Are Scores Maps? A Wayfinding Approach to Composition

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Abstract

In contrast to competing notational or linguistic theories, this thesis proposes that a certain class of musical scores is best understood as employing a map-like representational strategy. The proposed cartographic or wayfinding theory of notation draws on contemporary philosophical work on the representational modality of maps while pushing back on a Goodmanian conception of notation systems. Aspects of my own creative practice that draw on wayfinding design are detailed, and my compositional practice is situated within a contemporary tradition of graphic and animated notations.
“But how can you take such a map seriously,” the Poet snickered “when it shows
the earth flat, and you claim it’s a sphere?”

—Umberto Eco, Baudolino
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Chapter 1

Introduction

In an oft-quoted phrase, von Schelling describes architecture as “congealed music.”\textsuperscript{1} If we can flip the metaphor on its head, then what type of score could serve as a map to the “liquid architecture” of a musical work?

Spatial and architectural metaphors have antecedents in some of the earliest notated works of European music. Perhaps the earliest clear example is that of \textit{Nuper Rosarum Flore}. Famously, Guillaume Dufay’s motet is structured according to the biblical dimensions of the Temple of Solomon. Written for the consecration of the cathedral of Florence in 1436, the architectural metaphor suggests a symbolic architecture overlaid on the physical performance space (Wright, 1994). Although less explored in subsequent centuries, spatial and material metaphors continued to play a role in aesthetic discourse. A contributor to the 1871 issue of the \textit{Builder}, an architecture periodical, wrote that “what regular division of \textit{time} is to music, regular division of \textit{space} is to architecture” (Bright, 1984, p. 83), a sentiment that prefigures the spatiotemporal analogy widely studied by cognitive scientists in the twentieth century (Gentner, 2003).

\textsuperscript{1}“\textit{erstarrte Musik}” (von Schelling, 1859, my translation, 2017). Often attributed to Goethe (Eckermann, 1975), who reported finding the same thought among his papers.
Chapter 1. Introduction

If not for the primacy of literature and poetry over architecture and sculpture as the more prominent aesthetic metaphors in European culture during music’s common practice era, architecture might well have given rise to a fundamentally different conception of sound, one not indebted to grammar but rather to structure, material, surface, and space.¹

In the twentieth and twenty-first centuries, space and morphology have superseded linguistic conceptions of sound, most famously perhaps in the work of Iannis Xenakis, where sketches for his musical work, Metastaseis (1954), served as the initial sketches for his architectural design for the Philips Pavilion for the 1958 Brussels World’s Fair (2001). But conceptions of space, material, and structure permeate numerous threads of contemporary composition both abstractly, in the conception of the aural phenomena, and in the graphic metaphors used in music notation. In interviews and letters, Morton Feldman and George Antheil cite a new understanding of time and space as essential to understand the New York School of composition in the 1950s (Cline, 2016). Recently Swiss composer Jürge Frey has describe his compositions as constituting a kind of metaphorical empty space (Gottschalk, 2016). More generally, the turn towards spatial metaphor in composition and notation mirror a larger change in recent decades towards considering the gallery and the spaces in which performances take place (LaBelle, 2015).

Consider the manuscript for John Cage’s Williams Mix (Figure 1.1), which the composer described as “like a dress-maker’s pattern” (Cage, 1952).³ The score consists entirely of images showing how and where lengths of pre-recorded magnetic tape are to be cut and spliced. The score does not represent anything at all about an intended sonic ¹See Butler (1980) ³It is perhaps not obvious at this stage that “spatial” and “diagrammatic” are similar, and their synonymous use here should perhaps not be conceded so easily. What is important, however, is that both depend on a cognitive capacity to abstractly order objects, whether the objects are lengths of magnetic tape, names on a seating chart, or the component parts of a bookcase manufactured by a certain Swedish budget furniture retailer.
result; rather Cage has invented a representation for the physical exploration of the tape itself.

Or consider Robin Hoffmann’s *oehr für Hören solo* for a listener’s ears and hands (Figure 1.2). The nature of the material is so unique and goes so far beyond what any existing notation system is equipped to represent that a new kind of score must be invented for the material, a kind of choreography or map of the movements of the hands over time.

These kinds of examples suggest several key questions for anyone intent on representing the exploration of a new material, technology, or performance situation:

How can we be confident in the success of the analogy on which the representation depends?
And what is the nature and effects of an ambiguous or self-contradictory notation? 4

In this thesis I will try to move some way towards answering these questions by proposing a model of representation in a certain type of score, specifically scores that depend on spatial analogies.

One form of music notation is already recognized as map-like. The contemporary use of tableture—a system that represents the physical space of an instrument such as a guitar fingerboard—often goes far beyond the representation of chord changes familiar in jazz and popular music. Tablature notation is often associated with the more general term “action notation” (apparently attributable to Peter Böttinger) or “prescriptive notation,” in Kanno’s (2007) phrase, which refers to notation specifying the performative actions required to realize the score rather than a desired resultant sound. Frequently such notations represent the physical space of the instrument in great detail, with performer actions represented vectorially as “smears” of movement through time. 5 The approach is explicitly spatiotemporal—leveraging the human capacity to interpret properties of one domain as properties of another domain—and the strategy of representation is frequently described in cartographic terms by composers. For example, American composer Aaron Cassidy (2013, p. 1) uses terms like “topographical mapping, boundary spaces, and physical modeling” to describe this approach.

My philosophical project, however, takes this idea much further. I view a large class of scores as map-like. This thesis aims to clarify a semantics for scores that leverage cartographic strategies of representation. The result is a structuralist conception of

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4 Ambiguities and contradictions have their uses, a subject which will be explored in Section 3.3.1. The point is not to valorize a certain kind of score or notation but rather to explore what can be preserved and communicated and the consequences of certain notational decisions.

5 For discussion of the “smear” as an archetype in his composition, see Timothy McCormack's *Instrumental Mechanism and Physicality as Compositional Resources* (2010).
notation that frames scores in the context of a wide class of images: scientific illustrations, graphs, charts, maps, and even systems of public signage.

In addition, the requirements for self-consist systems of notation are clarified. Importantly, self-consistency is not represented as an aesthetic aim in itself, however, but rather as one of many properties that potentially convey meaning for an interpreter. The intentional subversion of clarity, consistency, or other expected features in a representation are described in terms of essentially Gricean pragmatics, which takes the flaunting of a maxim (an expected norm of cooperative linguistic communication) as possibly “implicating” meaning beyond the semantics of the words used.

Scores in practice are complicated artifacts, full of marks that stand in for performative actions, expressive metaphors, and temporal orderings. Particularly in the case of contemporary music notations, a wide gray area exists between different modes of representation, and it is not always clear how we should classify boundary cases. It is not my intention to classify such representations for the sake of classification. On the contrary, exploring how unusual cases of representation function can potentially reveal how and for whom such scores are intended and how their graphic strategies shape the creation of musical works and accommodate certain uses while constraining others.

Insights from philosophy, cognitive science, and design theory can help explain how scores function and how they fail, when they fail. But the gap between the score (or map) as an abstract representational modality and how it functions or could function in practice remains large. It remains the job of artists to perform experiments in perception which illuminate this gap between theory and practice. I see my role as an artist as being, in part, that of developing a speculative project that extends and explores where philosophy does not yet have the tools to explain.
Chapter 1. Introduction

It might be objected that regardless of their truth or falsity on a cognitive or perceptual level, notational, sentential, or semiotic theories of music notation already adequately explain scores, at least sufficiently for common usage of scores to take place. My response to this is in the form of examples from my own work. Through these examples, I hope to show how the notations in contemporary common usage often overflow the typical temporal or diastematic limits of current notational practice. How are we to approach notation for unfamiliar or ephemeral materials such as shards of ceramic? For chaotic electroacoustic processes? For human psychoacoustic perceptual limits? In such cases, the compositional task is often to curate an exploration under certain conditions, and to this end leveraging map semantics can allow composers to invoke a powerful ability to represent both tangible and conceptual qualities in spatiotemporal relationships.

My approach here will move from historical to analytical concerns and finally to examples and practical discussion of my own work. Chapter 2 is concerned with reviewing prevailing theories of music notation. Section 2.2 describes the stakes of this project, specifically Goodman’s concept of “worldmaking” is explored in a more limited sense, the sense in which we speak of a composer evoking a “musical world” or “sound world” in their works. Section 2.3 describes a corollary to the “Language of Thought” argument abjured by Camp (2007) through a history of linguistic metaphors applied to music and scores in the European tradition. Section 2.3.1 summarizes a refined version of this theory from Nelson Goodman’s Languages of Art (1976). Section 2.3.3 deals with objections raised against Goodman.

In Chapter 3, I aim to show how spatial and cartographic representations can address Goodman’s concerns about representation in graphic or hybrid scores. Section 3.1 reviews recent philosophical work on map semantics and introduces addressee-centric

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6 “Diastematic” refers to notation strategies that use vertical staff space to represent musical pitch.
indexicals as a basis for cartographic, as opposed to diagrammatic representation. Section 3.2 follows from Roberto Casati and Achille C. Varzi’s work on “formal maps” and compares such maps with “formal scores.” Section 3.3 provides a cartographic account of how map-like scores function by adding successive layers of representation to a simple spatial representation of spatiotemporal work features. Section 3.4 introduces an account of map pragmatics based on Abell’s (2005) Gricean account of implicature in images and addresses cases in which composers intentionally ambiguously score representations. In Section 3.4, I address holistic systems of public signage, which, like some scores, are seen found to involve a special case of addressee-centric indexicals, and in Section 3.5, I make a few observations about animated notation.

Finally, in Chapter 4, I turn to a practical discussion of my own creative practice which I frame in the context of my philosophical project, my influences, and my aesthetic intent as an artist.
Chapter 2

Background

2.1 Terminology

This thesis walks a delicate balance. My intention is to bring together two fields that share an interest in imagistic and acoustic representations. Composers and philosophers have much to say about representation that would be of interest to either field, but differences in terminology and contextual references continue to separate the fields. This thesis cannot hope to do more than scratch the surface of what could be said about cartographic representation in music, but I hope that my attempt to provide context for work in both fields will be useful.

Some terms used here have a precise technical sense that is specific to the disciplines of philosophy or music theory. Where possible, I will try to offer a more detailed explanation for concepts in both fields than would be typical of a less interdisciplinary academic work. However, it will also be helpful to clarify some terminology from the outset.

For simplicity, I have adopted the use of title case whenever I refer to strictly
Goodmanian “Notation” or “Notation Systems” (see Sections 2.3.1.2). This is not to be confused with the common usage of “notation,” which in music is often used to refer to many disparate representational approaches.

In arguing that a certain class of scores are maps, I follow Camp (2007) in assuming that maps have some cognitive corollary. This is in line with an enormous body of research on how human beings and animals mentally process space and spatial relationships (Downs and Stea, 1973; Hartley et al., 2003; Moore and Golledge, 1976; Tolman, 1948). Although my approach does not primarily rely on cognitive science, I use the term “map” on the assumption that external representations correlate to some comparable internal mental process.

In my usage, “score” and “notation” have the following (somewhat fuzzy) distinction: notations aim to represent granular aspects of musical acts or occurrences, while scores have various uses and may use or layer different forms of representation but generally at least represent musical works as unary works in some sense.

# 2.2 Scores and Worldmaking

The choice to create a representation of a musical work, and the means chosen to do so, corresponds closely with the ways creators and interpreters construct and interact with that work. That correspondence is so vital in much of contemporary music that we often think of scores as music just as we think of books as language. Here I use “worldmaking” is not in the sense of full epistemic irrealism as Goodman uses the term, but rather worldmaking refers to a more limited world within a composition where the acoustic material of the work, along with the means of representation which premise that work, categorize and recategorize the listeners pragmatic assumptions about sound,
Chapter 2. Background

noise, and structure.¹

In many contemporary works, the composition cannot be conceived of without considering the specific notational hand of the composer. Pisaro (2009), for example, describes the intimate connection felt in viewing a facsimile of John Cage’s Winter Music (1954), where the musical notes were derived from imperfections in the paper itself, the materiality of the score literally manifested in the sound.

Once you are attuned to this way of looking, and hearing, and thinking – where the writing of the score, the process of its creation and the object of the score, in all its materiality, are seen to play a decisive role in the music itself, you can find it everywhere in experimental music: in Morton Feldman’s copying procedures, in Cornelius Cardew’s Treatise and The Great Learning, in the curved eights and the prose of Christian Wolff, in Lucier’s Queen of the South, in Winter Yam by George Brecht, even in Cage’s 4’33. Through all this music it is clear that experimental music confronts ideas about writing. (2009, pp. 27-28).

Further discussion clarifies Pisaro’s intentions. By “writing” he means representations as well as the processes that enter into representations.

A score, no matter how beautiful, is still understood as a set of symbols whose goal is to be interpreted, in most cases, as a sound (and silence). At the same time this music raises, again and again, fundamental questions about the conditions (that is, the mechanics, the system of reference, the function and the process) of writing: as an exploration of what the hand can do, as a way of giving performers directions, as a frame of reference for sounds, as a model for certain kinds of musical behavior (2009, p. 28).

¹The more precise term “waymaking” will be introduced later to refer to the specific way in which scores and notations serve composers and reshape the act of composition, just as they also have a performative function for the musician.
In another example of the vitality of a score’s representations as they affect the act of composition, Aaron Cassidy provides an example from his *Second String Quartet* of a sound that could not have been conceived of without the particular pressures and opportunities provided by his intricate prescriptive notation scheme.

Crucially, it is the interaction between these many layers of constriction schemes—available movement windows and available gestural models for each of the six planes, combined with their independent rhythmic and tempo considerations—that provide for me the most interesting and challenging aspect of the work’s composition. This multi-layered system frequently establishes unexpected conflicts, frictions, and “accidents” that lead to unique sonic outcomes that, quite frankly, I don’t think I would have imagined on my own (2013, p. 14).

In the viola part of Cassidy’s quartet, in measures 109–110, the performer is required to press the frog of the bow (the lowest part of the bow hair) into the string above the left-hand fingers, reversing the usual locations of the bow (right hand) and string-stopping fingers (left hand). In this configuration, the normal movement of the left-hand fingers encroach quite close to the space occupied by the bow, creating a complex interaction between the tension and angle of the string under the bow hair and the two points at which the string is stopped (by fingers and by the bow). While the musical gesture itself is not outside the repertoire of a contemporary violinist or improviser, it’s quite clear that Cassidy’s discovery of this particular effect arose, at least in part, from the composer’s highly spatial notation scheme, where different vectors represent the performer’s hands and their actions independently.

The performative motions represented by this type of notation—the physical constraints of the action as well as the correlative graphic constraints of the representation—allow a composer like Cassidy to “think on the printed page.” A musical gesture is a
Chapter 2. Background

byproduct of the holistic intersection of different graphic processes (finger location, finger movement, amount of string depression, bow pressure, etc.). The result is a constellation of somewhat unpredictable effects that arise from the collision of different musical qualities and movements laid out diagrammatically in the score. Reinforcing this point, Cassidy goes on to describe the the viola’s “skittering, unstable crackles and clicks” (2013, p. 14) that arise from the intersection of the particular physical and notational constraints.

It is, quite simply, a physical gesture and a sonic result that I could not have imagined. It appears only as a solution to an extremely restricted space established by the movement and gestural constriction schemes (2013, p. 15).

Scores can be visually striking, but they are also highly utilitarian. It is almost impossible to overstate the effect that notational systems and tools have on many composers. What is at stake in considering the form and function of representation in scores is the nature of the connection that is made between the composer, interpreter, and listener.

But scores also serve other functions beyond facilitating the preservation and retrieval of work information. Scores support different kinds of uses. For composers, scores may serve as “waymakers” (see Sections 3.4) to define or constrain a set of musical features whose interaction in a work is facilitated by a specific graphical representational strategy. For interpreters, a score may have an additional de se function, to represent a temporally situated view of the work as it unfolds in time. A score may even serve a special representational function for a third person, who interprets not only the score but also the performers’ interpretation of the score, as occurs when an audience
member reads the score during a performance.²

The preceding discussion illustrates what is at stake for composers in considering score representation. Before considering how representations support other uses of scores, I will introduce a linguistic theory of scores.

2.3 The Score as Language Argument

To determine whether music, or mathematics, or the communication system of bees, or the system of ape calls, is a language, we must first be told what is to count as a language. If by language is meant human language, the answer will be trivially negative in all of these cases. If by language we mean symbolic system, or system of communication, then all of these examples will be languages, as will numerous other systems [...] (Chomsky, 1979, p. 32)

Music in the European tradition is strongly associated with language.³ Historically European music theorists and philosophers have metaphorized non-notational musics as emblematic of nonliterate societies, often valorizing this supposedly “unmediated” form of musical expression (Green, 1990). An early example of this trend is found in Jean-Jacques Rousseau’s Essay on the Origin of Languages (1999), where Rousseau envisions music emerging from protolinguistic vocalisations.

In Europe the association between music and language—the written word and the written score—is perhaps intuitive. The earliest precursors to European notation were

²My composition Teller Light features a special case of third-person score interpretation, as the audience is free to move about the performance space and look over the performers’ shoulders but has only limited knowledge of how icons relate to the work being performed (see Sections 4.3).

³A version of this chapter was previously published as “Are Scores Maps? A Response to Goodman,” in the proceedings of the International Conference on Technologies for Music Notation and Representation (Miller, 2017).
apparently diacritical marks in text that gradually came to indicate relative pitch and
duration (Rastall, 1982; Treitler, 1982).

Surveying contemporary attempts to construct a “Language of Music” argument,
Clark (1982) examines several proposals:

In The Principles of Art, Collingwood (1958) argues from David Hume’s distinc-
tion between “impressions” and “ideas” that the imaginative act of parsing raw sensory
input, together with expression based on that imaginative capacity, is language. “What
kind of thing must art be if it is to have the two characteristics of being expressive
and imaginative? [...] Art must be language.” This approach, although consistent with
Collingwood epistemology, is unsatisfying since it seems to trivially reduce all human
actions to language. The idealist account cannot obviously tell us about music as dis-

tinct from dance or cooking.

