AN ATOMIC APPROACH TO ANIMATED MUSIC NOTATION

Ryan Ross Smith
Rensselaer Polytechnic Institute
ryanrosssmith@gmail.com

ABSTRACT

Since the turn of the century, and in particular the last 15 years, [1] the discourse surrounding dynamic scoring techniques and practices has increased dramatically, while leading to an increasingly disparate terminological melee. With an awareness of what implications may exist in the premature analysis and theorization of an emerging field of practice, the author argues that in order to further develop the discourse surrounding dynamic scoring techniques and practices, it may be useful to take a reductionist approach toward defining the various low-level elements of dynamic scoring, in the case of this paper those elements that feature prominently in Animated Music Notation [AMN]. By targeting a set of low-level elements, and isolating the actualized indicators of contact and intersection as the primary functional components of AMN, the author will propose a working definition of AMN supported by examples drawn primarily from the author's work, [2] and the descriptive language generally employed during the author's compositional, rehearsal and performance experiences. To this end, this definition is not intended to entirely satisfy the broad range of dynamic scoring techniques that implement AMN, but to highlight prevalent methodologies, point toward the extension of existing taxonomies, and distinguish AMN as a notational methodology contained by the more general entity of the dynamic score, a methodology meant to clarify two basic compositional parameters: what to do and when to do it.

INTRODUCTION

In *Preface: Virtual Scores and Real-Time Playing*, Arthur Clay and Jason Freeman define real-time notation as "any notation, either traditional or graphic, which is created or transformed during an actual musical performance," and qualify this term by noting that within this particular issue of "Contemporary Music Review" alone "dynamic music notation, live scoring, virtual scoring, and reactive notation" are used by authors in describing their work, and are more or less particular to their specific approaches [1]. For the sake of this paper, I will use the term dynamic score to describe real-time scores with a collection of symbols that feature visual dynamism beyond performer interaction, this dynamism actualized as perceptible movement. At the risk of being overly pedantic, by 'beyond performer interaction' I mean to distinguish the difference between a score that generatively displays or activates notation in real-time as the result of some process autonomous from the performers, as opposed to the physical gesture of turning pages on a music stand, for instance, or the automated or hands-free turning of digital pages.

I also mean to distinguish between scores rendered for performance a priori by the performer through some process provided by the composer. John Cage's *Variations II*, for instance, requires the performer to create a unique version of the score before performance, and while this process is dynamic, in that the work *Variations II* is a set of constrained possibilities with no fixed state, its actualization as the score is ultimately fixed. Similarly, scores that are performer-determinant in real-time at the formal level (or, beyond conventional notions of interpretation) must still be considered from the score object itself as a fixed entity. Earle Brown's *December 1952* and Karlheinz Stockhausen's *Klavierstucke XI* (as graphically and conventionally notated examples respectively) are often cited in this regard. The score is a fixed entity, its dynamism or

[1] Due in large part to *Contemporary Music Review*, Vol. 29, No. 1, *Organized Sound*, Vol. 19, Special Issue 03, *Leonardo Music Journal*, Vol. 21, and animatednotation.blogspot.com. It is also important to note that dynamic scoring practices can be traced back well into the 20th century, but given the scope of this paper cannot be covered in detail.

[2] The author here acknowledges the potential downside of an analysis that focuses largely on the author's work, but contends that the concepts put forth are, while contextually-limited, available for expansion and generalization.

mobility largely conceptual, not perceptibly actualized [2].

Within these constraints, certain dynamic scoring practices present problematic actualization models. The scroll scores of Andy Ingamells feature long strips of paper, populated by small, multicolored circles that represent sonic events. In performance, the unrolled scroll is physically pulled, or scrolled, past the ensemble by two assistants. While the element of human interaction is clearly present, the assistants are not performers per se, but simply provide the mechanics necessary toward Ingamells' dynamic requirements autonomous of the performers, the theatricality of it all notwithstanding.

