Embodied, Representational, and Distributed Learning Practices

in a Professional String Quartet

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THESIS

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CONTRIBUTION OF AUTHORS

Portions of this dissertation are reprinted in part from a published manuscript, co-authored by myself and my advisor Josh Radinsky, for which I was the primary author and major driver of the research, and in which I developed the analytic constructs used in this study: Hospelhorn & Radinsky, 2016. A Method for Analyzing Gestural Communication in Musical Groups. *Discourse Processes* (an accepted manuscript of this article is available online at http://tandfonline.com/doi/full/10.1080/0163853X.2015.1137183).

Hospelhorn & Radinsky (2016) explicates the background and proposes a methodology for studying embodied communication in musical groups, including the constructs of *Expressive Musical Gesture* and *Group Expressive Musical Gesture* used in the current study. Therefore, portions of that paper, including figures depicting the constructs of *Expressive Musical Gesture* and *Group Expressive Musical Gesture,* are reproduced in chapters 1-4, which lay out the context, literature review, and methods for this broader-scale study, and in chapters 6-7, which connect the main findings of this study to extant literature and lay out directions for future work.

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LIST OF ABBREVIATIONS

EMG: Expressive Musical Gesture

GEMG: Group Expressive Musical Gesture

SUMMARY

This case study of a string quartet in rehearsal uses a distributed and embodied framework to track learning trajectories across talk, non-sound-producing gestures of the head and torso, and musician annotations over a three week rehearsal period. Chapter one lays out the rationale for and importance of the study. Chapter two locates the study with reference to extant literature on distributed processes of learning, embodied and gestural perspectives on group cognition, representational practices in groups, the semiotics of musical meaning, and embodied and conceptual metaphors in musical contexts. Chapter Two also outlines the pilot study in which the methods for this study were developed. Chapter Three lays out the research questions and methodology for the study. The principal question guiding this study is "how do musical groups learn to construct a performance?" In order to track the learning that occurred across rehearsals, I developed the construct of *Group Expressive Musical Gesture* (GEMG) to track the ways that entrained non-sound-producing motions of the head and torso emerged and evolved across multiple takes in rehearsals. In this study, GEMGs were tracked in conjunction with emergent annotations and changing types of rehearsal talk in order to explore the ways that a string quartet negotiated their shared musical conception of a piece. Chapter Four lays out an overview of the case, describing the learning context of the quartet, the piece they rehearsed, and giving a broad overview of the group's rehearsal process, as well as the two main musical segments that they rehearsed. Chapter Five analyzes the group's learning trajectory across shared GEMGs, written annotations, and rehearsal talk. Chapter Six discusses themes that emerged in the findings: that (1) gestures, talk, and annotation shared the burden of driving conceptual change across rehearsals; (2) these

three mediums of learning unfolded across different timescales; (3) the group's learning process consisted in part of a process of *spatialization* of musical concepts across multiple dimensions; (4) analyses of learning trajectories across all three modes show a shift across rehearsals from a focus on entrainment to explicating chordal context to the development of conceptual metaphors. Chapter Seven concludes the study and lays out directions for future work.

1. INTRODUCTION

*portions of this chapter are reprinted in part from Hospelhorn & Radinsky, 2016. An Accepted Manuscript of an article published in *Discourse Processes* online [January 15, 2016] is available online: http://tandfonline.com/doi/full/10.1080/0163853X.2015.1137183 (see Appendix F).

1.1 Problem Statement

How do musical groups learn? This case study bridges classical performance practice and the learning sciences by focusing on questions of interaction, representation, and learning in rehearsal. Through an in-depth case study of a single string quartet learning a single piece of music, I ask how a musical group learns to co-construct a performance from a written score. Using embodied and distributed cognition frameworks, I analyze data on the types of verbal, written, gestural, and metaphorical representations that the group produces over the course of its rehearsal cycle. I then examine how these representations change over time, coalescing into coherent musical interpretations that evince a learning trajectory at the group level of analysis, distinct from an analysis of any one individual. Over the course of three rehearsals and a Performance, the string quartet in this case moved from one type of shared understanding that highlighted temporal entrainment and depended on barlines as scaffolds, to another type of shared understanding that was both more structural and more metaphorical. In this introduction, I will argue that studying the way musical groups learn has deep implications for our understanding of learning processes across contexts.

Learning to work in group settings is a central goal of education (Dewey, 1963). How do groups of people learn to work with each other? This question, so

fundamental to organizational and educational research, has taken a "spatial turn" in recent years, as researchers have recognized that space is an integral part of both meaning-making and learning (Kostogriz, 2006). We communicate within, through, and about space and time. The spaces between us may become barriers or conduits through which we achieve shared understanding. When we read, or create, visual texts, we translate from spatial relationships between objects on a flat surface to conceptual relationships that we understand. This process of translation may apply to written texts, maps, pictures, scores, and other kinds of visual notation.

Within this spatial view of meaning-making, the role of the human body within that space becomes critically important. Embodied theories of learning locate cognition in the ways in which our bodies interact with the world (e.g. Wilson, 2002). These interactions might themselves constitute learning processes, or they might provide the basis for the metaphors we use to make sense of the world (e.g. Johnson, 2008). Within embodied views of cognition and interaction, *gesture* becomes an important window into the ways that we manifest meaning. Gesture mediates many forms of interaction, and gestures have been shown to play an important part in learning.

Musical rehearsals are one context in which non-speech-related interactive gestures take on particular importance. Musical groups are a critical and under-researched context for understanding the development of shared meaning, not least because the embodied, temporal, and spatial elements critical to all learning processes are particularly foregrounded in group musical performance. Music-making is explicitly multi-modal (Zbikowski, 2011). Modes of instrumental sound production, traces of energy, embodied motion, abstract imagery, and temporal unfolding come together in musical performances

in ways that make the idea of "musical representation" both complex and problematic (Kozak, 2012). Musical groups that learn to perform together successfully produce a multimodal product that brings people together emotionally, culturally, and experientially. But in order to do this, these groups must first learn to work together in space, in time, and with shared understandings.

Distributed perspectives on group learning (e.g. Hutchins, 1995) highlight the fact that interactions among and within groups have different properties at different levels of organization, and that knowledge and cognition may be distributed across groups, the individuals in those groups, their environments, the tools they use, and the artifacts they produce. In his work with naval navigators, Edwin Hutchins showed how the cognition necessary to navigate a boat was distributed among multiple people with different kinds of knowledge and roles, as well as material anchors for knowledge – e.g. maps and compasses. Zbikowski (2014) demonstrates the parallels between the kinds of distributed cognition happening on that naval vessel and the kinds of distributed cognition happening in the performance of a musical groove, which involves instrumentalists with different kinds of knowledge from each other, working around a material anchor (in this case, a musical chart). Using the groove example, Zbikowski pushes this idea of distributed cognition further, arguing that the musical sounds elicited by the players themselves form a type of extended cognition – that is, that the music itself is a type of thought. This claim resonates with Hutchins' later (2010) work on enaction, in which he shows how our enacted, embodied interactions with tools can extend our cognition into "creative acts of perception."