Another attempt to formulate a language of music takes a semiotic approach. Clark
focuses on two projects, that of Wilson Coker (1972) and Susanne Langer (1953).
For both philosophers, musical structures are theorized to correlate to meaning, and both
accounts analyze musical phrases or structures as having meaning in aggregate. Coker
struggles to give an account of how phrases of music might convey extramusical sig-
nification without being able to provide a sufficient semantics, while Langer assumes
the more reasonable goal of showing that musical structures evoke feelings but must
assume that the feelings expressed are merely aesthetic forms. The approach cannot
sustain its high ambitions. As Clark observes, “In Langer’s case the referent disappears
into the sign (what we hear is whatever is meant) and in Coker’s case the sign tends to
collapse into its referent (whatever is meant is just what we happen to hear)” (1982, p.
197).

A third project, whose articulation by Chomsky prefaces this section, is what
Clark refers to as the “formal approach.” Nelson Goodman’s theory of notation represents the most robust analytical version of this “Language of Music” argument; music notations are analyzed as having the same form and function as the symbolic representations of languages.\(^4\)

In what follows, I take Goodman’s challenge to work preservation in scores to be a challenge to new theories of notation. My counterproposal is meant to show how a cartographic system of representation is a plausible alternative to this linguistic theory of music scores and in fact better explains the uses to which scores are put by their users. Although maps do not preserve with the same fidelity of a Goodmanian Notational system, they preserve selected features to the degree that composers build that precision into their representational scheme, and through specifying a particular “scale,” they engage in a dialog with interpreter’s pre-existing knowledge and expectations of score-like representation. Contemporary scores in particular often rely on strongly pragmatic means representation.

I will first summarize Goodman’s theory of Notational scores and objections to the theory and then position scores in relation to maps as a hybrid representational modality.

### 2.3.1 Languages of Art

Nelson Goodman’s theory of music notation arises from his broader interest in symbols, which is mainly set forth in his 1968 book, *Languages of Art*. Subtitled *An Approach to a General Theory of Symbols*, this ambitious project sought to establish a unified theory of symbols that would be broad enough to encompass the many disciplines in which they function, including natural languages, visual arts, music, dance, and the sciences.

\(^4\)I will use of title case whenever I refer to strictly Goodmanian “Notation” (see Sections 2.3.1.2).
Although appealing in its scope and explanatory power, Goodman’s project has been unpopular with philosophers as a theory of music notation and has been largely dismissed by music theorists and composers as well (Anderson, 2013; Elkins, 1999; François, 1992; Webster, 1971; Ziff, 1971). In part, this resistance stems from the rigidity by which Goodman believed scores identify musical works. According to Goodman’s theory, symbols that participate in special systems of symbols (Notations) function in scores to preserve and identify works. Only Notational elements of a score can be confidently said to be preserved with accuracy over successive reproductions of a score, and only performances that comply fully and exactly with the Notational parts of a score can count as valid performances of a work. Non-Notational features of a score may be important to the quality of a performance but are not considered to be part of the score’s primary representational function, which is to manage the two-way retrievability of musical works from scores and scores from performances. Experimental or graphic notations, which do not rely primarily on Notational “scheme,” cannot be trusted as “preserving a work” in this strict sense.

Despite its seeming shortcomings and paradoxes, Goodman’s theory of representation deserves a second look. We need not accept the full breadth of Goodmanian irrealism to suspect that he is correct in observing that representations participate in worldmaking—at least on the level of the works of music and art themselves—by categorizing and recategorizing the objects of representation in new and revealing ways.

Additionally, Goodman’s theory of notation attempts to characterize music notation in the context of a broad class of representations, including, for example, scientific notations and data visualizations. As composers increasingly make use of new tools for notation, including vector-based graphic design software and computer animation, it is important to develop philosophical paradigms for analyzing these works in a multidisciplinary graphical context.
While a purely notational account of contemporary scores may be implausible for reasons that will be elaborated in Section 2.3.1.3, recent philosophical work on map semantics suggests that Goodman may have been right in his account of notations but mistaken in his account of what it means for music to constitute a “work.” In a discussion of maps, Goodman observed that road maps rely on a mix of analog and digital symbolism. In a similar vein, John Kulvicki has observed that maps are “picture-language hybrids.” It is striking that Goodman did not explicitly draw a parallel between the representation strategy of maps and that of scores. Both appear to play interesting games with representation, sometimes pushing the boundaries of what we can understand to be a map, diagram, or sentence in a symbolic language. Both seem to facilitate addressee-centric indexical representations which support their use as navigation systems, whether for a spatial structure or for the spatiotemporal structure of a musical work. Both play interesting games with representational pragmatics, e.g., playing with cartographic conventions or leveraging a performance practice for representational import.

By emphasizing the Notationality of scores, Goodman downplays the importance of other modalities of representation in scores, claiming that music notations “comes as near to meeting the theoretical requirements for Notationality as might reasonably be expected of any traditional system in constant actual use, and that the excisions and revisions needed to correct any infractions are rather plain and local” (Goodman, 1976, p. 186). This is not plausible, especially in the case of most contemporary scores where pictorial representations often significantly supplement or even replace traditional notation symbols.

In reframing Notation as a contingent feature of scores, a certain rigid conception of score-preservation and work-preservation must be sacrificed. However, in Section 3.3, these seeming shortcomings will be seen to play an expressive role, as composers use the scale and content of score representations, as well as highly local and also global
conventions, to implicate things beyond the pre-pragmatic analysis rendered by interpreting score symbols out of context.

2.3.1.1 Notation

For Goodman, Notational systems are systems of symbols that represent things with a particular kind of fidelity. Notations section off and label certain parts of the universe, allowing information to be preserved without loss of accuracy due to subjective evaluation or imperfect reproduction. This distinction is the difference, for example, between recording a particular geometric angle in degrees or radians versus recording that same angle as a line drawing of an angle. Given consistent measuring equipment, an angle notated in radians can be reproduced with absolute fidelity, whereas an image may be degraded by subsequent reproductions.

An example of a strictly Notational system is chess notation. At least one type of contemporary chess notation completely eliminates ambiguity from the recounting of a chess match. According to the “Figurine Algebraic Notation” (FAN) system of chess notation, each square on the board has a unique and discrete Cartesian coordinate. Furthermore, a unique pictogram represents each piece on the board (with the exception of pawns, which are described by their rank and capture history). For example, moving the white queen two squares forward from her starting position is indicated in FAN by her symbol and destination coordinates, $Q_d3$.

Although we commonly refer to many kinds of symbolic depictions as “notations,” Goodman restricts this term to symbolic systems that fulfill strict criteria. The importance of defining a technical sense for the word “notation,” which may depart from the vernacular use of the word, is to explicate how and in what cases we can be confident that a symbol refers without ambiguity.
2.3.1.2 Goodmanian Notational Criteria

In order to be Notational, the symbols that constitute a Notational scheme must fulfill five criteria. Goodman’s first two criteria relate to the syntax (or representational form) of symbols, while the remaining three criteria relate to the semantics of the symbols (or the content of these expressions). This distinction between form and content is normally associated with linguistic expressions, but in the present case, it applies to any Notational scheme and, as we will see later, is also relevant to the representational modality of maps. Goodman’s five criteria for Notational systems are as follows:

1. **The constituent symbols of a Notational system must be disjoint (or “character indifferent”).** In other words, marks that stand for equivalent symbols in a Notational system must be capable of being exchanged without syntactic consequence. For example, in Figurine Algebraic chess notation, no symbol ever counts as an instance of more than one symbol in the system, i.e., there is no mark that stands in for both the symbol for the white queen and the symbol for the black queen. What matters is not that two characters be easily differentiated in practice—symbols may still be disjoint even if they are difficult to distinguish; such a notation would simply be an inconvenient notation, not an invalid one—rather it is the quality of belonging to only one class of marks (containing instances of a single symbol) that makes a notation disjoint or not.

2. **Symbols must be finitely differentiable, and such symbols are said to be “articulate.”** A notation is “finitely differentiable” when we can ascertain whether two symbols are in fact instances of the same symbol Goodman (1976). The canonical example is the letters of the alphabet. Finite differentiability allows us to interpret the analog marks of a handwritten letter as a collection of digital symbols. The concept is related to syntactic density. A feature of certain non-finitely
differentiable notation, a dense symbolic scheme is one which has the quality that, for any two symbols, there exists a third symbol between them. For example, a notation system consisting of lines of different lengths would be dense in the sense that between any two lines of differing lengths there exists a third line of intermediate length.

3. **The extension (or compliance-class) of a symbol must be unambiguous.** That is, the semantic referent of a symbol must be uniquely picked out by that symbol. In other words, regardless of when or in what context a symbol is used, the object represented by that symbol will always be consistent. For example, in Figurine Algebraic chess Notation, the white queen is always referred to by the symbol ♕ regardless of time or context.

4. **The semantics of the Notational symbols must also be disjoint.** The set of objects to which a symbol refers may not overlap with the set of objects referred to by another symbol, e.g., redundancy within the field of reference is not permissible within a Notation system.

5. **The compliants of a symbol within a Notational system must be semantically finitely differentiated.** A semantic corollary to finitely differentiability, it must be theoretically possible to determine when an object fails to comply with any given symbol in the notation. In Goodman’s example, a system that would fail this test would be a symbol system composed of lines of different lengths in which two semantic complaints are picked out when a line differs in length to any degree at all. Since no practical system of measurement is ever precise enough to determine this, the notation based on these two lines is not semantically finitely differentiated.5

5In a more intuitive example from ?, we might imagine a notation based on the temperature of an object. Since no tool of measurement is ever precise enough to distinguish liminal cases, such as system would also fail semantic finite differentiation.
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Syntactically, symbols within a Notation system may be composed of an indi-
visible unit (“atomic symbols”) or composed of multiple atomic symbols (“compound
symbols”). On Goodman’s account, a musical score as a whole is a compound symbol
that uniquely identifies a particular musical work. The purpose of a score is therefore
to identify a particular musical performance with the musical composition of which it
is an instance.

A score, whether or not ever used as a guide for a performance, has
as a primary function the authoritative identification of a work from
performance to performance (Goodman, 1976, p. 128).

This theory, if true, would elegantly bring score representation into line with lin-
guistic representation. Like symbols of written language, Goodman sees scores as pre-
serving their respective musical works with the rigour we expect of the letters of the
alphabet. On this account, the compound symbol which is the score for Sibelius’s Finn-
landia picks out exactly one musical work, the Op. 26 composed by the man depicted
on the old Finnish hundred-mark note.

As a consequence of this view, in order to uniquely identify a performance as an
instance of a work, the score, as a Notational symbol, must conform to Goodman’s five
criteria. This further entails that at least some relevant portion of the score must itself
be based on Notational symbols. For example, Goodman identifies pitch and rhythmic
notation (the latter only in practice rather than in terms of its theoretical syntax) as be-
ing Notational, at least as far as can be expected for a Notational system in “traditional,
actual use.” On the other hand, tempo indications (and presumably dynamics, glissan-
dos, and much else), being syntactically dense, cannot be used to uniquely identify a
score. Work identification cannot hang on any of these properties; therefore, neither
can any graphic score count as a score of a musical work in a strict sense, since it con-
tains no Notational information. For that, Goodman says, we would need “stipulation
of minimal significant units of angle and distance” (1976, p. 188) for the various lines and dots used in Cage’s score (Figure 2.1. Anything less would fail to be a Notational symbol, and the resulting work would be in danger of failing to uniquely pick out a musical work. Additionally, Goodman points out that a non-Notational score is in danger of being degraded beyond recognition through a series of small errors of graphic reproduction among successive additions.

2.3.1.3 Critical Response to Goodman

Goodman’s theory sets such a high bar to “work identification” (the presumed purpose of scores) that on Goodman’s account we likely never hear a genuine performance of any musical work or score, a fact not lost on many of his critics. In separate papers Ziff (1971) and Webster (1971) have convincingly argued that Goodman’s theory of music notation failed to reflect the meaning and practical usage of scores, with Ziff additionally suggesting that Goodman overlooked the degree to which scores can only be accurately interpreted within the context of a particular performance-practice tradition.

\[^2\text{Page 53 from John Cage’s } \textit{Concert for Piano and Orchestra} \text{ is reprinted with the permission of Edition Peters.}\]
Elkins (1999) has questioned whether the “marks” (the specific manifestations of notation on the printed page, as opposed to the interchangeable “symbols”) of music notation are truly “indifferent,” that is, whether the shape of the score elements, apart from their symbolic meaning, might have a significant effect on how musicians interpret a score. François (1992) takes issue with Goodman’s assumption that scores identify works at all (at least in the modern era), preferring to consider the realization of a work alone to constitute that work, while Anderson (2013) notes that Goodman’s rejection of graphic scores as non-Notational leaves them in a kind of “limbo,” being far too score-like in their usage to be considered improvised compositions, while also apparently serving no work-preserving function, according to Goodman.

Although Goodman’s economy of means is elegant, his conception of a score requires that, strictly speaking, we must reject the authenticity of any performance of a musical work that fails to conform to the minutiae of the relevantly Notational elements of the score. An imperfect performance of a work is not, in a strict sense, a performance of that work, because the score only represents performances that fall within its compliance class. Although we are free to speak casually of a performance being a performance of “such and such a work,” in a strict sense Goodman is adamant that a performance of a composition is only a realization of that composition if it is an exact realization of the score’s Notation.

Since complete compliance with the score is the only requirement for a genuine instance of a work, the most miserable performance without actual mistakes does count as such an instance, while the most brilliant performance with a single wrong note does not. [...] If we allow the least deviation, all assurance of work-preservation and score preservation is lost; for by a series of one-note modifications, we can go all the way from Beethoven’s Fifth Symphony to Three Blind Mice (Goodman, 1976).
The strict sense in which a score identifies a work according to the score-as-symbol theory leads to some counterintuitive results. For example, since tempo marks are syntactically dense and hence not one of the relevant Notational elements of a score on which work identification hinges, a performance may still be an instance of a work even if it is played vastly faster or slower than the composer intended. The score for Beethoven’s Ninth Symphony would theoretically still identify a performance of that work as an instance of the work even if the Ode to Joy were played over the course of an entire week or as a blur of nearly unrecognizable noise lasting only seconds, so long as the performers didn’t actually miss or change the notes and rhythms of the work relative to each other.

It is also unclear exactly what it would mean for a musical work to be played according to the Notational elements of the score. Although pitch and rhythm (in practice) are Notational when considered on the level of a pre-pragmatic gloss, both of these parameters are correctly interpreted only when interpreted according to pragmatic norms which may involve, for example, the circumstances of the performance and the musical context in which the relevant passage occurs. The compliance class of score Notation is not unambiguous. Rather, the exact pitch or rhythm of a passage is the result of a complex web of contextual and expressive factors.

For example, when pitches in piano scores designate 12-TET tempered pitches, some of whose intervals are “out of tune” when compared to Pythagorean intervals. String players generally tune to Pythagorean intervals, except when they are playing with a keyboard instrument. In tonal music there is a tendency to raise the “leading tone” slightly; diminished tones are often played flat. Good musicians constantly vary their pitch and rhythm based on the local features of a work and their knowledge of historical style and performance practice. Analyses of phonograph recordings of violin music found that violinists deviate from tempered pitches by 0.05 tones about 60% of the time.
and by 0.1 tones about 32% of the time (Small, 1936). Gabrielsson (Deutsch, 1998) reports deviations of between 10–20% from the notated rhythm within two phrases of a Mozart piano sonata. To consider this merely “error” is to fail to appreciate the complexity of the pragmatic content of score representation.

Insofar as it is merely impractical to comply with all the Notational information conveyed by a score, this is not a challenge to the theory. There is value, perhaps, in demonstrating the futility of ever actually performing a work of music according to a Notation. (Some authors have in fact taken Goodman to have demonstrated that every musical performance is a kind of improvisation in a sense (Ake, 2002).) Nor do Notations require absolute precision of interpretation; semantic finite differentiation is sufficient to allow some tones to be identified as complying with no pitch in the Notation (or at least this was the case before the ubiquity of microtonal music). Rather the problem for a Notational conception of scores is that the symbolic representation of pitch seems to mean different things at different times, certainly between different instruments, but also even within a single phrase of music.

Even if we accept that the score-as-compound-symbol view of work identification is sufficient to describe the function of scores in common-practice era music, where it seems most plausible, we are left to explain a great variety of scores from the Middle Ages, Renaissance, and contemporary scores whose interpretation is heavily dependant on unwritten performance practice. This forms the basis of Ziff’s (1971) criticism of Goodman. Ziff points to Giuseppe Tartini’s Devil’s Trill Sonata, whose well known ornamentation, its trills, being a matter of performance convention rather than Notational representation, would have to be considered merely contingent features of the work on Goodman’s account. Since the identity of this work seems heavily dependant on the proper execution of the embellishment, the example would seem to challenge Goodman’s account of score compliance.
Goehr (1992) suggests that Goodman might have responded to Ziff’s objection by positing a system whereby notations reliant on performance practice are considered equivalent to a passage of music which has been “translated” into Notational symbols for the purposes of work identification and preservation. Goodman doesn’t favor this approach, however. Instead he holds that scores which dramatically fail to preserve Notational requirements are not in fact “works” in a strict sense (although they may still be regarded as music, of course).

Here Goodman and his critics appear to be at an impasse. Goodman maintains that to allow vagueness as to the identity of a musical work undercuts our pre-critical notion of a “work” as an immutable entity, while his critics find that the phenomenological significance of a work is not always best captured by an account of merely compliance with Notational score symbols.

Many of the quibbles about the Goodmanian account of work identification might be summarized by a single underlying concern. Score interpretation premised on producing precisely the correct referent of every Notational symbol in a score conflicts with what we feel to be the elemental aspiration of score makers and score interpreters, not that the score by interpreted merely “correctly” in a semantic sense, but rather that the score represent the work as something, in some sense, beyond the sum of its parts. Musical works are not found merely in the interpretation of hieroglyphs. Rather meaningful musical experiences have their provenance in the reflexive process by which the interpreter recognizes in the score the composer’s knowledge of the interpreter’s gaze.

This is particularly true of contemporary scores where the representational function of scores seems frequently to be complicated by pragmatic complexities. Contemporary composers generally express very different conceptions of “validity” for performances than the one Goodman endorses. Brian Ferneyhough, for example, frames the question in terms of performer intentions:
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The criteria for aesthetically adequate performances lie in the extent to which the performer is technically and spiritually able to recognize and embody the demands of fidelity (NOT “exactitude”!). It is not a question of 20% or 99% “of the notes”; it all depends what is being asked for (1995, p. 71).