Similarly, works that involve real-time human-computer interaction to influence the score, including Harris Wulfson's *LiveScore*, in which the audience, through their interaction "becomes a part of the performance," but "never exactly cross over into the 'proper' domain inhabited by the ensemble performers" [3], or Nick Didkovsky's *Zero Waste*, in which the pianist in tandem with the score application creates "the composition through the act of performance" clearly displays actualized notational dynamism in real-time [4]. The performers do not lead in the conventional sense, but are led through the score by an actualized dynamic process, interactive or otherwise. Returning to Stockhausen, *Klavierstucke XI* (or any conventional score for that matter) may be considered dynamic in terms of its mobility [2], but the cursor, represented here by the performer's eye, is virtual, not actual, or actualized. Simply put, agency lies primarily with the performer to activate or *dynamize* the conventional score, whereas the dynamic score has agency over the performer; movement is perceptible, not *of* the eye, but *to* the eye. While further discussion of the various distinctions between methods of real-time scoring practices may be warranted, it is beyond the scope of this paper. However, within the dynamic score exist the potential for a variety of dynamic representations. AMN will be considered as a form of real-time notation in which the actualization of contact and intersection, which provide perceptible indications as to the specific temporal location of sonic events, are its primary distinguishing feature.

BASIC ELEMENTS OF ANIMATED MUSIC NOTATION

> "A graphical method is successful only if the decoding is effective. No matter how clever and how technologically impressive the encoding, it fails if the decoding process fails." – Cleveland and McGill [5]

Introduction

Several high-level analyses and aesthetic reflections regarding the ontology of dynamic scores have provided foundational terminologies with which to describe the global functionalities of dynamic scoring techniques, including of course those represented by the wide variety of notational practices [3]. Lindsay Vickery has most recently extended existing score distinctions to include the Rhizomatic, 3D, and Animated scores respectively, distinctions based in part on their high-level functionality and visual design. What is of primary interest in Vickery's current project is the investigation into the perceptible qualities of the dynamic score, including an in-depth account of sight-reading studies, contingent on the "natural constraints based on the limitations of human visual processing," and the impact these constraints may have on communicative clarity, symbolic and functional design [6]. Similarly, David Kim-Boyle has recently investigated issues regarding the impact notational design may have on the relationship between score functionality and audience perception. [7]. These observations begin to enhance the distinction between not only high-level dynamic scoring approaches, and low-level functionalities that lead to their actualization, but suggest that analytics regarding the functional and perceptible effectiveness can be assessed at the symbolic and micro-functional level. To this end, an in-depth, low-level account of AMN specifically is largely absent, its admittedly pedantic particulars assumed, rendering the term AMN itself unfortunately colloquial.[4] I believe that to suggest particular delineations and definitions will lead toward a more rich discourse regarding AMN specifically, and distinguish AMN as a distinct methodology within the broad category of dynamic scoring, while also, through a deliberate focus on the author's own creative practice, suggest that these distinctions may be limited to particular compositional practices. To this end, a reductionist, atomic approach will be used to unpack and define the low-level elements of AMN. This reductionist analysis will not focus on musical content or concept, but target the nuts and bolts, so to speak, including prevalent symbologies and their respective dynamisms, symbol design and interaction, and an examination of actualized indication, including contact and intersection. As a global mapping of AMN practices is beyond the scope of this paper, those

[3] Scholarly contributions can be largely attributed to the work of Cat Hope, Lindsay Vickery, David Kim-Boyle, Jason Freeman, Pedro Rebelo and Gerhard E. Winkler, among many others, while their artistic contributions, and those within the field of dynamic scoring in general [Páll Ivan Pálsson's animatednotation.blogspot.com and the authors animatednotation.com provide numerous examples] continue to make significant contributions.

[4] It has been my admittedly contrary intention with `animatednotation.com`, following the model of `animatednotation.blogspot.com`, to be inclusive regarding the diversity of dynamic scoring practices, regardless of those low-level symbolic and functional requirements I will put forth here.

notational approaches that most clearly represent a clearly defined symbology, perceptible functionality, and actualized indication will be prioritized.

The symbolic elements of AMN, with which dynamic functionalities are actualized, can often be reduced to four increasingly complex entities: geometric primitives [primitives], semantically and visually integrated primitives [compound primitives], structures, and aggregates.

Primitives

A primitive is an irreducible static or dynamic symbol.[5] A primitive is irreducible when no aspect of its design can be removed without limiting its intended communicative potential. Channeling Goodman to some degree, Vickery writes "One important factor contributing to the efficacy of notation is semantic soundness – the degree to which the graphical representation makes inherent sense to the reader, rather than necessitates learning and memorization of new symbols." [6]. To this end, a primitive, which may be of any shape or size, is often cast as small geometric primitives [circles, squares, rectangles, lines (straight and curved)], favoring extensible clarity over verbose ambiguity. [7] As Gerhard E. Winkler notes, "the different parts of the score to be *reduced* to a number of elements, which can be learned and 'trained' in advance, and which can be seized with 'one glance' immediately during a performance." [8]

