneous time-movements co-existing in a shared, multi-layered universe where each maintains its own individuality while also influencing and being influenced by all others" (Morgan 1976 p. 153). Healey uses the term Superposition to describe a technique employed by Messiaen consisting "entirely of a stratification of procedures, particularly those that can extend over the length of a movement" (Healey 2008 p. 178).

The palimpsest technique describes the inverse of superposition and multilayering; a process of erasure in which portions of a work are removed to create either voids that disturb the linearity of the texture, or sites for the insertion of divergent materials. The term gained modern currency in postmodern theory, particularly in the work of Derrida[50] (1974), Kristeva (1980) and Genette (1997), where it is used with particular reference to the technique of "overwriting" an existing text. All three reference as their source, an article by Thomas De Quincy in which he describes a palimpsest as "a membrane or roll cleansed of its manuscript by reiterated successions" (1871 p. 10).[51]

In music, the term is particularly pertinent to the third movement of Berio's *Sinfonia* (1969) in which voids are incised from the third movement of Mahler's Second Symphony (1888-1894) and grafted with a multitude of quotations.[52] Composers Karl Aage Rasmussen, Xenakis, George Benjamin and David Sherr have all written

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[50] Derrida further defined by the term as "Sous Rature" usually translated as "under erasure", which refers to "inadequate yet necessary" (Sarup 1993 p. 33): words that are crossed out but remain in the text.

[51] For a full discussion of the origins of the term see Reisner 1982.

[52] This work will be discussed in more detail in the section on Referential Nonlinearity.

works called Palimpsest.[53] The works by Berio, Rasmussen and Sherr all contain strong referential connections to other works, however both Xenakis and Benjamin explore the concept in a purely abstract manner[54], suggesting that the excision of material from internally conjunctive musical layers has temporal as well as narrative and referential dimensions.

The effects of parametrical discontinuity, a key factor in sequential nonlinearity, are weakened in multilinear works because of the simultaneous sounding of events that renders the separation of musical parameters more problematic. Consequently, multilinear works require strong internal cohesion within and weak contingency between their component streams. For this reason composers often resort to reinforcing the internal cohesion of streams through narrative and referential strategies, rather than exclusively relying upon parametrical distinctions in purely abstract material. This is the reason for the abundance of descriptors, such as collage and polystylism, which refer to these prominent characteristics rather than to temporal ones.

Ives perhaps more than any other composer has explored the time distorting potential of multilinearity. He employs a wide range of techniques both referential and purely abstract, to disrupt and encourage temporal coherence. David Thurmaier gives a comprehensive inventory of forms of temporal distortion in Ives' music, which reveals a language with highly developed tools for managing temporal flow (see table 6).

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[53] Xenakis: *Palimpsest* (1979), Rasmussen (1947-): *Berio-Mask: A Palimpsest For Chamber Ensemble* (1977), Benjamin: *Palimpsest I* (1998-99) and II (2002), Sherr: *Palimpsest (accompaniment to Sequenza 7, by Berio)* (1999). Interestingly Karl Aage Rasmussen's *Berio-Mask*, turns to the already overwritten score of Berio Sinfonia III, erasing Berio's additions to Mahler (while "retaining" Berio's deletions) and replacing them with Rasmussen's own music.

[54] See Xenakis: Harley 2005 p. 124-125 and Benjamin: Lack 2001 pp. 10-14.

Motion	linearity, pitch organization, shadow lines, stasis, tempo
Interruption	Juxtaposition and superimposition, silence, divider motives
Style and Genre	modelling, narrative and allusion
Texture	contrapuntal with "progressive density", melody and accompaniment, dissipation
Borrowing	Combination, methods of distortion, fragmentation, tense and memory

Table 6: Classification of Temporal Phenomena in the Music of Charles Ives (from Thurmaier 2006 p. 29)

Figure 20 is a reduction of bars 52-4 from *Putnam's Camp* (1912), the second movement of Charles Ives *Three Places in New England* (1903, 1911-1929). The example demonstrates, in microcosm, some of the multilinear profusion of the work. Even disregarding the allusion to the popular song "Tramp, Tramp, Tramp" in the two mm. = 90 layers, the example demonstrates Ives' capacity to create divergent musical streams through the use of polymeter, polytempo and phase shifting of musical materials against the prevailing meter. The underlying $^4_4$ meter A. shown in the lower two staves is, within these three bars superimposed with: B. an "out of phase" by a quaver interjection in quaver-triplets, grouped and accented in $^4_4$ at a virtual mm. 180; C. an ostinato in $^3_4$; and D. and E. minim triplet layers also grouped in 4 at a virtual mm. = 90 entering out of phase on the second and third beats of the bar.

Figure 20: Charles Ives *Putnam's Camp* (1912) bars 42-54, showing multilinear superimposition of metrically- and tempo- divergent layers. The reduction is taken from Cooney 1996 p. 296; the lettering, enclosures, time signatures and tempi are by the author. (Score excerpt © 1935 Theodore Presser).

In *The Unanswered Question* (1908), Ives presents three distinct non-referential streams, distinguished only by timbre, tempo, dynamic, rhythm and articulation. The parametrical discontinuity between the streams is underlined by their diverging trajectories: parameters in Stream 1 are increasingly amplified; parameters in Stream 2 are also increasingly amplified but terminate in their initial state - suggesting a cyclic trajectory; and Stream 3 remains comparatively static and stable in all of its musical parameters (See Figure 21.). In this sense the work relies somewhat on narrative qualities, albeit abstract ones, to differentiate its streams.[55]

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[55] It is of course possible to interpret the work as programmatic, given Ives' own description in the work's preface: "The strings (...) represent "The Silences of the Druids – Who Know, See and Hear Nothing." The trumpet (...) "The Perennial Question of Existence," and states it in the same tone of voice each time. But the hunt for undertaken by the flutes and other human beings (...)"The Invisible Answer"" (Ives 1962 p. 10). However, the streams are discernable and arguably also comprehensible on a purely abstract level.
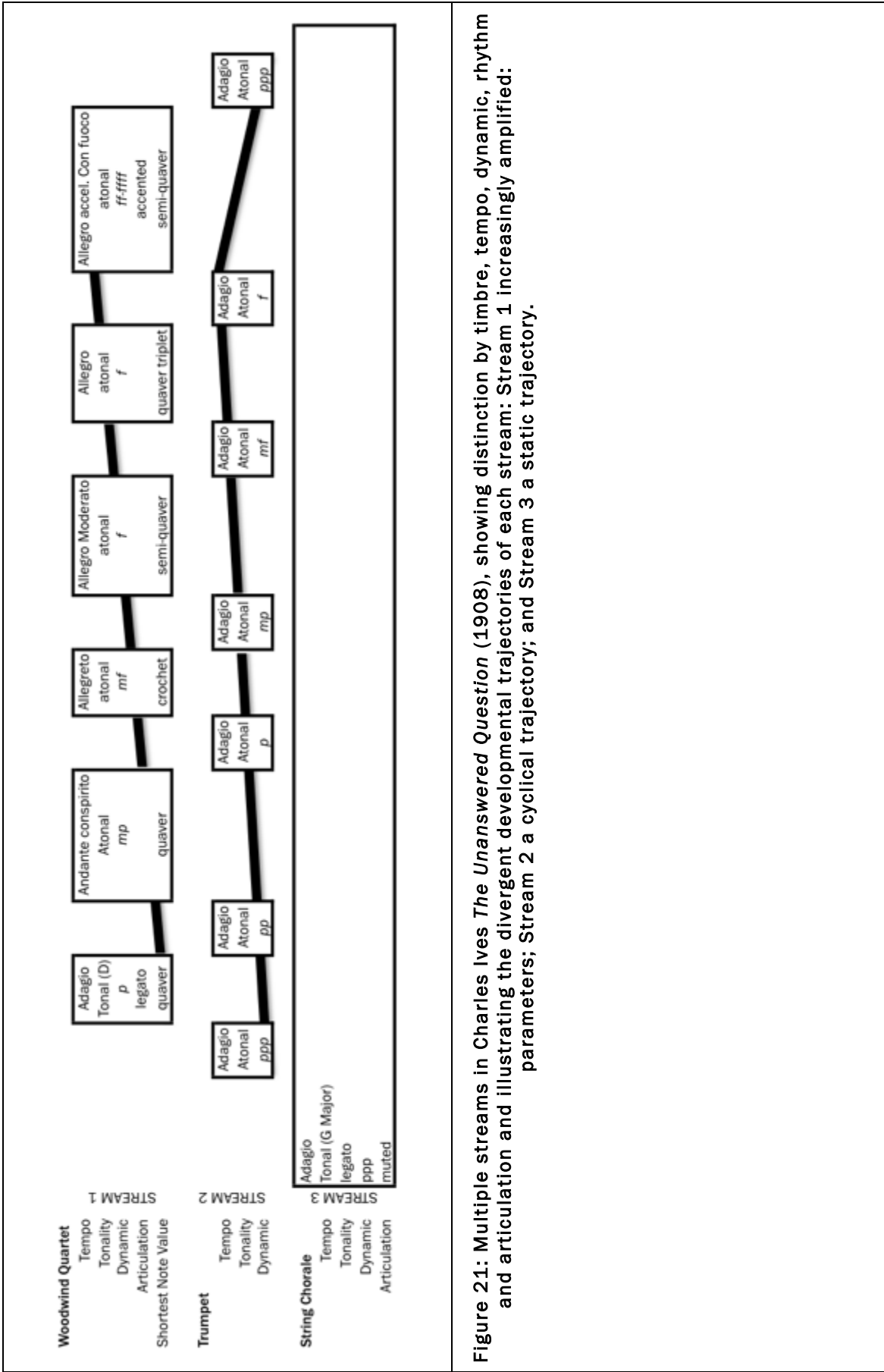
Figure 21: Multiple streams in Charles Ives *The Unanswered Question* (1908), showing distinction by timbre, tempo, dynamic, rhythm and articulation and illustrating the divergent developmental trajectories of each stream: Stream 1 increasingly amplified: parameters; Stream 2 a cyclical trajectory; and Stream 3 a static trajectory.

3.2. The Narrative Continuum

In the narrative continuum, nonlinearity is engendered through narrative disruptions. Although there can be "no general theory of semantics for music" (Dannenberg 2002 p. 43) musical works can produce a sense of directionality through a variety of means, and it is therefore possible to interrupt, reorder or subvert this apparent forward motion. This process requires the ability to infer in a work "an underlying linearity which is sufficiently straightforward and perceptible that we can understand a reordering of it" (Kramer 1981 p. 545).

Jonathan Kramer contends that the tension driven progression of tonal music can provide an interpretive framework within which events can be "read-in" in terms of their temporal relations (Kramer 1986 p. 25). He also argues for the presence of a level of semantic understanding, based upon the conventions of beginnings and endings, in addition to "gestures that sound characteristically like transitions, climaxes, contrasts, and other such conventions" (Kramer 1986 p. 140).

Likewise, Lutosławski identifies four distinct "musical characters" that he believes are identifiable in nontonal music.

> Narrative: "I hear this and nothing else occupies my attention"
>
> Transitional: "I hear this, but above all, I feel that what I hear now is leading me on to something different I shall hear in a moment."
>
> Introductory: "I hear this, but I realize that actually, I am anticipating hearing something else".
>
> Terminative: "I hear this, but I realize that in a moment the whole form or some stage of it is about to end."   (Lutosławski 2007 p. 13-14)

The presence of pre-existing musical constructs or practices - tonality, sonata form or characteristic dance rhythms for example – admits the possibility for the listener to evaluate deviations from known models that have been reordered in a nonlinear manner. It is not possible to innumerate all of the specific configurations that give rise to interpretable narrative gestures of this type: they are crucially listener dependent and they are possibly infinite in their diversity.

In order to allow detection of narrative reordering, composers are restricted to a relatively small number of compositional strategies. In abstract musical material, three principal categories of narrative technique may give rise to a sense of nonlinear reordering. These involve reordering of:

- Processual Narrative: based on musical processes with discernable directionality;
- Game-based Narrative: based upon discernable rule sets;
- Developmental Narrative: based upon development with discernable directionality.

3.2.1. Processual Nonlinearity

The simplest narrative strategy employs processual structures, in which transformations of material result in an identifiable contour, for example: the cumulative addition/expansion or subtraction/contraction of parameters. The gradual accretion of material, for example, creates an expectation of continual expansion that has directional narrative characteristics.

A simple example of a processual technique is the additive melody employed by Frederik Rzewski in his (thoroughly linear) work *Le Moutons des Panurge* (1969).[56] Here a melodic line is created by cumulatively adding notes from a reference sequence of pitches, as shown in Figure 22.

Figure 22: Additive melodic processes in Frederik Rzewski's *Le Moutons des Panurge* (1969). a.) Rzewski's reference sequence b.) The melody derived from additive accretion of pitches and durations from the sequence. (Score excerpt © 1969 Frederik Rzewski).

The kinds of structures that derive from processual procedures are most clearly understood on a structural level by their parametrical contour In order for such

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[56] Maurice Ravel s *Bolero* (1928) also utilises relentless expansion, dynamically and timbrally, as a structural device. It is discussed by Tenney in this regard as an exemplar of "isomorphic (identity of shape)" form (Tenney 1973 p. 13).

structures to be recognised once they have been reordered in a nonlinear manner, it is necessary that:

- their contours are relatively simple - archetypal forms - (for example expansion, contraction, arch shape);
- the number of structures is limited. The ability to differentiate individual contours is reduced by additional lines;
- the degree of reordering is simple. The ability to differentiate individual contours is reduced by increased reordering of segments.

Figure 23 schematically represents the permutations of expanding and contracting musical materials. In Example 23a the two structures are presented independently; in 23b they are interleaved but ordered in such a way that they retain their individual contour. In this arrangement it may be possible to "hold onto" the sense of contour through the interruption of the alternate materials and therefore retain a sense of continuity between the interrupted segments of the narrative contour.

In Example 23c the two structures are permutated: they are both out of order and out of sequence. This representation suggests that such an arrangement would require much stronger continuity between the musical materials themselves in order for them to be contextualised as belonging to the same structure.

a.
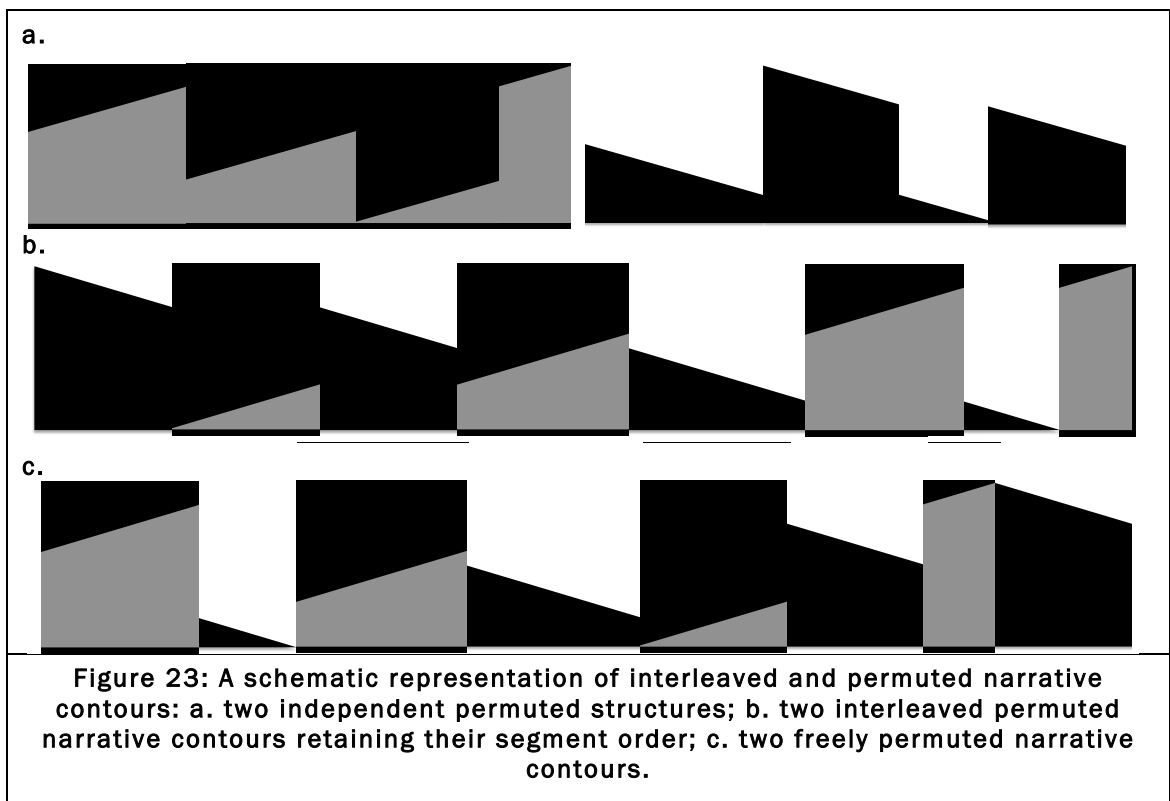
Karlheinz Stockhausen's *Klavierstück IX* (1961) comprises three narrative contours: the first two are heard successively (until the climax of the arch contour) and then both successively and simultaneously until the beginning of the final section in which the final contour appears alone. Stockhausen himself described this deployment in the following terms: "sometimes they are abruptly juxtaposed, sometimes they intermingle in constantly fresh conjunctions" (Wörner 1973 p. 36).

The Contour 1 material comprises repetitions of the same four-note chord in continuous decrescendo from *fff* to *pppp*. The number of repetitions of this chord undergoes a process of reduction with each repetition of the contour. The reductions and fragmentations of the contour are governed by progressively smaller values of the Fibonacci series.[57] This texture is unusual for Stockhausen in that it is periodic: both rhythmically regular and repetitive and at a constant tempo of mm. 160.[58]

The Contour 2 material is more typical of the other six piano pieces in this set[59], comprising "points" and "groups" of serial material such as a chromatically filled-in "melody", grace notes, polyphonic groups, trills, sustained pitch, and chords. The five iterations of the second contour, all at the constant tempo of mm. 60, form an arch: with increasing variety in range of materials and dynamics until the third iteration, and then progressively less in the fourth and fifth. The internal proportions of the Contour 2 material are also governed by the Fibonacci series.

The Contour 3 material is uniformly aperiodic and pointillist, at the tempo of mm. 120. Maconie claims that this final section results from the merger of the Contour 1 and 2 material (1990 p. 215-216), but it is hard to see how this is a supportable position. The final section is highly contrasting to the first two in character, register and pitch content and appears to erupt as a consequence of the conclusion of the shortening process of Contour 1, and the conclusion of the reduction of variety in

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[57] The first iteration is of 142 repetitions (1 + 2 + 3 + 5 + 8 + 13 + 21 + 34 + 55), the second 87 (1 + 2 + 3 + 5 + 8 + 13 + 21 + 34), the third 53 (13 + 21 + 1 + 8 + 5 + 2 + 3) fragmented through alternation with 32 beats of silence (2 + 8 + 3 + 1 + 13 + 5) and so on.

[58] Keith Potter has noted the possible influence of Minimalist composer La Monte Young in this regard, both in the passage's repetitive nature and its use of Fibonacci series numbers to define the number of repeats. (Potter 2002 p. 89)

[59] Stockhausen originally proposed a structure comprising 21 piano pieces in six related groups of 4, 6, 1, 5, 3, 2 works respectively (Smalley 1969 pp. 30–32). Upon his death the final set remained unrealised.

the materials of Contour 2.[60] Again the Fibonacci series underpins the structure, determining the length of the subsections, the number and length of bars in each subsection and the number of notes and accents in each bar.

Figure 24 illustrates the three contrasting types of material form *Klavierstück IX*.