What Ferneyhough frames as a distinction between “fidelity” and “exactitude” might also be thought of as the difference between “orders” and “invitations.”6 A Goodmanian score demands compliance; a performance of a work must meet a certain minimal threshold, the faithful reproduction of the Notation.

Camp suggests that maps are different in that they lack explicit force markers. A map or wayfinding signage system might invite a particular kinds of exploration, because it’s representations highlight specific features while abstracting or neglecting others, but cartographic representations are semantically far more neutral in the presentation of their contents than are sentential representations.

“Invitation” captures the sense in which the performance of a graphic score is often an exploration of a particular perceptual and spontaneous experience. But the word is perhaps too permissive to capture the constraints composers often intend to convey. Note, for example, Morton Feldman’s displeasure when a British pianist played a tonal chord in Projection II in a rehearsal during his 1966 visit to London (although the score—an excerpt of which is found in Figure 3.7—does not of course explicitly bar such a tonal chords).7 Limits to invitation extended by cartographic representation in scores my be imposed by the explicit use of language, as Camp suggests may occur in maps, but also through the pragmatics of performance practice (see Sections 3.3.1).

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6 Thanks to Liz Camp for suggesting this line of thinking.
7 “The pianist was rebuked for playing a close-position minor triad in the middle register, although there are of course no written instructions to the contrary” (Cline, 2016).
Chapter 3

Principles

While maps are defined by their characteristics, scores are defined by their aims, namely, that of representing a musical work as a unary work; the actual representational modalities employed by composers are very diverse. In the present work, I am not concerned with cataloging types of notations. Rather, I will highlight a particular counternarrative within music concerned with spatial-temporal isomorphism.

Before moving on to consider this approach, we should note (by way of contrast) that a subset of scores are mostly or entirely composed of language. Among this class are included works such as Karlheinz Stockhausen’s Aus den sieben Tagen, a collection consisting entirely of aphoristic-like questions and instructions, Pauline Oliveros’s introspective Sonic Meditations, and La Monte Young’s Compositions 1960, among

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1 Various authors, generally with a reformist agenda, have undertaken such a project. For example, Christian Dimpker divides scores into five categories, of which the first two are rejected for their perceived lack of precision or parsimony (2013). Dimpker’s categories of notation—graphic, descriptive, action, symbolic, diagrammatic, and schematic—suffer from imprecision in their syntactic and semantic requirements. The categories seem to mainly be rooted in music-historical precedents and give little insight into how notations could function or what the limits of various notations might be. Goodman references a different system of classification, that of Erhardt Kartoschka, which classifies notations as one of four categories—precise, range, suggestive, or graphic. The first three categories may or may not be Notational according to their structure; Goodman’s allowance that some “suggestive” notations (which includes sentential instructions, for example) might be Notational will be discussed later in relation to the small class of Goodmanian scores that might be in common usage.
Chapter 3. Principles

whose works is found *Piano Piece for David Tudor #1*, which instructs the performer to “Bring a bale of hay and a bucket of water onto the stage for the piano to eat and drink” (1968, 1960).

Sentential scores seem to commonly aim to put the performer in a particular frame of mind or else describe a kind of theatrical act, but this is not always the case. The archaic wenzipu (“full ideogram notation”) style of notation for the guqin (the seven-string Chinese zither famously played by Confucius) apparently specifies the order and quality of various playing techniques both descriptively and through metaphors (Yung, 1997). This strategy has not been popular historically. Natural human languages are not well equipped to represent spatial or temporal precision, and the kind of sentential description that would be required to fully render even a short musical composition would normally be immense.\(^2\)

Camp characterizes this distinction in terms of a processing deficit between holistic versus atomistic systems: “[…] when dealing with relative spatial locations, sentential systems face a processing challenge, and a risk of processing error, that cartographic systems don’t” (2007, p. 162).\(^3\) In other words, the components of maps not only stand for themselves but also their spatial (or temporal) relationship to all other components of a map. It should be unsurprising, then, to find that sentential scores normally leverage the hierarchical abstraction of language and, especially, metaphor (note the riddle-like evocations in *Aus den sieben Tagen*, e.g., “Play a vibration in the rhythm of dreaming.”) rather than attempting to represent intricately ordered actions, sounds, etc.

\(^2\)Of course, enormously complex compositions are preserved from generation to generation in purely oral music traditions, but in these cultures, musical compositions are normally transmitted by demonstration rather than through sentential descriptions. On Goodman and Elgin’s account, teaching by showing could be understood as exemplification, i.e., a phrase of the gamelan work *Udan Mas* demonstrated by a teacher to a student “exemplifies” the way this phrase is typically played according to a specific tradition, etc.

\(^3\)Although not the focus of Camp’s project, in the present context, every occurrence of “spatial location” should also be understood to imply the possibility of similarly representing “temporal location,” a corollary that will be further developed in 3.1.1.
Scores that comply fully with Goodman’s syntactic and semantic requirements for Notational symbols form another category of scores. Few scores qualify. One example is given by piano rolls, the scrolls of perforated paper that are the control interface for mechanical or pneumatic player pianos. Each hole in a piano roll corresponds to one pin on a rotating drum that depresses a corresponding key. Since piano rolls are punched by a machine, a music roll perforator, whose punching mechanism pierces the paper at strictly quantised distances along its length (corresponding to time) and breadth (corresponding to pitch), the resulting notation is strictly digital and complies with finite differentiability.

Goodman also suggests that even some sentential scores (“suggestive notations”) might be Notational if they “[proscribe] only relations between notes” (1976, p. 192), so the set of Notational scores conceivably intersects with both sentential and non-sentential notational systems. Although there may not be any clear example of a Notational sentential score in the literature, there seems to be no logical reason one could not be constructed.

Most score, however, do not have the ridged structure and abstract evocation of language, and as we saw in Section 2.3.1.3, the purpose and usage of many scores does not fit comfortably within a Goodmanian model. Equally rare are scores that function as pictures via analog visual similarity with that which they depict. Rather, most scores represent sounds, temporal events, performative actions, and instructions as images that relate in a nonpictorial isomorphic way to their referents.

Many types of images pull off this trick. Kulvicki (2015) points out that maps, diagrams, and even comics use abstracted graphic features to refer to qualities of the depicted object apart from their surface coloration. Each of these representations strikes a slightly different balance between pictorial resemblance and abstract isomorphic representation. Similarly, scores use forms of representation that often fall into interesting
interstitial zones between what can be straightforwardly identified as a map, diagram, or sentence (see Section 4.3.2.2 for a discussion of an interesting case study from my own work).

The following discussion will focus mainly on maps that feature highly cartographic representation. A discussion of scores of this type is timely, first, because spatial metaphors have been so central to how contemporary composers conceive of sound, and second, less obviously, because many scores are akin to holistic wayfinding signage systems which, like scores, support an interpreter’s ability to make inferences about graphic features relative to a de se perspective.\(^4\) This fact is key to understanding how scores relate to maps. In so far as the visual graphic elements of a score are map-like, they are also a “wayfinder” or “waymaker” for the users of the map or scores.\(^5\)

### 3.1 Map Semantics

Before discussing cartographic score representations, it will be helpful to clarify how map semantics work. (A discussion of pragmatics will be postponed until Section 3.3.1).

My interest is not primarily in what words we use to describe representations but rather how representational space is deployed in a range of different media and how those choices accommodate or discourage certain uses of the representational media. For clarity, however, my view is that maps are distinct from pictures, sentences, and diagrams in the following ways:

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\(^4\) That is, both scores and wayfinding signage systems are structured so as to strongly accommodate their use as aids for navigation according to a holistic understanding of the representational structure as a whole. The interpreter is, in a sense, viewing the representation from a point within that representation, and they themselves serve as a representational vehicle for the de se point of interpretation.

\(^5\) Scores may also be “waymakers” particularly for composer, a fact that was briefly described in Section 2.1 where scores were more generally discussed as a means of worldmaking within musical works, pending this and later discussions of wayfinding and waymaking.
Chapter 3. Principles

1. Maps deploy graphic visual features holistically to represent both a feature’s identity and its location.

2. Maps use isomorphism to represent features salient to the map’s intended use, and the representational icons used are themselves sufficiently isomorphic to allow holistic integration of salient graphic features.

3. Maps support the ability to make inferences about addressee-centric indexicals. A subclass of maps, notably many scores, additionally strongly support an interpreter’s ability to make de se inferences about map features.

I follow Camp in endorsing criteria (1) and (2). In endorsing (3), I emphasize the function of maps to serve as wayfinders and waymakers, which follows from my intuition that maps, scores, and holistic signage systems function as aids to navigation, and even fabrication, in a way that is notably distinct from diagrammatic representation. A detailed discussion of wayfinding and waymaking is the subject of Section 3.4.

It is currently a matter of debate whether maps feature Frege-Tarskian predication. Section 3.1.1 will serve to introduce my use of “formal maps” and “formal scores”; later this discussion of formal semantics will serve to support my contention that the uses accommodated by a representation are more central to the form of that representation than is the nature of what is represented.

3.1.1 Predication

In Frege-Tarskian predicate calculus, a predicate is a statement such as $F(x)$ where the function $F(\ )$ returns a truth value depending on its variable $x$. Predicates without their objects are said to be “unsaturated” and become “saturated” by the addition of an object. For example, the predicate “__ is a detective” (e.g., $D(\ )$) is true just in case $x$ is a
detective. The predicate $D(\text{Holmes})$ says of Holmes that he is a detective, which is true if Holmes is indeed a detective, but $D(\text{Holmes})$ does not say of Watson that he is not a detective. Normally predicates with variable $x$ are agnostic as to predication of all variables $n$ where $n \notin x$.

Casati and Varzi introduce map symbols as predicative of locations in the world. Therefore, in Figure 3.1, the colored patch $X$ says of a corresponding region in the world that it has a property associated with color $X$.

Color patches are taken to designate properties (of objects in the world). That a certain map region is covered with a certain color patch is taken to mean that the corresponding world region has a certain property (the one corresponding to the color). A uniformly colored map region is correctly colored whenever the corresponding world has indeed the property corresponding to the color (Casati and Varzi, 1999, p. 190).

For example, if $F$ is the predicate “__ is water,” then the colored patch in Figure 3.1 says of the corresponding area of the world that there is water there.

A problem appears to arise, however, when we consider that $F$ in Figure 3.1 does not only say of a region of the world that it is water; $F$ also appears to say that uncolored regions $n$ are not water. Recall that this is precisely what Frege-Tarskian predication does not do. Predicating a particular variable does not in itself say of other variables that they are not similarly predicated.

This seeming departure from Frege-Tarskian predication—what Rescorla (2008) calls the “absence intuition”—has been divisive, with Rescorla (2008), Casati and Varzi (1999), and Pratt (1993) holding that the intuition is best explained by a non-Frege-Tarskian semantics, while Camp (2007) and Blumson (2012) propose a pragmatic explanation, and Kulvicki (2015) proposes a reconception of map predication that make
the “absence intuition” compatible with Frege-Tarskian predication.

On Casati and Varzi’s account, color patches can only be logical subjects when “juxtaposed to a map region.” In other words color patches are “unsaturated” in Frege’s terms, unless analyzed in comparison to other regions of the map, in which case they become saturated.

Kulvicki proposes a more robust account of juxtaposition, introducing an attribute of Coverage: “For any quality P that a mapping system can represent, a map of any region can represent the full extent of P in that region.” In other words, the introduction of a mode of representation (what MacEachren (1995) refers to as a “visual variable”) into a map commits the map to representing the extent of that feature everywhere, even where the feature takes a null value. In Figure 3.2 for example, if $H$ represents areas of scrub vegetation, the introduction of the textured area commits untextured areas $n$ to represent the null value of $H$. In this case, only two values are represented—“scrubland” and “not scrubland”—but once a symbol for scrubland is introduced into the map we may introduce variations of this texture representing, for example, the density of the vegetation, while necessarily still preserving the null value to represent unvegetated land.

Mountain marks pair with smooth texture as mutually incompatible, but syntactically significant, aspects of a map. Once mountain
Figure 3.2: Predication of a world region represented by a colored expanse $F$ on a map. Uncolored areas $n$ are represented as explicitly not $F(n)$.

Texture is on the menu; it is easy to add more textures for different kinds of land: alps, piedmont, hills, bumps, etc. Each of those textures is incompatible with the others, and what each represents is incompatible with what the others represent. Untextured, smooth areas are the zero value along this degree of freedom. Being smooth carries representational weight just as the marks do (Kulvicki, 2015, p. 155).

It follows from this that care must be taken in choosing the symbols used to represent features in the world, lest map layers we desire to layer be found to be incompatible with one another, a dictum Kulvicki refers to as the incompatibility constraint: “incompatible locatable features represent incompatible qualities” (2015, p. 155).

New symbols are ideally introduced within “degrees of freedom,” symbolic schemes whose graphic incompatibility represents incompatible features in the world. Therefore, using blue for water and brown for land (incompatible colors) is acceptable for landscapes that are represented as either one or the other but not both. But using brown for land and crosshatching for water would potentially be problematic since crosshatching can potentially be layered over colors, resulting in the ambiguity that a section of the map could be represented as both land and water.
Success to set up a map’s incompatibility constraint can lead to maps that are not optimally capable of representing all possible combinations of features that could exist in the world. For example, if $F$ represents scrubland and $G$ represents sandy beach, the incompatibility of the two colored regions limits the map’s ability to represent the encroachment of scrubland onto the sandy beach. If, however, $H$ represents sandy beach and $G$ represents scrubland, the introduction of a compatible symbol, an area textured with hatching, to represent for scrubland (and scrubland encroaching on beach) solves this problem by allowing scrubland $H$ and beach $G$ to overlap.

Incompatibility constraints in scores are deployed according to both global and highly localized conventions, a topic which will be developed further in Section 3.3. Scores are made and interpreted by a relatively small and scholastic community of interpreters, a situation that provides frequent opportunities for musicians and composers to “agree to ‘play’ with the coding” as Boulez (1990) observes. Pragmatics, therefore, factor into score-like representation and interpretation in a central way, a subject which will be addressed in Section 3.3.2.
3.2 Formal Scores

Rather than attempting to characterize scores in common usage from the outset, it will be useful to start with an unambiguous example. Figure 3.3 is an example of a “Formal Score.” Analogous to a “formal language” and homologous to Casati and Varzi’s “formal map,” a simple formal score represents the extension of one or more events within a bounded temporal field.\(^7\)\(^8\)

In re-purposing formal map semantics to represent temporal events, I push back on a common sense notion that maps and diagrams are distinguished by the type of structure that they represent. This is the intuition that representation of a spatial structure with a graphic (visual) spatial structure is significantly distinct from the representation of other kinds of structures (temporal, logical, etc.) with a graphic spatial structure. In one sense, this intuition seems correct. Isometry will be significantly complicated when spatial structures are tasked with representing highly abstract structures. Camp follows this common convention, dichotomizing maps and diagrams on the basis of what they represent.

Where pictorial and cartographic syntaxes use concrete spatial structure to represent concrete spatial structure, and where sentential

\(^6\)The attempt to construct formal grammars similar in some ways to natural language but containing strict rules of inference is well preceded in linguistics and computation science. A brief survey of “formalism” as a standard for such systems is given by Catarina Novaes in *Formal Languages in Logic*. For our purposes a formal system might be roughly defined as one that is “de-semantified” (“symbols as blueprints [inscriptions] with no meaning at all”) and “computational” (“passage from one initial state [the premises, or more generally the initial state of information] to a final state [the conclusion, the result of the calculation], by means of successive ’small’ passages from state to state” (2012)).

\(^7\)I use “homologous” in roughly the sense in which the word is used in evolutionary biology, i.e., a structure having similar parts and similar origins, although possibly adapted for different functions.

\(^8\)Figure 3.1 is a simple formal score of the kind Casati and Varzi have in mind (minus the text labels).
syntax use abstract, functional structure to represent abstract, logico-metaphysical structure, diagrammatic systems often use concrete spatial structure to represent highly abstract structure. Thus, a Venn diagram might use intersections among circles to represent intersections among sets, while a bar graph might use height to represent annual expenditures. (Camp, 2007, 159)

As mentioned previously, I believe there is good reason to differentiate between maps and diagrams based not on their content specifically but rather based on their ability to support addressee-centric indexical reasoning. That is maps support intuitions about how map features relate to an embedded point of view. This point of view may actually be the point of view of the interpreter, such as when we use a map to find our way by representing ourselves as an imagined locatable feature within map’s holistic representational scheme. Other cases in which we make de se intuitions about the contents of a map include the act of performing a musical score, in which we represent ourselves as being temporally located within the score, and also when we navigate a built environment based on a holistic signage system.

Research on the spatiotemporal metaphor in language notes a corollary to this dichotomy in wayfinding approaches: European languages tend to discuss time using spatial metaphores with either an “ego-moving” perspective or a “time-moving” perspective. This follows from the frequent characterisation of the “indispensable attributes” of space and time as distinct and analogous features in both cartography and the cognitive science literature (MacEachren, 1995). Research by Gentner (2003) surveys fifty years of cognitive science and linguistic research that strongly supports the intuition that these features have a special correspondence. The metaphor is widespread

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Even cartographic or diagrammatic scores need not feature time, however; a score might conceivably consist simply of a circuit-board schematic for the construction of a particular electronic musical instrument, for example.
within European languages, but also appears to have specific features that make it an efficient vehicle of information:

[Ego-moving and time-moving metaphors] exhibit three characteristics that facilitate reasoning [...] They use ordered space to represent elements (here, events) and their relations (sequential ordering); they use spatial dimensions (here, a single linear dimension, which is placed in correspondence with time’s single dimension); and they appear to form non-arbitrary analogs for abstract concepts. Temporal reasoning is non-trivial, as any traveler can attest. Perhaps these metaphors retain their systematicity because they do serious work for us (2003, p. 221).