Spatial, embodied, and distributed perspectives from education research are of

interest in musical rehearsal contexts, where learning interactions are explicitly multimodal and lead to shared concepts that are independent of language. Classical musicians, working from a printed text in two dimensions, use their bodies to translate that text into a musical performance where their physical motions coincide with metaphorical "gestures" in the sounds they produce. How do musicians learn to do this? In my own practice as a professional flutist, this question has often assumed a quality of urgency: given a piece of music, a group of performers, and a Performance date, how can that group learn in a limited timeframe to greatest effect? In this work, I combine these frameworks in service to the following questions:

How do musical groups learn to construct a performance?

How do musicians' *body movements, talk, and written annotations* facilitate and reflect the group's learning process in rehearsal?

These are questions not only of interaction and representation, but also of learning. A group's emerging shared conception of a piece of music is a learning process at both the individual and group levels of analysis. In order to study that learning process, I conducted a case study of a professional string quartet rehearsing and performing a single piece of music over the course of three weeks, focusing on a) the way that musicians' gestures while playing the musical work changed over time and b) how musicians' representations of the musical work (verbal, gestural, and written) changed over time.

1.2 Description of the study

This study investigates the role of gesture, written annotations, and talk as mediums of a musical group's learning process in rehearsal. The study advances a set of methodological tools and strategies for tracking embodied interactions that show evidence of group learning over time, using the constructs of *expressive musical gesture* and *group expressive musical gesture*. These are distinct from gestures that are tied to speech or sound-producing actions. In addition, I explore the roles of *metaphor, time, and spatial relationships* in musical rehearsals, as musicians enact many continuously evolving performances of a written piece of music at different tempi and in different discursive contexts.

The interactions analyzed here consist of a string quartet in rehearsal, as they work on one of the sonatas that make up Josef Haydn's "Seven Last Words of Christ." They play isolated sections multiple times ("takes"), at multiple tempi (speeds, set by a metronome or by counting off), sometimes discussing performance issues between takes. The analysis tracks the interactions of the group across takes, combining gesture, discourse, and score analysis to generate a view of group learning as it emerges over time in rehearsal. The analysis shows how the group's gestural interactions constitute a medium in which learning occurs throughout a rehearsal, at both the group and individual levels of analysis. The method presented here addresses several unique temporal and spatial challenges of tracking gestures in musical contexts.

1.3 What constitutes learning in music?

Musicians themselves are well aware of the complex, collaborative learning process that must take place in order to achieve a good performance. In a May 4, 2011 interview

with Terry Gross (host of NPR's *Fresh Air*), conductor James Levine responded to a question about how he rehearsed the Metropolitan Opera orchestra in order to get them to color a certain particularly poignant chord. This question had at its heart a basic assumption: that in any orchestral performance, the music "comes from the conductor's baton"; i.e., the conductor coaches the orchestra to bring out his interpretation of a given piece of music. Levine, an experienced and critically acclaimed conductor who has led many of the world's foremost ensembles, including the New York Metropolitan Orchestra, had a different take on the issue:

> *LEVINE: They did it themselves.*
>
> *GROSS: Okay.*
>
> *LEVINE: They could feel it for themselves. I didn't have to do anything. That is, they understood this passage. We had worked on it over years before. When this particular revival came about, they all responded to [the singer's] particular phenomenal kind of expression. And that particular chord, that is such - that comes at a moment where what she's remembering and what she's imagining and what she's leaving is very wrenching…. And I think these are these miraculous things that composers do, some of which you can achieve by explanation and some by gesture and some by a combination and some by experience and some by the way one element in the combination chemically affects another. But there is no pro-forma, no predetermined way that works. If there were, you could always get a great performance.*
>
> *- James Levine, in an interview with Terry Gross on Fresh Air, May 4, 2011*

In this passage, Levine alludes to the knowledge each individual musician had acquired through "working on it years before." This knowledge might include the ability of each musician, acquired through years of work with each other, to coordinate his or her actions *in time* and *in tune* with every other musician. It also might include an understanding of the conceptual metaphors informing that compositional moment: memory, loss, and love, to name a few. Levine's mention of the way the musicians "respond to [the singer's] particular...expression" evokes the emergent, collaborative, and distributed nature of musical performance, in which each part influences and is influenced by every other part. These emergent sonic cues, along with the conductor's gestural cues, their knowledge of the context of the piece, and the notes on the page, coalesced into a sonic shape that would convey this complexity and depth of feeling. Finally, Levine's caution that there is "no pro-forma, pre-determined way that works" is a reminder that musical group performances are *negotiated* from moment to moment; some aspects of every performance must be improvised as the activity unfolds.

Similar themes to these emerged in an interview I conducted during a pilot study for this dissertation with the first violinist of a different professional classical string quartet. The violinist gave a number of insights into the different kinds of learning that must happen as a string quartet learns to play a piece of music. In rehearsal, performers must balance the dual goals of *creating a plan* and *learning to be present to each other:*

> *The mistake is to think that you're setting a plan in stone. Whereas you're just trying to come up with [your] basic approach. And the trust comes in knowing that in the Performance, you're gonna be present to each other, and so*

> *whatever happens is what you do...because I've played in groups where you come up with a plan, and then there are small deviations from the plan in the Performance, and people can't deal. They cannot flex at all in the Performance, and so you have problems in Performance because people aren't awake and alert in the room, they're trying to just execute the plan you came up with.*
>
> *-violinist Andrew McCann in interview with author, November 2010*

Note here that the word "performance" can be used in two senses: a run-through, or take, in one sense, and a public, end-goal run-through in front of an audience, in the other. For clarity, I will capitalize the word "Performance" when it is meant in the idealized, public performance sense, and use lower-case when it is used in the more general sense of any run-through of a piece of music.

Metaphor (as it has been studied by cognitive linguists over the past three decades) is a conceptual tool that musicians can use in lieu of, or in addition to, score analysis in order to learn to play together. I recently attended a recording session where a vocalist, over the course of several takes, had been unsuccessful in blending her voice with the other singers in a difficult passage that involved a series of short, separated harmonies. After several tries, she expressed her confusion: "I don't understand. Am I a horn or a bell?" By using the typical sonic profiles of orchestral instruments as metaphors for the kind of vocal articulation she would use, she was able to quickly assimilate a lot of information, including the type of attack she should use at the start of the note (gradual vs. sudden); the dynamic profile of each note (growing louder vs. quickly decaying); and

the timbre of her voice (full vs. light). After some discussion, the singers agreed that they would all be horns, and the next take blended perfectly.