Figure 24: The Diminishing, Arch and Block structures of Stockhausen's *Klavierstück IX*. (Score excerpt © 1961 Universal Edition)

Figure 21 summarises the processual contours of the three types of material used by Stockhausen in *Klavierstück XI*.

---

[60] A similar eruption occurs at the conclusion of the progressive shortening of silences in the first movement of a very different work: Arvo Pärt's *Tabula Rasa* (1977).

	Contour 1	Contour 2	Contour 3
Material	mm. 160 Repeated Four-note Chord	mm. 60 Chromatic Melody/Grace Notes /Polyphonic groups/Trill /Sustained pitch/Chords	mm. 120 Pointillist
Profile	Decrescendo (fff to pppp) Decreasing repetitions Increasing Fragmentation Fixed Register	Crescendo - decrescendo Increasing and then decreasing density, registral and rhythmic complexity	High Register Aperiodic sporadic low-notes
Contour			

Figure 25: The three principal formal structures in Karlheinz Stockhausen:
Klavierstück IX **(1961)**

3.2.2. Game-based Narrative

Game-based structures began to emerge in music in the mid-twentieth century. The inherently competitive quality of such works, arguably promotes nonlinearity because of the necessity for contrast between musical materials of the opponents and the possibility of disjunctive interruptions created by the opponents divergent goals.

Game Theory is a rule-based system for "managing possible outcomes and conflicts that result from decision making when both parties operate on the basis of each party's self-interest" (Havryliv 2005 p. 24). Sward places the origin of game-based analysis in the 1920s when it *"began to be used in mathematics for predicting outcomes in economics and later human conflicts"* (Sward 1981 p. 244).[61] The first employment of Game structure for musical purposes was probably by Xenakis in the works *Duel* (1959) and *Strategie* (1962) (Griffiths 2007 p. 133).

In *Duel* two conductors direct tactical deployments of musical material played by two orchestras, in contest with each other. The six "fundamental tactics" and ten "simultaneous combinations" available to the conductors are shown in Table 7.

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[61] The foundational text in Game theory is generally agreed to be Theory of Games and Economic Behavior (Von Neumann, Morgenstern, Rubinstein and Kuhn, 2007 [1944]).

Six Fundamental Tactics		
I	Pointillisme des Cordes	(Strings Pointillism)
II	Glissandi croisés des cordes	(Strings Crossing Glissandi)
III	Tenues des cordes	(Held strings)
IV	Percussion Normale	(Normal Percussion)
V	Vents	(Winds)
VI	Silence	
Ten Simultaneous Combinations		
A	I	II	III
B	A + IV	A + V	IV + V
C	A + V + IV		
IV	Percussion Normale		
V	Vents		
VI	Silence		

Duel Game Matrix

		Conductor Y					
		A	B	C	IV	V	VI
Conductor X	A	-1	+1	3	-1	+1	-1
	B	+1	-1	-1	-1	+1	-1
	C	+3	-1	-3	5	+1	-3
	IV	-1	+3	+3	-1	-1	-1
	V	+1	-1	+1	+1	-1	-1
	VI	-1	-1	-3	-1	-1	+3

Table 7: The six fundamental tactics and ten simultaneous combinations available to conductors in Iannis Xenakis *Duel* (1959) and the *Duel* "Game Matrix" used to calculate scores (Xenakis 1959 p. 3).

In the instructions to the score, Xenakis describes the process in the following way:

> the game presents itself as the successive execution of different pairings which are the result of tactics played simultaneously by the two orchestras according to the choice effected alternatively by each conductor, without interruption.   Xenakis 1959 p. 4

Although the conductor's choices are made according to their "own taste" (Xenakis 1992 p. 123), their interactions are scored according to a matrix of possible combinations of materials. The scores are totaled at the completion of the work and a winning team is declared: the *"victory and defeat, (…) may be expressed by a moral or material prize, (…) and a penalty for the other"* (Xenakis 1992 pp. 112-13).

As can be seen by their designations and the excerpts from the score in Figure 22, the musical materials are discrete and parametrically divergent. Only sections II and IV have tempo markings (both minim = 60) and the physical spatial arrangement of the orchestras also contributes to the discontinuity between the materials in a performance, in a similar manner to Earle Brown's *Event Synergy II*.

Figure 26. Excerpts of the six Fundamental Tactics of Iannis Xenakis *Duel*. The length of each section is: I - 68 bars, II – 77 bars, III – 42 bars, IV- 71 bars and V – 69 bars. (The "held strings" and "strings crossing glissandi" tactics are actually labeled II and III respectively in the score) (Xenakis 1959). (Score excerpts © 1959 Editions Salabert).

Droseltis claims that the five blocks of musical material are derived from entirely different earlier works by Xenakis: the material for sections, I, II and III from *Syrmos* (1959), and the material from sections IV and V from *Achorripsis* (1956-7) using a self-borrowing "jigsaw construction" similar to that of his late orchestral work *Mosaïques* (1993) (Droseltis 2010).

Despite the innumerable possible instantiations of *Duel,* performance of the work will always result in a nonlinear structure, both because of the inherent discontinuity between the musical materials and the combative performance practice that favours contrast between the choices of the two composers.

The possibilities of creating structures on the basis of combative interactions as well as more collaborative environments continued to be explored through works such as those by Henri Pousseur (*Repons* (1960)), (Butor and Pousseur 1971, p. 107), Mauricio Kagel (*Match* (1964)) (Heile 2006 p. 47), John Cage (*Reunion* (1968)) (Cross 1999 pp. 35-42) and numerous examples developed by Cornelius Cardew's *Scratch Orchestra* and John White's *Promenade Theatre Orchestra*

(Anderson 2007). But perhaps the best-known composer of "game" compositions is John Zorn who created some 27 such works between 1974 and 1992.[62]

3.2.3.Developmental Nonlinearity

Developmental forms involve transformation of the identifiable materials, rather than contrast of divergent static structures. In this sense linearity and disjunction are subsumed in developmental works into the same process. Developmental strategies often attempt to balance disjunction and continuity, and this means that establishing a nonlinear formal structure requires distinguishing between discontinuities that can also be contextualised as elements of linear development and those result from ruptures in the formal structure.

In late Romantic and Post-Romantic eras composers pushed towards boundary of nonlinearity with formal strategies that challenged the contextualizing qualities of developmental structures such as Sonata form.

The development section in Sonata form opened a space for composers to explore transformations of musical materials introduced in the Exposition. Transformations, including modulation, motivic manipulation and so forth, increased the complexity of the formal structure by injecting a higher level of discontinuity. Composers in the Late Romantic and Post-Romantic periods increasingly exploited the disjunctive potential of the Development section, pushing Sonata form towards the boundaries of nonlinearity.

James Hepokoski describes such extended and hybrid forms as "deformations" of conventional structures, a term "most appropriate when one encounters a strikingly nonnormative individual structure, one that contravenes some of the most central defining traditions, or default gestures, of a genre while explicitly retaining others" (Hepokoski 1993 p. 143). Hepokoski's description of extended and hybrid forms as being "in dialogue with (...) generic norms" (Hepokoski 2002 p. 130), highlights their distinction from nonlinear formal structures through the contextualization of their discontinuities by existing models.

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[62] *Klarina* (1974), *Baseball* (1976), *Dominoes* (1977), *Curling* (1977), *Lacrosse* (1977), *Golf* (1977), *Hockey* (1978), *Cricket* (1978), *Fencing* (1978), *Pool* (1979), *Archery* (1979), *Tennis* (1979), *Track and Field* (1980), *Jai Alai* (1980), *Goi* (1981), *Croquet* (1981), *Locus Solus* (1982), *Sebastopol* (1983), *Rugby* (1983), *Cobra* (1984), *Xu Feng* (1985), *Hu Die* (1986), *Ruan Lingyu* (1987), *Hwang Chin-ee* (1988), *Bezique* (1989), *Que Tran* (1990) and *The Sand's Share* (1992).

The deviations of "Sonata Deformation"[63] are summarized in Table 8:

Progressive tonality	avoidance of a return the tonic key of the Exposition (Newlin 1947).
Strophic/Sonata Form Hybrids	oscillating between sonata and French strophic song Forms (Rodgers 2009 pp.4-5).
Break-through Deformation	an unforeseen inbreaking of a seemingly new (...) event in or at the close of the "developmental space" [which] typically renders a normative (...) recapitulation invalid" (Hepokoski 1993 p. 142).
Introduction-coda Frame	an approach that "gives the effect of subordinating 'sonata-activity' to the overriding contents of an encasing introduction and coda" (Ibid. p. 6).
Episodes within the developmental Space	in which "the space normally allotted to development is partially of wholly given over to one of more episodes" (Ibid. p. 7).
Rotational Form	"A structural process within which a basic thematic or rhetorical pattern presented at the outset of a piece (...) is subsequently treated to a series of immediate, though often substantially varied, repetitions" (Hepokoski 2001 p. 325).
Table 8: Categories of Sonata Deformation	

Although the practice of Sonata Deformation led to increasing levels of disjunction, the unambiguous and contextualising frame of the Exposition and Recapitulation placed such works, at least minimally, within the boundaries of linear structure. Sonata deformation was also accompanied by an increasing tendency towards gigantism, and interpolations of disjunctive material tended to be very extensive, in effect creating their own context in the same way as the movements of a suite.

The practice of tonal harmony is so deeply explored, and ubiquitous that there are structures that are able, due to elements such as harmonic rhythm, motivic content and degree of modulation, to be recognised out of context and outside of the specific narrative form which they spring. The rich syntax and formulaic practices of tonal harmony, developed over several centuries, make it *"particularly susceptible to such reorderings"* (Kramer, 1981 p. 545).

This phenomenon suggests structures with characteristic functions (coda, bridge and so forth), might be dislocated from their customary locations in the temporal ordering of a composition while still retaining some essential qualities of their traditional purpose. Kramer, controversially, holds that this is the case in

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[63] See Darcy, W. (1997). "Bruckner's Sonata Deformations", in Bruckner Studies, ed. Timothy L. Jackson and Paul Hawkshaw, Cambridge University Press: Cambridge pp.256–77.

Beethoven's *String Quartet in F Major Op. 135*[64] (Kramer 1973; Kramer 1988; Kramer 1996). Kramer states:

> The closing profile of m. 10 recurs in mm. 104-9 and 188-93 (the absolute time close) (...) The gesture of mm 5-10 is too final to simply be anticipation; the impact of m. 10 is too great to dismiss as foreshadowing. Rather, the movement has three endings; or, more precisely, the movement ends three times, always using the same cadential gesture. The three closing gestures do not refer to, or repeat, one another but are precisely the same moment (in gestural time) experienced thrice (in absolute time).
>
> (Kramer 1988 pp. 151-2)

Kramer does not propose that Opus 135 is a direct and absolute reordering of a concrete linear referent, rather that it is an exploratory recontextualisation of musical gestures. Kramer claims it creates two forms of time, the real time of the listener and the imaginary time of the abstract and expected formal order (Ibid p. 161). The two "endings" prior to the absolute, "real" ending of the work, for example, weaken the finality of the work, since they open the possibility that the work may continue beyond a "final" cadence.

A perhaps less contentious example of a nonlinear developmental form is Arnold Schoenberg's *String Trio Op. 45* (1946). In this work gestures proliferate, not only contrasted in the contextual manner suggested by Kramer, but parametrically contrasted - often by tempo, register, dynamic, articulation and melodic contour.

> It represents a dramatic departure from the kind of music he had been writing for twenty years. Gone are the traditional forms-sonata, rondo and so forth-The wide-arched Brahmsian themes, the classical methods of transformation and development. In its place we have little fragments, one after the other. Much of the material is quite disparate with improbable juxtapositions. The continuity is marked by interpolations, interruptions, even non-sequiturs, so that at time Schoenberg seems to be poised at the edge of incoherence.
>
> (Boykan 2004 p. 197-8)

The unusually disjunctive surface of *String Trio* is, in part, a reflection of an underlying extra-musical program: that the work was "a very detailed and realistic narration of his recent heart attack, including the doctors, the nurses, and so forth" (Ibid p. 197). Comments attributed to Schoenberg's pupil Leonard Stein (Bailey 1984 p. 156), claim that the composer described the work as a depiction "of time and events as perceived from a semiconscious or highly sedated state". However,

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[64] See also Lively (2000) and Barry (2005).

the disjunctions of the *Trio* cannot be explained away as simply programmatic. Dalhaus notes that extra-musical origins of the work are not recorded in the published score and claims "it would be inappropriate to describe it as programme music". He goes on to say, "the trio should be understood as autonomous music, as form and structure" (Dalhaus 1987 p. 103).

Even if we were to search for meaning in this work based upon an underlying programmatic narrative, the subject here is the fleeting, irrational nature of the mind under the influence of stress and anesthetic. Both Dalhaus (Ibid p. 104) and Arnold Whittall (1974 pp. 739–43) characterize the work as four movement Sonata form compressed into a single movement – a strategy employed in Schoenberg's early works *Pelleas und Melisande* and the *First Chamber Symphony, Op. 9*. Cherlin and others[65] have found this reading highly problematic.[66]

Kramer makes the point that despite its discontinuities, Op. 45 is not comprised of discrete non-developmental "Moments".

> Gestures are continually interrupted and transitions frequently do not go where they seem to be heading (...) Surely it does not represent a mosaic of discrete "moments", because the fragments that continually interrupt each other are neither static (the piece is full of directed energy, progressing rhythms, evolving textures, and stepwise pitch connections) nor self-contained (the fragments rarely cadence internally).   (Kramer 1988 p. 48)

However, the nonlinear disjunctions and disruptions in the work are readily evident in the score itself. There are 51 identifiable sections or blocks, comprising 22 types of musical material contrasted by a high degree of parametrical disjunction. In the work's 293 measures there are 41 tempo changes –the shortest of only one beat. Forward motion in the *Trio* is interrupted by 18 commas and pauses - the longest uninterrupted passages are of only 20 bars each (bars 18-38 and 85-104).

Figure 27 is an analysis of measures 35-70 of the Trio showing the disjunctions in texture, articulation/timbre, melodic contour, tempo and dynamic between sections of the work. Unlike Block Form compositions such as Stravinsky's *Symphonies of*

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[65] Cherlin 1998 pp.575-576, De Vito 2002, Boykan 2004 pp. 197-236, Mattes 2011 pp. 43–62.

[66] "First, it ignores strong correlations that interrelate the two episodes and distinguish them from the first and second parts. Both episodes, in addition to their distinctive row ordering, move through row areas related by three semitones, a technique uncommon in other sections of the work. Second, and more important, the recapitulation of the cantabile theme from Part 2 (beginning originally in m. 159 and recapitulated in m. 282) brings it into the row area of Part 1, while the recapitulation of the First Episode (beginning in m. 233) is without change of "key" (Cherlin pp. 575-576).

Wind Instruments however, the contrasting blocks of musical material are not monolithic, but continually varied throughout the evolution of the work.

Figure 27: Schoenberg *Trio Op. 45* bars 35-70, showing parametrically disjunct blocks of musical material by texture, articulation, melodic contour, tempo and dynamic. (Score Excerpt © 1950 Boelke – Bomart).

> The 'perpetual variation' is there all right, but the prominence of abrupt contrasts between relatively brief musical units is new: the greater the surface contrast, the more repressed the continuity.   Whittall 1974 p. 740

Schoenberg's *Trio* is perhaps ambiguous enough to escape definitive categorization, but is certainly a strong candidate for a hybrid form incorporating developmental principals and nonlinearity.[67]

3.3. The Referential Continuum

A nonlinear work can be classified according a referential continuum measuring the degree to which it comprises unique sonic material or refers to musical artifact(s) that bear a context external to the work. Referentiality is an established musical technique, present in musical compositions by major composers throughout the history of Western Music, including Machaut (c. 1300-1377) (Gallo 1985 p. 47), Bach (1685-1750) (Williams 2001 p. 102) and Berlioz (1803-1869) (Brooks 2003 pp. 10-13).

Reference to external musical sources assumes shared knowledge and usually implies that the listener both recognizes the reference and is able to contextualize it. In this sense referentiality is shorthand for communicating ideas, and its effectiveness and power is dependent on the relationship between the understood reference's understood meaning and the context in which it is being presented. This relationship is not stable. It is established anew with each hearing in relation to shifting cultural changes in the meaning of both the reference and its context. In a sonic environment where "radio, records, and more recently, tapes allow the listener to enter and exit a composition at will" (Kramer 1981 p. 543) the disjunctive listening experience has become increasingly naturalised.

Referential materials retain their fundamental sonic qualities: pitch, contour, dynamic and so forth and are therefore capable of parametrical disjunction in the same manner as abstract materials. However they also possess the ability to signify a larger sound object external to the work. This effect is amplified by the associations linked to the sound object itself which, in order to be evoked in the first place, generally bears its own context and meaning. This process of

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[67] Kramer also mentions Debussy's *Jeux* (1913), (as does Pasler 1982), Lucas Foss's *Time Cycle* (1960) and Harrison Birtwistle's *The Mask of Orpheus* (1970-83), as combining aspects of development and nonlinearity (Kramer 1988 pp. 48-49).

deterritorialisation (Deleuze and Guattari 2002 p. 538) of referential material when placed in a new context creates a particular opportunity for disjunctive rupture.

> The twofold nature of the process required that the music be distinctly recognizable as a representative of its original source, and yet appear to be reactivated in a new context. (Morgan 1978 p. 75)

In his article *Polystylistic Tendencies in Modern Music* (2002), Alfred Schnittke identified three categories of polystylistic composition common in music (see Table 9).

Stylistic Allusion	Reference to stylistic features and techniques associated with known musical styles.
Adaptation	Adaptation and hybridisation of known works or sounds
Quotation	Precise quotation of known musical works or sounds
Table 9: Categories of Polystylistic Composition (Adapted from Schnittke 2002 p. 87-90)	

All three of Schnittke's categories are capable of application in a nonlinear structure as a means of creating disjunction. The degree of specificity of each technique equates to their degree of referential abstraction, with stylistic allusion the most abstract and quotation the most concrete of the three forms.

The most common type of referential form is the collage, referred to by Burkholder as:

> The juxtaposition of multiple quotations, styles or textures so that each element maintains its individuality and the elements are perceived as excerpted from many sources and arranged together, rather than sharing common origins (...) Elements in a collage differ in key, timbre, texture, meter or tempo, and lack of fit is an important factor in preserving the individuality of each and conveying the impression of a diverse assemblage.
>
> (Burkholder 2001)

The point of origin for the disjunctive use of referential material must surely be Charles Ives. His exploration of quotation had an inherent tendency to open his music to ruptures in context and to the influence of the multiple temporal implications of the quoted material itself. Both of these issues brought the perception of linear progression in his music into question.

> The temporal, forward-directed nature of his music is deliberately thwarted by (among other things) passages of stasis and multiple quotations.
>
> (Thurmaier 2006 p. 30)

Ives' use of disjunctive referential material such as "polymeter, polytonality, the dense simultaneous layering of seemingly independent and contrasting elements, and quotations from traditional songs and march tunes" (Nelson 1984 p. 353) generally aided the formation of discrete strands of music in multilinear textures as previously discussed. The capacity for referential material to bind together horizontal strands of music in a multilinear texture is one of its key functions in regard to nonlinear structure. However, the converse is also true: that the specificity of referential material allows it to rapidly establish the identity of vertical blocks of music, enabling extremely abrupt juxtapositions as will be shown in the work of John Zorn.

3.3.1. Nonlinearity based on Quotation

The third movement of Berio's *Sinfonia: In ruhig fliessender Bewegung* (1968-9) is in many ways the acme of the nonlinear referential work. It revels in excess, bringing the use of musical quotation to an unheard of climax, in which references, allusions and appropriations are piled upon one another in a wild frenzy.