It is on the basis of these “non-arbitrary analogs” that I maintain that the structure of a representation often has more to do with its function for an addressee than it does with the nature of the content represented. Of course, analogies are partially a matter of habituation and custom, but Gentner’s (2003) observations about spatiotemporal cognitions suggest that there may be a minimum bar for usefulness in analogies, which I take to be the degree to which they allow for an isomorphism which supports a given analogy. The properties of a representational medium may represent isomorphically across different types of world features (locations, events, logical structures, etc.), but those representations must be able to “do work” for us relative to what we wish to represent. For example, insofar as we experience time in a (de se) relatively continuous linear manner, a straight line is able to retain the systematicity of that experience when used as a wayfinding system for temporal events.10 (On the other hand, the use of various smells, for example, to represent events in time would tend to undermine the usefulness

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10Time may be represented many different ways of course, and a linear graphic representation may not be the best way to do it relative to the aims of the composer or artist. A successful new means of representing time is an act of worldmaking on Goodman’s (1978) account, indeed the reclassification of musical time involved is precisely the kind of representational game which is of interest to composers in crafting a new form of score representation.
of the representation, since there are practical reasons why olfactory representations poorly support mapping spatiotemporal events.)

A formal score (Figure 3.3) is identical in most respects with a formal map (Figure 3.1), the only major difference being that the formal score has just a single representational dimension—length—whereas a formal map uses the two-dimensional colored regions. (My purpose in initially neglecting the $y$-axis here is to clarify the spatiotemporal metaphor on which homomorphism between printed page and temporal event depends.) Basic formal scores are timelines; they represent the location or duration of one or more events in time. The $x$-axis is doing all the work here. The thickness of lines, their color, texture, or displacement on the $y$-axis are entirely incidental, relying on the common convention in geometry that lines may represent lengths but not width.

Delimited temporal areas introduce a single degree of freedom on Kulvicki’s account. By far the most common dimension is sound versus silence. Specific filled areas predicate specific parts of a musical work, and unfilled areas of the score represent the null value: silence.

This alone is sufficient to give us something like Cage’s score to *William’s Mix* (Figure 1.1). Overlapping temporal areas are represented along the numbered $y$-axis, but this is simply for clarity and is a purely incidental feature. Text labels are used instead of colors, and the shape of the delineated areas are isomorphic to the shape of the splicing to be performed on the tape (literally how the tape should be cut—isomorphic representation will be discussed in Section 3.3), but essentially Cage’s score is a very basic kind of map.

*William’s Mix* is unusual in its austerity. Most scores represent considerably more than the identity and order of lengths of magnetic tape. But to ensure a consistent system of representation, each new dimension that a score represents must be introduced within
its own degrees of freedom. The most promising approach to building up a consistent score, therefore, would be to introduce degrees of freedom one at a time, taking care to represent incompatibility of musical features with incompatible “visual variables.”

Visual variables—the palette of graphic qualities that cartographers can manipulate to represent features in the world—have been studied extensively by semioticians. One of the earliest and most influential studies was that of Jacques Bertin (1983). His graphic variables are characterised in terms of three elemental forms: points, lines, and areas. Any point, line, or area is distinguished from others by one of seven variables: $x - y$ location, size, value, texture, color, orientation, or shape (Figure 3.4).

Bertin’s map syntax has proven both influential and unpopular with contemporary cartographers. Numerous authors have amended or extended the semantics, including suggestions that, for example, color saturation be regarded as a separate variable (Morrison, 1974), that texture be broken down into variables of “directionality,” “size,” and “density” (Caivanoy, 1990), and that edge and fill crispness constitute a variable of “clarity” (MacEachren, 1995).

Theoretically, a vast supply of visual variables are available if relations of things, or even moving images, are permitted to be variables. But this misses the point. Visual variables are contingent representations to which the creators of images and their viewers assign meaning based on their familiarity with a representational scheme and within the requirement that symbols are reasonably homomorphic with what they represent (see Section 3.3).

Conceptually, areas of the one-dimensional formal score, representing temporal areas, may be layered just as colored patches are layered in a two-dimensional map. In practice, the $y$-axis must be used to allow differentiation of “colored map regions.” In this way, $y$-axis location as a visual variable is entailed whenever scores must represent
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overlapping map regions. In William’s Mix, the $y$-axis is used primarily to visually differentiate between different strips of magnetic tape. (The obliquity with which the segments of tape are to be cut or spliced is also indicated by the slope of angled lines.)

The vertical dimension generally represents one or more musical parameters that are central to a composition’s implicit aims. Vertical displacement appears to have been one of the first visual variables used in European music notation, and the use of vertical space is nearly as ubiquitous and complex as representation of time on the $x$-axis. Gestalt psychology has sought to quantify the precise conditions under which apparent contours are perceptible within visual noise, but it’s clear that human visual perceptions are highly attuned to perceive illusory shapes, even among pointillist patterns or fragmented objects (Bissinger, 2006). Spatially deploying symbols with similar features, such as note heads in classical music notation, potentially leverages the human perceptual tendency to group objects based on both proximity and common shape.

In traditional classical notation, the $y$-axis represents tempered pitches discretely on a five-line staff. However, the use of this convention heavily privileges a tonal understanding of pitch space, since distribution of vertical space does not match the perceived distance between pitches in the spectrum. This fact, as well as the coexistence of analog and digital representations in traditional notations, allows inconsistencies such as Figure 3.4 to occur. Since pitch is represented by both spatial location and symbolic modifiers, it is possible to represent pitch contours opposite to the proper interpretation of the score.

Well-designed graphic notations and tablatures fix this kind of inconsistency by representing pitch with a consistent distribution of pitch- or physical-space on the $y$-axis and by doing away with redundant symbolic representations of pitch. This reestablishes an isomorphic relationship to pitch contour and brings scores back into line with the representational standards of cartography. A minimal example of this (only slightly
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Figure 3.4: Inconsistency between glissandos (an analog notation showing the contour of a pitch bend or slide), vertical use of space to represent pitch, and symbolic representations of pitch (accidentals which raise or lower a pitch from the pitch shown “naturally” by a note’s vertical location). Although \( y \)-axis location of notes and directions of glissando lines suggest a falling, then rising, and then falling contour, the passage actually stays flat, rises by a half-step, and then rises by a whole step.

More complex than Williams Mix) is found in Morton Feldman’s “graph music” scores (Figure 3.7), where vertical space is deployed in a constantly to refer to a indeterminate musical event in certain pitch range of the instrument.

Many contemporary scores use space on the \( y \)-axis in a highly sophisticated diagrammatic way. In Figure 3.5—an excerpt from the violin part of James Bean’s this will be changed and made solid II—the cyan and magenta line represents the vector of the violinist’s bow movements, with the bottom of the staff representing the frog of the bow while the top of the staff represents the tip of the bow. At the same time, gray scale solid or dashed vectors represent movement of the fingers on the fingerboard of the instrument, with the bottom of the staff representing the nut while the top of the staff represents the top of the fingerboard.

The representational space of the staff in this will be changed and made solid II is used very efficiently to represent multiple physical spaces in the world, e.g., both the space of the performer’s bow and the physical of the performer’s fingerboard. It is as if two maps are layered on top of each other, while the vectors, relative to the two frames of reference, are isomorphic to the performer’s movements.
FIGURE 3.5: An excerpt from James Bean’s *this will be changed and made solid II* for string quartet. Color represents bow placement; colored-line thickness represents bow pressure; colored-linear vectors represent bow movements; vertical, striated rectangles represent the string to be bowed, while the thinness of the vector relative to the height of these “string indicator boxes” represents the maximum bow pressure; black or dashed vectors and filled or open circles/diamonds represent finger movements along the strings with the indicated amounts of pressure; rhythms above the staff indicate temporal placement of right-hand information, while rhythms beneath the staff are for the left-hand.
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Figure 3.6: A ten-day weather forecast by weatherunderground.com, showing how variables are layered, each of which uses the same $y$-axis space isomorphically according to its own scale (The Weather Company LLC).

An interesting precedent to scores of this type is found in certain types of diagrams that use diagrammatic space to represent more than two variables (Figure 3.6).\(^{11}\) For example, some weather forecast diagrams use the $x$-axis to represent time, while the $y$-axis may represent a number of possible variables, such as cloud cover, chance of precipitation, humidity, atmospheric pressure, etc. This type of layering works well in diagrams, where representational space is repurposed efficiently for different representational aims. But layering is perhaps far less common in maps, possibly because it would tend to complicate an interpreter’s ability to understand the map from an addressee-centric perspective in most cases.

\(^{11}\) I am grateful to John Kulvicki for suggesting this example, particularly the Weather Underground graph in Figure 3.6 (personal communication, April 13, 2017).
3.3 A Theory of Cartographic Scores

Not all scores represent with spatial analogies. Of those that do, there is wide variation in how efficiently they deploy spatial representations ranging from traditional classical notation of pitch—which is often inconsistent in its use of space (Figure 3.4) and is highly conventionalized and optimized for tonal semantics—to contemporary tablatures that represent multiple spatial domains simultaneously with the vertical space of the staff.

Cartographic scores make use of a spatiotemporal analogy. Within that analogy, scores deploy spatial properties isomorphically to represent both spatial and temporal properties of the works and performance situations they represent. Like other maps, scores can leverage this isomorphic scheme to represent particulars and qualities of particulars as ordered components of an interdependent abstracted spatial syntax.

Cartographic systems are a little like pictures and a little like sentences. Like pictures, maps represent by exploiting isomorphisms between the physical properties of vehicle and content. But maps abstract away from much of the detail that encumbers pictorial systems. [...] Further, typically this spatial isomorphism itself only captures functionally salient features of the represented domain: for a road map, say, only streets and buildings and not trees and benches. Maps also depart from the direct replication of visual appearance by employing a disengaged, “God’s eye” perspective instead of an embedded point of view (Camp, 2007, p. 157-158).

What constitutes isomorphism in scores is highly conventionalized and dependent on human acoustic perceptions and analogies. “Higher” pitches generally appear visually higher on musical staves; rhythms are ordered as they occur in time from left to
right; in percussion music, instruments are grouped as they appear before the performer, with each instrument in a collection assigned to a line on a special staff.

But as Camp points out, maps and scores are generally only isomorphic to “salient” features of their domain. Thus seating charts are isomorphic to the spatial order of guests at a party, although the seating chart itself may simply represent guests by their names and locations on a scrap of paper. Similarly, subway maps are isometric to the order and approximate spatial distribution of subway stations on the various lines of the subway system, although almost all other features of the city may be abstracted way from such maps.

Different types of maps abstract different features and range in their level of detail from Google Maps renderings that allow for satellite and street view images to be overlaid over roadways (at the less abstract end of the spectrum) to subway maps, technical schematics, and charts (some of the most abstract maps in common usage) (Camp, 2007). By depicting certain properties as highly isomorphic while other details are omitted or stylized, map designers affirm the importance of certain kinds of information and relationships while downplaying other details.
Maps are isomorphic in the properties most vital to a map’s intended usage. A nautical map must reflect the depths of oceans and waterways, while a road map need only show the location of water. Depicting the depth of water on a road map would only serve to distract from the map’s intended purpose (Kulvicki, 2015). Similarly, composers adopt a position on what criteria are vital to a musical work when they prioritize certain types of representation in their scores. The score for Williams Mix (Figure 1.1) commits to representing shape and order of sections of magnetic tape, whereas specific musical pitches are incidental and not represented by the score. On the other hand, Morton Feldman’s Projection II (Figure 3.7) commits only to representing spatial location and extension, pitch, and mode of sound production (and whatever incidental properties entail from this scheme). The score serves as a “waymaker” which invites not only a certain kind of performance, but also premises a certain kind of musical world and way of listening (although these premises are also subject to pragmatic concerns [see Section 3.3.1]).

Maps commit only to representing absence intuition for the variables they represent as salient. Most scores have features that are purely or largely incidental. Such features can be changed without seriously altering the representational import of the score. For example, in classical notation, the precise distance between notes on the page and the lengths of measures (global units of rhythmic aggregation representing the denominator of a fractional division of a beat) are incidental to what the score represents. Although care is taken by music copyists to follow graphical standards for such features, this accommodation is meant as a convenience for the interpreter. On the other hand, the order of symbols along the interpretive vector of a score is nonincidental. Changing the order of symbols alters what a score represents in a fundamental way.

Maps similarly represent a one-to-one representational scheme only for the features they emphasize as central to the intended uses of the map. Subway maps are
isomorphic to the number and order of stations, while the spatial relationships and contours of the subway lines are at best rough, diagrammatic approximations. Aeronautical charts represent the locations of various kinds of restricted airspace with a great deal of detail, while reducing even oceanic coastlines to geometric approximations.

Various authors have proposed different conceptions of isomorphism to cover cases where the one-to-one relationship between model and subject holds for only certain aspects of the model. For example, Bueno (1997) proposes a standard of “partial isomorphism” while Lloyd (1994) and Mundy (1986) talk about homomorphism or “even weaker types of morphism” (Lloyd, 1994, p. 168). The point is not, however, what type of morphism is employed by scores but rather that the representational scheme chosen by the composer always necessarily prioritizes certain kinds of accuracy of reproduction while de-emphasizing other less salient syntactic components. Musicians rely on pragmatic inferences (see Section 3.3.1) to determine which graphic features of a score are relevantly isomorphic and which features are incidental.

The accuracy of a map may be interpreted as a commitment to a certain value system for interpretation of that score. The scale of a score gives some indication of what kinds of uses that score (or other map) might be good for. If we wish to know the travel time required to drive from Bremen to Stuttgart, we may be happy with a map that represents distance in kilometers. On the other hand, if we must know the location of the gas line entering a house, only a map or diagram representing distances in inches or centimeters will suffice. The degree of inaccuracy we are willing to accept in a map depends on what we want to do with the map. Similarly, different musical works accept different levels of inaccuracy, and according to the conventions of the style, we may or may not be inclined to accept a particular performance as a genuine instance of a work depending on the degree to which the performance departs from the score. The choice of a particular scheme implies that certain syntactic components will receive
more consideration in making judgments of work preservation than others.

Goodman misjudges the nature of representation in scores when he conceives of them functioning as compound Notational symbols that preserve or identify works. Scores only ever do so for features they represent as salient and according to the level of detail they represent as important.

For example, Figure 3.8 represents two hypothetical scores. “Score 1” leverages Cartesian graph notation and allows for nuances at least down to tens of cents (one hundredth of a 12-TET whole step interval). By choosing to represent this kind of detail, the composer implicitly takes a position on the “scale factor” for the score, which in turn has implications for the score-preservation criteria for the work. The score is not fully notational by Goodman’s standards. For that we would need a syntax for the contour line including notation for angles, path lengths, etc. However, we can infer that an existential threat to the score would be one that prevents us from interpreting the contour paths with accuracy on the order of tens of cents. We can also make map-like intuitions that will constrain the inaccuracy of the contour paths within the limits of the scale factor. For example, we can note that the first contour in the work (beginning between 0 and 100 milliseconds) is in the third space up from the bottom of the graph and is just touching the third line up from the bottom.

It is true that over successive reproductions of the score, the exact path traced by the contour line may be affected by successive inaccuracies in the reproduction process (as in Goodman’s score-preservation challenge to Cage, Figure 2.1). However, by not defining the contour line’s path more strictly, we should understand (pre-pragmatically) that the composer is implicitly assenting to the proposition that score preservation still holds so long as the contour line does not depart too far from the constraints of the scale. In other words, a change of 20 cents in contour line morphology would destroy score preservation. A change of 3 cents (hardly visible on the score) does not threaten score
FIGURE 3.8: Two hypothetical notations showing differences in scale.
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preservation, and any change much more than this will be rapidly detected in relation to the graph. The graph lines, like cartographic symbols for longitude and latitude, are notational and therefore limit the degree to which the analog parts of the score could conceivably deviate from the manuscript.

In Figure 3.8, “Score 2,” the composer has implied a different scale and hence very different criteria for evaluating salient detail. Here our only indication of pitch is a range between high and low. By constraining pitch only loosely, the composer implicitly assents to the proposition that precise pitch is not a factor that affects score preservation. Rather, the map-like syntax implies that the ordering of pitches is mandatory, and changing the order of high and low pitches would pose an existential threat to score preservation. Similarly, by not providing a graph by which to compare note lengths in milliseconds, the composer is assenting to a scale factor that requires performers to follow only very approximate note durations. In this case, playing a notated short note for a longer duration than a notated long note would pose an existential threat to score preservation, but minor inconsistencies in note duration are tacitly permitted.

As in many maps, scores can use sentential representation, and through the map-like structure of the score, these expressions gain the ability to refer to specific temporally and spatially locatable features. Performance directions can be far more conceptual than can be easily expressed either through pictures or diagrams, with Pierre Boulez, for example, calling on the performer of his Second Sonata to play in an “exasperated” or “strident” manner or, later, to “pulverize the sound.” Through the map-like scheme, these abstract invocations are applied only to certain sections of a work, thereby increasing the expressive power of language beyond the contents of the sentential expression.

Scores are not themselves sentential in structure, however, since they lack the hierarchies and abstractions of language. Disregarding aesthetic or stylistic concerns, the discrete parts of a score can generally be rearranged with a great deal of freedom, and
musicians even refer to these parts in spatial terms. A musical line can be “inverted”; melodic lines are said to be “close” or to “cross” or contain too many “leaps”; harmonies are said to “revolve” around a “harmonic center.”

3.3.1 Implicature

Up to this point I have been assuming the useful fiction that composers strive to maximize the consistency and clarity of the representations they create. This is not always the case. In fact, it is one of the more interesting features of musical scores, and especially contemporary musical scores, that they make liberal use of tension among the graphic elements, often for the purpose of suggesting or evoking something beyond what is trivially communicated in the notation.

British philosopher Paul Grice (1913–1988) was the first to make a formal study of how the meaning speakers intend to convey sometimes differs from the content of their words. He characterised normal, nonimplicative speech in terms of four “maxims” whose violation often suggests meaning beyond what is directly said 1989.

Take, for example, the following exchange:

1. A: “We’re out of milk.”

   B: “I’m going by the store on the way home.”

   It is understood that B means to buy more milk from the store, but what B actually says is quite different. B’s meaning is implicated. Grice characterised this type of interaction as a communication which occurs when a speaker transgresses a contextual expectation. Although in principle there are innumerable conceivable precepts that speakers could use to implicate, Grice focused on four conversational maxims: Quality
(avoid stating known falsehoods), Quantity (avoid making over- or under-informative statements), Relation (avoid stating the irrelevant), and Manner (avoid making ambiguous or obscure statements).