A stationary, or static primitive is referred to as a node, while a stationary or static *line* is referred to as an attack line or play head. A non-line dynamic primitive is referred to as a cursor or attack cursor, while a dynamic line is often referred to as a dynamic attack line or a *swiping* play head (see Figure 1) [9]. Screen boundaries, the physical (or projected) limitations of the score may or may not be treated symbolically, but are necessarily static.[6] Representative images [frogs, spaceships, etc.] are less common, and often serve higher-level purposes, as a visual representation of a particular action to be performed or instrument to be activated, as opposed to the more robust, contextually-variable symbol.[7]

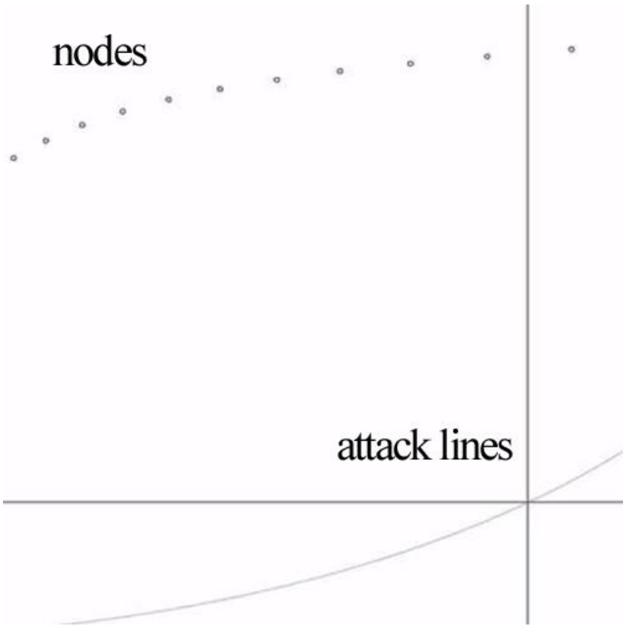

Figure 1. *y = f(x)* (2012) by Þráinn Hjálmarsson [detail] Example of sonic events represented as static circular nodes, their temporality denoted by the crossing of the dynamic attack lines/swiping play heads.

Two or more primitives can be seamlessly combined in such a way that a secondary primitive enhances or embellishes the primary, creating a compound primitive. For instance, a vertical line intersecting a circular primitive in order to clarify the moment of intersection with a static attack line.

The visual qualities of a primitive, including size and color, can also be modified to denote changes to the sonic qualities of the corresponding sonic event, insofar as it can still be 'decoded' by the performer [5]. Changes of this type are, from the visual perspective, necessarily linked to the ontology of the irreducible primitive, and so would not be considered compound (see Figure 2).

Cases where information regarding the qualities of a particular sonic event as prescribed by a primitive appear in conjunction with the primitive, but not visually embedded within it, can still be considered a compound primitive, so long as it clearly references a single instance of a primitive (see Figure 3), as opposed to a modifier, which applies to two or more primitives, and is thus not integrated.

Regions describe a subset of both static nodes and dynamic attack cursors, and are represented by a large primitive, often functionally integrated by intersecting a line (see Figure 5), or its intersection *by* a line (see Figure 6). Regions generally represent an event that is sustained, and/or modified over time. In K. Michael Fox's *Accretion* (2014), the ADSR curve is cast as a notational region, representing relative dynamics in its relation to the static attack line and vertical boundaries (see Figure 4).

[5] The focus here is on those symbols abstracted from, or distinct from conventional symbologies, but this should not presuppose their exclusion in practice.

[6] This refers to the *physical* limitations of the score, not boundaries that may result from letterboxing, for instance, which may be treated dynamically.

[7] In *The Limitations of Representing Sound and Notation on Screen*, Lindsay Vickery develops this through a continuum ranging from the spectrogram [detailed image] to the text score [distilled image]. References to frogs and spaceships is in regards to the particularly interesting experiments in notational design by the S.L.A.T.U.R. collective in Reykjavík, Iceland.