At the most fundamental level, the movement is a (nearly) complete quotation of the third movement of Mahler's *Second Symphony (The Resurrection)* (1894). Substantial passages from Samuel Beckett's *The Unnamable* (1958) are also overlaid throughout the work by a narrator, as a sort of running commentary to the performance. Mahler's work serves as a bed, or perhaps more appropriately, a river in which many hundreds of smaller quotations bob up and down in the current, while Beckett's text acts as a context for the proceedings.

At the next level are hundreds of passages, some extremely short and obscure, from works by composers from Bach to Stockhausen. There is also self-quotation and additionally (in the first performance and recording) musical quotes from the conductor's own works (Pierre Boulez). A chamber choir articulates of a wide range of language fragments including songs, solfégè, radical slogans, clichés of 'Classical-Orchestral-Audience' conversation, as well as grunts and noises. Finally there are self-referential asides apparently to the audience *"You can't leave, you're afraid to leave, you make the best of it"*, and places to fill in details about the current performance. These include speculations about its reception in the press, a jazz-style '*thank you*' to the vocal soloists, and in the last bar a '*thank yo*u' to the audience and conductor.

Schnittke claims Berio's approach

> represents a new, more generalized type of thematicism, in which the semantic unit is not confined to an intonation as such, with its conventional expressive responsibility, but rather to an entire intonational bloc (the quotation), an intonational coalition with an enormous range of emotional, stylistic, and historical associations.   (Schnittke 2002 p. 216)
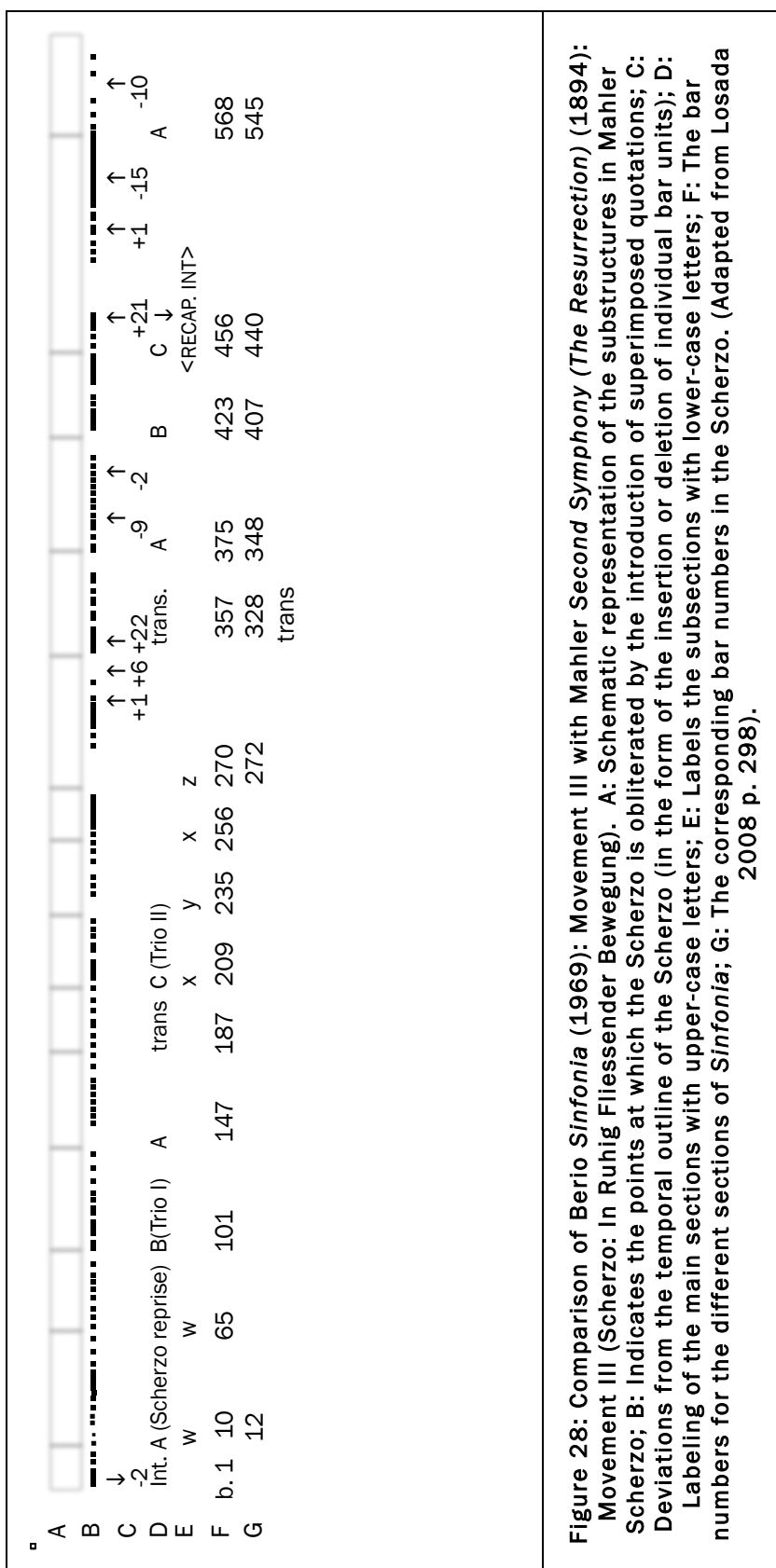
Sinfonia's excess takes the quality of knowingness and 'in-joke' inherent in quotation to its absurd extreme. The form and function of its quotations are diverse. Some references are obvious to the uninitiated - such as the asides to the audience and "thank-you's". Other references are probably readable by the initiated - such the quote from Debussy's *La Mer* (1905) that bubbles up following the line "the sea". While others remain obscure and inexplicable to all but the most obsessive allusion hunter.

> a subtle network of hints, allusions, and oblique associations that unify all the seemingly disconnected images into a poetic musical picture of the modern world being shaken and torn apart.   (Schnittke 2002 p. 221)

The structural implications of the abundant quotations in the *Sinfonia* have been explored in detail (Osmond-Smith (1981 and 1985), Hicks (1981-2), Burkholder (1994 and 2001) and Metzer (2003)). Interestingly, these commentators sometimes reach opposing views in regard to the structural effects of this network of intertextual associations. Hicks claims "the movement is best viewed as a setting and interpretation of that text (The Unnamable): it is a book turned into music" (1981-2 p. 207) while Osmond-Smith views the work as a commentary upon the Mahler *Scherzo* (1981 pp. 39-71). The assumption in both cases is that the formal concerns are subsumed by the nonlinear interjections of commentary and quotation.

Catherine Losada's two penetrating studies of the work (2008 and 2009) demonstrate the co-existence of "inner" and "outer" formal structures: an outer form that "for the most part conforms to the structure of Mahler's Scherzo" and the inner form in which the "interplay of disparate elements, musical languages, and musical styles (…) subsumes the structure of the Scherzo" (2009 pp. 64-66). Losada's characterisation of the work as exhibiting two simultaneous formal structures supports the view of the movement as a multilinear structure where "everything happens at once" (Deleuze and Guattari 2002 p. 328).

Figure 28 shows Losada's schematic representation of the third movement of *Sinfonia* illustrating the relationship between the formal structure of Mahler's *Scherzo* and its super-imposed interruptions.

A																		
B																		
C	→-2							+1 +6 +22	-9	-2		+21	+1	-15	-10			
D	Int. A (Scherzo reprise)	B(Trio I)	A		trans C (Trio II)				trans. A		B	C			A			
E	w w				x y x z							<RECAP. INT>						
F	b.1 10	65	101	147	187 209 235 256 270			357 375			423	456			568			
G	12				272			328 348			407	440			545			
						trans												

Figure 28: Comparison of Berio *Sinfonia* (1969): Movement III with Mahler Second Symphony (*The Resurrection*) (1894): Movement III (Scherzo: In Ruhig Fliessender Bewegung). A: Schematic representation of the substructures in Mahler Scherzo; B: Indicates the points at which the Scherzo is obliterated by the introduction of superimposed quotations; C: Deviations from the temporal outline of the Scherzo (in the form of the insertion or deletion of individual bar units); D: Labelling of the main sections with upper-case letters; E: Labels the subsections with lower-case letters; F: The bar numbers for the different sections of *Sinfonia*; G: The corresponding bar numbers in the Scherzo. (Adapted from Losada 2008 p. 298).

Losada demonstrates that the patina of quotations generally thins at pivotal points in the *Scherzo*'s formal structure, allowing the transitions between substructures to be heard.

> quotations are generally layered over the Scherzo such that they serve to coincide with or are even made to emphasise important formal subdivisions. Within these inherited boundaries, however, the thematic substance of the Scherzo is typically dismembered, sometimes disappearing altogether from the texture, at other times appearing in juxtaposition with other fragments.
>
> (Losada 2008 p. 298)

Similarly, Osmond-Smith notes that despite the

> ruthless fragmentation of the surface structure of Mahler's Scherzo in the third movement of Sinfonia, no listener acquainted with the original is likely to level (...) accusations of random selection since the underlying metric and formal structure is preserved by Berio for the greater part of the movement- thus allowing the listener familiar with the original to pick up the shattered syntactic thread with relative ease.   (Osmond-Smith 1981 p. 247)

Osmond-Smith and Hicks have noted in detail the referential connotations of the appearance of particular works in relation to Mahler's music and Beckett's text. While acknowledging the importance of these connections, Losada identifies a number of techniques employed by Berio to integrate the many disparate quotations into a the work while maintaining at least a minimal sense of continuity, "creating relationships which are akin to the sophisticated types of modulatory techniques that operate in tonal music on both local and large-scale levels" (2009 p. 324). Consequently, she is able to show that Berio chooses specific passages from each piece because of their aptitude to disjunctive or integrative treatment.

The categories of disjunctive and integrative collage techniques developed by Catherine Losada are listed in Table 10. The term integrative here refers to ability to smoothly transition between or superimpose quotations onto the underlying continuity of the Scherzo "cantus firmus"; in this sense the continuity aids retention of "the underlying metric and formal structure". In this sense it is comparable to filmmaker Andrei Tarkovsky's (1932-1986) notion of "time-pressure":

> The distinctive time running through the shots makes the rhythm (...) rhythm is not determined by the length of the edited pieces, but by the pressure of the time that runs through them.   (Tarkovsky 1996 p. 117)

Integrative Techniques	
Pitch Convergence	Pitch connections which support the process of transition between disparate elements. (2008 p. 302)
Textural Dispersal/ Emergence	Two simultaneously sounding quotations are subjected to a process of fragmentation. For example: one source is gradually dispersed while another gradually emerges. (ibid p. 310)
Pitch-based Overlap	Material inserted between the quotations bridges the pitch domains of the elements it connects. (ibid p. 305)
Rhythmic Plasticity	The rhythmic profile of the music is manipulated in order gradually to introduce or to lead away from a quotation. For example by increasing rhythmic complexity towards a quotation featuring a faster rhythmic momentum. (ibid p. 302)
Disjunctive Techniques	
Chromatic Complementation	Disparate quotations are brought into relationship with one another in a manner that seeks to build upon by combine to create progressively larger collections. (2009 p. 61)
Chromatic Saturation	The musical space is completely filled in through the appearance of each one of its constituent members as a result of chromatic complementation. (ibid p. 61)
Table 10: Categories of integrative and disjunctive collage techniques identified by Catherine Losada.	

The concept of Time-Pressure acknowledges the internal momentum of a shot, "direct perception of time that exists and emanates from the shot" (Menard 2003 p. 5), as something independent of its narrative content. In an analogous manner these integrative techniques assist the retention of continuity and momentum at one level while allowing the independent juxtaposition of referential material at another. This idea supports Losada's notion of "inner" and "outer" formal structures acting simultaneously in the movement.

The third movement of *Sinfonia* is a true 'tour-de-force' encapsulating the inner-sanctum knowingness and in-jokery of the Avant Garde along with absurdist self-referentiality of *The Goons* and *Monty Python's Flying Circus* that was such a key feature of the late 60s.

3.3.2. Nonlinearity based on Stylistic Allusion

Much of John Zorn's opus employs referential material, taking the split second channel-hopping of the technological age and realizing it in a live context. Speed is a crucial factor for Zorn.
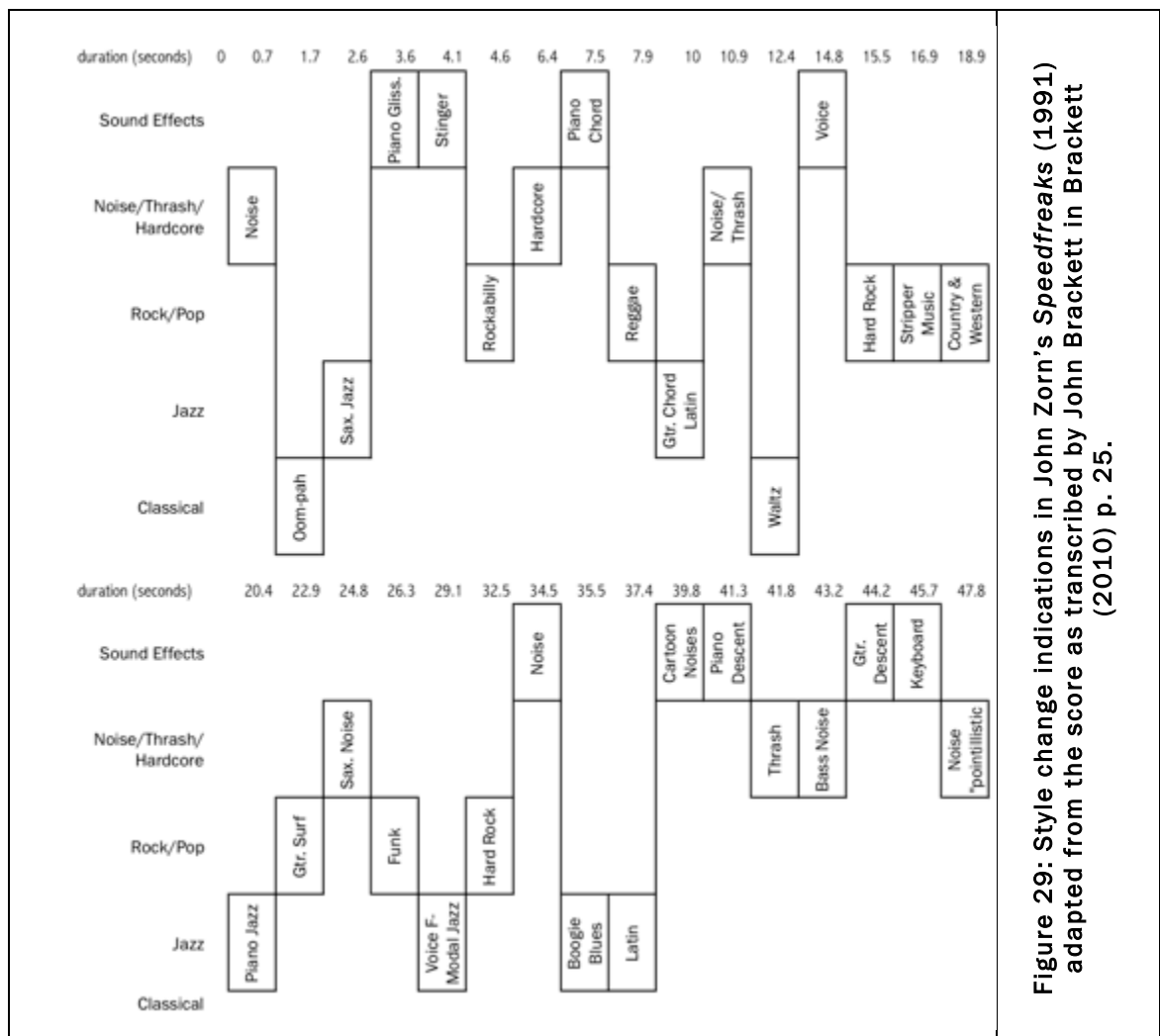
> I believe that in a technological situation like the present one, where we are exposed to thousands of stimuli and in which information moves faster and

faster, it is necessary to keep up with these things: it is a way of life and of thinking and we have to come to terms with it.'

(Zorn in Rovere and Chiti 1998 p. 11)

Particularly in the work of Zorn's *Naked City* project, stylistic contrasts, generally signifying formal differentiation, are accelerated to an unprecedented degree.

The *Naked City* work *Speedfreaks* (1992) is only 48 seconds long and contains no less than 32 substructures[68] (marked by extreme changes of instrumentation, style and genre). The average length of each substructure then is under two seconds; the shortest is half a second and the longest nearly four seconds. Only two style indications are repeated (although several of the indications only vary in orchestration). The style change indications are shown schematically in Figure 29, grouped into five principal musical genres.

Figure 29: Style change indications in John Zorn's *Speedfreaks* (1991) adapted from the score as transcribed by John Brackett in Brackett (2010) p. 25.

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[68] Brackett claims that the 32 subsections are a deliberate evocation of 32-bar song form. (Brackett 2010 p. 25)

The work is not fully notated, but rather represented pragmatically in the style of a jazz "chart", albeit with extended notation. Figure 30 shows the opening of the score for the Zorn's *Snagglepuss* (1992). The range of Zorn's succinct but effective notation is demonstrated within the space of these first six sections, including in this example: traditional notation, chord symbols, graphics, instructions pertaining only to dynamics or instrumentation, stylistic allusions and dramatic visual images.

Figure 30: The First Six Sections of John Zorn's *Snagglepuss* (1992). (Score excerpt © 1992 John Zorn).
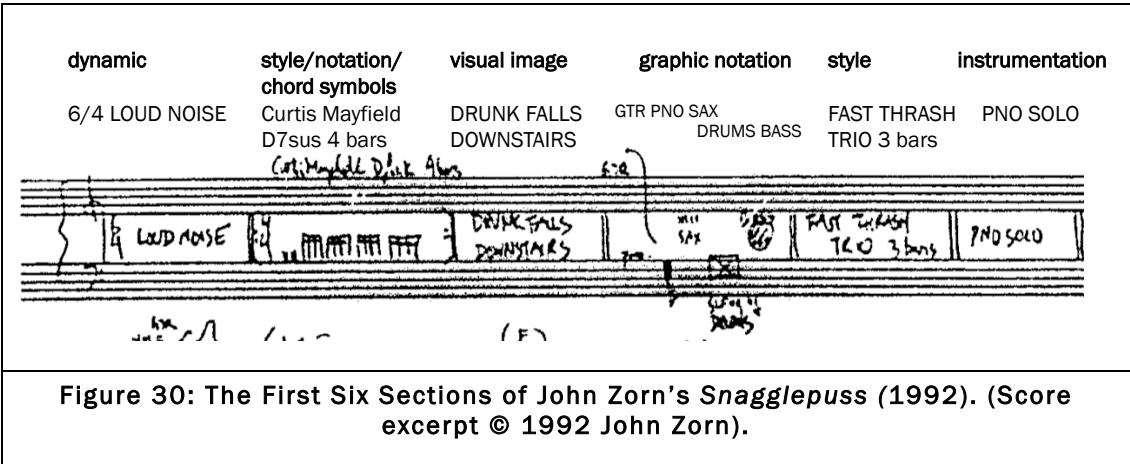
Virtuoso performers are clearly necessary to render such notation extremely rapidly, while making transitions that are both abrupt and smooth, contrasting but homogenous enough to maintain the momentum of the work. Indeed Zorn acknowledges the crucial contribution of the performers, not only on a purely virtuosic level, but also as bearers of musical experience.

> Each Musician has his own musical world in his head so that, as soon as he gets involved, is interested and excited, he's going to add his world to it. That makes my piece, my world, deeper.'   (Zorn in Rovere and Chiti 1998 p. 13)

Zorn's comments underline the function of referential material in evoking sound "worlds" external to a work and therefore enabling juxtapositions that are deeper than just the parametrical divergence between their musical materials. The fact that such wildly gear-changing transitions as those found in Zorn's *Naked City* compositions, can be comprehended (let alone performed) suggests that the minimum length of a substructure in a nonlinear work may be very short provided that the disjunctions are very pronounced.