In (1), B does not merely violate the third maxim—the maxim of Relation—B conspicuously highlights the non sequitur; B *flouts* the maxim in Grice’s terminology. Assuming the Cooperative Principle (A and B assume that their interlocutor approaches the conversation in good faith), the only plausible analysis is that B means to *imply* that he or she will buy milk at the store.

Implicature is normally discussed in the context of language, which highlights the conspicuous distinction between informal use of language and the formal devices of logic. However, a number of authors have considered how images may be implicative. Frixione and Lombardi (2015) discuss Grician implication for street signs and IKEA furniture assembly instruction manuals. Oberlander (1995) proposes a Grician approach to computer network diagrams and schematics. And Abell has extended an account of implicature in signage to also explain paintings and photographs (2005).

Abell’s approach requires some explanation of how representations relate to context. Grice “characterizes conversational implicatures as things that speakers make, rather than as properties of speakers’ statements or utterances” (Abell, 2005, p. 63). For images it’s not clear that this would be the case, since the context in which an image is interpreted is often not under the control of the image maker. Abell follows Levinson (1983) in thinking that there is a sense in which images can have an embedded pragmatics: “taking an utterance to be a pairing of a sentence and a context, we may derivatively talk of utterances having implicatures” (1983, p. 104).

If viewers of a picture or photograph are able to workout the intentions of its creator, either from knowledge of the techniques or circumstances of its creation or
from other observers “in the know,” then they are able to understand the pragmatic implicature of images and distinguish accidental images from puzzling intentional ones.

Thus it is perfectly possible for an observer to fail to work out what is pictorially implicated by a picture painted by a particularly subtle artist, so long as there are other observers, or possible observers, who, possessed of requisite knowledge, are able to work out what implicature the artist intended the picture to have (2005, p. 64).

The suggestion that observers can rely, in essence, on an interpretive tradition to understand the intentions of an artist (and hence implicature) is particularly intriguing in the context of music scores where compositional and performance practices are, if anything, far more codified than in most other traditions of image making. While photography is now practiced by nearly everyone in developed nations in some form—regardless of whether they have training in the history of photography, the optics of cameras, the aesthetics of composition, etc.—scores are still produced by a relatively hermetic community of composers, and while new forms of notation are constantly being developed, it’s quite rare that a new notation does not arise in some way out of a preexisting tradition.\(^\text{12}\)

The standard in classical music notation is generally to keep symbols as compact within and around the staff as is possible without crowding. Therefore, stems (the lines descending or ascending from note heads which give faster notes their duration) descend when the note head is positioned high in the staff and ascend when the note head is positioned low in the staff. This maxim is flaunted in the case of “cues” in orchestral parts. These extra-small notes are used to help orchestral musicians find their

\(^{12}\) Of course, Goodman too allowed that a score’s interpretive tradition could play a role in determining a symbol’s meaning, but on Goodman’s account, tradition is made to bear an untenable weight, filling that gap between a supposedly articulate score and an infinite variety of subtle, analog interpretive features that arise not only from tradition but also from context, expression, and personal preference. As Clark (1982) observes, “neither style nor tradition can supply a lexicon of truth conditions.”
place, particularly after not playing for an extended time. Cues are normally prominent passages played by highly audible instruments such as the brass or percussion.

To prominently display the fact that cues are intended to be heard and not played, the stem direction of cue notes is generally reversed from the norm (Figure 3.9). A classic orchestration text from an era when most orchestral parts were copied out by hand suggests an even more robust way to implicate their special status:

Cues should be written in small notes with stems in the “wrong” direction to allow for the rests that are included. If red ink can be used, that will help to distinguish the cues from the notes to be played (Kennan, 1952, p. 294).

Cue notes have a standardised syntax in classical music notation, so in some sense the implication is a convention. However, implicature truly became a central feature of scores in the twentieth and twenty-first centuries when the well-establishish performance practice and notation standards of earlier decades were frequently exploited to implicate something “beyond” the nuts and bolts of the score. For example, composers may want to put a performer in a particular frame of mind or else force a particular performative situation that might result in something unexpected. At other times, a dissonance between conflicting representations is intended to force musicians out of habituated responses.
Examples range from Luigi Russolo’s staff-based notation for acousmatic noise in *Risveglio di una Città* (1913), to the highly pictorial distortions of the staff in the music of Sir Peter Maxwell Davies and George Crumb, to the graphic experiments of Earl Brown and others. An extreme example of semantic implicature is found in some of Christian Wolff’s scores where the notation demands impossible actions, presumably in an attempt to provoke a crisis for the performer:

In the mid-fifties he was getting back to indeterminacy by writing pieces which were impossible to play due to aspects of rhythm, fingering or keyboard layout. The impossibility would force the player to discover a solution of his own, or force Wolff himself to find a compositional way out by declaring tempo as zero—that is, any duration *(Nyman, 1999, p. 67)*.

The latter suggestion is particularly intriguing since it suggests that notations may function in certain cases as a catalyst for composers themselves, a score functioning not so much as a record or instructions for a work as like a puzzle whose solution suggests new avenues of creativity.

The “complexity” of score syntax is also sometimes used to implicate, a fairly straightforward example of a violation of Grice’s first maxim of quantity. Extremely detailed notation (to the point of seriously challenging a performer’s ability to perform a piece) was a hallmark of the so-called “New Complexity” school of composition in the 1980s. Although, clearly, different composers use complexity to different ends, it’s generally understood that members of the “New Complexity” school were overt in their intention to implicate.¹³ What exactly is implicated is a difficult question and one better

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¹³ The use of complexity has generally been self-consciously implicative. In response to a 1990 survey seeking his opinion on the question of “complexity,” Brian Ferneyhough replied to a question seeking his opinion on the use of complexity as a means of communication: “Clearly it is, at least to the extent that it is perceived as such, and is thus distinguished from alternative modes of organisation. There is a particular texture or grain to the slowness of comprehension traversed by the mercurial scanning beam of speculation which is not reproducible in any other way” *(1995, p. 69)*.
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directed to a scholar of New Complexity or a skilled interpreter of the works, perhaps. Possibly the composer of such a work intends to self-consciously highlight the artifice of the translation between notation and performance, or maybe the intention is to reveal the falsity of individual notational or sonic events which clash and perturb each other, constantly foregrounding some material while hiding or distorting other details.

Interestingly, Ferneyhough distinguishes between implicature occasioned by syntax and implicature occasioned by semantics, which he talks about in terms of “difficulty” versus “obscurity”: “A text may be quote conventional in its structure (say a sonnet form) whilst resisting comprehension by reason of lack of clear meaning in the terms employed” (1995, p. 69).

Clearly not every case is as straightforward as Ferneyhough, however. Grice was quite clear that he never intended to suggest that a decisive test could be formulated for implicature. When specific contextual clues are not present (from a performance-practice tradition, for example) we may be unable to determine conclusively what if anything is implied.

Cornelius Cardew’s Treatise (1967) is composed of 193 pages of symbols without text annotation or explication.14 Treatise appears score-like, frequently referencing familiar syntactic conventions of notation, but distorting them in a fanciful and highly pictorial way (Figure 3.10). Without further context, it seems impossible to know what if anything is being implied, although a performer can play a game of “make-believe” where a personal syntax and semantics are gradually developed for the score.

In still other cases, composers seem intent on breaking with the representational intent of scores altogether, perhaps wishing to explore them more as abstract pictorial

14Although Cardew did publish a handbook to Treatise, its cryptic musings offer little insight for an interpreter. His statements at other times repudiated any kind of annotation: “I wrote Treatus with the definite intention that it should stand entirely on its own, without any form of introduction or instruction to mislead prospective performers into the slavish practice of ’doing what they are told’” (Harris, 2016).
representations than as notations.

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, 1991, p. 135).

However, regardless of how far composers flaunt the contemporary representational norms of scores, Cathrine Abell’s insight suggests that we are still dependant on the existence of those norms in order to implicate. Conventions and the communities of artists and listeners who preserve and transmit an understanding of those conventions, are essential to successful representation in scores, because without them the depth of understanding that comes from the reflexive creator-listener relationship would be lost.
3.4 Wayfinding Systems

“Wayfinding” is sometimes used in a general sense to refer to an organism’s capability of orienting itself in relation to an environment. In this sense wayfinding could involve a range of representations and technologies, from maps to dead reckoning to GPS, involving fields as varied as psychology and cartography. In a more specific, commonly encountered sense, “wayfinding design” or “wayfinding signage” refers to the design of systems of symbology and nomenclature designed to help people navigate through a built environment (Jacobson and Wurman, 2000).

As noted in Sections 3.1 and 3.3, “wayfinding” and “waymaking” are central to the representational strategy of maps and scores; both maps and scores support a user’s ability to make inferences about addressee-centric idexicals and represented spatiotemporal features. Sometimes the addressee of a map is also the person interpreting the map. An orienteer imagines the features of a map as if they were relative to a particular reference point or points within the map. A musician interprets a score from the perspective of a particular location within the score, a point in time, often with some features of the score having been interpreted in the past and some features left to interpret in the future.

I don’t claim that in either case the interpreter in fact does or must imagine himself “within” the map or score in order to interpret it. We can of course make inferences about the locations and relationships between objects or events without imagining ourselves at the center of these structures. In certain cases we also make holistic inferences about third-person addressee, such as when we read a score during a musical performance and notice how the musician situates herself in relation to the score representation. The important distinction is that maps’ epistemic power as wayfinders and waymakers drawing on our acute awareness of how objects and events relate to our own
perspectival experience of the world.

This account of cartography suggests an interesting parallel between maps and scores and systems of “wayfinding signage.” Wayfinding signage systems can be regarded as maps superimposed on top of the space they represent. When interpreting a signage system, the viewer represents herself as herself on the map which is laid out around her and appears relative to her frame of reference. When signs function holistically—representing not atomistic identity, but rather holistic spatial location of world features, other signs, and the location of the viewer—such systems may be regarded as a kind of map, since they correspond to our intuition that maps represent via holistic, isomorphic, and addressee-centric indexical representation. Like other maps, systems of wayfinding signage abstract away the granular details of an environment, reducing the complexity of a space to relations between simple representational vehicles.

A number of authors have treated public signage as merely examples of conventionalized symbolism. For example, Bertin distinguishes signage from diagrams and maps on the grounds that the former permit “internal processing [...] whereas symbolism, like language, seeks only to resolve the problem of external identification, through immediate recognition” (1983, p. 51). This view disregards the way signs can be deployed holistically as members of systems. Signs of this type not only stand for features of a space, they commit to degrees of freedom that give signification to all regions of a space immediately surrounding an interpreter.

Imagine that a seating chart is blown up to enormous size and laid out on the floor of a conference room. From a high enough vantage point, a small seating chart on an index card and the big one on the floor appear to display a similar representational strategy.

The obvious challenge to the idea that a big map laid out on a floor is in fact a map
is to say that in the case of the room-sized seating chart, the viewer can only see a small part of the map from ground level, and therefore they interact with the "symbols" of the map like simple atomistic location labels. But imagine that the big map on the floor has some representational scheme that allows a particular location to be conceived of holistically. For example, seating signs are colored. Saturated colors represent the major shareholders seated at the front of the room while desaturated colors represent minor employees in the advertising department at the back of the room. While the interpreter may only be able to see a fraction of the signs around them, they can conceive of the whole layout of the room abstractly and holistically as they move through the room because the interpreter knows how specific colors and names map abstract qualities of guests to spatial locations.

Public signage systems appear to support the absence intuition in most cases, although the intuition is this case is based heavily on implicature, the viewer’s knowledge that the signage system’s designers were aware of her knowledge of their intention. While a “wet paint” sign does not tell us anything about where else there might be wet paint, an exit sign on only one of two doors strongly suggests that the other door is not an exit. Exit signs in normal usage are not sufficiently holistic to constitute a wayfinding signage system, but the intuition can be extended to more complex context, such as the network of bicycle paths in the Netherlands in which junction points at intersections between paths are labeled via a holistic system of numbers (knooppunten) allowing for easy navigation.

Wayfinding signage systems commit to Coverage in a similar way to maps, but their scope is restricted to a viewer’s point of view and likely goals. An airport sign pointing travelers to an automated teller machine strongly implies that an even closer ATM is not available; a road sign for a hospital strongly implies that this is the closest hospital, and so on. The fact that other ATMs exist in the airport and other hospitals
exist in the county is not a challenge to the consistency of wayfinding system, because
the system is only expected to represent objects salient to the user’s immediate goals.
Kulvicki offers a similar example from sea charts that represent only certain buildings,
those visible to ships at sea. Such selectivity of representation does not threaten the
absence intuition because it is consistent with the way the map is meant to be used

Many graphs also represent data along a temporal axis, also this type of representation is very simple and direct compared to
the elaborate games scores can play with events in time. In a sense, graphs that represent space or time on one axis are map-
like in that they support simple addressee-centric wayfinding inferences. In the ten-day weather forecast in Figure 3.6, we understand our relationship to weather as clustering around our temporal location. The time of days implies something about how we should interpret the high and low projected temperatures for the day, for example. But these kinds of representations support spatiotemporal reasoning in less granular detail than we would expect to find in most scores. They exist in the margins between cartographic and diagramatic forms of representation.

Understanding how wayfinding systems work vis-à-vis maps and spatial representation is important because many contemporary scores feature a highly performer-centric representation scheme reminiscent of a wayfinding system. Toshi Ichiyanagi’s *Music for Electric Metronomes* (Figure 3.11), for example, allows the performer to choose their own path through a network of vectors representing various performance actions and metronome tempi. Among the pathways available (and following the rules of the “game” given by the performance instructions) the performer has choice in how to proceed at each juncture.\footnote{My creative practice is indebted to scores such as Ichiyanagi’s and others like it. For discussion of a dynamic corollary, an “Abortive Score,” see Section 4.3.1.2}

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\footnote{My creative practice is indebted to scores such as Ichiyanagi’s and others like it. For discussion of a dynamic corollary, an “Abortive Score,” see Section 4.3.1.2}
While Ichiyanagi’s score uses an interpreter-centric representation of time and precise duration, allowing the performer to choose how the work progresses from among a few “signposted” options, interpreter-centric scores need not be nonlinear; other scores strike a different balance between interpreter-centric and interpreter-neutral representations. Gordon Mumma’s *Medium Size Mograph 1962* represents time in a conventional linear manner, but space—specifically the space of the piano keyboard—is represented through a performer-centric scheme (Figure 3.12).


The process of performance becomes similar to that of a movement within a structural space, where the observer chooses his way about
it. In a comparable manner, both the performer in the open composition and the observer in the structural space gather several of the infinitely existing possibilities inherent in the art-work to an artistic entity which is but one of its many “realizations” (2011, pp. 90-91).

Nor are such scores necessarily nonlinear in their approach to time. Gordon Mumma’s *Medium Size Mograph 1962* represents the piano keyboard in relation to the performer’s body. Distances and and locations on the keyboard are all represented according to a performer-centric perspective.

A wayfinding approach is an appealing way to structure a score because it centers the process by which a work unfolds on the performers’ or listeners’ perceptions. Unlike a map, which normally represents the full extent of salient features and their relations
within a bounded space, a signage system represents the full extent of salient features at a given juncture.

A wayfinding score does not represent a musical architecture as being an objective, external structure; rather it asks the performer to find points of delimitation relative to their own experience, and directs the way forward when each new goal is achieved.

Early research on spatial cognition emerged from the observations of brain lesion patients who developed spatial agnosia, the inability to remember spatial features. In response it was hypothesized that certain aspects of cognition must take the form of “cognitive maps,” a supposed internal corollary to an external spatial field (Arthur and Passini, 1992). Further research has challenged this model, however. Studies of traditional Polynesian navigators suggest that these navigators find their way based on a process derived from environmental cues. Research by Passini (1981) found that people tasked with navigating an unfamiliar building relied on two styles of navigation, which he termed linear and spatial wayfinding, which different individuals appear to use to different degrees on different occasions.

It has already been noted above that the dichotomy in wayfinding approaches has corollary in linguistic metaphores for time: “ego-moving” (representing oneself as the agent at the center of time) or “time-moving” (seeing oneself as an observer of an external expanse of time). Although the present analysis of wayfinding in music scores is more concerned with structural features of representation than with their supposed cognitive corollaries, Passini’s findings are in line with Elisabeth Camp’s observation that the structure of mental representations is likely variable and context dependent (2007).
3.5 Animated Scores

Hope and Vickery (2010) have remarked on the curious fact that, although the composers of the New York School were well aware of the work of abstract animators and filmmakers such as Stan Brakhage, Jordan Belson, and Oskar Fischinger, few if any examples of projected notation were created before the twenty-first century, and animated notation and scholarship seem to be entirely a phenomena of recent decades. Although a performance tradition exists for still images of the kind often employed in animated notations, the only precursor of projected scores that is widely noted in the literature seems to be *Prima Vista*, by Argentine composer Mauricio Kagel, which consists of still images projected in performance with a slide projector (Vickery, 2012).

The addition of movement as a variable in scores significantly complicates any theory of representation or depiction and potentially involves a huge body of scholarship on representational and nonrepresentational film and animation, representation of movement and time in film, and visual and cognitive processing of moving objects. I cannot hope to do more than make a few general observations here.

Most obviously, animated scores potentially unburden the score’s $x$-axis of the necessity of representing time, so any given frame of the animation can represent spatial relationships in two dimensions, potentially bringing animated notations more in line with spatial maps in certain respects. When time is no longer represented by a fixed linear spatial metaphor, the two dimensions of planar space in the animation can represent any number of musical properties. For example, the $y$-axis could represent pitch as in classical notation, but $x$-axis could equally well represent pitch while the $y$-axis represented magnitude, as might be expected for an animation of a piano keyboard.

In practice, the most prominent representational feature of many animated scores
is “intersection,” the point at which two graphic elements appear to “touch.”\textsuperscript{16} In part, this is due to the popularity of physically based animation. Dubbed a “dynamic attack cursor” (Smith, 2015), this type of notation simulates the movement of a physical mass through relatively Newtonian behaviors. Time is often represented with a physics simulation of a moving object; musical events are mapped to the moment of contact between the “cursor” and “play head.”