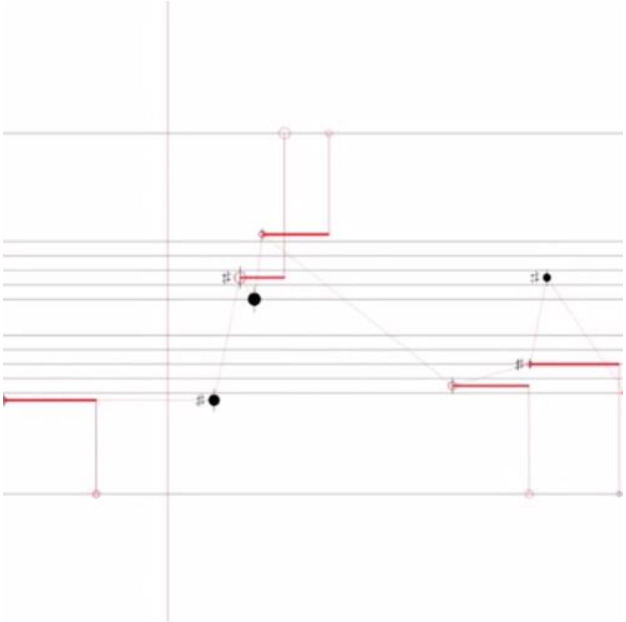

Figure 2. *Study no. 10* (2012) by Ryan Ross Smith [detail] Dynamics are embedded within each primitive, represented by relative size.

Figure 3. *Spam* (2009) by Luciano Azzigotti [detail] Dynamic markings follow the same speed and trajectory as the symbol they are applied to.

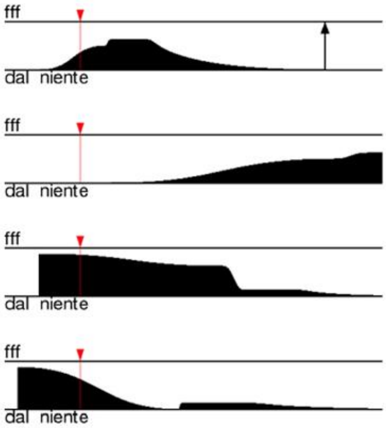

Figure 4. *Accretion* by K. Michael Fox (2014).

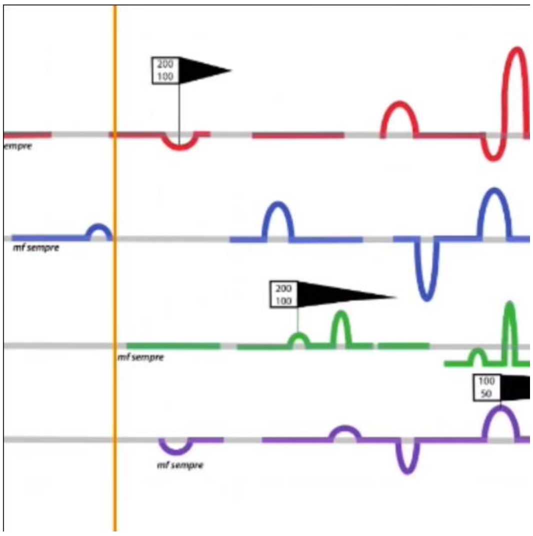

Figure 5. *Cruel and Usual* (2011) by Cat Hope.

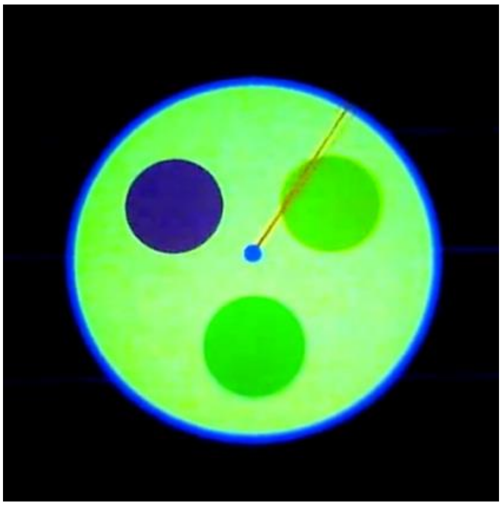

Figure 6. *Spooky Circle* (2012) by Jesper Pedersen.

Structures

A structure refers to two or more primitives in some interrelated relationship. This may be represented by an object, for example a line connecting two circular primitives (see Figure 7 [left]), or created through some dynamic relationship between symbols (see Figure 7 [right]). A structure may contain one or more primitives that are not functionally symbolic, but *clarify* functionality and "semantic soundness." [6] Many of the author's radial scores incorporate a rotating line that connects a rotating attack cursor to a central static node. This line has negligible value regarding its notational functionality, but clarifies moments of contact and intersection (see Figure 8). At the lowest level, a single structure may contain the elements necessary to produce an actualized indication of contact or intersection, an AMN capable of determining the temporal location and quality of a sonic event. To this end, an instantiation of AMN will contain at least one structure, which will in turn contain two or more primitives, at least one of which will exhibit dynamic qualities (see Figure 7 [right]).