The relationship between this kind of quick metaphorical analysis to more abstract score analysis is a tension that can unfold in many different ways depending on the backgrounds and dispositions of the players involved. Again, violinist Andrew McCann:

> *I think American training is very un-metaphorical actually, and I think that American musicians tend to be very impatient with that sort of thing and wanna talk about things in terms of loud and soft.....If you micro-analyze something, you either have to go through a very extended learning process to consolidate that kind of analysis or it's gonna screw with you. So if you don't have that kind of time, then you need to come up with some sort of gestalt, to bring those elements together, you know, so that you're not overthinking. And I think that's where imagery and metaphor and [violist] in particular is very skilled that way. He's such an intuitive musician.*
> *-Andrew McCann in interview with author, November 2010*

The *pacing* of a rehearsal – that is, the way a rehearsal unfolds through time, is also an important element of the learning process:

> *[violinist] is a really brilliant rehearser, and she's a great taskmaster, which is really necessary in a group, you know, she really has a [great] sense of how you move through rehearsal, you don't get bogged down.*

-violinist Andrew McCann in interview with author, November 2010

Finally, the violinist highlighted the tension between needing to analyze the music, on the one hand, and to develop a sense of "flow" (Csikszentmihalyi, 2008) on the other, in order to develop a musical *narrative,* or "story":

[the violist] always brings it back to the music, you know, and to the moment. Which I really appreciate, and which is rare. Um, I mean, classically trained musicians, you're trained at such a high level of analysis.....So the funny thing in a Performance is that you do play an abstraction but you play the feel and you play the story of the piece rather than playing, um, something that's intellectual, you know. [But] if you don't do the analysis part, then things are sloppy.

-violinist Andrew McCann in interview with author, November 2010

As this violinist's remarks highlight, a chamber music rehearsal is a phenomenon of learning on multiple levels, in which score analysis, conceptual metaphor, leadership, pacing, musical storytelling, and scaffolded "flow" all play a part. Additionally, the musicians involved in both the pilot study and dissertation study are highly aware of their own learning processes on many of these vectors, and reflect deeply and consistently about the tensions involved in their own musical learning practices.

This dissertation is an attempt to explore those improvisatory learning processes that occur in musical groups, and to bridge the space between music research, which asks

"what happens when musicians perform?" and the learning sciences, which asks not only "how do people learn?" but "how do groups of people learn together?"

1.4 Goal of the Study and Importance of the Project

Musical rehearsals are particularly interesting sites for the study of gesture and interaction, contrasting as they do with other discursive contexts where gesture research has been conducted. First, in these rehearsals talk is nearly eliminated from realtime communication. Second, the musicians cannot use their hands to gesture. There are also unique features of the discursive work they are doing: they are interpreting a text (a musical score) that places complex constraints on their joint performance in terms of timing and mutual coordination. Finally, musicians' embodied communication occurs simultaneously, rather than in sequential turns.

However, these aspects of this discursive context are differences of degree, rather than of kind. Other contexts may place limitations on verbal communication, make hands unavailable for gesture, require close coordination in space or time, or constrain interactions around the close interpretation of texts (e.g., Hutchins, 1995). Also, even in dyadic, turn-based verbal interactions, gestures can establish a communicative system that extends beyond mere alternating monologues (Bavelas, Chovil, Lawrie, & Wade,1992), suggesting perhaps more similarity to the simultaneous communications of musicians than it might at first appear. As such, rather than consider musical rehearsals as essentially different than other contexts of shared problem-solving, I suggest that careful attention to the ways embodied meanings develop and evolve among rehearsing musicians offers opportunities for conceptual and methodological insights that may have relevance for our understanding of discourse more broadly.

In this study I examine the learning process of a string quartet through rehearsal. This learning process takes place across multiple scales of time: from second-to-minute exchanges, to multi-hour rehearsals, to week-long learning practice sequences. These musicians are not simply learning to coordinate their bodies; they are learning what the group's view of the piece is. Through their learning process, they create shared, emergent representations through which they learn the musical world of that particular piece.

Musicians' body movements during rehearsal, like gestures used in conversation, provide a means of communication beyond speech, and constitute a medium for shared negotiation of meaning and learning. An analysis of these movements can show the learning taking place in the spatial relationship among people collaborating, which has mainly been studied in contexts where talk is foregrounded. Careful attention to the ways embodied meanings develop and evolve among rehearsing musicians offers opportunities for conceptual and methodological insights that may have relevance for our broader understanding of interactive learning processes.

In order to explore the ways that musicians learn in rehearsal, this study will examine the role of non-sound-producing motions, and especially *shared* non-sound-producing motions, in the rehearsal process. In addition, I will examine the relationships among talk, score annotations, and non-sound-producing motions in rehearsal, with the goal of finding out how these relationships reflect the group's learning processes. By analyzing the gestures that occurred across multiple rehearsals by a string quartet, mapping body-movements, talk, and annotations to structural elements of a composed score, and tracking the ways that body-movements, talk, and annotations changed over time, this project will shed light on the types of representations and embodied interactions

that characterize learning in musical groups, as well as the causes and consequences of each of those kinds of interactions. An investigation of the ways that groups of learners use their bodies to come to shared understandings in musical contexts has the potential to inform educational theory on embodied and spatial practices of learning across disciplines.

2. LITERATURE REVIEW

*portions of this chapter are reprinted in part from Hospelhorn & Radinsky, 2016. An Accepted Manuscript of the article published in *Discourse Processes* online [January 15, 2016] is available online: http://tandfonline.com/doi/full/10.1080/0163853X.2015.1137183 (see Appendix F).

2.1 Musical Groups as Sites of Collaboration

Musical groups are sites of collaboration and learning. As such, they share characteristics with many other kinds of collaborative groups where learning processes have been examined. When playing together in an ensemble, musicians must attend to a score, to each other, and to the joint creation of an emergent performance (Sawyer, 1996; 2003). These musicians work within a specialized community of practice (Lave & Wenger, 1991) with shared tools (e.g. metronomes, musical instruments); documents (e.g. musical scores); routines (cues, slow practice, deliberate listening), vocabulary, and symbols. In doing so, they share organizational and interactional practices in common with any large, coordinated group of people, including medical professionals (Engestrom, 2001, archeologists (Goodwin, 2010), and classroom learners (Radinsky, Ping, Hospelhorn, & Goldman, 2012).

Every time they rehearse a segment of music, musicians negotiate and change the parameters that will constrain their final Performance. Simultaneously, they interpret the score, co-constructing a narrative as they perform a real-time instantiation of the score, in which each element of the music's structure is reactive and dependent on emergent elements (Stefanou & Antoniadis, 2009). For every piece of performed music, each musician, must learn who to listen to (or, in frequent situations, watch) at any given moment, in order to keep in synchronous time with every other member of the group

while keeping track of their own phrasing and position in relation to the overarching composition. In this vein, ethnographic studies of orchestral musicians have highlighted the "multiple acts of consciousness which are layered, shaped, and pulled together in the joint act of making music" (Malhotra, 1981).