The implication here is that the employment of referential strategies aids the definition of very short substructures. Half a second is listed by Pressing as within the temporal domain of a "single note" (Pressing 1993 p. 110). It is impossible to

imagine how disjunction could be established without referentiality in such a short time span.

This raises the issue of the boundaries of substructure duration in nonlinear works. Ole Kuhl and Kristoffer Jensen have spoken of an average length to formal substructures, claiming that most music

> is structured in such a way that a formal change takes place every 30–40 seconds or so (…) this innate tendency of human cognition to structure and group musical sound into sections of certain proportions is difficult to explain. It may be tied to the limitations of our working memory as suggested by some; or it could be seen as the product of an attention cycle, that would then be the result of the need of the human brain to perform an attention switch every so often in order to reorganize its content. (Kuhl and Jensen 2007 p. 263)

This would mean that substructures greater than forty seconds would be increasingly reliant upon contextualization and conjunction horizontally, within their own boundaries to retain a sense of continuity. Substructures shorter than thirty seconds by contrast would be more reliant upon decontextualisation and disjunction at their boundaries, from external substructures, to establish a sense of discontinuity from the surrounding texture (see Figure 31).
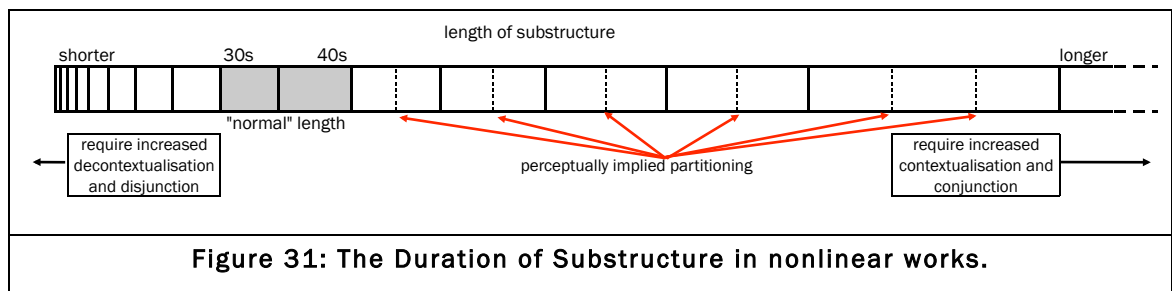

Figure 31: The Duration of Substructure in nonlinear works.

Therefore in works comprising of extremely short or extremely long substructures, it would be expected to find composers turning to narrative, and more importantly, referential techniques to assist in defining subsections. The fact that multilinear works with extended substructures (such as *Sinfonia* third movement) and sequential works with very abbreviated substructures (such as *Speedfreaks*) both employ referential strategies, supports this view. LeBaron quotes John Oswald as claiming that familiarity may allow the identification of a sample at the very limits of perception.

> At what point does a fragment lose its recognizability? Surprisingly, Oswald claims that he can recognize a sliver measuring twenty milliseconds (a 50th of a second), provided that he's already familiar with the piece to which it belongs. (LeBaron 2002 pp. 52-3)

Oswald's exploration of quotation, as part of his "plunderphonics" projects, has tested the minimal limits of substructural duration. His work *Z*, takes as its source the already radically "cut-up" music of John Zorn's Naked City and digitally reduces its fragmented structure beyond the possibilities available with live performers:

> in fourteen seconds, he rips through 47 edits of 35 sound slices, each between 1/20 and 1 second long. With his choices of fragments and their ordering, Oswald not only captures the breathless, manic energy of the band, but also invokes a kind of sonic fingerprint that encapsulates the essence of Naked City. (LeBaron 2002 p. 51)

In contrast we might mention the soundworld of Glitch, a genre that draws in part on the digital techniques outlined by Curtis Roads in his book *Microsound* (2002). Phil Thomson describes Microsound as an

> approach to music composition and analysis which places emphasis on extremely brief time-scales, usually a tenth of a second or less, as well as an integration of this micro-time level with the time-levels of sound gestures, sections, movements and whole pieces (2004 p. 207).

Despite the focus upon fragmentation, "mangling" or "crunching" as Cascone refers to it (2000 p. 12), much of the Glitch genre reserves its focus for nonlinear disruption of the musical surface rather than of musical structure. Perhaps belying it origins as a "more or less explicit reaction to the predominant form of electronic music in pop culture, which is rave-oriented techno" (Thomson 2004 p. 212), a survey of the *Clicks & Cuts* compilations of Glitch music by the label Mille Plateaux[69], suggests that the formal structures derive more from the "build and breakdown" models of dance music, than from than sequential or multilinear models[70].

3.4. The Three Continuums of Nonlinear Structure

The continuums of nonlinear structure outlined in this chapter may be combined to create a three-dimensional classification of nonlinear structure as shown in Figure 32.

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[69] Clicks & Cuts Volumes 1 (2000), 2 (2001), 3 (2003), 4 (2004) and 5 and 5.1 (2010) (Mille Plateaux: Frankfurt).

[70] This is not to say that examples of nonlinear structure do not exist in Glitch and other relates genres. *Gwarek2* from the Aphex Twin (Richard D. James) album *Drukqs* (2001) for example is an exemplar of a sequential (or partially overlapping) nonlinear structure, comprising disjunctive samples of voice, processed voice, with synthesised and processed concrete sounds.

Figure 32: The three-dimensions of classification of nonlinear structure.
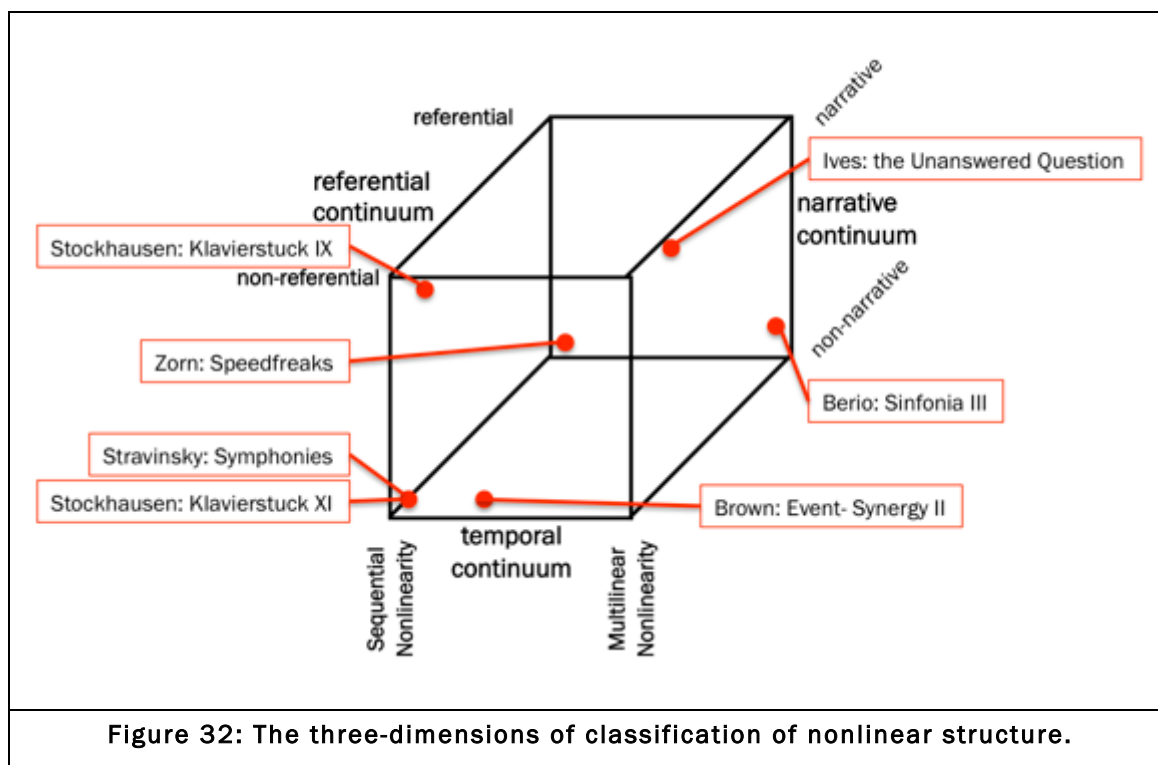
In abstract (nonreferential) nonlinear structures, the listener cannot attribute structure to an already existing mental schema and is therefore forced to create a novel structural interpretation based principally on the work's constituent features. Sequential works such as Stravinsky's *Symphonies of Wind Instruments* and Stockhausen's *Klavierstück XI* can be plotted upon the "Sequential Nonlinearity/Non-Narrative/Non-Referential" axis of this space. Works allowing for some overlap of nonlinear substructures, such as Earle Brown's *Event Synergy II,* would be plotted further towards the Multilinear axis of the temporal continuum.

Narrative and Referential nonlinear works must also always be evaluated against the temporal continuum. Stockhausen's *Klavierstück IX* would be plotted towards the narrative pole of the Narrative Continuum and near the sequential pole of the temporal continuum, for example, as there is a small degree of overlap of several subsections in the work. Berio's *Sinfonia* third movement would lie at the multilinear pole of the temporal continuum, at the referential pole of the referential continuum and near the centre of the narrative continuum (as there is significant formal momentum generated by the underlying structure of the Mahler Scherzo that is heard for the majority of the work).

Figure 33 evaluates all of the works referenced to this point against the temporal, narrative and referential continuums. It highlights the diversity of possible approaches to engendering nonlinearity in a musical structure.

Continuum	Approach	Work	Sequential	Multilinear	Non-narrative	Narrative	Non-referential	Referential
The Temporal Continuum	Block Form/Montage	*Symphonies of Wind Instruments*	■		■		■	
	Mosaic	*Regard de l'Onction Terrible*	■		■		■	
	Mobile/Polyvalent	*Klavierstuck XI*	■		■		■	
	Moment Form	*Momente*		■	■		■	
	The Open Work	*Event Synergy II*		■	■		■	
	Multilayered Form/Superposition	*The Unanswered Question*		■		■	■	
	Palimpsest	*Sinfonia*		■	■			■
The Narrative Continuum	Processual Nonlinearity	*Klavierstuck IX*	■			■	■	
	Game-based Narrative	*Duel*		■		■	■	
	Developmental Nonlinearity	*String Trio Op. 45*	■			■	■	
The Referential Continuum	Quotation	*Putnam's Camp*		■		■		■
	Stylistic Allusion	*Speedfreaks*	■			■		■

Figure 33: The works discussed in Chapters One and Two evaluated against the temporal, narrative and referential continuums.

Figure 34 provides a chronological overview of the musical works discussed in this chapter categorised according to the proposed nonlinear formal structures.

The Temporal Continuum

Sequential — Block Form/Montage, Mosaic
Mobile/Polyvalent
Moment Form, The Open Work
Multilayered Form/Superposition

Multilinear — Palimpsest

The Narrative Continuum — Processual Nonlinearity, Game-based Narrative, Developmental Nonlinearity

The Referential Continuum — Quotation, Stylistic Allusion

Works (chronological, 1998–1908):

- Sciarrino: Sonata V
- Takemitsu: Archipelago S.
- Adams: John's Book of Alleged Dances
- Zorn: Speedfreaks
- Birtwistle: The Mask of Orpheus
- Schwanter: Aftertones of Infinity
- Zorn: Cobra
- Xenakis: Palimpsest
- Birtwistle: Carmen Arcadiae Mechanicae Perpetuum
- Rasmussen: Berio-Mask: A Palimpsest
- Birtwistle: Verses for Ensembles
- Berio: Sinfonia
- Zorn: Klarina
- Cage: Reunion
- Brown: Event-Synergy II
- Kagel: Match
- Stockhausen: Momente
- Stockhausen: Mixtur
- Messiaen: Couleurs de la cité céleste
- Boulez: Third Sonata
- Xenakis: ST/4
- Xenakis: Strategie
- Tenney: Collage #1 "Blue Suede"
- Stockhausen: Kontakte
- Stockhausen: Klavierstück IX
- Pousseur: Repons
- Xenakis: Duel
- Foss: Time Cycle
- Pousseur: Scambi
- Cage: Winter Music
- Stockhausen: Klavierstück XI
- Brown: Folio and Four Systems
- Feldman: Intermission 6
- Cage: Imaginary Landscape No. 5
- Schaeffer: Étude aux Chemins de Fer
- Brown: December 1952
- Messiaen: Turangâlila-Symphonie
- Cage: Credo in US
- Messiaen: Vingt regards sur l'enfant-Jésus
- Schoenberg: String Trio Op. 45
- Messiaen: Cantéyodjayâ
- Kagel: Prima Vista
- Benjamin: Palimpsest I
- Stockhausen: Klavierstück I
- Ives: The Unanswered Question
- Ives: Putnam's Camp
- Stravinsky: Symphonies of Wind Instruments
- Debussy: Jeux

Years listed: 1998, 1994, 1993, 1992, 1984, 1983, 1979, 1978, 1977, 1976, 1974, 1969, 1968, 1967, 1964, 1963, 1962, 1961, 1960, 1959, 1957, 1956, 1954, 1953, 1952, 1948, 1946, 1944, 1942, 1920, 1913, 1912, 1908
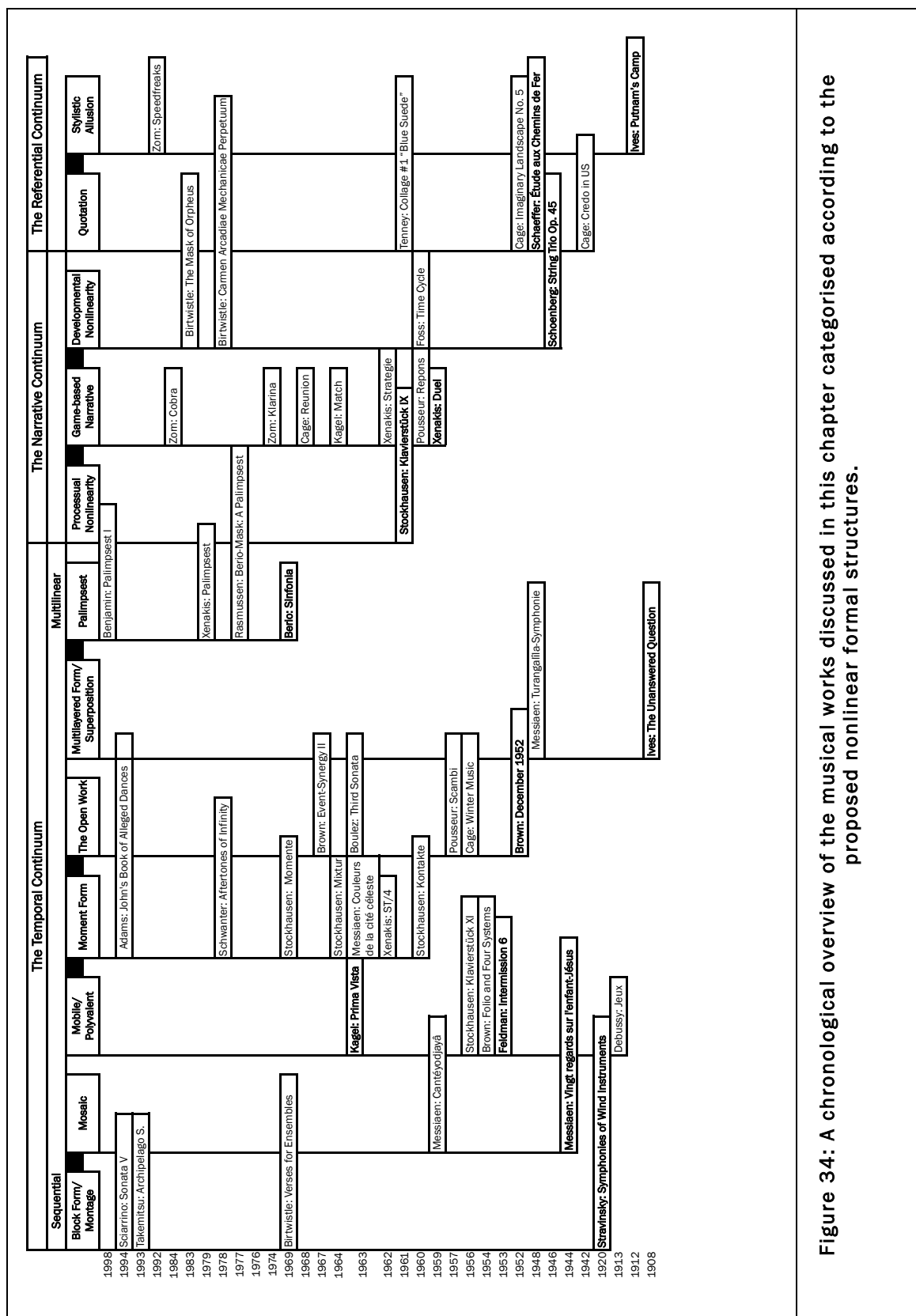
Figure 34: A chronological overview of the musical works discussed in this chapter categorised according to the proposed nonlinear formal structures.

4. Compositional Techniques for Nonlinear Works

This chapter contextualises the emergence of nonlinear structures in music against the background of the rapid cultural, ideological, scientific, technological and compositional shifts, that have occurred since the beginning of the Modernist era. These shifts are indicated as promoting the ideology of nonlinearity that is evident in the works discussed in the previous chapters. In the final section, the evolution of music notational practices from avant-garde-era experiments in 'mobility' to the advent of the digital 'screen score' is charted. The varied goals of the composers who initiated these developments and the dissonance between these goals and the practical possibilities actually afforded by the paper score are also considered.

4.1. The Contribution of Cultural, Ideological, Scientific and Technological Shifts to the Emergence of Nonlinearity in Music

Nonlinearity in music has arisen in a time of cultural transformations that include the increasing diversity and pluralism of society caused by mass inter-cultural migration and the exponential growth in the speed and ubiquity of communication. Jean-François Lyotard claims that the evolving conditions of contemporary society result in the dissolution of the linear meta-narratives or 'grand narratives' of cultural ideologies. He claims "heterogeneity, for lack of a common idiom, makes consensus impossible" (Lyotard 1988 p. 92) and that as a result "history does not necessarily have a universal finality" (Lyotard 1992 p. 51). These claims echo Berio's definition of nonlinear structure as "an agglomeration of events, without any prearranged center" (Berio 2006 pp. 97-98). Kramer too, notes that cultural pluralism has played an important role in the development of nonlinearity:

> One factor contributing to the increase of discontinuity was the gradual absorption of music from totally different cultures, which had evolved for centuries with virtually no contact with Western ideas. (Kramer 1981 p. 543)

Some of the key early influences that arguably promoted the emergence of nonlinearity were: Debussy's contact with the temporally cyclic music of Indonesia in 1883) (Kramer 1981 p. 540)[71]; Ives' exposure to pluralistic transcendental aspects of Eastern philosophies through Ralph Waldo Emerson and Henry Thoreau

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[71] See also Smith and Potter 2005 p. 215, Cooke 1997 p. 259 and Gerstle and Milner 1995 p. 2.

(Bellamann 1933 p. 48)[72], Messiaen's contact with the "timeless" musical concepts of ancient Greek music through Marc Dupré and Maurice Emmanuel and study of the 13th century Hindu music treatise The *Samgitaratnakara of Carnagadeva* (Rischin 2006 p. 52)[73], and Cage's study of nondevelopmental aspects of Hindustani music with Gita Sarabhai and nonintentionality and immanence[74] in Zen Buddhism under D. T. Suzuki (Pepper 1997 p. 34)[75].

Concurrently in the Sciences, notions of "time and space" were the focus of new scientific re-evaluation throughout the century.