Another very simple example of intersection is a scrolling score, a score that represents a musician’s position in time as the intersection between a cursor and a scrolling musical staff (Figure 3.13). In the simplest case, where the scrolling speed is uniform, monodirectional, and representational of the realtime passage of musical time within

\textsuperscript{16}An interesting case of intersection as a representational strategy is found in Jesper Pedersen’s Ha-jodakese (Section 4.1.1) where intersection of a foreground object (representing a musical event) with background topology of color gradients encodes the dynamics (loudness) of that musical event.
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the musical work, there is a corollary between the function of a holistic wayfinding sig-
nage system—which acts as a map laid out over the space it actually represents—and an
animated score, which acts like a musical score layed out in time to signpost the actual
times represented in realtime.

Although intuitively a scrolling score scheme would appear to preserve an iso-
morphic relationship between the extension and order of score events and correspond-
ing sounds in time, this is not necessarily the case. Isometry only holds so long as a
constant scrolling speed and direction are preserved, and without knowing the score (or
the algorithm that renders it) ahead of time, musicians have only inductive evidence for
assuming this to be the case.

Appearances are deceiving. Experience with printed scores strongly prejudices
the interpreter towards assuming that a similar-looking animation will employ repre-
sentational tropes familiar from still images. The strength of these expectations can be
radically undercut through the use of animated images; results might range from subtle
and implicative to absurd and incomprehensible, depending on how these expectations
are managed.

Another advantage of animation can be to reduce the cognitive load which fol-
lowing multiple simultaneous vectors of information on a printed page places on the
performer. For example, Figure 3.14 is a hypothetical notation for the independent
movement of the three valves on a trumpet. (This is similar to the approach I took in my
composition Bluegill [Section 4.2.2], an exploration of the complex acoustic response
of liminal valves states.) The notation in Figure 3.14 simply consists of three vectors
representing the valve positions in time, from fully extended (top line) to fully depressed
(bottom line). While layering these three vectors in the same space slightly assists in
perceiving the notation as a gestalt (a similar approach to that found in Figures 3.5 and
3.6), the passage would likely still have to be painstakingly memorized in order to be

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**Figure 3.14:** Example of a hypothetical vectorial notation for the movement of trumpet valves.

**Figure 3.15:** The same vector notation as in Figure 3.10 with the vectors overlaid. Although perception off the staff as a gestalt is improved, it does not seem to be much easier to follow the three independent movement vectors when they are overlaid.

Anecdotally, I have found that musicians are much better able to follow the movements of three trumpet valves when they are presented as animations. The mechanism for this effect requires further study. My hypothesis is that—whereas tracking multiple vectors in a still image requires the performer to scan both vertically and horizontally to track not only the current state of the valves but also upcoming states—animation
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requires only that the performer reproduce the current location of the valves, their direction of movement, and their approximate speed. In the case of the still vectorial representation, the smooth curves representing analog movement also provide few temporal landmarks, so the eye is deprived of references points for how the valves movements are to be synchronized.

In Chapter 4, a number of animated scores will be detailed as examples of wayfinding systems superimposed over ordered temporal events.
Chapter 4

Works

My current compositional practice is indebted to a certain thread of American experimentalism and follows particularly on the example of James Tenney in the sense that each composition might be regarded as a kind of phenomenological experiment, probing the scope of a sound, processes, or psychacoustic phenomena. This approach echoes British painter John Constable’s (and later Ernst Gombrich’s) well-known observation that landscape painting might be regarded as “a branch of natural philosophy, of which pictures are but the experiments” (Belet, 2008; Gombrich, 1960, p. 33).

Such experimental situations are, by their nature, unruly. The material or choreography of a particular action pushes back against the intervention of the performer or composer, requiring accommodation in certain regards while yielding in other aspects. As John Cage describes experimental action, “sounds are to come into their own, rather than being exploited to express sentiments or ideas of order” (1961).

Up to this point, I have focused on characterising a type of score, and indeed a compositional approach, predicated on the spatiotemporal metaphor. I regard understanding how representation occurs in scores and how it can be subverted as first
principles. But philosophy by necessity typically addresses uncontroversial examples. It remains the job of artists to explore the speculative domain at or beyond the current limits of analysis.

My interest in maps, both as metaphorical artifacts and as a representational idiom, first emerged out of the necessities of my particular sonic pallet. As a Thomas J. Watson Fellow in 2012–13, I spent a year studying with “outsider” sound artists on four continents. A chance encounter with Australian sound artist Martin Kay and my interest in the abstract work of Japanese recordist Toshiya Tsunoda, led me to develop a contemplative practice that revolved mostly around listening through microphones, piezos, and hydrophones. Eventually, I also experimented with “preparing” recording locations by placing mics within resonant objects or attaching strings or makeshift windsocks to objects in the surroundings. Later, I had the privilege and good fortune to meet Luciano Azzigotti in Buenos Aires and Jesper Pedersen in Reykjavik, two composers whose work with animated, projected, and interactive notations influenced me deeply.

The exploratory and interventionist approach that I first developed as a field recordist was very much concerned with sonic maps in a very literal sense; my recordings trace the contours of audibility, dispersion, and resonance within particular restricted spaces. As a composer and sound artist, I now focus, in my creative practice, on composed works for the concert hall or found environment. However, my practice is still concerned with perceiving and responding to the vitality latent in simple processes, materials, and technologies. In particular, I have recently sought to explore the limits of fleeting, ephemeral states that fall in between stable modes of vibration or movement. For example, the compositions in my Chitin series, for amplitude-controlled LFO, microphone, and speaker cones prepared with shards of ceramic, requires the performer to find and sustain certain vibrational patterns in the ceramic shards that occur because of their particular shape and location on the speaker. Teller Light, for string trio, live
electronics, and fixed media is notated entirely with animated images and almost ex-
clusively uses natural harmonics above the 13th partial where success in finding any
particular partial is never assured. Bluegill, another animated notation piece, explores
the acoustic response of a trumpet when all of its valves are in liminal states. Each
of these works leverages a map-like notational approach to suggest ways a performer
might interact with instruments and materials, although the sonic result remains a rare,
elusive goal.

4.1 Precedence: Two Case Studies

A multiplicity of approaches have been developed to notate music with animated im-
ages, many exploiting nonlinear spatiotemporal mappings. In this section, I will situate
my recent work in the context of two notable works by other artists.

4.1.1 Hajodakese

Jesper Pedersen’s Hajodakese is a work for five performers reading off of a single fixed
video score rendered in the open source graphic programming environments Pure Data
and Gen. Commissioned by the Iceland Symphony, the score is intended to be projected
for the audience to see during the performance.

The whimsical visual aspects of the score mirrors the lo-fi aesthetic of Reykjavik
arts collective S.L.Á.T.U.R.; each performer in the score is represented by a rainbow-
colored sliced-okra symbol. Scrolling background colors render a kind of topology of
dynamics, while small moving colored circles represent one of five distinct sounds to be
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FIGURE 4.1: A still from Hajodakese.

played when a circle contacts any of the okra slices (see Figure 4.1).\(^1\) Near the end of the work, performers are instructed to improvise raucously “following the movements” of a “dancing beard” that appears on the screen (Pederson, 2013).

Jesper identifies the roots of S.L.Á.T.U.R.’s playful aesthetic in the “80’s punk movement” in Iceland. Although the Day-Glo color palette and game-like appearance of Hajodakese might be perceived as radical, even confrontational, for many concert audiences in mainland Europe or North America, Jesper identifies the aesthetic as having more to do with filling a void:

\(^1\)A common semiotic feature of animated scores, this simulated movement of a mass is what Ryan Smith has labeled a “dynamic attack cursor” (2015). Time is represented with a physics simulation of a moving object; musical events are mapped to the moment of contact between the “cursor” and “play head.” This representational strategy was also the subject of a master’s thesis by S.L.Á.T.U.R. founding member, Guðmundur Steinn Gunnarsson (2007).
When S.L.Á.T.U.R. started out it was more a reaction to the total lack of experimental music. We were not connected to academia at the time (that happened later), so we were trying to fill a void and create a new Icelandic musical expression. A lot of the LoFi aesthetics we use are not always intentional (at least not in the beginning when we were trying to figure out all the tech) But I think today LoFi / home made aesthetic [...] is definitely a trademark of what we do. Partly because we never have big budgets (Pederson, 2017).

For me, Hajodakese is representative of an aim shared by many animated notation composers who view the medium as a means of reclaiming playful experimentalism, often using free software or scripting platforms intended for more conventional tasks. In particular, the choice to project the score in view of the audience, suggests a very different dynamic between composer, performer, and observer. As Hope and Vickery (2010) have observed,

When graphic scores are employed [projected], there is perhaps less specialist decoding required than for complex languages such as traditional musical notation and programming code. In many cases, non-standard graphical notation is nearly as unfamiliar to the performer as it is to the audience and the codes employed in realizing the symbols are a source of interest and speculation for the audience. Hence, an untrained (non-musician) audience member is likely to understand at least certain elements of the scores. This understanding means that the audience member will engage with the score in a way they would not using more traditional music notation (Hope and Vickery, 2010).

Graphically, the work is an example of an animated symbolic terrain whose potential is implied but never fully explored in any single rendering of the generative algorithm. Most of the screen space is devoted to color and activity that has no direct performative meaning; rather the sonic outcomes originate from the collision of
multiple, apparently independent, spatiotemporal processes. Whether these streams of information are truly separate or are linked in some way is unclear to the observer, but the layering of these degrees of freedom is distinctly reminiscent of the layering of physical processes in some detailed tablature scores.

4.1.2  Epinicios y Agonales

Epinicios y Agonales by Buenos Aires-based composer Luciano Azzigotti takes its name from a genre of Greek poetry celebrating the victors of the Panhellenic Games as well as from “agon” (ἀγων) which refers both to struggle or competition in the arena and in music or literature.

Epinicios y Agonales was premiered in Buenos Aires in 2011 by Nonsense Ensemble at cheLA (Centro Hipermediático Experimental Latinoamericano), whose converted car factory floor near Parque Patricios served as an enormous “navigable score,” with instructions for the work’s performance projected on the floor. The Grecian theme is taken literally, with singers sprinting at times, their movements, musical attributes, and texts represented by colors and shapes as well as by oversized diastematic symbols (Figure 4.2). Singers wear wireless headphones that provided audio cue tones, allowing Epinicios y Agonales to play out over a huge physical space while also being fully microtonal.

As noted in Section 3.3.1, “wayfinding” designs (systems of public signage or other representational aids to navigation) are a form of map in which the user herself serves as a symbol on the map, the map being overlaid on some navigable physical space. The score for Epinicios y Agonales serves this function, with parts representing not simply a sound of a certain quality but also the location, movement, and transformation over time of that sound within the performance space (Figure 4.3).
Figure 4.2: A still from the projected score for *Epinicios y Agonales.*

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FIGURE 4.3: The score for Epinicios y Agonales projected during performance.

As in Hajodakese, the performative outcome is the result of the collision of multiple simultaneous processes, but here the processes are explicitly physical. Singers must maintain the poetry of epinicios without sacrificing the competitiveness of agon. As they move and sprint according to the requirements of the score, their breath becomes labored. Singing is audibly transmuted by the physical toll of the athleticism required, a process explicitly referenced in the instruction to the singers: “[...] búsqueda del cansancio como generador de una materialidad corporal.”

The interplay of the body and the instrument interacting, violently physical processes from which the particular sound is a kind of residue, is what Timothy McCormack terms the “catastrophe” in music. Virtuosity here is grounded in the flow state of the musician-athlete and their body’s functioning according to the “game’s” rules. For the audience, who is encouraged to

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2 “Search for fatigue as the generator of a corporeal materiality” (my translation, 2017).
3 “But what is the catastrophe in my music? [...] the energies at play in the production of sound on acoustic instruments can be understood as nonaural forces that have nevertheless been rendered aural. Like painting, the catastrophic space is entirely physical, consisting of energies, speeds and pressures. It is a zone of intensity created at the point(s) of contact between the body and an instrument, of which sound is the result” (McCormack, 2010).
observe from amongst the celebrants, the score is not merely instructions for the work but in fact the terrain in which the work, and their own contact with the work, plays out.

4.2 Early Experiments

The choice to break with more traditional notation paradigms in Teller Light (see Section 4.3) proceeded from certain compositional problems and pressures encountered in earlier work. Before talking about Teller Light, I will survey some of the representational challenges I encountered in preceding works.

Interrogating these problems will help shed light on the choices I made in writing Teller Light, specifically the choice to break from my earlier use of still printed scores and also my use of increasingly complex forms of representation that at times seem to fall somewhere between cartographic, diagrammatic, and sentential forms of representation and also stretch the limits of the absence intuition in interesting ways.

4.2.1 Coelacanth

Coelacanth was composed in early 2016 for New York–based contemporary music collective mise-en. Although notated largely with standard contemporary staff notation, the first section of the work breaks with convention in its treatment of linear time. Intended as a global movement from noisy transients (represented by a loud stabs in the simantra and a range of homemade “tin can” instruments) to noisy tone (represented by scratch tone and bass trombone prepared with tinfoil), the first section of Coelacanth was composed entirely via a deterministic Python algorithm. Each attack, cued by the simantra, triggers a flurry of sympathetic hits throughout the ensemble, at first in rhythmic monophony with the simantra but rapidly falling out of sync.
Figure 4.4: Excerpt from Coelacanth with boxed areas in which tempo varies according vectors.
From the beginning, this first section of *Coelacanth* had the unusual characteristic of sounding more spontaneous in MIDI sequencer realisations than when played by a human. The generative algorithmic rhythms quantised to complex tuplets and short rhythmic values (almost unplayable by humans in an ensemble context) provided a highly improvisatory effect when played back in a sequencer. More heavily quantising the output of the algorithm made the output more playable but destroyed the spontaneity of the rhythms.

My solution was to distort the linearity of temporal representation within bounded areas, allowing musicians to *ritardando* or *accelerando* textitad libitum according to vectors drawn over certain staves (Figure 4.4). In so doing, it was also important to not make the rhythmic values *too* easy to play, since the tension generated by the specificity of the notation was desirable. (See inset quote from Brian Ferneyhough in Section 3.4 on p. 42.)

Representation of time and space, as the two “indispensable attributes” (see Section 3.1), are the least easily distorted variables. In *Coelacanth*, this was only made practical by the periodic application of an open-duration “tacet” rest for the whole ensemble, allowing players to reset to the original tempo at frequent intervals. Few examples are readily available of localized distortions of indispensable attributes in cartography, so their use in music provides an interesting case study, even if not fully successful in this case.

The tension between spontaneity versus complexity and precision which I encountered in writing *Coelacanth* motivated my later investigation into alternative means of rhythmic representation, and specifically the concept of merging the algorithmic aspects of a score with a distributed system of real-time representation.
4.2.2 Bluegill

Bluegill was my earliest experiment with animated notation, a response to my experience with Coelacanth, the piece was written for trumpet player Émilie Fortin and percussionist Joey Fox for the Montréal Contemporary Music Lab in 2016.

The notation for Bluegill, which is rendered in real time during a performance in the Processing IDE, consists of three parts (see Figure 4.5):

1. A real-time depiction of the movement of trumpet valves.

2. A vertically bouncing ball (representing diaphragmatic intensity pulses for the trumpet player) constrained by a box whose vertical dimension is pseudorandomly varied with increasing frequency throughout the performance.

3. A depiction of the movement of objects (foil, pistachio shells, sleigh bell, etc.) on and off two vertical-facing speaker cones.

For the trumpet player, the “game” of Bluegill consists in attempting to sustain the highest partial that can be played at a pianissimo dynamic level for the entirety of the performance while simultaneously exploring all liminal states between full depression and full extension of each valve. Meanwhile, the prepared speaker cones—which project only infrasound mapped from the intensity of the live trumpet signal—serve as a kind of spatially displaced “preparation” of the trumpet tone.

Bluegill was heavily influenced by dynamic attack cursor notation, in particular a thesis by Icelandic composer Guðmundur Steinn Gunnarsson (2007) on rhythm in the form of a “bouncing ball”. Pseudorandomly varying the size of the space in which the attack cursor bounces provides an interesting structural principle for the work, intuitively drawing on a graphic and cartographic understanding of space and time. The
natural extension of this principle would be to allow the “ball” to bounce obliquely off the internal surfaces of more complex geometric shapes which could be varied at pseudorandom intervals. This more complex conception of “geometrical derived” rhythmic material will be incorporated into future versions of Bluegill.

Drawing on the influence of Epinicios y Agonales, Bluegill exploits a simple process which is complexified by the physicality of the performance ritual. Allowing only short intermittent breaks to expel stale air and refill the lungs, diaphragm and lip fatigue for the trumpet player rapidly challenge the performer’s ability to sustain a very high partial with the extreme control required. At the same time, incredibly unstable vibrational states are created when the ports in the trumpet valve’s pistons pass slowly between the valve loop and main tubing. Explorations of these kinds of “cracks” between
otherwise stable tones or performance paradigms deeply influenced my subsequent experiments in *Plumage* and *Teller Light*.

### 4.2.3 *Plumage*

*Plumage* was written for FORUM 2016, a residency with Nouvel Ensemble Moderne in Montréal in November 2016. The performance notes for the work describe the work’s technical concept as revolving around heavily repressed or liminal performative actions:

Beginning with the performance instruction “at the edge of sounding,” *Plumage* explores a world of halting, intermittent sounds. Instruments are blown with a fraction of the air normally required; bows skid and skim across strings. The results are delicate and unpredictable.

Explicitly cartographic notations were developed to explore the “cracks” within the spectra of the instrument. A three-line staff above the flute part depicts low, high,
and very high partials within a complex multiphonic. In the flute part for example, magenta vectors represent where within the spectrum the performer should focus her exploration, what parts of the multiphonic should receive the most acoustic energy. Circled numbers within the vector lines represent how many simultaneous tones the flutist should attempt to sustain simultaneously (see Figure 4.6).

Although not every multiphonic would be flexible enough to allow full compliance with the represented spectral filtering, the intention of the notation is to focus the performer on a delicate, unstable material whose ephemeral timbres would normally be rapidly discarded or passed over without conscious perception. The spatial metaphor here plays a big part in the notation’s implicature, asking the performer to explore within a single sonority even when that is near impossible. It is hoped that the specificity of the notation causes the performer to explore much deeper within the minuscule fluctuations of a single tone than would be common for any passage employing a more conventional notation.