Some kinds of musical groups, including the ones in this study, work from notated music (musical scores and parts). As such, they share some characteristics of other groups that construct meanings around a text, including digital art makers (Halverson, 2013), classroom students (Gavelek & Raphael, 1996; Radinsky, Hospelhorn, Melendez, Riel, & Washington, 2014), and scientists (Ochs, Gonzales, and Jacoby, 1996). While scores, to varying degrees, contain crucial information about note durations, articulations, dynamics, and tempi, they by no means contain all of the information needed to effect a convincing Performance. A score is a simplified visual re-presentation of an idealized sonic output, and realizing it in real-time requires a complex combination of perception, cultural and technical knowledge, and action on the part of the performer.

As sites of group learning, musical groups share characteristics with other collaborative groups in a variety of contexts. The following section will summarize extant research on spatial, embodied, and discursive properties of group collaborations, as well as distributed cognition frameworks for studying group interactions.

2.1.1 Interaction in group collaborations

When groups work together with the explicit goal of developing shared concepts, they engage in a process of changing representational states that can be categorized as "sensemaking" (Maitlis, Vogus, & Lawrence, 2013). These sensemaking interactions occur across modes. The end-goal of sensemaking might not result in a set of individuals

with identical conceptual models, but rather with a group who has achieved a level of intersubjectivity where they can understand each others' conflicting representations across modes of discourse including speech, gesture, and illustration (Nathan, Eilam, & Kim, 2007). In order to achieve common understandings, group participants use interactional gestures (Bavelas, Chovil, Lawrie, & Wade, 1992) along with multiple modes of communication, including facial expressions, body position, and expressive gestures (Hospelhorn & Radinsky, 2016; Nomura & Hutchins, 2007; Singer, Radinsky, & Goldman, 2008;).

The kinds of collaboration that are important in group learning extend across contexts and age groups. Barron's (2003) research on problem solving in groups of 6th graders led her to the conclusion that the quality of interactions in a group, rather than the knowledge of individual members, determines that group's problem-solving ability. In any collaborative problem-solving process, each individual must simultaneously attend to her own efforts as well as the group, in an overall effort to coordinate everyone's attention so that joint engagement can proceed.

The interactions that drive conceptual change in groups both act upon and are situated within the representational context of the group (Roschelle, 1992). Roschelle characterizes sensemaking in scientific groups as "convergent conceptual change," where interactions build upon each other towards converging, shared concepts. His work highlights the ways that students' iterative cycles of interaction around metaphors in conjunction with representations contribute to their process of constructing an increasingly "deep-featured situation" – that is, an increasingly rich shared conceptual model of the situation. Although musical collaborations at first glance might seem quite

different from scientific collaborations, musicians, too, engage in multifarious, metaphorical, and occasionally vague interactions around representations in the service of shared concepts, which become increasingly "deep-featured" over time.

2.1.2 Distributed cognition in group collaborations

When groups interact, there is a mixture of individual, group, and social cognition; group cognition is not a "type" of cognition, but rather a unit of analysis (Stahl, 2006). Edwin Hutchins has famously used the example of naval ships (1995) to show that cognitive work is distributed across the group of individuals, the tools and representations they use, and the cultural contexts from which they draw. This type of distributed cognition is a characteristic of any large-scale human endeavor, from grade-school science classrooms (Brown, Ash, Rutherford, Nakagawa, Gordon, & Campione, 1993), to collaborative internet technologies (Steels, 2006). Musical rehearsals are sites of "distributed creativity" (Sawyer & DeZutter, 2009). Keith Sawyer defines "distributed creativity" as a type of distributed cognition, in which creative processes are nonindividualistic and emerge through interactions among group members. In successful improvisation groups, for example, members play off each other, building on each others' ideas (Sawyer, 2008).

A growing body of research suggests that there is a social negotiation process through which a "semiotic field" emerges as a shared space in which embodied actions can take on particular symbolic meanings (Goodwin, 2007; Hall, 1999). Goodwin's *participation framework* (2007) organizes group participation at several levels, wherein actors attend not only to talk and gestures, but to the environment and objects in that environment that those talk and gestures reference. Thus, a participation framework

offers an analytic frame for documenting the ways groups come to shared understandings, through combinations of speech, gesture, and arrangements of the physical space. This unit of analysis assumes that the spaces in which gestures take on meanings are improvised, emergent, and in flux as activity unfolds – rather than static and implicitly defined around an individual (Radinsky, Ping, Hospelhorn & Goldman, 2012).

In participatory analyses of group learning, gestural and spatial cues provide insight into the ways that socially mediated representations lead to joint understanding, whether in classroom science talk (Nathan et al., 2013), narrative literacy performances (Leander & Rowe, 2006), or professional working contexts (Maitlis, 2013; Goodwin, 2010; Engestrom, 2001). This approach has generally been applied to interactions in which spoken or written language is central to the goal of the group.

In prior work in which I have collaborated with Radinsky, Ping & Goldman on embodiment in classroom group work settings, we use a participation framework to focus on children using software in groups, allowing us to analyze a group task that involves extremely close coordination of joint attention and joint movement in space and time (Radinsky et al, 2012b). This work builds on Goodwin's participatory framing by focusing on the ways that participants construct spatial representations through different types of embodied moves, including requests for and denials of access to co-assembled representational fields. The present study does not focus on the function of specific embodied moves in the co-construction of representation, but does explore the spatial transmigrations that occur across representations (gestural, spoken, written, and sonic) as performers deepens their group conception of a musical composition.

the role of representations in group collaborations.

When groups engage in sensemaking, their learning may be mediated by multiple representations that emerge across widely different timescales. Lemke (2000) illustrates the ways that material objects (charts, books) may be imbued with meaning that can interact with processes happening on much shorter, minute-to-minute timescales (conversations, gestures). Hall, Wieckert, & Wright (2010) explore the ways that cognition may be distributed at these different timescales in scientific workplace collaborations. And Stefanou & Antoniadis (2009) engage this concept of time scales when they characterize a musical score as an "interstructure" – that is, a written "hieroglyph" which functions as a temporal anchor around which multiple performances are constructed. The score that a classical group works from is a semiotic artifact that functions as a material anchor establishing connections across multiple time scales (or "heterochrony," per Lemke, 2000). This is to say, whether the music is played quickly or slowly, whether it is played tomorrow or next year, the score anchors the relationships between the first note of any given performance and the last.

Written representations also provide the learners using them with a "cognitive and spatial domain to inhabit and wander in" (Ochs, Gonzales, and Jacoby, 1996, p. 350). Ochs et al. showed that in scientists' collaborative talk and gestures around representations, those scientists oriented themselves in changing relationships to those representations, in a multimodal process that brings the scientist and the phenomenon they are studying into both real-world and metaphorical contact. This study explores a similar relationship between musicians' interactions and the written representations of the music they play together.