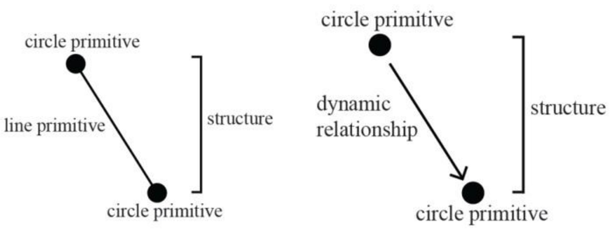

Figure 7. [left] Two circular primitives in a static relationship with one another form a structure. [right] Two circular primitives in a dynamic relationship with one another form a structure.

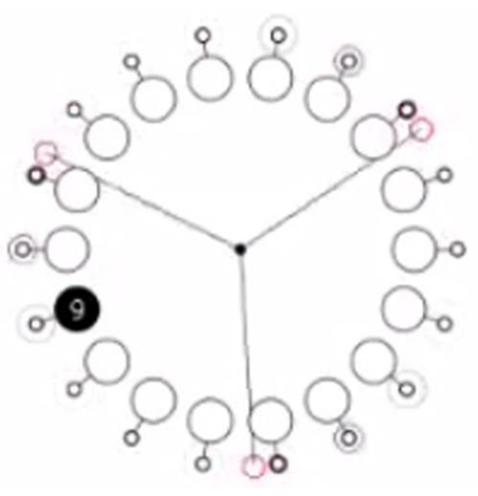

Figure 8. *Study 40.1* [Pulseighteen] (2014) by Ryan Ross Smith [detail] Each of the 18 outer nodes is activated by the intersection by the three attack cursors. The functional structure includes the rotating attack cursors and nodes. The line connecting the attack cursor to the center is a non-essential aspect of the structure, but may improve legibility and clarify functionality.

Aggregates

An aggregate is the collection of primitives, structures, and their respective dynamisms that corresponds to a single player. Aggregates may be visually displaced or integrated, and may be functionally autonomous (see Figure 9) or dependent regarding its relation to other aggregates (see Figure 10). Aggregates range in complexity from a single, simple structure (see Figure 9) to a set of integrated structures, each comprised of several primitives (see Figure 11 & 12).

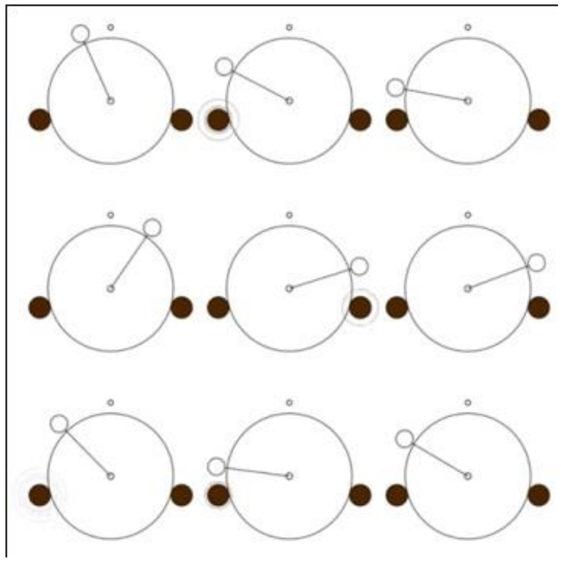

Figure 9. *Study no. 8* [15 Percussionists] (2012) by Ryan Ross Smith [detail]. Visually displaced, functionally autonomous.

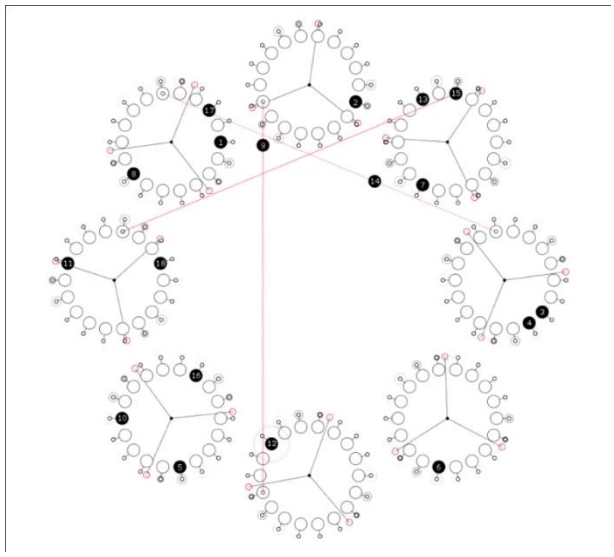

Figure 10. *Study 40.1* [Pulseighteen] (2014) by Ryan Ross Smith. Visually displaced, functionally dependent.