### 4.3 Teller Light

A major work which synthesizes many aesthetic and research interests from preceding works, *Teller Light* was meant as a largely speculative exploration of the extremes of cartographic abstraction, representing highly conceptual, aggregate musical properties through spatial and temporal abstractions. In particular, my research focused on developing an approach to representing the perceived “instability” of very high natural harmonics on the string instruments, harmonics not typically used in notated compositions due to the near impossibility of picking them out on the string with any degree of reliability.
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The nature of string instruments is such that variations in humidity, temperature, performer attention, muscle fatigue, and mental state, or the age of the strings used on the instrument may significantly aid or compromise performers’ abilities to achieve the desired effect, therefore the notation had to account for the possibility of “failure.”

Simply put, the notation, and the approach pursued in rehearsal was structured as a series of challenges that the performers set for themselves and pursued through a process of deep listening, adjustment, and reevaluation. “Instability” is represented not as a quality of sound but rather as the propensity or inclination of certain materials and performative situations. Wayfinding design is highly suited for representing this type of performative journey, representing not what necessarily exists but rather suggesting goals or possible avenues of further exploration.

4.3.1 Conceptual Approach

My use of video notation in *Teller Light* substantially expands on my early experiments in the medium, both in terms of technical and conceptual sophistication.

4.3.1.1 Score as Generative Algorithm

Relatively little research has attempted to untangle the aesthetic implications of using computer algorithms to structure musical works. In *Algorithmic Composition: A Guide to Composing Music with Nyquist*, Mary Simoni and Roger Dannenberg propose that the problem can be broken down into essentially three camps based on the relative value of the algorithm versus the product of the algorithm.

How do we decide if a composition that uses algorithms has aesthetic merit? [...] one must separate the process of composition from the product of composition, e.g., the music. Some algorithmic
composers would argue that the aesthetic merit of an algorithmic composition should be based solely on the algorithm used to create the music. Other composers assert that both the algorithms used to create the composition and the composition itself should be assessed when determining aesthetic merit. There are still others who would argue that the algorithms used in algorithmic composition are simply a means to an end and for that reason, the algorithms themselves are not worthy of artistic scrutiny. These composers may believe that their success or failure as a composer is based on the listener’s response, and therefore they have the right to throw away or modify the output of an algorithm to achieve their aesthetic goal (Simoni and Dannenberg, 2008, p. 14).

In *Teller Light*, I attempt to find a different relationship to generativity. Rather than viewing the composition as separate from the algorithm, I view the composition as simply a set of performance circumstances, determinstic methods, and stochastic weightings. Any performance that takes place under these circumstances might be regarded as *Teller Light* in a certain sense. Therefore, my use of an algorithm is not something that can be evaluated apart from its outcome; both together constitute the aesthetic outcome of my compositional intentions.

On Goodman’s account scores serve to identify and preserve musical works. In Section 2.1 and 2.3.1.3 various reasons were considered for doubting that scores can or do function in this way. The reconception of a score as an algorithmically constrained performance situation only feeds this fire. While it may be argued that a fixed video score or a pseudorandom (i.e., deterministic) score is no more interactive than marks on paper, the addition of truly responsive electroacoustic or dynamic score elements complicates the issue substantially.

Such a score potentially draws heavily on a wayfinding approach. Each action taken in a performance may participate in a complex scheme of stochastic weightings
or scripted responses, but the composition, by a serious of such moves may wander quite far from its initial states. The score itself would then constitute a kind of Monte Carlo algorithm, each performance adding to a picture of the possible states attainable by the score but never exhausting the possibilities for that score.

Agency is distributed widely in the performance of such a work. To begin with, the composer’s role seems to be that of setting up a particular kind of generative system. As Xenakis observed in 1962 “[...] the role of the living composer seems to have evolved, on the one hand, to one of inventing schemes (previously forms) and exploring the limits of these schemes, and on the other, to effecting the scientific synthesis of the new methods of construction and sound emission [...]” (2001, p. 133). Then again, when the score is structured as a kind of “game” in which performers struggle to achieve or maintain certain states through listening and dynamic feedback provided by the computer in real-time, the performers themselves have substantial agency in realizing the work. Finally, with increasingly sophisticated software algorithms, the computer too might constitute a kind of pseudoagency, based perhaps on initial states set up by the composer, but (especially in the case of artificial neural networks) developing in certain ways that represent a particular identity, with that process of self-individuation drawing substantially on material explored by performers.

4.3.1.2 Aberrative Scores

*Teller Light* is conceived of as a proof of concept for a kind of wayfinding score in which stimulus to future action (the live video score or projected audio) is determined by what the musician plays. In other words, the score is in a feedback cycle with the performer (Figure 4.7).

To be more precise, in a full rendering of such a score, the stochastic parameters
Figure 4.7: A diagram of an aberrative score. Light gray indicates conceptual elements of such a score that were not realized in the Teller Light but will be explored in future work.

for rendering upcoming audio and video projection are set by computer analysis of the current state of the sound produced by the performer, which in turn is a response to the video score and projected audio, etc.

A score of this type might be referred to as an “aberrative score,” since, although the conditions for any new score state are based on coded parameters, the unfolding of the work by a series of such choices is based on what the computer perceives in the particular performance situation. The score literally “aberrates,” tracing out innumerable possible realizations depending on the particular instance and conditions of performance. Even if elements of the score are pseudorandom, the performance itself is
potentially far more unpredictable because the score responds to the performance situation in a subtle and unpredictable way, as do the musicians in response. Vickery (2012) points to a nascent conception of such a score in Umberto Eco’s *The Open Work*:

As in the Einsteinian universe, in the “work in movement” we may well deny that there is a single prescribed point of view. But this does not mean complete chaos in its internal relations. What it does imply is an organizing rule which governs these relations. Therefore, to sum up, we can say that the “work in movement” is the possibility of numerous different personal interventions, but it is not an amorphous invitation to indiscriminate participation. The invitation offers the performer the opportunity for an oriented insertion into something which always remains the world intended by the author (1989, p. 19).

In *Teller Light* this concept is only realized in the live electroacoustic audio processing; the video score remains fixed. A full realization of the concept would implement a fully responsive video score as well. However, because much of *Teller Light* is based on listening for specific sound cues and responding, even the audio implementation has the potential to substantially transform the score from performance to performance.

### 4.3.2 Technical Approach

Composed for the Boston-based string trio Sound Energy, *Teller Light* was written expressly for performance in Rollins Chapel at Dartmouth College (Figure 4.8). Although the work may be performed in any space with the necessary size and acoustics, the structure and sonic landscape were chosen to complement Rollins Chapel specifically. A vaulted, reverberant cruciform church, the space allowed for significant spatial separation between the members of the trio, with the violinist and violist sitting at the
entrance to the right and left transepts while the cellist sat approximately halfway down the choir with his back to the apse. The audience was invited to take off their shoes before the performance and wandered freely around the space during the performance.

Sonic qualities of the space were consciously incorporated into the structure and aesthetics of *Teller Light*. Widely dispersing the trio spatially maximized the acoustic effect of the architecture, allowing the audience to fully explore their own perception of the sound as a spatial phenomena. In addition, the sounds used for the tape parts were developed to complement a frequent acoustic artifact within the space: metal radiators lining the transepts close to the baseboards periodically produce a diffuse, metallic filigree of pops and pings of expanding metal. Although all sounds in the tape parts were
created with a violin and various found objects, the transient-dense texture and cyclical emergence of the projected sound complemented similar qualities in the soundscape.

*Teller Light* is notated via either a fixed or live video score. The algorithmic back-end of the score runs in Max/MSP, while the video notation is rendered in the Processing IDE, which receives real-time values from Max via the Open Sound Control (OSC) protocol. Global section lengths and Markov chain transition weightings are calculated via Python algorithms, and these parameters are set before a performance of the work.

*Teller Light* includes live electroacoustic audio processing, which is also implemented in a Max/MSP patch. The processing consists of four distinct functions:

1. Light amplification of the ensemble.
2. Synthesis of sine waves projected through transducers affixed to the bridges of the string instruments.
3. Live mixing of seven prerecorded tape parts based on pseudorandom walks.
4. Pitch tracking of each performer which is used to calculate an arbitrary real-time metric of the “stability” of pitch within the timbres being explored by the ensemble. (The transducers and tape parts are cued by the stability metric when it exceeds an arbitrary limit.)

Simultaneously running the real-time score back-end calculations, front-end rendering, and live audio processing results in very high CPU usage. Therefore, live rendering of the score requires a distributed hardware setup where the performance laptop executes back-end calculations and audio processing while the performer-side computers render the score in the Processing integrated developed environment based on data.
Figure 4.9: Hardware setup for Teller Light. The piece may be optionally performed with a fixed video score instead of a networked score.
received from the performance laptop via OSC over a closed network connection (Figure 4.9).

*Teller Light* may also be performed with a fixed video score recorded from the live score. For the work’s premier at Dartmouth College, a fixed video score with live audio processing was used.

### 4.3.2.1 Structure and Graphic Design

Structurally, the work alternates between dense and sparse sections. Dense sections are further broken down into subsections that ask the performer to focus attention according to one of two modes of listening, which Oliveros (2005) refers to as “exclusive” versus “inclusive” listening. The former is a practice of deeply focused attention intended to pick out specific features of one’s own sound making, while the latter is an open, receptive mode of listening that allows one to place one’s own sound within an ambient sonic space. To this end I developed a set of symbols to represent the most salient aspects of each listening experience as it pertained to the goal of sustaining increasingly unstable tones (Figure 4.10).

Degrees of freedom were developed both for high-level structural sections of the work as well as for low-level granular representations. On the structural level, the work is divided into “inclusive,” “exclusive,” and “tape” sections. Different symbolic ecosystems populated each type of section although “exclusive” listening sections are sometimes allowed to bleed-over into “tape” sections, and some performers start or stop sections slightly “early” or slightly “late” (as determined by the structural pseudo-probabilistic algorithm—see Appendix A), so the division of the work is more a conceptual compositional approach than a prominent feature of the listener’s experience.
**Figure 4.10:** Degrees of freedom in the notation of *Teller Light.*
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Figure 4.11: Notation for the “Tape” sections of Teller Light.
Inclusive and exclusive symbolic systems are shown in Figure 4.10. Tape sections are far more sparse, allowing the tape part to project through the texture much more prominently. An entirely different notation based on listening and imitating was used for the tape sections (Figure 4.11).

While “exclusive” listening sections feature a notation which focuses the performers’ attentions on an exploration of a certain area of the string and certain specified timbres (Figure 4.12), “inclusive” listening sections are represented through an abstracted macroscopic map of the ensemble, with relations between performers represented by simple musical morphologies (Figure 4.13). For example, performers are asked to emerge or submerge into the timbre of another musician. At other times, a performer is asked to listen for the “beating” (constructive and destructive interference pattern) between their sound and any other sound within the texture, and musicians may be asked to transform their sound in order to find a tone that beats against an ambient tone in a different way.

To represent such highly ephemeral musical materials, a different kind of music notation had to be developed, drawing on not only mapping the physical space of the instruments’ strings but also mapping the interpersonal musical relationships between the members of the ensemble and the conceptual space of a listening experience as well. In essence, several wayfinding systems for both tangible and conceptual descriptive features are layered on top of a map representing invitations to engage in performative actions. Allowing these layers of meaning to coexist without unintended contradictions or ambiguities of representation was the primary challenge in composing Teller Light, and the representational system developed to display these priorities served as a waymaker for me as the composer just as it serves as a wayfinding system for the performers.

The cartographic notation for left-hand performative actions consists mainly of an image of the body of a string instrument (see Figure 4.14). Since the musical material of
Figure 4.12: Cello part in an exclusive listening section of Teller Light
Figure 4.13: Inclusive listen section Teller Light (violin view) showing map of macroscopic formal structures between members of the ensemble and magenta timing cue around the perimeter of the circle.
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*Teller Light* consists mainly of natural harmonics, it seemed appropriate to notate space in terms of the locations of harmonics on the strings of the instruments.

Since taut strings theoretically vibrate to a near infinite number of harmonics (the “harmonic series”), it was necessary to make choices about what would be emphasized. A wayfinding system was created from the concept of highlighting “landmarks” which performers could use to find their way around the harmonic fingerboard. Certain harmonics, generally the first 2–3 overtones on each string, are very well known to all string players. Harmonics at the half, third, and quarter divisions of the string are already commonly used to tune the instruments and as reference points for establishing intonation, so these three harmonics and the harmonic at the eighth division of the string are represented along the main fingerboard on the schematic of each instrument.

Three shades of red—arranged inversely according to their brightness—were used to notate the first three harmonics. Tests of the notation viewed on a screen at the distance that string players would typically view a score revealed that distinctions of brightness below RGB(153, 0 0) were poor. Therefore, a medium shade of gray was used to indicate the harmonic at the eighth division of the string instead. In addition, the thickness of the line representing each harmonic node was used as an additional visual cue.

Depending on the string instrument and the fundamental pitch of the particular string, it is often possible for string players to play natural harmonics up to the 16th partial or even higher, although not with any reliability above the first few partials. Since harmonics are found at simple integer divisions of the string length, the same partial is often found in many locations on the string, with partials laid out symmetrically around the midpoint of the string.

The density of harmonic nodes makes it difficult to represent their locations to
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**Figure 4.14:** Detail of tablature notation.

a scale easily visible on a standard-size computer monitor. My solution to this problem was to use a dynamic inset map which changes based on the location of the string currently being explored by the performer (Figure 4.14). An inset map is a common technique in cartography used to highlight a detail within a large-scale map or conversely to allow the viewer a sense of context and perspective for a small-scale map (Tyner, 2014).

Depending on where the player is asked to play on the string, one of six insets are used. Insets always span one quarter of the string’s length and have as their lower boundary either a node at the quarter division of the string or a node at the eighth division of the string; therefore, the span of any inset overlaps with the next inset above or below it on the string, which helps to provide smooth transitions between ranges.
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To the left of the instrument body schematic, labels in conventional notation display the lower and upper boundaries of the current inset range for all four strings of the instrument. Since the location of natural harmonics on a string instrument does not necessarily correspond to a tempered pitch when the string is depressed at that location, notated pitches are approximated to the nearest quarter tone.

To help with wayfinding within any single inset, I developed a syntax for the different harmonic nodes. Although picking out a specific harmonic was rarely required of the performers in *Teller Light*, I believed it would be valuable to develop a detailed syntax which could inform the design of future scores as well. I follow Tufte (1991) in preferring to represent the full detail of available data, relying on good design to clarify the information, rather than simplifying the subject matter. To this end, all harmonic nodes are labeled, with two sizes of text emphasizing the “landmark” nodes, which are presented on both the instrument schematic and the inset, allowing for easier comparison of these frames of reference.

Within the inset, to further differentiate the different harmonic nodes, a unique shade of gray is used for each harmonic node beyond the harmonic at the 5th. This presents a known perceptual problem. Cartographers take into account the fact that ganglia in the human eye overlap slightly and also influence the firing of adjacent ganglia. This can lead to difficulties in perceiving gradations of gray tones, with gray tones appearing much darker when situated next to light areas than when situated adjacent to areas of contrasting gray tones. Therefore, a series of gray lines of different shades on a white background can be assumed to be poorly differentiated by color tint alone (MacEachren, 1995).

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4“Micro/macro designs enforce both local and global comparisons and, at the same time, avoid the disruption of context switching. [...] High-density designs also allow viewers to select, to narrate, to recast and personalize data for their own uses. Thus control of information is given over to viewers, not to editors, designers, or decorators” (Tufte, 1991, p. 50).
To increase the differentiability of harmonic nodes, line thickness is used as an additional visual cue. Additionally, prime-numbered nodes above seven are represented as dotted lines of increasing fineness and density (Figure 4.15).

Typographic design was also carefully designed with both conceptual and utilitarian representation in mind. Fonts were chosen to highlight the two layers of notational representation. To the left (see Figure 4.11), Frutiger LT 87 Black Condensed highlights the utilitarian physical features of the instruments, while on the right a more airy font—a light version of Brandon Grotesque—is used to refer to more conceptual properties, such as directing musicians to listen to certain features of the spectrum.

The use of color in public signage is often intended to maximize visibility while also balancing contrast between different presentations of text. For example, for the design of Charles de Gaulle airport, color expert Jacques Filacier suggested signs should use a dark yellow ground on which either white or black text contrasts equally. Similarly, color in the notation of Teller Light was used to increase the visibility of certain symbols and highlight graphic themes, but care was taken not to fatigue the eyes. Eduard Imhof describes the strategy in terms of foreground and background colors: “Pure, bright or very strong colors have loud, unbearable effects when they stand unrelieved

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5It makes sense conceptually to use prime-number nodes as landmarks since the highest prime number represented in tuning ratios gives the so-called “limit” of a just intonation scheme.

6The Frutiger font, originally called Roissy, was designed by Adrian Frutiger for the Charles de Gaulle Airport in 1970–71 and was intended to be highly legible to travelers on the move. As such, it is an excellent font for animated notation, where moving images must be perceived immediately without unnecessary clutter or distraction.
over large areas adjacent to each other, but extraordinary effects can be achieved when they are used sparingly on or between dull background tones” (2007, p. 72).

Since *Teller Light* would always be viewed on computer screens, the RGBA color space was used throughout. Color highlights are based on various color schemes, especially triadic and complementary color relations (Figure 4.16). Many symbols—such as the exclusive listening symbols (Figure 4.10), arrows representing temporal vectors, and also the box delineating the physical space on the string to explore (Figure 4.12)—use the additive secondary cyan which is the complement to the electric red used to notate harmonic nodes below the 5th harmonic. RGB primary magenta is reserved for notation relating to the passage of time. Dials and loading bars showing transitions between ideograms all use magenta. Finally, the RGB primary green (the complement of magenta) was not used, as it was found to be too garish to use both. However, a green hue with substantial blue RGB(0, 255, 128) was used as a substitute in “tape” sections representing the audio features to imitate (Figure 4.11).
4.3.2.2 The Experience of Interpreting Teller Light

The experience of interpreting the score for Teller Light differs in interesting ways from the experience of interpreting my previous compositions.