A distributed framework for analyzing learning in musical groups must take into account the multiple modes of representation through which an abstract musical concept is realized, including sound, physical gesture, and written text. The representations that are generated in musical practice, which may span multiple modes, are inherently metaphoric. Musical metaphors are deeply rooted in embodied and visual metaphors (Tagg, 2005). An essential part of a musical group's learning process, then, must be the construction of metaphorical mappings across multiple representations – verbal, written, sonic, and embodied.

gesture in group learning processes.

Research on embodied interaction foregrounds *gesture* as a medium through which meaning is constructed. Much of this work on gesture has focused on interaction that is dominated by speech – e.g., in casual conversation (Kendon, 1997), classroom instruction (Singer & Goldin-Meadow, 2005), collaborative learning (Crowder, 1996; Singer, Radinsky, & Goldman, 2008), interviews (Parrill & Kimbara, 2006), or professional meetings (Becvar, Hollan & Hutchins, 2005; Ochs, Gonzalez & Jacoby, 1996). Studies of the relationships among gestures, representational artifacts, forms, and tools (e.g., Goodwin, 2007; Hutchins, 1995, 2010) have also examined the speech-gesture relationship as a central focus. However, not all meaningful gestures are tied to speech. In musical contexts, gestures of the head and torso that co-occur with musical production, rather than speech, may shed light on the ways that musical meaning is co-constructed.

enaction as a learning process in distributed cognition frameworks.

Hutchins (2010) uses the framework of enaction to make the claim that

representations have no inherent meaning in and of themselves; rather, we enact their meanings through culturally situated interactions with those representations. In analyzing the actions and perceptual activities of a navigator working with his body around a representation, Hutchins locates the navigator's moment of problem-solving insight in the ways that his embodied actions may subvert "overly-learned cultural practices," leading to an "aha!" moment. "What makes ordinary acts of perception ordinary is only that the cultural practices of enacting them are over-learned and the outcomes follow as anticipated. Creative acts of perception can occur when emergent relations arise in the enaction of integrated, multimodal, temporally extended, embodied representations." (Hutchins, 2010, p. 447)

The enaction of embodied representations can be seen in a different way in the ways that musicians perform notated music. In musical contexts, players enact music around a score, performing it again and again. Musical performances are *rehearsed* over time; the role of rehearsal in organizational learning is by no means limited to music, but has been explored in teacher practice (Lampert et al., 2013) and improvisational theater (Sawyer, 1996), among others. In addition, rehearsal of embodied action has been shown to be a critical factor in learning observable motor skills in general (Carroll & Bandura, 1985). Following Hutchins (2010), we might claim that these rehearsals constitute a form of *enaction,* where musicians' gestural, embodied enactions of a musical representation open the possibility for creative acts of perception. By tracking these embodied enactions of music over time, we might gain further insight into the processes by which musicians make sense of a musical score.

2.2 Meaning in Music

The idea that musicians "make sense of a musical score" implies that there is sense to be made – that music has meaning. But what constitutes meaning in music? The following sections discuss some structural, semantic, and metaphorical perspectives on meaning in music, before examining the role of musicians' interactions in constructing that meaning.

2.2.1 Structural models of musical meaning

Music is a meaning-making tool. Like language, music has syntactic and semantic structures; like language, music can be analyzed both structurally and pragmatically (Lerdahl & Jackendoff, 1983). In the end, any description of music as analogous to language is itself nothing more than a metaphor (Zbikowski, 2008), but that metaphor can be a useful tool for understanding some kinds of musical meaning. Structuralist views of music, such as those laid out below, are arguably similar to structural views of language: derived from Saussurian symbolic models of signifiers and the things they signify (Chandler, 2007), such models create a structural model of a system that is assumed to be static.

A number of theories of musical syntax follow this structural model, including Schenkerian analysis, the system derived by Heinrich Schenker that many people today still think of simply as "music theory." Schenkerian analysis, which applies most readily to genre-specific forms from the Common Tonal Era, as well as jazz and pop forms built on those conventions, identifies tonal areas and progressions (e.g., the famous I-IV-V-I) as the backbone of musical structure. This kind of analysis takes an analytic, chordal relationship-based approach to musical structure that bears a strong resemblance to the

structural linguistics of Noam Chomsky (for a deeper analysis of this resemblance, see Sloboda, 1985).

In contrast, *Generative Theory of Tonal Music*, first published by Fred Lerdahl and Ray Jackendoff in 1983, gives a more robust explication of the "formal description of the musical intuitions of a listener who is experienced in a musical idiom." By relying on "preference rules" instead of formal definitions, GTTM manages to arrive at a comprehensive analysis of tonal music that acknowledges and works with the inherent uncertainty of a workable, formal semantics (cf. Wittgenstein 1953, as quoted in Lerdahl and Jackendoff, 1983).

GTTM, like cognitive science, has its origins in an attempt to simulate human behavior through computational means. As a system, GTTM is quite successful at replicating the musical idiom of common-practice tonality. But as Lerdahl and Jackendoff acknowledge, that idiom requires *experience* on the part of the listener to be relevant. Structural analyses of music cognition address only one aspect of musical "meaning;" the links between music and language also extend into more developmental, dialogic, and pragmatic territory.

2.2.2 Process-based models of musical meaning

Just as we may find analogues between musical and linguistic structures, so we can find links between the *processes* by which we learn to comprehend both musical and linguistic meanings. In contrast to structuralism, the pragmatic semiotic system developed by Charles Saunders Pierce (e.g. Pierce, 1902) yields a more process-based model of how symbol systems evolve. In Pierce's triadic model of a sign, anything invested with meaning may be categorized as having a representamen (form), object

(concept or idea to which the sign points), and interpretant (sense which is made of the sign, or in other words, the "sign" that is formed in the person's mind who is interpreting the *representamen* as being an object with meaning (Chandler, 2007). Although most of Pierce's work was based on emergent analyses of language, the triadic sign model can be applied to music with more success than can Saussure's sign-signified model. The idea of the interpretant allows room for the fact that a musical event may evoke different meanings, emotions, and conceptual metaphors depending on its context and the knowledge and disposition of the person attending to it.

Musical "signs" rarely contain a single agreed-upon meaning; they may contain double and triple entendres, intimations and evocations that go far beyond dictionary definitions and depend, partially, upon the knowledge and disposition of the person perceiving the sign. Even the emotional responses that music elicits must be learned: Listeners familiar with classical music, for example, routinely characterize Stravinsky's Rite of Spring as "savage" and "uncanny," while listeners who are less familiar with classical music do not. (Kruse, 2007). Kruse identifies the cause of this phenomenon as relating to the interrelation between logical and emotional interpretants: logical interpretants, in the form of prior knowledge and associations, are required in order for emotional interpretants to activate. In other words, the perception of musical meaning requires a continuous action on the part of the listener; in interpreting music, that listener continually accesses her own knowledge and experience.