> Max Planck's 'quantum hypothesis' (1900), Albert Einstein's 'special theory of relativity' (1905) and Neils Bohr's model of the atom (1913) undermined Newton's theory that the world was stable and mechanically ordered.
>
> (Hall 1996 p.2)

Delaere and Daly have proposed that the scientific models that replaced universality with subjectivity were analogous to the fragmentation of language in Western music: from an overarching "common practice", to "schools" (such as Neoclassicism and Serialism), to individual idiolects in which each composer's influences, methodology and technique are predominantly governed by individual concerns.

> In the first half of the twentieth century the idea gained currency that in music too a system was not so much a physical reality and an eternal universally valid law, but rather one of the possible devices used by man to impose order on external reality. (...) objective reality outside the mind of the observer was called into question (...) Alternative compositional intentions can require alternative forms of arrangement or systems (manners of approach to musical reality), and this is precisely what occurred.   (Delaere and Daly 1990 p. 20)

Stockhausen (Stockhausen 1989 p. 10)[76], Ligeti (Lochhead 2001)[77] and Xenakis

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[72] See also Riepe 1967 p. 115, Cowell 1969 p. 94, Rosa 1971 p. 437, Hepokoski 1994 p. 747, Whitesell 1994 p. 314, LeBarron 2002 p. 59 and Thurmaier 2006 p. 30.

[73] See also Fulcher 2002, Pickstock 2008 and Healey 2008.

[74] Deleuze defines as "a pure stream of a-subjective consciousness, a pre-reflexive impersonal consciousness, a qualitative duration of consciousness without a self" (2001 p. 29). Compare Cage's description of his *Winter Music* (1957):" sounds were just sounds, and (...) since the sounds were sounds, this gave people hearing them the chance to be people, centered within themselves, where they actually are, not off artificially in the distance as they are accustomed to be" (Cage 1985 p. 134).

[75] See also Shultis 1995 p. 31, Kahn 1997 p. 564, Ross 2007 p. 404, Perloff and Junkerman 1994 p. 1 and Clark 1970 p. 356.

[76] See also Morgan 1975, Coenen 1994 and Koenigsberg 1991.

[77] See also Steinitz 1996a, 1996b and 1996c.

(McHard 2006 p. 212)[78] in particular have acknowledged the importance of developments in the sciences to their work.

> Science and art share this use of logic and metaphor in their practices. Artists and scientists have utilised the power of the metaphor since the genesis of their disciplines. (Sturm 2001 p. 144)

The connection between developments in the understanding of the workings of the mind, initially psychology and psychoanalysis and more recently cognitive modeling and neuroscience have been, and continue to be influential. The influence of the ideas of Freud fed directly into the post-tonal language of Schoenberg[79] and the Second Viennese School. Schoenberg wrote in 1926:

> Tonality's origin is found – and rightly so – in the laws of sound. But there are other laws that music obeys, in addition to these, namely those governing the workings of our minds. (Schoenberg 1992 p. 259)

James Tenney in his entry on "Form" in the Dictionary of Contemporary Music speaks of "subconscious, irrational thought-processes (…) still related to the older rhetorical model in its implication that some kind of idea (or "thought-process") is being communicated" as the first two of four new experiential models in 20th-century music. The pursuit of psychological "mind-like" qualities in composition has been (and remains), a strong element of composition, involving "the "irrational" juxtaposition and superimposition of otherwise "rational" clangs[80] and sequences" (Tenney 1970 p. 17). Rosenboom goes as far as to claim "it is appropriate to view the act of musical composition, at least in part, as an act of cognitive modeling" (1987 p. 441). This approach supported the exploration of nonlinearity as a means to represent these aspects of thought through musical structure.

Linearity was also challenged by technology. The advent of visual and audio recording technologies allowed for the unprecedented manipulation of temporal events "outside" of time.[81] For music, the invention of recording techniques in

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[78] See also Xenakis 1987 and 1992, Sward 1981 and DeLio 2001.

[79] See Adorno 2002, Carpenter 2002 and Feder 2004.

[80] Tenney's term "Clang" denotes "singular configurations of elements, forming gestalt units at the second hierarchical level." (Tenney 1970 p. 3).

[81] Askew and Wilk list the following dates for the emergence of a range of technologies: Communications: Telephone (1876), Satellite Communication (1957), the Internet (1969), World-Wide Web (1990); Media: Phonograph (1877), Motion Pictures (1895), Radio Broadcasting (1920), Television (1933), Long-play Records (1948), Audio CD (1982), DVD (1997), MP3 (1999); Computing: Mainframe Computer (1946), Microcomputer (1975), Laptop (1976) (Askew and Wilk 2002 pp. x-xi))

particular, had far-reaching consequences for the way that music could be listened to and manipulated. Kramer states:

> (Recording) brought distant and ancient musics into the here and now. (…) allow(ing) the listener to enter and exit a composition at will. (…) An overriding progression from beginning to end may or may not be in the music, but the listener is not captive to that completeness. Tape can be spliced; thus, events recorded at different times can be made adjacent.   (Kramer 1981 p. 543)

Technological advances have provided an enhanced means to explore juxtaposition, both through the expansion of potential content and the ability to transition seamlessly and rapidly between contents. As early as the 1950s Cage was exploiting these qualities in works such as *Imaginary Landscape No. 4 (March No. 2)* (1951) (for 24 performers at 12 radios) and *Imaginary Landscape No. 5* (1952) (for magnetic tape recording of any 42 phonograph records). The practice of exploiting emerging technology for subversive purposes has continued through the work of artists such as Christian Maclay, Yasunao Tone, Markus Popp, Toshimaru Nakamura and others[82].

The advent of the computer added the capacity for random access to temporal locations within a file, to link materials together, group according to categories, and to access them through increasingly subtle interfaces.

4.2. Compositional Factors Contributing to the Emergence of Musical Nonlinearity

Over the course of the Twentieth Century there was a rapid and significant expansion of the range of materials and methods utilised by composers. These changes expanded the potential for the exploration of nonlinear structures in musical compositions through musical styles and ideologies that promoted disjunction, through the potential for increased discontinuity between musical materials afforded by the broadening of the sonic pallet and other novel methods of nonlinear choice for ordering of musical materials.

It is important to note that although a number of compositional techniques have been developed that involve nonlinear or potentially nonlinear *processes*, such as chance, "automatism", probability and "found systems", such approaches do not necessarily give rise to nonlinear formal structures.

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[82] See Kelly 2009, Holmes 2008, Cascone 2000, Thomson 2004 Stuart 2003 and Tone 2003.

To illustrate this issue, consider the example of *Musikalisches Würfelspiel* (1792) a set of rules and musical materials allowing minuets to be (literally) cast according to coin tosses. This work, attributed to Mozart (O'Beirne 1967), is frequently cited as a precursor both to aleatoric music and algorithmic music.[83]

The indeterminate nature of choices delivers minuets that are analytically indiscernible from those composed in the traditional, supposedly determinate, manner (this is of course the paradoxical diversion of the "game"). Here the syntax of the tonal structures necessary to produce a minuet are sufficiently simple that a large number of possible "solutions" are admissible to maintain a convincing continuity, so that any choice will yield an acceptable outcome.[84]

> The material is arranged in the charts in such a way that all compositional problems such as cadences are automatically adjusted and the compositional process is reduced to a game of throwing dice and matching measure numbers. By using repeat signs and a chart for the B material, a composition eighty measures in length is generated, having the form AABB aabb AB.
>
> (Husarik 1983 p. 7)

The compositional technique employed in creating a *Musikalisches Würfelspiel* minuet is nonlinear according to Kramer's definition that *"the generation of each event* (is) *independent of all others"* (Kramer, 1981 p. 554). The fact that it is still capable of producing a linear formal structure underlines the independence of compositional methods and formal outcomes. In the dice game minuet, linearity is provided by the high degree of continuity between its musical components, indeed the composer calculated them to fulfill a dependably linear outcome.

In 1969 Mozart's compositional techniques were revisited in an altogether different context in John Cage and Lejaren Hiller's multimedia work *HPSCHD*. A computing student Edward Kobrin (Cage and Kostelanetz 1988 p. 41) created a program called DICEGAME that algorithmically encoded the *Würfelspiel* rules (Husarik 1983 p. 7). Using this program, Cage and Hiller generated seven harpsichord solos, substituting the original musical material created with linear implications by Mozart, with selections from Mozart piano sonatas, "Beethoven's *Appassionata* Sonata; Chopin's *Prelude in D Minor, opus 28*; Schumann's "Reconaissance" from *Carnaval;*

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[83] See Schwartz and Godfrey (1993) p. 227, Roads (1996) p. 823, DiMartino (1999) p. 16, Cope (2000) p. 82, Cope (2000) p. 110, Zbikowski (2005) p. 140, Ciprut (2009) p. 248

[84] For a discussion of this issue see Boehmer (1967) p. 43. And de Groot (1997) p. 202. An online Minuet generator using the *Musikalisches Würfelspiel* to realise Minuets can be found at http://sunsite.univie.ac.at/Mozart/dice/

Gottschalk's *The Banjo*, Busoni's *Sonatina no. 2*; Cage's *Winter Music*; and Hiller's *Sonata no. 5"* that were chosen at random according to coin tosses (Heimbecker 2008 p. 493).

Cage and Hiller's realizations of the *Würfelspiel*, comprising musical materials that were not chosen according to any overarching continuity, result in nonlinear structures, despite the ordering of their segments being generated using the same nonlinear process as the original Mozart version: as summarised in Table 11.

	Technique	Material	Structure
Mozart: Würfelspiel	Nonlinear	Linear	Linear
Cage/Hiller: Dicegame	Nonlinear	Nonlinear	Nonlinear
Table 11: A comparison of the structural outcomes generated from Mozart's *Würfenspiel* games.			

These two examples point to the primary function of disjunction between the musical materials themselves in the determination of nonlinearity in a formal structure. The following discussion points to developments in musical language that provide the opportunity for the exploitation of greater disjunction between musical materials through the expansion of the sonic pallet, compositional techniques resulting from parametric thinking,

4.2.1. Expansion of the Sonic Pallet

From the beginning of the century numerous "manifesti" presented radical new visions for the future of music.[85] Many composers strove to reach beyond the limits of "common practice", exploring the sound-world beyond traditional instruments and instrumental techniques and new forms of generating musical materials and structure.

> The pitch domain has grown from a handful of tones as basis to a universe of infinite possibilities. Also the realm of time (rhythm tempo), dynamics and even timbre have undergone this form of expansion. (Landy 1991 p. 8)

Classical performance technique was developed to support the aims of the common practice period. Homogeneity, clarity and evenness of tone were key considered virtues in "musical" sound. The expansion of the timbral pallet available through the use of traditional instruments encompassed additional practices such as extended instrumental techniques. Some of the earliest examples include

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[85] See Busoni (1911), Russolo (2004) [1913], Ives (1962 [1920]) Cowell (1996 [1930]), Varésè (1966 [1939]) pp.11-19; and Cage "Experimental Music" J. (1961[1957]).

fluttertongue and sprechstimme, found respectively in Strauss's *Don Quixote* (1897) (De Souza 1989 p. 27) and Humperdinck's *Königskinder* (1897) (Soder 2008 p. 2). A wave of virtuoso soloists[86] who emerged in the Post-War era strongly contributed to this expansion. A summary of some of these extended techniques is provided in Table 12.

Multiphonics	First employed in Berio *Sequenza 1* for Flute (1958) and first codified in Bartolozzi 1969. These new techniques included multiphonics, alternative "timbral" fingerings and microtones documented in Bruno Bartolozzi's 1969 treatise on new sounds for woodwinds.
Musique Concrete instrumentale	Stockhausen's *Klavierstück IX* (1961), included examples of "simulated electronic manipulation "flap echo", pedal reverb, the initial chord is dislocated, as if left and right hands were tapes moving slowly out of synchronisation" (Maconie 2006 p. 216). Helmut Lachenmann's notion of 'instrumental musique concrète' (Cross and Harvey 1997 p. 66) is the most overt example of this phenomenon. In a series of works between 1968 and 1976 explored the possibilities of "defamiliarisation of instrumental technique" (Ryan 1999 p. 20).
Spectral Effects	Spectral Composers, such as Grisey, Murail and Rissett directly emulated electronic processes (as opposed to timbres) within acoustic instruments. An example is acoustic "ring modulation" produced by the simultaneous playing and singing of different tones by a single performer. "The resultant spectra of simultaneously sung and played notes can easily be predicted: the sung tone modulates the played one, producing sum and difference tones of the two" (Anderson and Murail 1993 p. 322).
Parametrical division of instrumental techniques	The elements that comprise a traditional instrumental technique, for example fingering, bowing, lip and air pressure, are typically unified into the single goal of "note production". Beginning with Berio's *Sequenza V* (1966) for trombone, composers have explored the possibility of partitioning components of instrumental technique, allowing them to act independently often with unpredictable outcomes. In *Sequenza V*, the trombonist is directed to move the slide according to one contour while blowing (regardless of the outcome) at times defined by a separate, unrelated stave. The works of Aaron Cassidy expand this approach, often notating different components of instrumental technique on up to ten independent, simultaneous staves. This radical approach is the product of "experimentation with the polyphonicization of the various components of performative, physical action involved in producing sound in/on an instrument (...) the final resulting sounds of the piece are not in fact denoted in the score as such but instead arise as "aural byproducts" of the interaction of the (...) decoupled layers" (Cassidy 2000).
Table 12: Examples of Extended Instrumental Techniques.	

These extensions of the instrumental sound world were expanded by the almost limitless possibilities of synthesised and sampled electronic sound. As Cutler notes, "From the moment of the first recording, the actual performances of musicians on the one hand, and all possible sound on the other, had become the proper matter

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[86] Such as Vinko Globokar (trombone), David Tudor (piano), Sylvio Gualda (percussion), Cathy Berberian (voice), Heinz Holliger (oboe), Severino Gazzelloni (flute) and the Arditti String Quartet.

of music creation" (Cutler 1993 p. 33).

The expansion of the available sound pallet led to attempts at codification first by the Futurists (Russolo p. 10), and later by Musique Concrete composer Pierre Schaeffer (Schaeffer and Reibel 1966 and Schaeffer 1966) and Denis Smalley (1986 and 1997). Such taxonomies provided composers with explicit means to plot conjunction and disjunction between timbres specifically and sonic objects in general.

4.2.2. Parametric Thinking

Josef Häusler defines a music parameter as "all sound or compositional components that can be isolated and ordered" (quoted in Landy 1991 p. 9). The influence of "Parametric Thinking", as Landy refers to it (Ibid pp. 8-18), has been profound. Beginning with Schoenberg's isolation of pitch for special consideration in his serial technique (Schoenberg 1992 [1923] p. 214-249), many composers "undertook to apply serial principles to all aspects of music" (Pickstock p. 182) partitioning musical parameters, such as pitch, duration and timbre, and manipulate them independently in a non-hierarchical manner. This expansion included: dynamics and articulation in Webern *Variations Op. 27* (1936)[87]; register in Messiaen's *Mode de valeurs et d'intensities* (1949); tempo in Stockhausen's *Kontrapunkte* (1953)), timbre and spatialisation in Stockhausen's *Gesang der Jünglinge* (1956).

The ability to generate disjunction through the combination of an exponentially expanded range of sounds and the development of methodologies for controlling parameters, were interdependent. In addition to serial methods for manipulating musical parameters, a range of techniques began to be employed arguably as a result of the emerging ideology of parametric thinking, including: aleatoricism, stochasticism and algorithmic methods.

Cage's privileging of structure over content opened the material available to the composer to encompass "the absolute equality and interchangeability of all sounds" (Pepper 1997 p. 34). From 1951 he began to employ methods involving choice of musical materials through chance procedures. Initially his methods were

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[87] See Nolan 1995 pp. 47-76

much the same as those of the total serialists: temporally defining multi-parametrical musical singularities through numerical selection. Bernstein even notes, "Boulez's charts are strikingly similar to those used by Cage" (Bernstein 2001 p. 31). Cage's "charts" might be regarded as quasi-serial, employing a similar disjunction between the materials and the parametrical method of choice.

The source of Cage's numerical data in 1951 was the *I Ching*, a Chinese divination system consisting of has 64 trigrams (8^2) and as such was serendipitously in line with Cage's square-root methodology for defining formal shapes. The materials of his *Music of Changes* (1951), for example, were derived from

> Eight charts containing sounds (and silences), eight charts with durations, and eight charts with dynamics. In addition single charts were used to determine tempi and superpositions (the number of contrapuntal layers in each phrase).
> (Bernstein 2001 p. 31)

Cage describes the process of choice in *Music of Changes* as follows:

> What brings about this unpredictability is the use of the method established in the I Ching (Book of Changes) for the obtaining of oracles, that of tossing three coins six times. Three coins tossed once yields four lines, (...) Three coins tossed thrice yields eight trigrams (...). Three coins tossed six times yield sixty-four hexagrams.
> (Cage 1961 pp. 57-58)

The resulting material obtained using chance procedures was then applied to "phrase and section lengths of a precompositionally determined rhythmic structure" (Pritchett 1988 pp. 237-301). It follows that the structural nonlinearity of *Music of Changes* would be dependent upon the manner in which the subsections were differentiated rather than the indeterminate method of choice of materials. David Bernstein's description of the process, showing that phrases were "differentiated by tempo and number of layers", suggests that the result would be perceptually nonlinear.

> There are 29 $^5/_8$ sections, each 29 $^5/_8$ measures long and divided into phrases of 3, 5, 6 ¼, 5 and 3 $^1/_8$ measures. For each phrase the tempo and number of layers were determined by a single hexagram.
> (Bernstein 2001 p. 36)

The I Ching dominated Cage's approach to choice through chance. In 1969 unable to maintain the rigorous demands of coin tossing, Cage began to use a computer program simulation of the I Ching (Bernstein 2001 p. 235). However, the I Ching was by no means Cage's only resource for mapping musical materials. A complete list of Cage's chance methods are listed in Table 13.

Work	Method of Choice	Materials generated from:
Chance		
Imaginary Landscape No. 5 (1952)	I Ching	42 LP Records (Holmes, 2008 p. 83)
Williams Mix (1953)	I Ching	Six categories of Field Recordings (Holmes 2008 p. 85)
Music of Changes (1951)	I Ching	Multi-parametrical Charts
HPSCHD (1968)	Random Number Generation	Mozart's *Musicalishes Würfelspeil* and other Pre-existing, Audiovisual materials. (Pritchett p. 160)
Found Systems		
Music for Carillion No. 1 (1952)	Folded Paper Templates	Pitch/Time-Space (Pritchett p. 92)
Music for Piano (1952-6)	Paper Imperfection Technique	Pitch/Time-Space (Pritchett p. 94)
Music for Carillion No. 4 (1961)	Astronomical maps	Pitch/Time-Space (Pritchett p. 211)
Atlas Eclipticalis (1961)	Astronomical maps	Pitch/Time-Space (Nicholls p. 139)
Cheap Imitation (1970)	I Ching Recomposition	Pre-existing Works
Apartment House 1776 (1976)	Subtraction[88]	Pre-existing Works
Song Book (song 85)	Rubbing[89]	Pre-existing Works
Indeterminacy		
Winter Music (1957)	Indeterminate notation	Performer
Table 13: Cage's Chance Techniques.		