It is important to note that autonomous aggregates that appear to be visually integrated with other aggregates does not necessarily imply any functional integration, dependence or influence (see Figure 9).

Figure 11. *Study no. 31* (2013) by Ryan Ross Smith. Each aggregate (including one of the seven concentric circles, four dynamic 'barbells,' and single rotating attack cursor) is functionally autonomous, but visually integrated, in that each aggregate seems to *encapsulate* smaller aggregates.

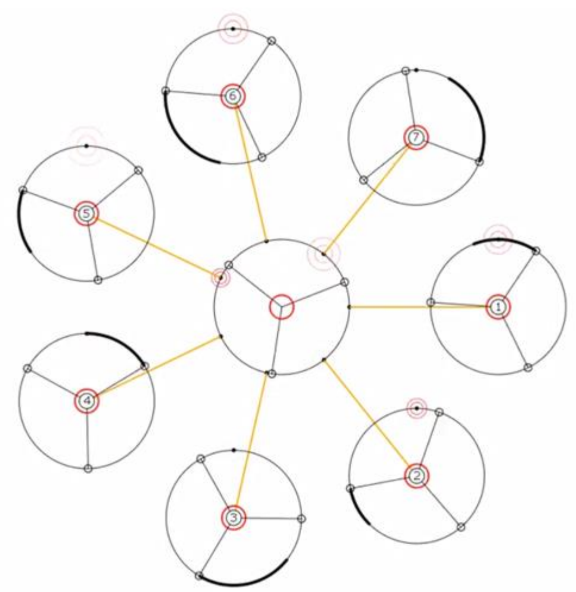

Figure 12. *Study no. 40.3* [pulseven] (2014) by Ryan Ross Smith [detail] Each numbered aggregate (numbers corresponding to players) is dependent on the central aggregate for particular functionalities throughout the piece. The central aggregate is a *collective* aggregate, in that it is accessible by more than one player.

Furthermore, the distinction between autonomous and dependent aggregates is necessarily independent from any global functionality imposed by the score generator, as all elements of the score are necessarily dependent on the score generator for their actualization.

Traversal Duration

Traversal duration refers to the time it takes for an attack cursor to move from its starting point to the point of contact or intersection. Traversal offset refers to the distance a cursor, or line, travels over the course of the traversal duration (see Figure 13). Cursor traversal must be perceptible, or trackable, in order that the performer can clearly gauge the arrival of an incoming cursor and prepare for the moment of attack, and traversal duration and cursor offset must be considered in conjunction toward this end. Lindsay Vickery considers these issues in depth, suggesting that "at scroll rates greater than 3 cm per second the reader struggles to capture information" [6]. A concatenation of nodes or cursors may extend the potential ranges of both the traversal duration and cursor offset, due in part to the regularity or *feel* that concatenation may evoke (see Figure 8). Furthermore, these particular limitations of legibility can be exploited to create, as Winkler notes "'stress' or even 'frustration'" for the players, a music *and* theatrical disruption [8], and explore the extremities of such real-time practices [10].

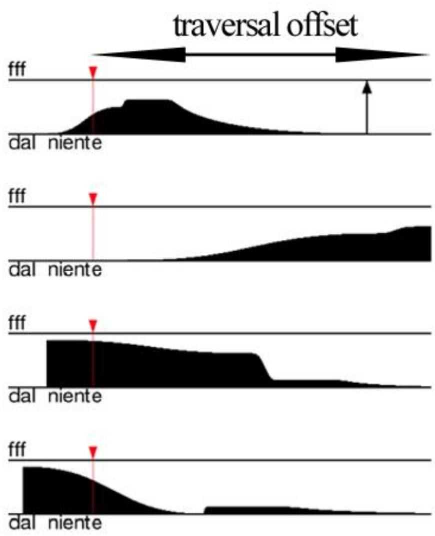

Figure 13. *Accretion* (2014) by K. Michael Fox [detail] In this example, traversal duration impacts not only onset, but the performer's current 'location' within a sustained or continuously-modified event, represented here as a region.