There is evidence that performers understand quite well the idea that meaning in music is not fixed, but must be negotiated. In an essay on his experience at a contemporary classical music festival, oboist Andrew Nogal reflects on the wildly

different associations listeners can bring to a musical experience: “It turns out that different listeners bring different life experiences to their seats in the concert hall, and those are hardly ever cut and dried; sounds that one person drably brushes off as “academic” might remind someone else of beats blasting at a warehouse rave (yes, I heard these two differing reactions to the exact same piece).” (Nogal, 2016). Thus, there may be no such thing as a “pure” sign in music; emotional interpretants depend on both context and culture (Mirigliano, 1995).

Signs and interpretants constitute one way of analyzing the way we perceive music; in more cognitive traditions, we might talk about musical meaning in terms of embodied metaphors. Emotion is, first and foremost, an embodied phenomenon (e.g., Niedenthal (2007)). In his discussion of musical meaning through the lens of “intersensoriality,” Delalande (2003) notes that music’s emotional impact itself results from the representation of bodily movement created by musical sounds.

Emotions are not the only musical experiences rooted in the body. Marc Leman describes musical meaning formation as a process of transformations, in which auditory sensations of pitch, duration, timbre, and volume are transformed into *“impressions of space, visual and tactile nature, such as extension, density, weight, smoothness, roughness, hardness, softness, liquidness, and ephemerality.”* (Leman, 2010, p. 128). These transformations are grounded in the ways our bodies interact with the world, and serve as a precondition for the semiotic levels of meaning formation in which “felt properties or descriptions thereof are linked with cultural symbols and topics.” Even our more abstract and symbolic perceptions are rooted in our corporeal experience.

2.2.3 Embodied metaphors in music

Many of our basic narrative and abstract concepts depend on embodied metaphors. In their book *Metaphors We Live By*, Lakoff & Johnson (2003) argue that these embodied metaphors underlie just about everything in our meaning-making interactions. For instance, consider the "container" image schema, which we might apply to a variety of musical, visual, or linguistic experiences:

> *Because we must constantly interact with containers of all shapes and sizes, we naturally learn the "logic" of containment…Containers have at least the minimal structure of a boundary, an interior, and an exterior...we know, in a bodily way, that something that is inside a container is not outside it.*
> *(Johnson, 2008, p. 138)*

To apply the container metaphor to a musical example, we might experience it in a theme that is repeated once at the beginning of some musical material, and once at the end. In the tactile mode, we might experience a great deal of resistance to pressure, followed by a sudden lessening (as we pass through the container wall), followed by more pressure.

We experience these kinds of somatic metaphors cross-modally. Almost all concepts are, in some way, multimodal (Barsalou, 2003). Metaphor, accordingly, has become a popular lens in musicology through which to analyze musical discourse. Lidov (2005) claims that "somatic imagery in music anchors the semantics of musical discourses that are very elaborate in their scope of reference….Music is significant only if we identify perceived sonorous motion with somatic experience." Key to this understanding of musical-meaning-as-bodily-experience is the analogical mapping of

sequential sound onto physical gestures, which unfold through time. These mappings occur across visual, tactile, and auditory modes. For example, Tagg (2005) explicates the multiple mappings that naturally occur between the undulant waves of a singer's voice, the "waves" of text and somatic imagery in the score that represents it, and the visual image of "rolling hills" that the text itself elicits.

Musical compositions consist not just of a series of multi-modal, somatic gestures; these gestures must be arranged in some meaningful way. Johnson (2008) claimes that “our very experience of musical meaning is fundamentally shaped by conceptual metaphors that are grounded in our bodily experience.” (p. 256) It is possible, then, that the success of a musical Performance might depend in part of the strength of its conceptual metaphoricity, in which source domains and target domains are mapped on to each other, such that two domains may be completely different, but evoke one another (Johnson, 2010). In support of this idea, Antle, Corness, and Droumeva (2009) devised a series of interactive experiments that indicated that children may have an easier time learning musical concepts if they are presented as embodied metaphors, while Wilkie, Holland, & Mulholland (2010) used dialogue analysis to identify common embodied conceptual metaphors that musicians use in talk around musical compositions.

A performing group’s learning process, then, might include the development of an increasingly robust set of metaphorical and conceptual mappings. To apply this idea of cross-domain mapping to a specific example, a performance of Haydn’s Seven Last Words of Christ might map a two note descending quarter motif with the idea of sighing, or dying, and in the more general space, the pathos of Jesus on the cross calling out to his mother in his dying moment (this example will be explored in the data analysis that

follows).

2.2.4 Mapping musical metaphors

If multiple metaphorical mappings are the key to a strong musical conception, how can we trace those mappings? Zbikowski (2008) uses the Conceptual Integration Networks (CINs) of Fauconnier & Turner (1998) to outline the metaphorical mappings present in musical compositions. CINs were originally conceived as tools for mapping linguistic metaphors (e.g., "dead as a doornail"). A CIN documents the conceptual blend that occurs when two inputs (in this case, death and a doornail) are mapped on to each other, with a generic space that holds the common characteristics of each input, and a blended space that melds the two.

A number of musicologists have used the CIN construct, or adaptations of it, to map the metaphors at play in musical compositions. Zbikowski has used the construct of CINs to map the metaphors present in, for example, a Bach cantata (Zbikowski, 2008). These spaces blend analogies across differing conceptual domains, but cross-domain blends are not the only type of conceptual mapping possible in music. Stefanou & Cambouropoulos (2015) point out that conceptual blends might be applied not only to mappings across domains, but to "mappings between incongruous spaces *within* a domain (e.g., conflicting tonalities within a composition)." (2015, p. 1). A potential example of this kind of intra-domain mapping is the Rossini annotation discussed later in this section.

Conceptual metaphors are present not just in speech and music, but, unsurprisingly, in nonverbal gestures. Parrill & Sweetser (2004) argue for CINs as useful formalist tools for making sense of the multiple metaphorical mappings present in speech-accompanying gestures. These CINs highlight the *fluidity* of the metaphorical

mappings present in gestures. For example, in a speech-accompanying gesture, a speaker's hand might become a container, or it might be encompassed by one – or the gesturing hand might fluidly change our frame of reference to the container, as in the maze metaphor outlined by Parrill & Sweetser (2004) where the speaker's hand in quick succession outlines a maze, depicts a location within that maze, and depicts a wanderer within the maze.

Conceptual metaphors are a key meaning-making component of musical compositions as well as verbal and non-verbal interactions. They can be mapped onto musical works as static representations, or mapped onto transcripts of performed speech and gesture, where emergent and in-situ meanings appear and transform in real-time. In the analysis below, I do not generate CINs, but list some potential metaphorical mappings that are generated over the course of rehearsals.

2.3 Representation and interaction in musical learning processes

In order to document the kinds of metaphorical mappings that are built into a successful Performance, an analyst must document musicians' emergent conceptions of the musical material they are interpreting together. To do so, it is necessary to integrate the multiple kinds of representations that the musicians generate during their rehearsals and discussions.