Certain aspects of Teller Light’s notation are of course familiar from other contemporary scores. Tablatures have been a standard part of the contemporary string player’s repertoire since at least Helmut Lachenmann’s Pression (1969), and, as I’ve described elsewhere (e.g., Section 2.1 and 3.2), recent tablatures have become increasingly thorough in detailing the performative actions which they represent.

The score for Teller Light is different from other highly cartographic scores in that it shows performer actions only very generally. A bounded, pseudorandomly generated, moving area on the fingerboard is indicated, not a specific location and pressure vector for the stopping finger. Performers are instructed to keep the bow pressure fairly light and as continuous as possible throughout; bow changes and locations are left to the discretion of the performer.

Instead of complexly detailing specific performative actions, Teller Light focuses on indicating aggregate qualities (which are identified through deep listening), particularly the concept of “instability” which results from a large number of largely discretionary variables: the bow speed and pressure, the point of contact between the bow hair and the string, the particular harmonic node selected, the finger pressure, etc.

Many tablature scores may in fact aim to create similar musical textures to Teller Light, but they aim to do so as a byproduct of the collision of physical performative gestures. In my work, the performers’ attention is lifted out of the haptic and refocused on listening, albeit listening complicated by granular constraints and goals.
Figure 4.17: David Dunn’s *Purposeful Listening In Complex States of Time* details a virtuosic series of listening tasks that include the height of sound events to perceive, their distance and direction from the listener, the duration of sound events to listen to, and even vectors entailing a moving focal point of perception of the environment around the listener.

Such an approach draws comparisons most readily to Pauline Oliveros’s aphoristic *Sonic Meditations*, although the video score in *Teller Light* delineates microstructure more rigidly than do text scores. Comparison can be drawn more readily, perhaps, to David Dunn’s *Purposeful Listening in Complex States of Time* which aims, through an elaborate staff-like notation, to script a sequences of “direct mental conditions for listening without any other expressive intention or content” (1998, p. iii) (Figure 4.17).

The experience of interpreting *Teller Light* is something like navigating a varied acoustic terrain. In general terms, the score indicates areas, destinations, methods, points of interest, and the time required to traverse a sonic topography, but the specific sounds existing along these “vectors of intentionality” remain for the performer to find and sustain. Sounds within the moment of present awareness become incredibly fleeting when we attempt to freeze any fragment of parity which emerges within the tapestry of acoustic microfluctuations. This is true of any sound listened to with sufficient acuteness, but it is especially true of sounds drawn from the interstitial area between different stable performative actions, sounds such as the fleeting harmonics that emerge right at the edges of more stable harmonics.
The complexity of this musical exploration requires a specific vocabulary and approach in rehearsal. The way in which the central game of *Teller Light* is described is very important to the musical outcome. This process was framed as follows: I asked performers to find a sound with a given quality (see Figure 4.10 for notation of degrees of stability) and then do their absolute best to sustain that sound. “Stability” and “instability” were framed as predilections of a given material, not the perceptual acoustic outcome of a given notation. For example, where the score for *Teller Light* requires a highly unstable sound, this indicates a combination of performative actions which significantly complicate the performer’s ability to achieve sustainment of that sound. A request for an unstable sound is not a request for the performer to temper their attempt to sustain that sound. In a sense the physical actions of the performer and the expressive musical goals of the performer (always guided by listening) are in conflict. The performer is constantly attempting to perform to limits of their skill and ability, but the goal posts constantly move. If one sound is successfully sustained, a new and more complex sound must be found and sustained, and the physical, haptic constraints of that performative act are constantly being altered.

This very specific framing for the task of interpreting *Teller Light* provides an interesting and complex case study of score representation. The absence intuition is stretched almost to the breaking point in order to allow the score to represent musical material which may or may not sound according to its particular physical tendencies.

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7 Special means were also used to help performers practice the physical techniques required to perform *Teller Light*. Since the natural harmonics used in the work are almost never used in the string repertoire, I created a Max/MSP patch which provides score and audio cues for the natural harmonics up to the 16th partial (Figure 4.18). Notably, this patch provides a Pythagorean tuned string fundamental based on the tuning reference pitch (defaulting to 440 Hz). Mirroring the way string players actually tune their open strings, this feature helps guarantee the pitch accuracy of the reference tones for extremely high natural harmonics. In working with Sound Energy trio, I found that rehearsing with the “Flight Simulator” patch helped improve the ensemble’s ability to find and sustain these very high harmonics.

8 Another way to understand this is that musical materials produced in a certain way have a probabilistic tendency to sound in a certain way, i.e., a specific finger placement and pressure in combination with a specific bow speed and pressure will tend to result in a highly variable, complex, and noisy sound, although this tendency can be influenced slightly by the performer making minute adjustments in their technique.
Where the score represents a musical feature, the score is in fact representing a particular internal state or goal which the performer is invited to seek. The score is entirely agnostic about the acoustic result of attempting to attain these goals.

The score for *Teller Light* is, in a sense, both a wayfinding and a waymaking system. Although points of demarcation are signposted throughout, these demarcations are understood only in relation to the acoustic landscape which is in part the creation of the performer. The score invites the performer to participate in creating the sound world from the ordered qualities it exhibits to be most salient to the work, but how the performer perceives these states, how those perceptions precipitate performative actions, and what specific acoustic features rise to the forefront of the musical experience is a
matter of worldmaking, to use Goodman’s term.

4.3.2.3 Future Work

*Teller Light* is a significant maturation of strategies that I developed to address representational problems I encountered in trying to notate my music through more conventional means. As predicted by my theoretical approach which emphasizes the utility of scores in the creative process, re-conceptualizing notation to feature different aesthetic and interactional priorities has made available to me a new means of structuring sound and interfacing with musicians and with listeners. However, many aspects of the conceptual and technical approach inspired by *Teller Light* remain to be explored and expanded upon in future work.

Nontrivial technical challenges must be solved to fully realize the complete aberrative score concept illustrated in Figure 4.7. In particular, implementing real-time responsive animation and real-time responsive audio tracking and synthesis for each performer, within a synchronised, networked video score, demands both efficiency and resilience to be practical in real-world performance contexts. Max/MSP and Processing, while convenient for prototyping, are far from ideal on both counts.

In a survey of a subset of the more common off-the-shelf or repurposable platforms, Freeman and Colella (2010) note the relative poverty of available approaches to representing animated scores whether as fixed or real-time processes. Although efficient data or screen sharing protocols such as Open Sound Control (OSC) and Virtual Network Computing (VNC) theoretically have the potential to overcome the most pressing challenges, future scores should be developed from the ground up with more powerful
and flexible tools such as the openFrameworks library. James Bean’s “dynamic notation for music” (dn-m) project—an interactive notation program for iOS tablet devices designed to assist performers in real time—clearly shows the power of developing a purpose-built platform from first principles.

More sophisticated use of transducers could further complicate the intersection of intuitive and algorithmic conceptions of stability (exemplified in Teller Light by the “black box” algorithm which resynthesizes tones into the bridges of the instruments when a sound is perceived by the computer to be “stable”). In particular, Chang et al. (2017) have demonstrated nonlinear acoustic synthesis in the form of intermodulation. This works by transducing a modulation signal into a bridge-interface attached to an acoustic instrument. Although their work demonstrates the effect of transduction in custom-built idiophones, membranophones, and aerophones, they describe the possibility of creating similar effects with chordophones. Future work should explore the feasibility of implementing their approach in the context of a data-feedback system such as the one realized in Teller Light (see Section 4.3.1.2).

Musically, future works should better allow for the perceptibility of macroscopic gestures emerging from a score’s spatial and interpersonal interactions. Dispersing musicians far apart within the performance space contributes to the audience curating a unique personal experience of that space and the work. However, in future work I would like to better accommodate interpersonal listening between the musicians in sections of a work where this is appropriate. This should be done by either changing the spatial conditions of a performance, incorporating technology to compensate for deficits in interpersonal contact (monitor speakers, closed-circuit video links, or even audio cues),

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9 http://openframeworks.cc
10 https://github.com/dn-m
11 Thanks to Ashley Fure for this insightful observation.
or by refining the score representation to incorporate an even more holistic understanding of the wayfinding system to better curate a specific perceptual and performative journey.
Chapter 5

Conclusion

Structural approaches to representation, such as Nelson Goodman’s theory of notations, have the advantage that they allow us to analyze music representations in the context of a broad category of disciplines, including, for example, scientific notations and data visualizations. With the increasing adoption of new software approaches for notation (and the realization of notation) and, in particular, the recent turn towards vector-graphic and hybridized graphic scores and tablature notations, the ability to contextualize scores as one of many forms of data representation becomes increasingly appealing. Better understanding the context and terms under which scores are produced and interpreted can, for example, help us to understand the pragmatics involved in decoding and interpretation. However, attempts to understand music notations linguistically are limiting and seem to overlook something essential about how composers and performers have treated scores in the twentieth and twenty-first centuries. My project here has been to take a few steps towards understanding how scores use space and visual variables to represent spatiotemporal information and how that understanding can inform compositional choices.
Chapter 5. Conclusion

Although many forms of representation rely on spatial aspects of images to represent information, and these approaches range from highly isomorphic to the very abstract, I have focused on a particular thread of contemporary composition concerned with musical space, morphology, and map-like representations. Composers have increasingly turned to spatial metaphors throughout the last century; they appear prominently in Xenakis’s architectural sketches, in the space-time scores of the New York School of composition, in the writings of Wandelweiser composers, in the turn towards gallery works, and recently in the use of vector graphic design software and intensely prescriptive tablature in the works of Aaron Cassidy, Timothy McCormack, James Bean, and others. Although less unified in their approach and goals, composers working with animated notation also largely draw on space and spatial metaphors and additionally reflect a tradition of graphic scores steeped in the diagrammatic experiments of Cage and his contemporaries.

My use of animation in Teller Light and other works draws on a very recent, but historically cognizant, exploration of live, networked animation as a new resource for exploring performer-computer interactions and spatially situated listening and performance. The representational approach of this work hybridizes subtle cartographic and diagrammatic representations of physical performative exploration with the kind of highly virtuosic listening cues explored by Pauline Oliveros and David Dunn. If we understand scores to be vehicles for creating meaning through the categorization and recategorization of the world, as Goodman (1976) and Elgin (2002) propose (even on a scale merely limited to work pragmatics), then animated scores leverage a particularly powerful ability to extend, distort, and reconceptualize how musical events and actions are represented across space and time.

Scores that leverage map-like graphic strategies also provide an interesting case study of homomorphic representation. In particular, their addressee-centric vectorial
use of score space draws interesting parallels with systems of wayfinding signage. While scores generally represent the order and extension of events in time, a small number of score-like maps use the same representational scheme to display a de se experience of an environmental space. To return to the von Schelling quote with which I began, such “scores” use the representational vehicles of music notation to trace an experience through a built environment or topographical space.

For example, Hanoch-Roe (2011) has developed her own method for scoring a walk along a path, notating such things as the walk’s “rhythm” and the relative “sense of enclosure” experienced at particular points along the way. Hanoch-Roe situates her score of architectural peregrination among a short history of similar works, including the experimental “highway score” by which Appleyard et al. (1971) sought to express the aesthetic experience of traveling along a highway “by placing elements along a single line or staff, as in music notation” (Figure 5.1).

Other aspects of experimental score representations also suggest interesting extensions of conventional maps. While contemporary scores may suspend the prevailing temporal scheme in certain areas (see Section 4.2.1), few conventional maps similarly suspend spatial relationships in arbitrary local areas. In a conversation with Liz Camp in April 2017, she suggested to me an interesting speculative corollary: as an act of personal and community memory, people might stretch or otherwise reshape the dimensions of a digital map to reflect aspects of their personal experience, recollection, or relationship to place. If a means were available to decode a map of this kind, it could serve as a tool not only of mimesis, but additionally as an expressive vehicle not unlike a score.

It remains to be seen how other extensions of score-like representation might suggest new ways of worldmaking.
FIGURE 5.1: Score for the experience of a Northeast Expressway near Boston by Appleyard et al. (1971)
The following Python algorithm is used to pseudo-randomly generate sections lengths for *Teller Light*. Output is formatted for use in Max/MSP “coll” objects in the *Teller Light* Max patch.

```python
# Teller Light
# Pseudo-Random Temporal Structure
#
# The purpose of this program is to pseudo-randomly generate the section lengths and subsection lengths for each performance of *Teller Light*. The Max patch should be loaded with a .txt file generated by this Python script.
#
import random
import numpy as np
from random import randint
from random import shuffle
from scipy.interpolate import interp1d
import itertools

## Use this variable to set whether section lengths are represented as min. [1], sec. [60], or ms. [60000]
## -----------------------------
sec_min = 60000
## -----------------------------

## Use this variable to set the approximate duration of the piece.
## -----------------------------
```

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sizelimit = 30*sec_min
## ---------------------------------------
## Converts a list of section durations to a list of time points for the start time of each section (starting with 0)
## ---------------------------------------
def lengthsToTimePoints(input_list):
    attack_points_list = []
    summing_loop_list = []

    attack_points_list.append(0)

    for item in input_list:
        summing_loop_list.append(item)
        attack_points_list.append(sum(summing_loop_list))

    return attack_points_list
## ---------------------------------------
## This code is from SilentGhost at http://stackoverflow.com/q/2400840
## ---------------------------------------
def timePointsToLengths(input_list):
    return [j-i for i, j in zip(input_list[:-1], input_list[1:])]  
## ---------------------------------------
## We want some variation in section start and end times; hence this function
## ---------------------------------------
def randomizeSectionLengths(start_times, durations):
    output_list = []
    for onset, length in zip(start_times, durations):
        if (onset == 0):
            output_list.append(0)
        elif (length > 2*sec_min):
            output_list.append(onset + (random.uniform(-1.5*sec_min, 1.5*sec_min)))
        else:
            output_list.append(onset + (random.uniform(0, 1.5*sec_min)))

    output_list2 = []
    for new_onset, old_onset in zip(output_list, start_times):
        if (randint(0,9) < 6):
            output_list2.append(old_onset)
        else:
            output_list2.append(new_onset)
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```
output_list2.append(new_onset)

return output_list2

## Now we make the small subsections between each large section timepoint
##
## parseForColl(large_section_time_points, large_section_lengths, count):
def parseForColl(large_section_time_points, large_section_lengths, count):
    index_counter = 0
    subsection_list = []
    for time_point, length in zip(large_section_time_points, large_section_lengths):
        subsection = []
        while (sum(subsection) < length):
            subsection.append(random.uniform(1., (random.uniform(2.*sec_min,4.*sec_min))))
        interped = interp1d([0.0, (sum(subsection))], [0.0, length])
        subsection_lengths = interped(subsection)
        subsection_time_points = lengthsToTimePoints(subsection_lengths)
        subsection_lengths = [ round(elem, 4) for elem in subsection_lengths ]
        subsection_time_points = [ round(elem, 4) for elem in subsection_time_points ]
        count = (count + 1) % 2
        if (count == 1):
            quality = "HARMONICS"
        else:
            quality = "SILENCE"
        print index_counter, ",", time_point, length, quality, ";"
        index_counter += 1
        for sublengths, sub_time_points in zip(subsection_lengths, subsection_time_points):
            print index_counter, ",", sub_time_points+time_point, sublengths, "subsection", ";"
            index_counter += 1
        #subsection_list.extend(subsection_time_points)
    #print subsection_list

## Now we make the small subsections between each large section timepoint
```
def parseForColl2(large_section_time_points, large_section_lengths, count):
    index_counter = 0
    subsection_list = []
    for time_point, length in zip(large_section_time_points, large_section_lengths):  # first we iterate over both lists
        subsection = []
        while sum(subsection) < length:
            subsection.append(random.uniform(1., random.uniform(2.*sec_min,4.*sec_min))) # fill sections with subsections
        interp = interp1d([0.0,(sum(subsection))],[0.0,length]) # scale subsections to match lengths
        subsection_lengths = interp(subsection)
        subsection_time_points = lengthsToTimePoints(subsection_lengths)
        subsection_lengths = [round(elem, 4) for elem in subsection_lengths]
        subsection_time_points = [round(elem, 4) for elem in subsection_time_points]
        count = (count + 1) % 2
        if count == 1:
            quality = "HARMONICS"
            quality2 = "harmonics"
        else:
            quality = "SILENCE"
            quality2 = "silence"

        print index_counter, ",", time_point, length, quality, ";"
        index_counter += 1
        for sublengths, sub_time_points in zip(subsection_lengths, subsection_time_points):
            print index_counter, ",", sub_time_points+time_point, sublengths, quality2, ";"
            index_counter += 1
        print index_counter, ",", sum(large_section_lengths), "0.0", "end", ";"
        #subsection_list.extend(subsection_time_points)

# <h2>Global Section Lengths</h2>

# Now we create the large section lengths in abstract. Note that later the start and end times of these
# If you change the "sec_min" variable above, remember to rerun the first cell again before running this
large_sections = []  ## A list on which to append the large sections values

## Here we creat one large section between 12. and 15.
large_sections.append(random.uniform(12.*sec_min, 15.*sec_min))

## Now fill up the rest of the time with sections between 1.5 and 7.
while (sum(large_sections) < sizelimit):
    large_sections.append(random.uniform(1.5*sec_min, 7.*sec_min))

## suffle the order of the sections
random.shuffle(large_sections)

## Changing the variable names to make it more clear
large_section_lengths = large_sections
large_section_time_points = lengthsToTimePoints(large_sections)

## What is the index of the longest LARGE section?
count = large_section_lengths.index(max(large_section_lengths)) % 2

print "LARGE SECTION LENGTHS: ", "[sum = ", str(sum(large_section_lengths))+"]"
print large_section_lengths
print " 
print "LARGE SECTION TIME POINTS:"
print large_section_time_points

print "VIOLIN SECTIONS FORMATED FOR MAX COLL: index, start_time section_length type;" 
print " 
print parseForColl2(large_section_time_points_vn, large_section_lengths_vn, count)
print " 
print "VIOLA SECTIONS FORMATED FOR MAX COLL: index, start_time section_length type;" 
print " 
print parseForColl2(large_section_time_points_va, large_section_lengths_vc, count)
print " 
print "CELLO SECTIONS FORMATED FOR MAX COLL: index, start_time section_length type;" 
print " 
print parseForColl2(large_section_time_points_vc, large_section_lengths_vc, count)
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