ACTUALIZED INDICATION

Contact

"...the true nature of things may be said to lie not in things themselves, but in the relationships which we construct, and then perceive, between them." – Terence Hawkes [11]

Actualized indication refers to a particular methodology by which the temporal location of a sonic event can visually represented with a high degree of specificity. While the history of notation provides myriad ways to locate a sonic event, this section will deal with only those that best distinguish those functionalities necessary to AMN: contact and intersection.

Contact is the "union or junction of surfaces" [12], and 'surfaces' will here refer to the boundaries of any object, visually defined by its own delineated boundaries [13]. In *Features and Objects in Visual Processing*, Anne Treisman writes "…boundaries are salient between elements that differ in simple properties such as color, brightness, and line orientation but not between elements that differ in how their properties are combined or arranged" [14]. In other words, in order for two objects, or symbols as it were, to appear to come into contact with one another, their respective visual representation must be well defined, differentiated, and at least one must demonstrate dynamic qualities.

The physical gestures of performers and conductors alike most clearly represent the *concept* of contact as a meaningful, perceptible action. The conductor's baton 'bouncing' off a virtual or imaginary boundary elicits a predetermined response based on score location and intensity; The violinist's quick breath and head snap cues an upcoming unison entrance; the guitar player jumps off the drum kit at the correct time in order to make contact with the floor at the following downbeat. These physical gestures of contact, their necessary 'setup,' as (un)subtle as they may be, within virtual and physical constraints, more or less clearly convey a bundle of performance instructions in reference to, but beyond any conventional notion of notation; in other words, the speed at which the violinist snaps her head back, and the amplitude of 'sniff volume' may determine not only the moment of attack, but relative dynamic, tempo, and other less quantifiable parameters (smooth or jagged, heroic or melancholic, etc.); A set of dynamic qualities represented by perceptible movement.

The moment of contact as a notational indicator is not new, nor dependent on digital media,[8] but does suggest a method whereby these interactions can be actualized with a high degree of temporal specificity, even in a generative context, and effectively transfer temporal agency from the performer to the score.

Contact in the context of AMN is represented by the collision of two symbols, actualized as surface juncture. Contact can occur between objects of any shape or size, with at least one exhibiting dynamic qualities. The moment at which contact occurs signifies that some sonic event is to be performed by the player.

One of the most common methods of contact includes a [dynamic] attack cursor making surface contact with a [static] node or play head. In these cases, contact occurs at the moment the cursor's boundary collides with the node or play head's boundary, followed by the cursor reversing its previous trajectory, appearing to bounce of the node, moving away in some other trajectory or simply disappearing. The cursor will not penetrate the node's boundary, and often follows a consistent trajectory (see Figure 14).

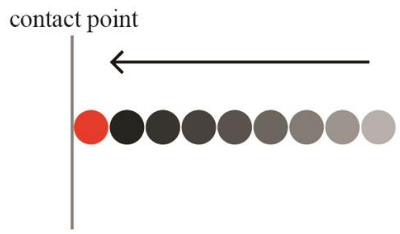

Figure 14. *Contact*: Dynamic attack cursor and static play head.

Intersection

Intersection, as an actualized indicator, consists of a [dynamic] attack cursor intersecting a [static] node or play head. This functionality requires the cursor to penetrate the node or play head, the cursor often continuing on in the same direction following intersection (see Figure 15). Intersection is often utilized for sustained or continuously modified events, and is regularly represented by a region. For continuously modified events, the alignment of the centroid is not applicable, but the position of the attack point (line or node) within the region. In Cat Hope's *Cruel and Usual* (2011), sustained tones are represented by regions in the form of straight and curved lines, their position in relation to the fixed attack line determining the relative degree to which the current pitch is detuned (see Figure 5).

Related to this functionality is the aforementioned dynamic attack line, or swiping play head, in which the nodes are rendered static, the moment of attack determined by the attack line *intersecting* the node, although the general functionality is similar (see Figure 16) [5].

[8] From Max Fleischer to Karaoke, player piano rolls to Guitar Hero, contact and intersection have been the basis for a variety of media applications of real-time notational approaches throughout the 20th century.