When they rehearse from a written score, musicians engage in multi-modal interactions including gestures (of varying types, discussed below), written annotations, talk, and musical sound production, constructing their shared conception of a musical score through ever-deepening metaphorical mappings. The following sections discuss extant research on representational and embodied musical practices.

2.3.1 Representations in musical interactions

In this dissertation, I will analyze the in-situ learning practices of a string quartet. In classical and contemporary composed genres of music, the use of a score is assumed; musical groups read from a printed score that has been generated by a composer. These texts are mostly standardized, conforming to shared cultural practices in order to communicate information about pitch, duration, and timbre. However, in contemporary classical cases, composers may "invent" notations for new or non-standard techniques, which must then be learned and interpreted by the group.

Thus, musical scores require the same kind of contextual knowledge as any other text artifact, in which "structural aspects of the surface text are only *potential* processing instructions to the reader; their effectiveness depends on readers having the prior knowledge of how to accurately interpret and use them" (Goldman & Rakestraw, 2000). When they work from a score, musicians must translate notes printed on a page to movements with instruments that then make sound waves. Musicians use their bodies to translate written musical directions into not only sound-producing movements, but into communicative gestures that comprise a sort of embodied "grammar" (Davidson and Malloch, 2009).

spatialization in musical representation.

Two of the musical dimensions that are communicated through this "embodied grammar" are time and pitch. Time and pitch, among other musical variables, are spatialized in common-era Western musical notation. Temporal relationships are translated onto an X-axis, where note durations are arranged sequentially one after another; meanwhile, pitch relationships between simultaneously occurring sounds are

depicted vertically, "stacked" on top of each other on the Y-axis. Isaacson (2005) offers a brief summary of some of the spatial metaphors that are embedded in our notational system:

> *"Our notation system embodies a number of metaphors that both reflect and shape how we understand music. Primary among these is the notion that pitches are discrete objects that exist in spatial relationships: one note is "higher" and "longer" than another. These basic spatial metaphors lead to others: scale degrees are arranged in "steps"; melodies "ascend" and "descend"; we speak of "big sounds," "thick textures," of motives being "stretched" or "compressed"; we speak of not just "voice leading," but "smooth" voice leading; we speak of "soft" dynamics, "hard" attacks, "harsh" dissonances, melodic "shape," and musical "form."*
> *(Isaacson, 2005, p. 389)*

These spatial translations happen not just in the conversion from real or imagined sound to notated music, but in the reverse direction, as two-dimensional representations are converted back into temporally unfolding physical motions that elicit sound.

Stefanou and Antoniadis (2009) describe this process of recreating the score as the assemblage of a multi-dimensional "score-space" in which pitches, durations, dynamics, and physical motions come into contact (and sometimes conflict) with choices about phrasing and flow. The "score-space" exists in the intersection between the written score and the bodily enactment of that score in time. Stefanou & Antoniadis draw a line between post 1945 repertoire and common-era performative choices, citing the instability of increasingly complex, non-intuitive structures in contemporary musical scores. I argue

that this process may remain the same, regardless of the level of post-structuralist complexity in the music: This process requires a translation between the abstract score-space and the physical body-space, culminating in the act of performance itself. Although Stefanou and Antoniadis take care to explicate the emergent and flexible nature of the performed "score-space," taking into account the ways that performative and compositional conventions have changed over time, the methods by which performers learn to negotiate this score-space remain unclear.

This process of translation can occur in a variety of ways. The plasticity of time and space in musical meaning are highlighted in work in which researchers have asked students to invent their own visual notations for music that they hear (Blair, 2007; Bamberger, 1996). Jeanne Bamberger's work with children on musical conceptual models, in which children invent a variety of different sequences of bells in order to play a different tune, highlights the different conception of musical structure that such representations both reveal and afford. In this study, a child with a sequence of musical bells tries a series of arrangements in order to play "hot cross buns." His initial conception is sequential; each note is a discrete object. This initial conception of a tune evolves into a set of instructions dependent on pitch classes, once the child recognizes that repeated pitches can be played on the same bell – demonstrating a musical conception at a higher level of generalization. This work highlights the *learning* aspect of musical representation, in which representations change as learner's understanding of musical structure changes.

annotation as a representational practice in musical performance.

The current study tracks the evolution of annotations in individual parts as one

strand of a musical group's learning process. Research in the learning sciences has shown that "representational notations can have significant effects on learners' interactions, and may differ in their influence on subsequent collaborative use of the knowledge being manipulated" (Suthers & Hundhausen, 2003). Performing musicians habitually annotate their parts, highlighting the fact that conventional western notation conveys only a limited amount of abstract information. These annotations may sometimes serve to highlight contextual information that may be opaque in the written score. For example, historically informed performance practice[1] dictates that a staccato marking should be played more gently for Haydn's music than for Bartok's (e.g., Bowen 1996). As the markings in both types of scores typically look the same, an annotation might help to encode some of this additional information. Players may also use annotations to encode data about speed, affect, musical meaning, and chordal context for pitches[2].

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[1] Historically informed performance practice, or "authentic performance," or, in

[2] This last point about chordal context deserves some explication: while casual music listeners may believe that pitch consist of absolute frequencies, and that notes may be either "in tune" or "out of tune," in actuality there are a number of different musical tuning systems that offer different options for frequency relationships between different pitch classes. Hence, in the key of E Major, the third of the tonic chord would be a G#. In the context of an E Major chord, the G# is ~14 cents flatter in the "just intonation" tuning system than it would be in an "equal tempered" tuning system. A performer playing a G# in this intonation system might therefore play two different pitches depending on the other notes surrounding the G#; if the other notes are an E and a B, forming an E major

The annotations produced by performers range from the fully conventional to the utterly idiosyncratic: markings for upbows and downbows are standardized for string players, while notations for a gradual increase in volume have a much wider range. “Stuff People Write In Parts,” a digitized collection of annotations in rental orchestral parts photographed by orchestra librarians in Chicago, includes a wide range of such annotations. For pianissimo (very quiet) passages, for example, the annotations in this collection range from a a modification of a *p* printed dynamic to *pp* with a circle around it (see Fig. 1) to “STFU” and “SHHH!,” among others.

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chord, she will play the note flatter than if the other notes are a B# and a D#, forming a G# major chord. Thus, an annotation of a chord symbol (e.g. EM) over a printed pitch in a musical part offers context that might aid in the production of a more in-tune chord. Not all musical instruments afford the same amount of flexibility in intonation; pianos, fretted string instruments, and harps must play in a fixed tuning system, while orchestral string and wind instrumentalists may adjust their pitch more freely based on context.