The *I Ching* provided a source of random numbers[90] for Cage, and therefore it was employed in a way that was not dissimilar to the methodology of multiple serialism. With the exception of "Folded Paper Templates", the chance techniques mentioned in the table above - Paper Imperfection Technique, Astronomical maps, Recomposition, Rubbing and Subtraction – rely on "found systems": that is, pre-

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[88] Subtraction: "in each piece he selected certain pitches from each of the vocal lines and extended these through an arbitrary number of succeeding notes, with the sustained note replacing the original pitches. After each such sustained pitch there followed a silence which extended, similarly, though an arbitrary number of succeeding tones. Cage's transformation preserved the structure (proportion), materials (pitch content) and even aspects of the method (the rhythmic placement of the sustained pitches); but the form (the morphology of the continuity, grounded in this case on the reductive aspects of harmonic logic) was altered substantially." (Nichols p. 137)

[89] Rubbing: a larger staff is placed over the score and the note-heads inscribed on it. The effect is to preserve the contour of the original (although in a very restricted range) but to transform the rhythm, phrasing, and inflection. (Ibid)

[90] "The I Ching was for Cage far more than a quaint and antique source of random numbers, as it is so often characterized. It was the way of seasoning and sobering the mind" (Bernstein 2001 p .87)

existing (chance) formal structures embedded in graphical artifacts. The result of chance distribution of musical events is not structural, but is a form of nonlinear generation of materials.

Another approach was taken by Xenakis, whose stochastic methodology used mathematical probability to allow statistical control of over stretches of time with some dependence in the generation of each event, in order to "shape" their distribution. He first employed stochastic procedures in his orchestral work *Metastasis* (1953-4) to generate glissandi speeds, which are represented as lines in the pitch-time space (du Toit 2009 p. 24). His later work *Achorripsis* (1956-7) inaugurated Stochastic music as a generalised methodology in which probabilistic rules "are applied to generate both the parameters of the notes and the global structure" (Serra 1993 p. 237).

> What counts will be the statistical mean of isolated states and of transformations of sonic components at a given moment. The macroscopic effect can then be controlled by the mean of the movements of elements which we select. The result is the introduction of the notion of probability, which implies, in this particular case, combinatory calculus.
>
> (Xenakis 1992 p. 8)

As Xenakis and others rapidly discovered, probability was not the only potential source of generative material for musical compositions. Diaz-Jerez identifies four general types of algorithmic generative processes that have been employed by composers to this end.

- Stochastic processes (probability functions, Markov chains.)
- Iterative (chaos, fractals, non-linear equations, number theory.)
- Rule-based (L-systems, formal grammars.)
- Genetic algorithms.   (Diaz-Jerez 2000 p. 8)

These methodologies did not ensure the emergence of nonlinearity in a structure, however they were, to greater and lesser degrees, intrinsically capable of generating musical materials and structures in which each music event was independent of all others: Kramer's definition of nonlinearity (Kramer, 1981 p. 554).

4.3. The Evolution of Notational Innovations from the Mobile Score to the Screen Score

In the 1950s a concerted effort was made in some quarters to liberate the music score from the manacles of left-right/up-down orientation. In music and across a range of art forms in the mid-twentieth century, there was a growing impetus to

generate works that allowed for multiple readings to be defined by the individual. Žižek claims that, as developments in ideology and formal innovation are interlocked, ideology and technology also evolve in parallel. He argues that "old artistic forms pushing against their own boundaries (…) seem to point towards a new technology" (Žižek 2000 p. 39).

These "excessive experiments" with traditional paper scores, such as multi-pathway "mobile scores", "graphic" and "indeterminate" notation, eventually found a more "natural and appropriate" (Ibid) platform in graphical computing, which furnished the notated score with the capacity for the permutative, transformative, and generative qualities of that medium. In addition, the computer provided a platform in which complex realtime manipulations of the score could be both shared and precisely coordinated through networks. The new medium for the presentation of notated materials to performers might most appropriately be termed the "screen score". These developments possess the promise of novel compositional approaches to multiple varied instantiations of a work as well as conception and realisation of hybrid and multiple formal structures.

4.3.1. The Emergence of "Mobility" in the Musical Score

The mid-century saw a sudden abundance of ideas pushing against their own boundaries and pointing towards a new paradigm of openness and mobility in art works. In technology and the non-musical arts, these developments included Alexander Calder's first sculptural "mobile" *Feathers* (1931) (Selz 1966 p. 72); the invention of the *Memex* (1945) - a method of organizing data "as we may think" by Vannevar Bush (Bush 1945 pp. 101-108); the publication of Raymond Queneau's *Cent mille milliards de poèmes* (Hundred Thousand Billion Poems 1961), a compendium (and "writing machine") for generating 10^{14} possible "mobile" sonnets (Dack 2005 p. 2); Theodore Nelson's description of a system linking related texts together in the digital medium as "hypertext" (1963) (Nelson 1967 pp. 191-210); Alain Robbe-Grillet's *Pour un Nouveau Roman* (Towards a New Novel), espoused disjunctions in time, place and point of view as a method of breaking down the dominance of the omniscient narrator (Robbe-Grillet 1963); and Umberto Eco published the first major theoretical text on the field *Opera Aperta* (The Open Work) (Eco 1989).

During the same period, some of the basic notions that underpinned notated music

were also confronted by developments such as Graphic Notation, Indeterminate Notation, and the Mobile Score. These deviations from the conventions of traditional musical notation often introduced a greater "openness" to the performer's interpretation and realisation of the work. The avoidance of traditional notational conventions changed the performer's relationship to the score, allowing great interpretive latitude and sometimes implying the freedom to move around the page in a more interrogative fashion. As Cornelius Cardew put it:

> Notation and composition determine each other. Differentiate between creating a language in order to say something and evolving a language in which you can say anything. (Cardew 1961 p. 21)
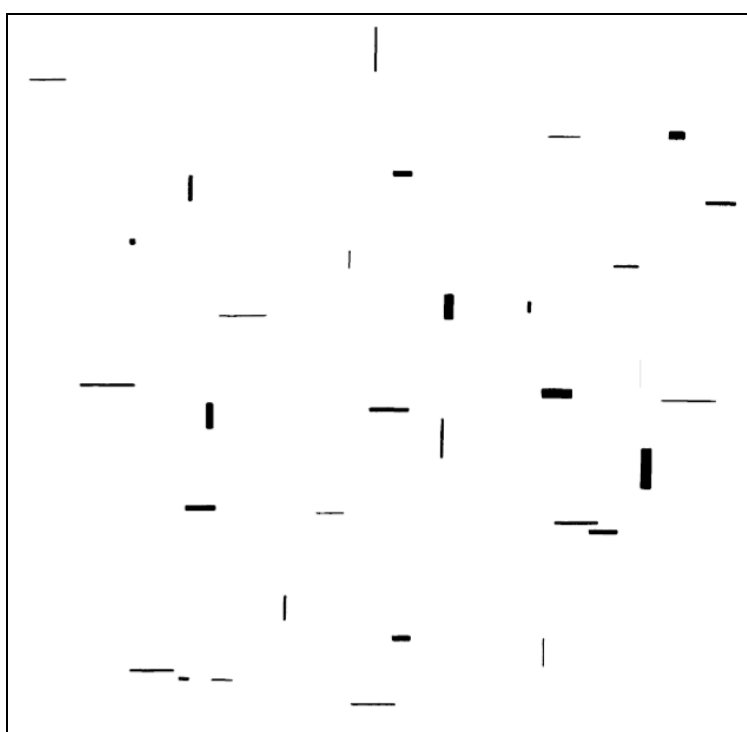
Figure 35: Earle Brown: December 1952 (1954). (score © 1954 AMP/Schirmer).

Earle Brown's *December 1952* (Figure 35), is thought to be the earliest example of these challenges to notational convention: "filled with nontraditional notational signs and symbols, (…) with the resulting shape totally unfixed and different each time" (Dubinets 2007 p.412). The score for his *December 1952* is "open" in a number of ways:

> The 'ambiguity' of the notation exists with regard to the macroform (ordering of modules or units); to the microform (how to interpret one graphic symbol in relation to its neighbours); or to the time process (between groups of materials in minute, flexible detail, as in proportional notation). (Gresser 2007 p. 378)

The work employs asemic[91] graphical notation appearing more like a painting of the Neo-Plasticism school than a traditional musical score. The deviation from musical notational conventions points towards meaning that is more "open" to

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[91] Notation without semantic content and therefore that does not privilege any manner of reading or interpretation.

interpretation and also implies the freedom for the performer to move around the page in a more interrogative fashion.

> Composers who work with such notation, where the distinction between symbol and drawing is blurred, hope that it may excite the performer's imagination. (Hanoch-Roe 2003 p. 155)

John Cage, beginning with *Winter Music* (1957), amplified the existing ambiguities of musical notation to create scores in which semantic interpretation was more indeterminate. The 63 pages of his *Concert for Piano* (1958) are a virtually encyclopedic exploration of non-traditional notational (See Figure 36). Such notation presumes that "the performer's mind is (...) inspired by the graphics through some sort of mental resonance" (Hajdu 2004 p. 5). Cage emphasised the indeterminate nature of this approach:

> One cannot determine exactly what effect the notation causes. The observer-listener is able to stop saying I do not understand, since no point-to-point linear communication has been attempted. (Cage 1970 p. 135)
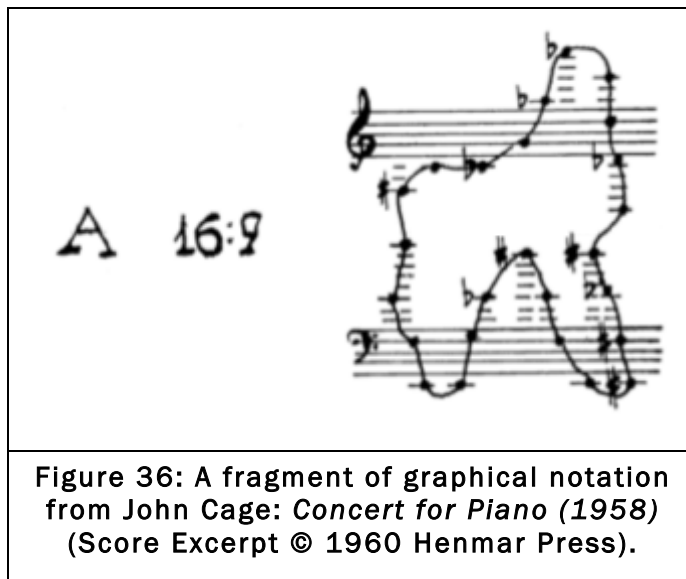
Figure 36: A fragment of graphical notation from John Cage: *Concert for Piano (1958)* (Score Excerpt © 1960 Henmar Press).

A simultaneous development in notation was the mobile score: the idea that a music notation (graphic or otherwise) could be reordered or reorganised for, or even during, each performance. Mobile scores most commonly offered performer choice in the pathway(s) taken through the work. The ability for performers to read rhythm from left to right, or for composers to express harmony from top to bottom, was no longer required.

In the mobile score, the composer defers the final ordering and distribution of notated musical events until the performance. In such works

> the instrumentalist's freedom is a function of the "narrative" structure of the piece, which allows him to "mount" the sequence of musical units in the order he chooses (Brown 1970)

Figure 37 shows the mobile score for Earle Brown's *Calder Piece.*

Figure 37: The score of Earle Brown's *Calder Piece* (1965-6) (Score excerpt © 1966 Edition Peters).
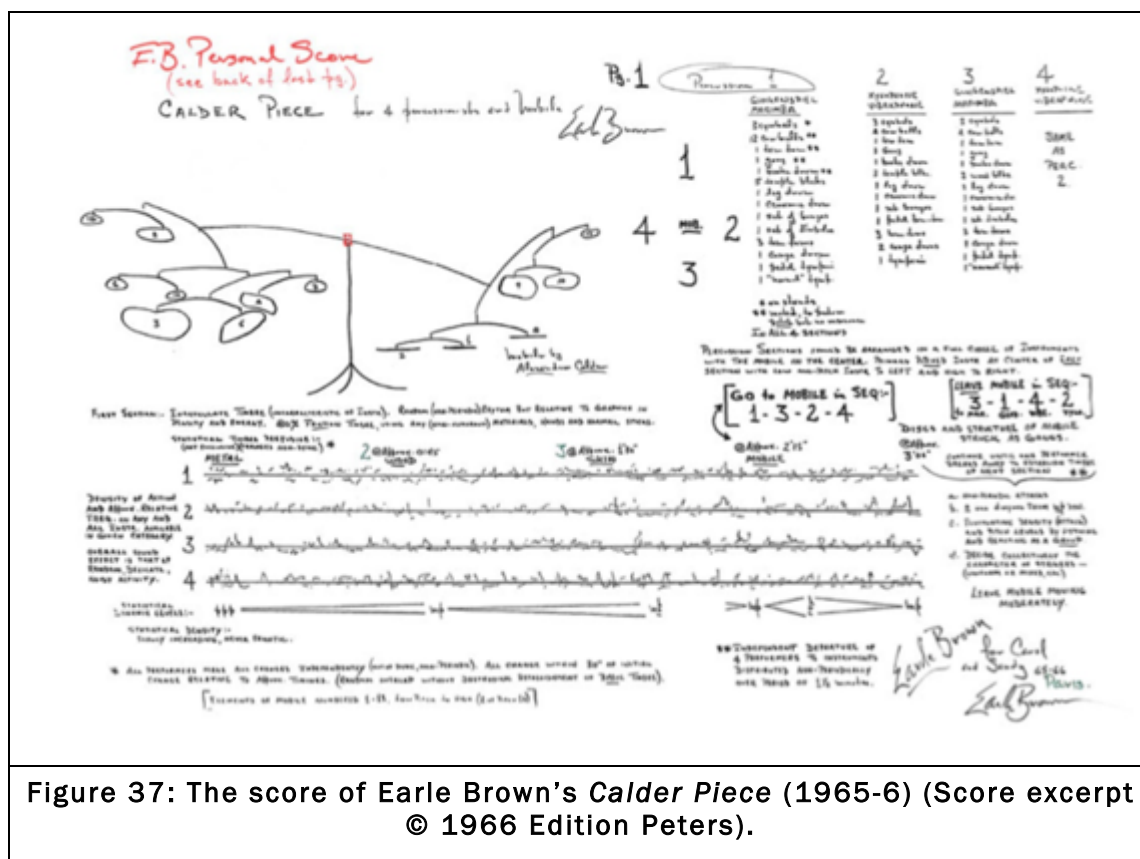
The musical developments towards mobility of the score pioneered by Brown and Feldman quickly spread to the European Avant Garde and elsewhere (Griffiths 2007 pp. 104-115). Mobile structure works by Stockhausen (*Klavierstück XI* (1956) and *Zyklus* (1959)) and Boulez (*Third Sonata* (1955–57/63)) appeared almost immediately in the wake of visits to New York by Boulez in 1952 and to Darmstadt and Paris by David Tudor (1954), Earle Brown and Morton Feldman (1956) and Cage (1958) (Beal 2007 p. 341-2).

It is strange to note that in the Avant Garde scene of the 1950s and 60s, the work of numerous abstract filmmakers[92] such as the Whitneys, Fischinger, Harry Smith, Joseph Cornell, Maya Deren, Kenneth Anger, Stan Brakhage and Jordan Belson, did not exert more influence on the experimental music works of the New York School and the Fluxus movement. As revolutionary as composers in the New York school

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[92] Since the 1930s, numerous projects in the Visual Arts sought to explore the visualisation of music. Interestingly there was little crossover between the "Visualised Music" and the "Sonified Image" of the musical score. These included Arseny Avraamov's hand-drawn motion picture soundtracks (1930) (Holzer 2010), Len Lye's A Colour Box (1935), camera-less animation, abstract films painted and scratched directly onto film (Manovich 2001 p. 258) and James and John Whitney's experiments (1943-4) in which sounds and images were synchronised optically by light shot through a stencil system (Brougher 2005 p.125).

were musically, the paper medium for presentation of notation to musicians remained relatively unchallenged.

4.3.2. Issues Complicating the "Real" Mobility of Mobile Scores

The ideological shifts that drove composers to explore new methods of notating music were varied. Roman Haubenstock-Ramati claims that:

> During the compositional process a reciprocal relationship develops between the idea (thought) and the slowly evolving manner of writing it down. This relationship of continuous mutual influence lasts during the whole time of composition, and has the effect that, if the original idea of the work is musically pure and true, the resulting piece will be the best possible in terms of both music and notation.   (Haubenstock-Ramati 1976 pp. 97-98)

According to Earle Brown graphical notation and mobility provided a greater level of "spontaneity, direct spontaneous action, and more spontaneity in the compositional process" (Brown 1970), allowing "the performer to share directly with the composer in the construction of the music" (Welsh 1994 p. 300). Stockhausen's earliest mobile structure works reflected his interest in representing the aleatoric nature of the structure of sound itself. Later "moment" works such as *Kontakte* (1958-60), *Momente* (1958-60) and *Mixtur* (1964) sought to explicitly avoid traditional musical narrative structure: "The piece tells no story. Every moment exists for itself" (Pasler 2007 p. 38). Composers such as Xenakis used game structures, in works such as Duel (discussed in Chapter 3) to draw on mobile form's "field of possibilities" to create tension.

The reasons for the resilience of the paper medium in music until recent times are not entirely clear. In the past practical issues such as the expense, convenience or even the operating noise of projections systems may have played a part. However many of the compositional goals implied by the innovations were, in part, at odds with the capabilities of the paper score. Crucially, the space-inefficient paper-score imposed upon composers an inverse relationship between the ease of mobility and the amount of information that could be provided for performer.

Some early mobile scores, such as *Intermission 6* and *Klavierstück XI,* solved this problem by employing a single performer and including all of the necessary information on a (sometimes very large) single page. Feldman's work comprises 15 fragments or musical objects, each a single note, chord or grace note. They fit comfortably on a standard sheet of paper and there is no great challenge to the

performer in the realization of the work, namely to freely order the fragments.

Stockhausen's *Klavierstück XI* provides somewhat greater challenges for the performer. Stockhausen instructs the performer to 'look at random to any other group' in order to determine which group to perform next. It is hard to imagine how the composer, listener or even performer might verify whether this instruction is being followed. In the case of a paper score however, involuntary choice is the most pragmatic solution for achieving an aleatoric order of groups. Stockhausen's stated motivation for this instruction is 'that the performer will never link up expressly chosen groups or intentionally leave out others. Each group can be joined to any of the other eighteen' (Stockhausen 1954).

The coordination of multiple performers and scores in a live situation creates an even greater impediment to the goal of formal mobility in real-time. Preparation of the order of the events in the score prior to the performance becomes a necessity rather than just a pragmatic convenience. Clearly the pre-ordering of the performance materials prevents any formal reorganization "at will". Although the ability to assemble a unique sequence of musical events allows a form of "openness" in the score, the pre-ordering essentially reduces the work to a closed form in performance.

Boulez' exploration of mobility in his Third Sonata drew on the emerging concept of the "open work": a labyrinth to be explored through multiple, variable instantiations.