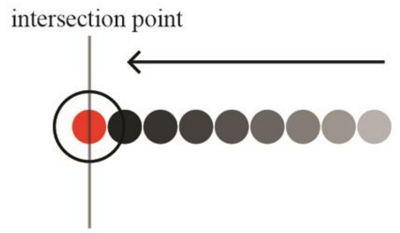

Figure 15. Intersection: Dynamic attack cursor and static play head.

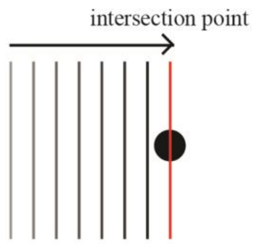

Figure 16. Intersection: Dynamic attack line, or swiping play head, and static node. Similar to the previous example, an event occurs at the moment the line aligns with the node's center.

Certain design schemes and functionalities may render these distinctions negligible. For instance, a node and cursor of relatively small size may make the *exact* moment of contact or intersection difficult to perceive, which often occurs with a concatenation of nodes or cursors [6].

A less common but similarly effective actualized indication includes the convergence by a dynamic cursor on an encapsulated static node. This describes the relationship between a dynamic cursor of similar shape to a static node sharing the same center, beginning larger, and diminishing in size until it makes contact with the node. Contact occurs when the inner boundary of the cursor reaches the outer boundary of the node (see Figures 17, 18 & 19).

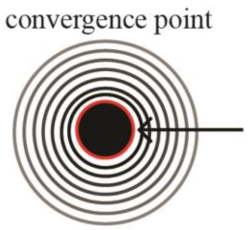

Figure 17. Convergence: Dynamic attack cursor and static node.

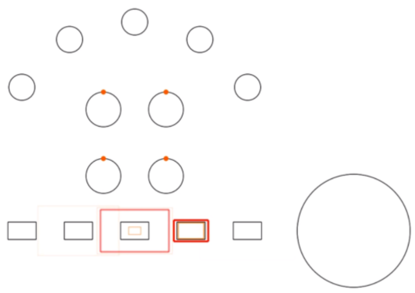

Figure 18. *Study no.16* [NavavaN] (2013) by Ryan Ross Smith. Red rectangles [attack cursor] converge on the black rectangles [static node] to denote the moment of attack.

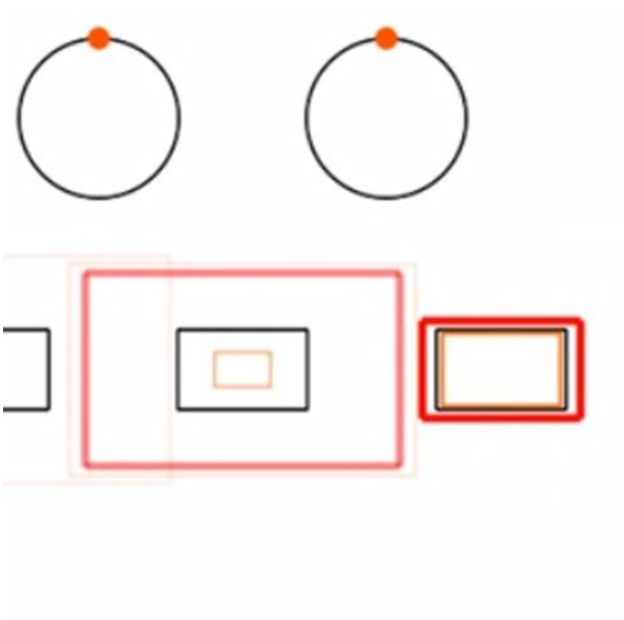

Figure 19. *Study no.16* [NavavaN] (2013) by Ryan Ross Smith [detail].

CONCLUSION

AMN is a form of dynamic notation that utilizes actualized contact and intersection between two or more symbols to denote the temporal location of sonic events. The purpose of this paper has been to propose a distinction between the low level elements [primitives, structures, aggregates, and actualized indication] that distinguish AMN as a particular notational methodology, and the dynamic score as a container which AMN and other approaches are realized, largely framed its utilization by the author to obtain temporal specificity. The continued expansion of this reductive analysis may lead to not only further this distinction, but to suggest a terminological and functional foundation from which one can clearly and consistently explain "how the system works" [8], and present possibilities for tactical subversion.

Acknowledgments

Thank you to those composers and researchers who have inspired my initial and continued interest in this field of practice, in particular the work of Páll Ivan Pálsson, Jesper Pedersen, Cat Hope, Lindsay Vickery, David Kim-Boyle, K. Michael Fox, and the composers of the S.L.A.T.U.R. collective.

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