> Because a development that is fixed in a final way has struck me as no longer coinciding exactly with the current state of musical thought, with the very evolution of musical technique, which it must be recognized is turning more and more toward the search for a relative universe, toward a permanent discovery-comparable to a "permanent revolution".   (Boulez 1963 p. 32)

Xenakis' *Duel* employs a more radical (and awkward) means of coordination of its two orchestras. Non-notational visual cues, consisting of a complex arrangement of yellow, blue, red and violet coloured lights are used to cue the different musical materials (Xenakis 1959). Such a solution, in addition to being logistically complex, adds a further cognitive layer to the, already taxing, requirements for the performers and arguably creates unnecessary non-musical distraction. Figure 38 shows the arrangement of performers and visual cueing systems in Xenakis' *Duel.*
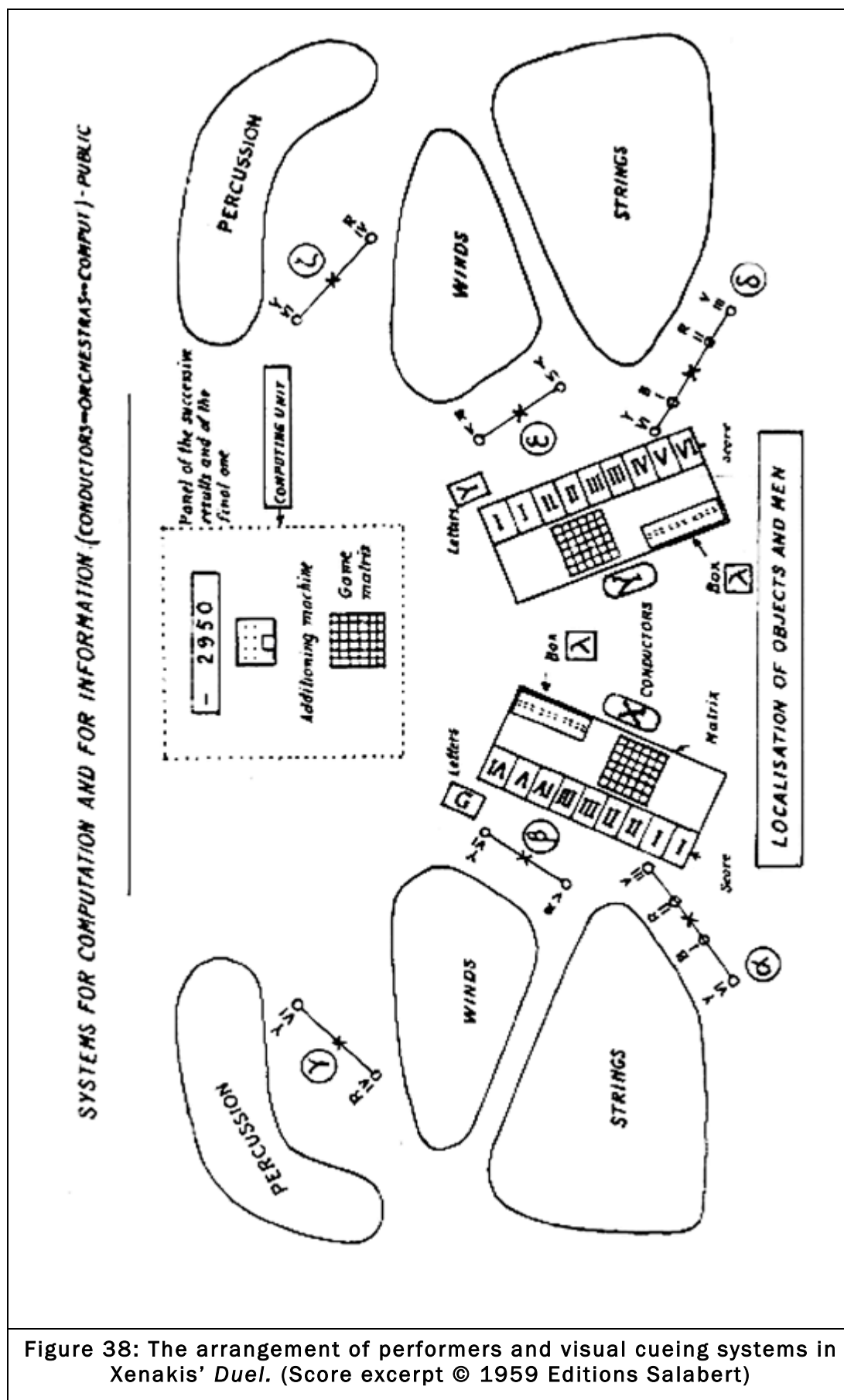
Figure 38: The arrangement of performers and visual cueing systems in Xenakis' *Duel.* (Score excerpt © 1959 Editions Salabert)

In regard to *December 1952,* Brown's original intention was that the performers should be left entirely to their own devices in the realization of the work, however as he later indicated, the creation of a new paradigm combining composition and performance required a level of creativity not always reached by performers accustomed to traditional notated music.

> I had this idealistic, romantic feeling that I could (create improvisational composition), with a graphic score and classical musicians (...) I couldn't understand why classical musicians couldn't improvise, and why so many looked down on improvisation. (Brown in Yaffé 2007 p. 300)

If the problem with scores such as *Klavierstück XI is* that the detailed notation lends itself to pre-ordering by performers into a linear form indistinguishable from a "closed" work, the problem with the very openness of *December 1952* is that it lends itself to improvisation with little regard for the score. The freedom created by allowing the unspecified interpretation of the range, duration and nature of the sound events as well as the orientation of the score and rate at which it should be read, leaves the performer with little necessity for precision in their interpretation.

Composers such as Brown, Stockhausen and Xenakis pushed the paper score medium to its limits in these works. The pursuit of true mobility would require the avoidance of pre-determined ordering of materials, the possibility of real-time re-ordering of materials based on aleatoric or other procedures and the ability to coordinate longer and more complex materials with larger and more complex instrumental and/or electronic forces. Following the advances of the Avant Garde, the continued exploration of these ideas lay dormant, waiting, as Žižek would say for the advent of a more "natural" medium for their expression (2000 p. 39). A computer controlled performative model provides the solution to many of these issues.

4.4. Computer Controlled Live Performance

The renewal of the goal of mobility of the musical score has been a product of developments in technology. The advent of computing provided a platform for controlling musical performance in a manner far more rapidly, seamlessly and interactively than previous media. James Hollan identifies two key features that distinguish computer interfaces from previous forms of representation:
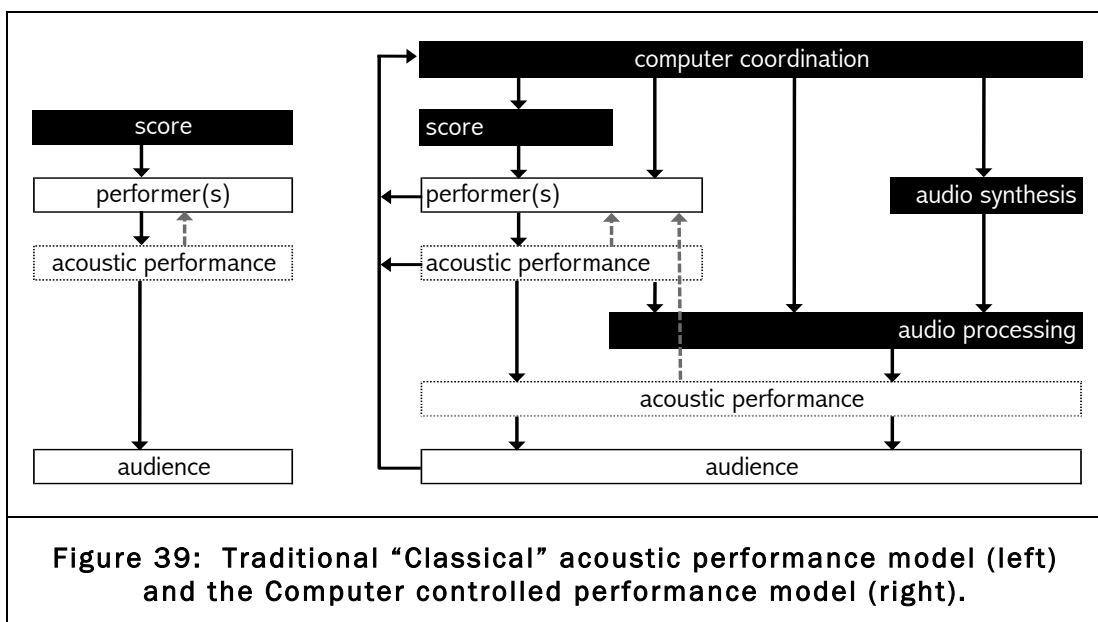
> they provide the most plastic representational medium we have ever known, and they enable novel forms of communication. (...) This plasticity in

combination with the dynamic character of computation makes possible new interactive representations and forms of communication that are impossible in other media. (Hollan 1999 p.379)

In a traditional acoustic performance model (Figure 40 left), coordination of the performance is, in the first case, determined by the composer who provides materials, which incorporate both events to be performed and a tempo/metric framework for their synchronization. Coordination of the actual performance is managed by the performers alone, through visual cues and auditory feedback.

This is not to diminish the crucial role played by performers who, in addition to their technical and interpretive skills, draw their own experience and judgments (still far more complex than any computer) into the equation. As John Zorn states in regard to the role of the performers of his work *Cobra* (1984): they "bring in their own private perceptions, past experiences, instrumental techniques, and interpersonal attitudes" (Cobussen 2002).

Computer coordination of live musical performance (Figure 39 right) allows for the control and synchronisation of the score and the temporal framework, in addition to the generation of electronic sounds and electronic transformation of both the acoustically and electronically generated sounds. The computer-generated clicktrack creates the opportunity not only to independently control the tempi of multiple performers, but also to transmit formal (for example nonlinear selection of score materials) and performance (such as articulation, dynamics and so forth) parameters in real-time.

Figure 39: Traditional "Classical" acoustic performance model (left)
and the Computer controlled performance model (right).

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

- the performers may interact with the computer via hardware interface(s);

- the acoustic performance itself may be used as an interface through computer analysis; and

- the audience may interact with the computer, playing a role in defining the performance.

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

4.4.1. The Screen Score

The rapid improvements in graphics processing capacity, smaller, lighter and cheaper screens, data projection have all played an important part in promoting the exploration of these possibilities. Development of a range of software capable of robust real-time manipulation of notation began to emerge in 2007[93] and has also enhanced the potential of this approach.
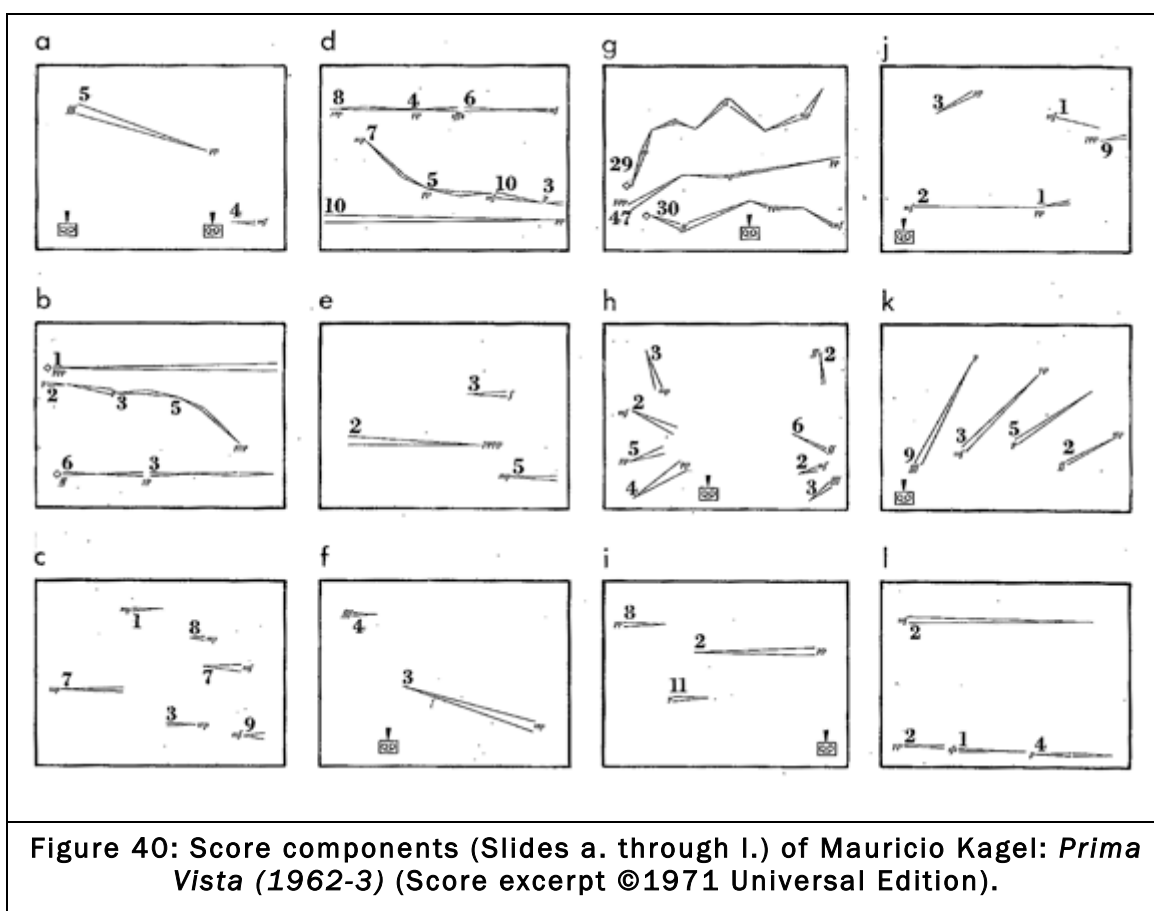
> One general effect of the digital revolution is that avant-garde aesthetic strategies became embedded in the commands and interface metaphors of computer software. In short, the avant-garde became materialized in a computer   (Manovich 2001 p.258)

Academic discussion of this approach is, however, quite recent, gaining momentum as recently as 2004 with the publication of research by Didkovsky (2004) and Winkler (2004).[94]

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[93] In addition to individual solutions based in notation-capable software such as JAVA and Max/MSP, generic real-time notation software has been developed by Barrett, Winter and Wulfson: *Spectmore* and *LiveScore* (2007), Psenicka*: FOMUS* (2007), Didkovsky and Hajdu: *MaxScore* (2008), and Lopes: Ōdaiko (2010).

[94] Other notable contributions have been made to the debate by Kim-Boyle (2005, 2006, 2010), Barrett, Winter and Wulfson (2007), Freeman (2008, 2010), McClelland and Alcorn (2008), and Lopes (2010) and

There were a number of precursors to the presentation of musical notation on screen, such as Mauricio Kagel's work *Prima Vista* (1962-63) that uses 25 slides randomly placed in the carousel of a slide projector, and is one of the earliest examples of score to be screened visible to both the musicians and audience (See Figure 40).

Figure 40: Score components (Slides a. through l.) of Mauricio Kagel: *Prima Vista (1962-3)* (Score excerpt ©1971 Universal Edition).

The range of approaches to the digital presentation of notation has resulted in a technology that is perhaps best referred to as the "screen-score".

Clay and Freeman note that terms to describe the range of new approaches to presenting the score on a computer screen have not yet been standardised (Clay and Freeman 2010). However, the considerations they outline can be likened to those faced by the New Media genre "Hypertext". The relationships between new and traditional textual models have been categorised by Aarseth (p.64.) in his landmark *Cybertext: Perspectives on Ergodic Literature* (1997). In Table 14 the principal models for the presentation of notation for performers are categorised in a similar manner.

Contemporary Music Review Issue 29 (2010) (Clay and Freeman eds.) was also devoted to the discussion of "Real-time Scores".

MEDIUM	STRUCTURE	PERFORMER	SCORE
Screen-score	generative	immanent	realtime score
	transformative		
	permutative		
	sequential	interpretative	scrolling score segmented score
Paper-score	permutative	explorative	mobile score
	sequential	interpretative	traditional score
Table 14. Paradigms for the presentation of notation to live performers. (The categorizations in this table are based on similar categories proposed by Aarseth 1997 p.64.)			

1. *Medium* - the expanded range of approaches may give rise to either static or dynamic arrangement of materials analogous to traditional print text and computer-based hypertext.

2. *Structure* - the musical materials may be configured so that they are read sequentially, permutated, transformed or generated in real-time. The computer-generated score provides a seamless medium for such approaches.

3. *Performer* - the relationship between the performer and the score may be characterised as interpretative (of a traditional score), explorative (of a "mobile score"), 'Immanent' in that reading may be expected to occur more "in the moment" or interactive in the case that the performer's actions result in changes in the score.

4. *Score* - Traditional musical notation implies the abstraction of taking a continuous 'scroll' of music and splitting it into segments that can be arranged on successive pages. The scrolling score uses the computer to actualize the continuous paradigm of linear music on screen. In the mobile paper score, the notation remains fixed on paper, but "the order of musical sections is outlined either just before or during performance" (Kim-Boyle 2010). The real-time score "refers to any notation, either traditional or graphic, which is created or transformed during an actual musical performance" (Clay and Freeman 2010 p. 1).

The Scrolling Score

The scrolling score (Figure 41) moves a continuous notational graphic from left to right, allowing performers to execute events as they strike a fixed 'playhead'. This approach is best suited to scores that are notated proportionally, that is the time

durations of the musical events are proportional to the spatial lengths of their graphical representations.


Figure 41: Scrolling Score and fixed playhead.
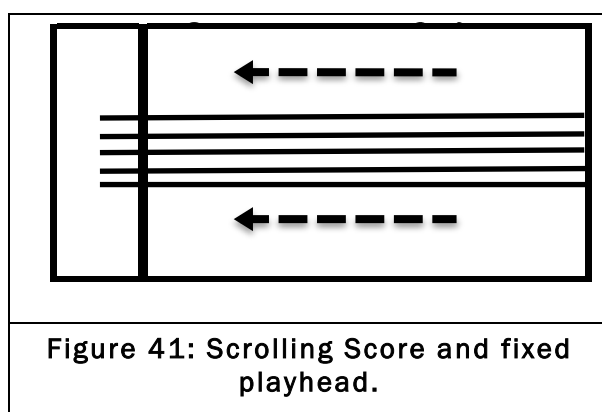
In traditional notation, note lengths are principally determined by their shape within a known sign-system. To save space, traditional scores do not typically place musical events proportionally on the page: longer notes tend to take less space in comparison to short notes and spacing may be dependent upon the duration of events that are taking place across multiple staves, as seen in Figure 42.

Figure 42: The opening of Bach's D major Fugue BWV 850 in traditional notation (below), proportional traditional notation (centre) and graphically ("piano roll notation") (above).

For this reason, the scrolling score is best suited to proportional graphical notation. It allows graphical scores that would normally need to be broken up over multiple pages, such as Penderecki's *Threnody to the Victims of Hiroshima* (1960), to be presented to performers as an unbroken continuum, revealing to the performer what sound to execute in each moment as well as what will be subsequently realised.

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Figure 43: Fixed Score with swiping playhead.
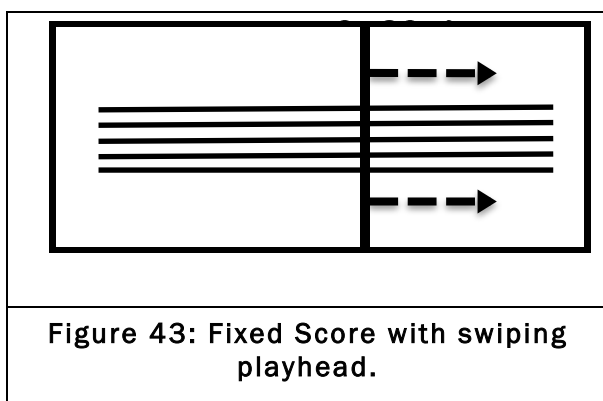
It is also possible to swipe the playhead across the score (See Figure 43). Such an arrangement limits the amount of graphical material that is visible to a single page or "screen". It is therefore not suited to the presentation of continuous "multiple page" scores; however this limitation provides the opportunity for nonlinear presentation of the material, in the manner of a permutative score.

Permutation

Computational control of the score allows the permutation of musical materials that are presented to performers and the synchronisation of their presentation (See Figure 44). Permutation of scored materials may involve translocation, insertion, duplication and/or deletion of musical materials. The materials may vary in size from large structural blocks, to sub-structural cells or even individual parameters.

Figure 44: The Permutative Score.
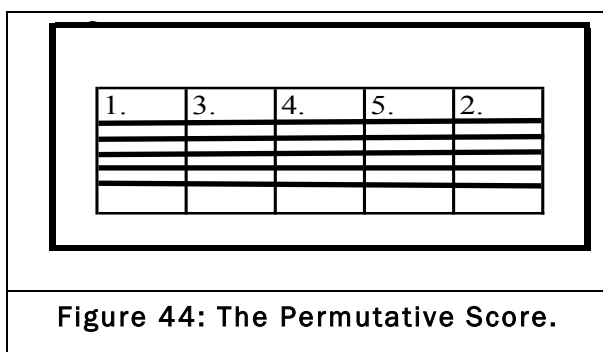
The permutation of large structural blocks of music may be found in traditional paper scores such as Stockhausen's *Momente* (1962-69) and *Mixtur* (1964), however synchronization issues rule out real-time permutation in these works.

Although short fragments of a few seconds length are permutated in the performance of Feldman's *Intermission 6* (1953), the fragments remain isolated "sound objects" rather than functioning at any time as components of a continuous musical passage or discourse.
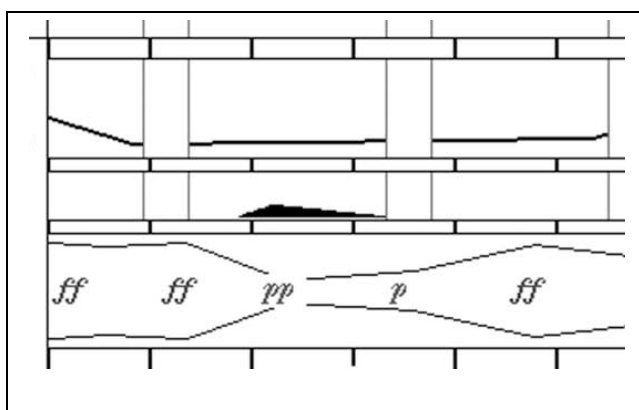
Figure 45. Detail from Winkler's *Hybrid II* for viola and interactive live electronics (1996/2001), showing graphs representing (from the top) string position, bow pressure and dynamics Winkler 2010) pp.89-100.

The independent manipulation of even smaller units, the parameters that are combined to form musical events, is also possible with digital media. This approach is exploited in Gerhard Winkler's *Hybrid* series (1991-) (Winkler 2004). In *Hybrid II* (See Figure 45), for example, the glissando, string position, bow pressure and dynamics are graphically conveyed to the performer in real-time.

Transformative

Transformation differs from permutation in that it acts upon an "original" object to which alterations occur over time (See Figure 46). In this sense transformation is related to the musical concept of development, as permutation is related to "concatenation" or "block" forms (Coenen 1994 p.218). The notion of development is expanded by digital transformation in that the alterations need not be predetermined: they may act uniquely on the materials in each performance.
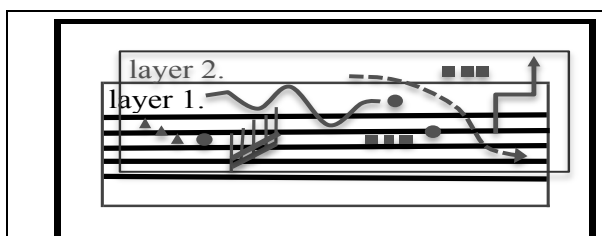

Figure 46: The Transformative Score.

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

In David Kim-Boyle's *tunings* (2006) for cello and computer, "real-time blurring and other distortion techniques" (Kim-Boyle 2006) are employed to reveal only portions of an underlying score. Boyle states that the work is modeled on "the idea of an old-fashioned radio tuning into different stations, sometimes pausing, often moving on" (Ibid) (See Figure 47).

Figure 47: Excerpt from Kim-Boyle's *tunings* (2006), showing "real-time blurring and other distortion techniques" used to transform the score (Kim-Boyle 2006).
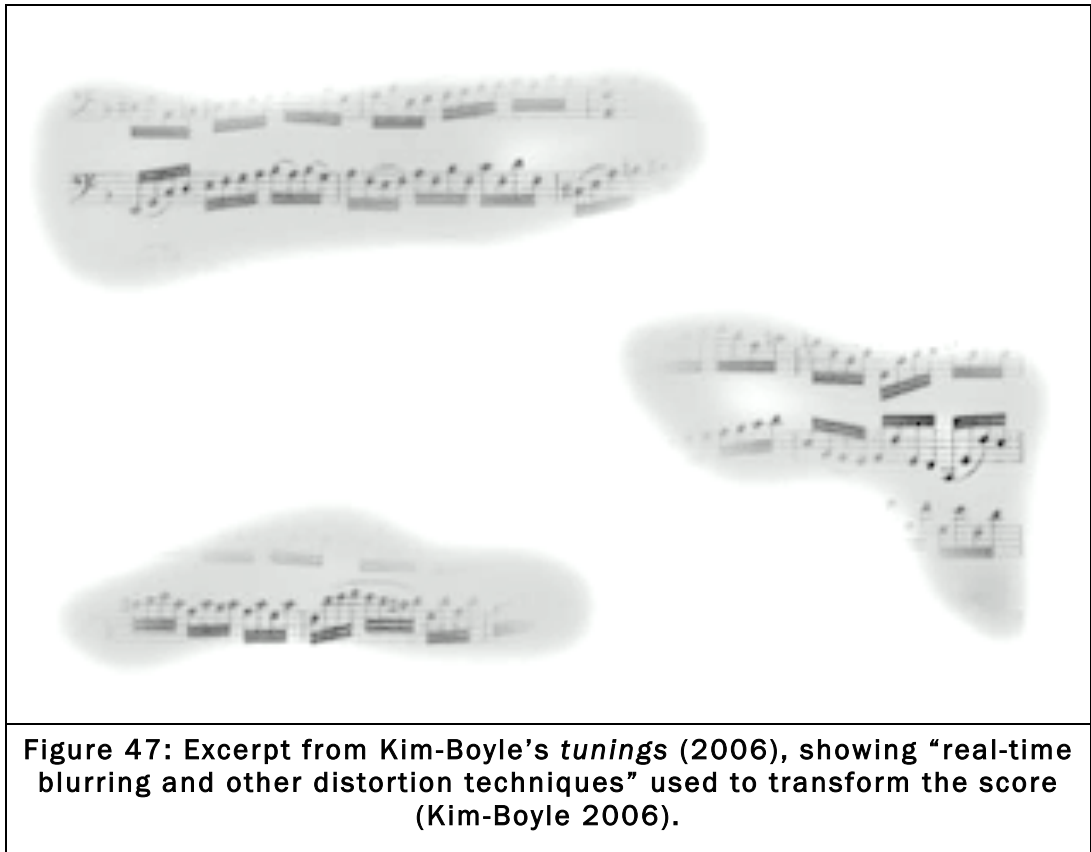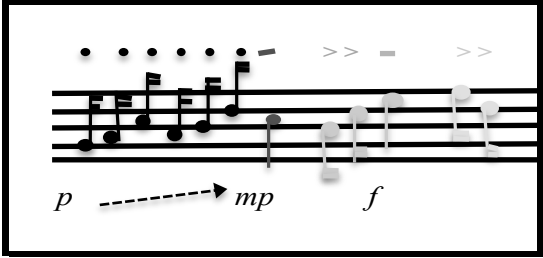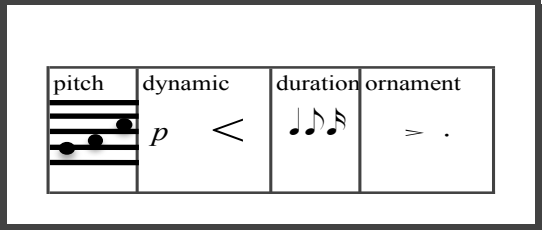
In this Open Work (Eco 1989), Kim-Boyle refers to a range of musical materials, amongst them Bach's second Cello Suite. The reference to this work extends the "tuning" metaphor, drawing on the performer's own memory and familiarity with this core repertoire work.

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

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

Generative

Algorithmic or interactive generative processes may be employed to construct components of a digital score in real-time (See Figure 48 and 49). This approach opens a range of structural possibilities often linked to a narrative or dramatic concept.

| Figure 48: The Generative Score - Traditional Notation. | Figure 49: The Generative Score - Separated parameters. |

In the broad sense permutation and transformation may both be viewed as having generative characteristics. The distinction here is the complete absence of any "object" prior to the performance in generative works. Although algorithmic processes may be predetermined in a generative work, the outcome, in the form of a score or sonic product is completely undefined prior to the performance. For this reason, this form of dynamic scoring is sometimes euphemistically referred to as "extreme sight reading" (Freeman 2008).

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

Interaction with a generative model may also take place directly with the algorithmic processes themselves as is the case with live coding, an approach that "involves writing and modifying computer programs that generate music in real-time. Often this music making activity occurs in a live performance situation with the code source projected for the audience" (Brown and Sorensen 2009 p.17).

In general terms, scrolling and segmented presentation of a screen score is best suited to a pre-composed score that is both continuous and linear, while permutative, transformative and generative approaches suit nonlinear real-time instantiation of scores that are nonlinear in their conception (See Table 15).

Table 15. Classification of Score components that be presented in a Screen-Score
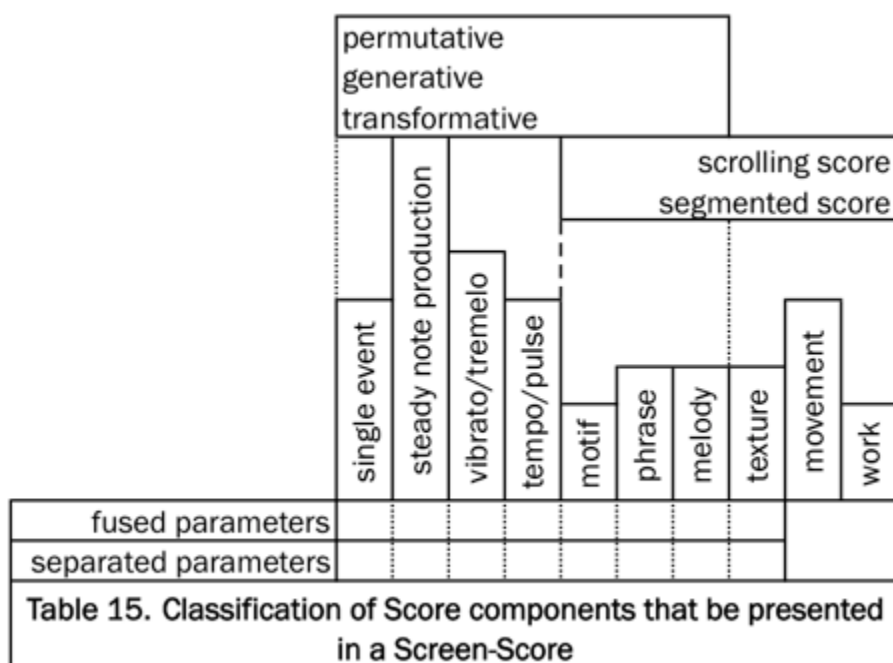
4.4.2. Performer Co-ordination

The computer-generated clicktrack creates the opportunity not only to independently control the tempi of multiple performers, but also to transmit formal (for example nonlinear selection of score materials) and performance (such as articulation, dynamics and so forth) parameters in real-time. The capacity to manipulate the performer tempi independently allows for the precise exploration of this parameter in a multilinear, polytemporal manner.

Charles Ives' experiments with polytempo techniques may date back to 1898. Three early works by Ives from the first decade of the twentieth century, *Three Harvest Home Chorales* (1898-1912), *Central Park in the Dark (*1906) and *The Unanswered Question* (1908) all feature independent tempi, including accelerandi in different parts of the orchestra. In the notes to *Central Park in the Dark* Ives states "the relation of the string orchestra's measures to those of the other instruments need not and cannot be written down exactly, as the gradual accelerando of all but the strings cannot be played in precisely the same tempi each time" *(*Nicholls 1991 p.63).

The desire to obtain precise coordination of live performers led to the development of mechanical means for the management of multiple tempi by Emmanuel Ghent (Ghent 1967). In his 1967 article *Programmed Signals to Performers: A New. Compositional Resource,* Ghent outlined a method by which "performers could

maintain complete independence as to tempo, meter, and positioning of the beat, and yet be precisely coordinated in time". The analog system used "a magnetic tape recording on which signals to the individual performers (had) been pre-recorded at different pitch levels" (Ibid. p. 97).

Ghent also identified the potential application of this system 'as a means of synchonising electronic tape music with live performers' and for works exploring "wide spatial separation" (Ibid. p. 103). A further development of the system by Robert Moog allowed for the "control of electronic devices such as oscillators, amplifiers, frequency modulators..." (Ibid. p. 105).

Ghent observed that "performers adapt very quickly to the use of the miniature headphone"(Ibid. p. 103). It is possible that once familiar, the regular click replaces the need for an internally generated sense of pulse and may even reduce the cognitive load on the performer.

4.5. Structural Implications of Computer Coordinated Performance

A sense of structure is derived from changes in continuity and discontinuity in materials, processes and transformations evident in the sonic outcomes arising from a particular performance model. In the traditional classical model the sense of structure derives principally from the score, with a relatively minor contribution drawn from the performers' interpretation and interaction. Computer coordination allows a radical redistribution of the relationships between the performers, the score, the digital components and the audience. Structural decisions may arise from any player in the performance model and may be the result of interaction and improvisation as well as predetermination. In Jason Freeman's *Glimmer* (2004) for chamber orchestra and audience participation, for example, the audience influences the unfolding composition "by waving four-inch battery-operated LED light sticks back and forth" in front of video cameras (Freeman 2008 p. 31).

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

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

Computer coordination arguably reduces the cognitive load on the performer. The manipulation of musical materials and the provision of coordination for their performance reduces non-musical decision-making, and potentially allows the performer to give greater focus to their performance. It is also possible to apply structure to materials that are freely improvised, placing the performer(s) in an environment where the only consideration is the "performed moment". George Lewis the composer of the *Voyager* (1987), an "interactive musical environment that privileges improvisation" states "with no built-in hierarchy of human leader/computer follower—no "veto" buttons, footpedals or physical cues—all communication between the system and the improvisor takes place sonically" (Lewis 2000 p. 36). Other systems specifically designed for improvised performance include those of Lawrence Casserley and Evan Parker (Casserley 1998) and William Hsu and John Butcher (Hsu 2005).

In this environment the performer might be potentially capable of playing in an "immanent" state, what Deleuze defines as "a pure stream of a-subjective consciousness, a pre-reflexive impersonal consciousness, a qualitative duration of consciousness without a self" (Deleuze 2001 p. 29).

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

4.5.1. Permutation, Transformation and Generation

Computer coordination allows the permutation, transformation and/or generation of musical materials that are presented to performers and the synchronisation of their performance. The materials may vary in size from large structural blocks, to sub-

structural cells or even individual parameters.

The structural implication of permutation, transformation and/or generation of blocks, cells or parameters in "mobile" forms are the same as those identified by Boulez in Stravinsky's *The Rite of Spring* (1913) (see Boulez 1991), namely that synchronous permutation of all parts simultaneously results in "vertical" changes in the performed materials, and asynchronous permutation of the parts, given that they are sufficiently distinct, results in "horizontal" or layered changes (See Figure 50).

Figure 50: Synchronous "vertical' permutation (top), A-synchronous "horizontal" permutation (bottom).
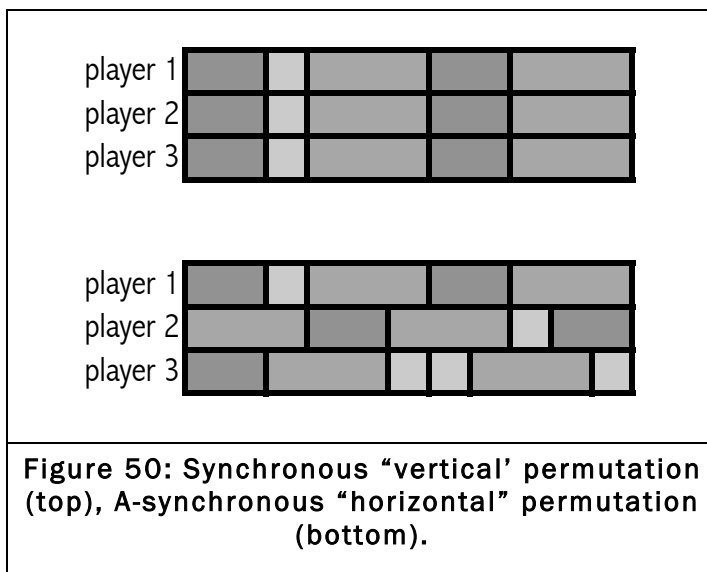
The vertical and horizontal structural implications of the permutation of audio that is digitally derived are identical to those pertaining to scored materials. However, the source of the sounds may strongly bear on the sense of formal structure that arises, especially in the case that the materials are referential to existing, familiar sources, or derived from processed acoustic sounds from the performance itself. In the first case, familiar sound sources carry their own signification: a ten second burst of a sample from Beethoven or Elvis will sound more isolated in the context of the average minute performance, for example, than a ten second burst of white noise.

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

4.5.2. Multiple versions

In *The Open Work*, Umberto Eco theorised the possibility of the "work in movement" permitting "numerous different personal interventions" (1989 p.19). The Computer

coordinated performance provides just such a possibility, allowing for the existence of a precise, unique but variable, multi-versioned work, in which each performance renders a new outcome.

4.5.3. Poly-structure

Permutative, transformative and generative strategies can be independently employed in a single work through computer coordination (See Figure 52). The combination of formal structures in a single work leads to structural polyphony – poly-structure.

Figure 51: A representation of poly-structure (top) and interleaved poly-structure (bottom).
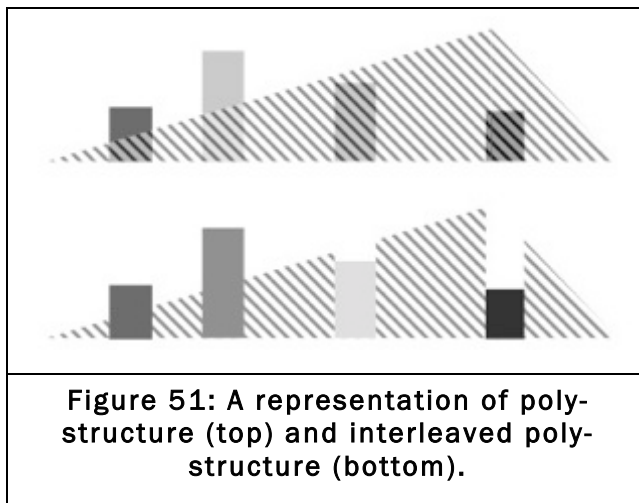
A poly-structure may comprise nonlinearity engendered by the disjunction between multiple structural principals operating simultaneously, or comprise interleaved alternating sections that are based on distinct formal principals.

4.5.4. Erasure

Poly-structures are additive in nature allowing the accretion of formally distinct material. The converse process – removing structural material – is also facilitated by computer coordination resulting in what might be termed a Subtractive structure. Precise real-time excisions of material provide a novel structural approach, analogous to the Surrealist technique Étrécissement (Cut–out), the opposite of Collage, in which elements are removed instead of added.

In the visual arts, Tom Phillips' *A Humument* (1970), for example, a Victorian Era novel "A Human Document" by William Hurrell Mallock (1849), is "treated" by graphically obscuring words of the original text to create a new one. Phillips claims that each page of the novel offer multiple possibilities for treatment, stating "In order to prove (to myself) the inexhaustibility of even a single page I started a set of variations on page 85: I have already made over twenty" (Hayles 2002 p. 88)

This technique has existed in music in Cage's "subtractive" work *Apartment House*

1776 (1976). Kim-Boyle's *tunings*, as discussed previously, is a real-time instantiation of this concept.

4.6. Affordances of Computer Coordination

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

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

- the synchronisation and interaction of performance elements such as the score, performer(s), audio synthesis, acoustic performance, audio processing and audience;

- the permutation, transformation and generation of these elements;

- the instantiation of multiple versions of works;

- the formation of new formal paradigms such as poly-structure, subtractive structures, substructural organisational procedures.

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