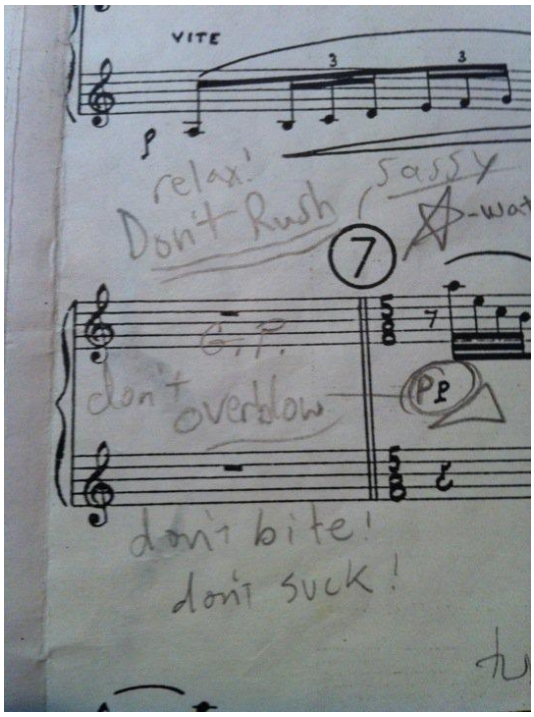

Figure 1. Annotated Clarinet Part from "Stuff People Write in Parts (Stokdyk, 2016)

The set of annotations in Figure 1 contain a mix of non-expert annotations, related to physical knowledge needed to execute music on a given instrument ("don't bite," e.g.) and exhortation of a coaching or encouraging nature ("don't suck!") with annotations that might be more typical of expert performers, including instructions on affect ("sassy"); modification of time and indications of context (the conversion of a four-beat rest to "G.P.," or Grand Pause, changes the written timeframe as well as signifying that no other instruments will be playing during that pause); and modification of a printed dynamic, from *piano* (p) to *pianissimo* (pp), indicating that this part's relation to the rest of the musical structure requires an extremely low dynamic, possibly at the edge of this particular clarinetist's physical capability. Some of these notations are relatively standard – G.P., for example – while the triangle next to the pp marking is non-conventional,

meaning that its import is lost to this writer in the absence of further context.

Metaphorical annotations can help in mapping across conceptual domains ("sassy," e.g. maps between music and linguistic domains), or within domains. As an example of the latter, Figure 2 is a section of a score of Franco Donatoni's "Triplum" for wind trio, written in 1975, that I rehearsed and performed in 2015:

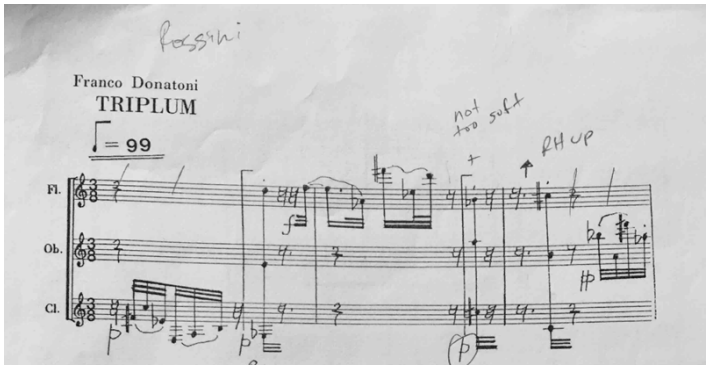

Figure 2. Annotated score of Donatoni's Triplum (Hospelhorn, 2015)

In addition to dynamic emphases ("not too soft"), rhythmic scaffolds (vertical lines depicting beats) and intonation markings (an up arrow, combined with fingering instructions for a sharper C# pitch, indicate that the C# in measure 3 should be played sharper than the performer's natural tendency), the word "Rossini" is written across the top. This annotation was generated as a result of a discussion about the kinds of articulation the trio should use in these fast, staccato passages. The word "Rossini" conjures a world of musical associations having to do with the works of the nineteenth-century opera composer Gioachino Rossini. Rossini's instrumental writing is played with a light touch and a quite specific operatic style. A cross-domain metaphorical annotation that might have achieved a similar result might be "light & airy;" instead, the metaphorical mapping from a Donatoni composition to a body of music composed two centuries previously elicits associations of a wide domain of musical material in a

specific style, provided the performers have the cultural background to access those associations.

Research on musical annotations is an emerging field. Marine Blassel (2016) has documented the different kinds of annotations used by a group of pianists to signify the physical gestures involved in Marc Durand's "holistic approach" to piano technique. In this approach, the distinction between sound-producing and non-sound-producing physical gestures is blurred, as physical motions that at first seem to be sound-facilitating or non-sound-producing are formalized into codified motions that conflate representation, ergonomics, and sound-production. Examples include "the wheel," the "curve," and "attack absorption," among others. "The wheel," for example, consists of a rotating wrist that carries the hand further along the keyboard. Blassel's work attempts to attempt to formalize a shared set of notational conventions for these formalized gestures.

These kinds of annotations constitute a kind of *de facto* score analysis, in which musical materials are organized differently according to where Durandian gestures are deployed. (Blassel & Traube, 2016). Note here that Blassel & Traube refer both to physical gestures, and to "musical gestures," which are conceptual organizations of musical material in which the organizing principle *is* the physical gesture used to enact it. While Blassel's work is able to conflate score-analyzing gestures and physical gestures due to the formalization of Durand's sound-producing gestures, the present study analyzes non-sound-producing gestures that are improvised and non-systematized. However, Blassel's study points to the relationships that may exist between written annotations, physical gestures, and musical (conceptual) gestures that performers produce in rehearsal.

mapping between representations in different modes in musical performance.

In order to achieve a successful mapping of Jesus dying on the cross in a musical performance of Haydn's "Seven Last Words of Christ", a performer might annotate their part in a number of different ways to remind themselves of some conceptual metaphors (for example, musical figures might map to "sighing" or "dying" or "crying" metaphors, or metaphors of death and resurrection, descending to earth or ascending into heaven). These annotations might include text (the word "sigh"), or more graphic depictions of a sonic metaphor (e.g., a squiggly line to indicate emphasis). These metaphorical mappings might be highlighted not only in written representations, but in embodied representations (more on this in the next section). Mapping between inscribed textual metaphors, embodied, and sonic representations is one of the central tasks of live music performance.

However, representations in music can cause difficulties, even as they are necessary. One reason for this is that not all of the metaphorical mappings contained in visual notations may be intentional:

> *"Very often, there are built-in traps in the notation of even the best composers...these traps exist when one translates the visual representation of the music into sound, because the text is composed of vertical barlines, whereas sound moves across time horizontally, oblivious to imposed barlines." (Gordy, 1999)*

Visual, temporal, auditory, and metaphorical modes both conflict and converge in the real-time realization of a musical score. Musicians may create annotations on a score in order to document performative choices, elaborate context, or mitigate contradictions inherent in an existing written representation. These evolving annotations may constitute

a reflection of a learning process whereby musical representations begin to align across modes into a coherent musical concept.

Tracking representations across time can reveal learning processes, as in Halverson's (2013) case study of representation in digital art-making practices of youth. Halverson traces learning processes in groups by examining the evolution of representations over time, and locates this process of evolving representation in a *representational trajectory* that begins before the first visual representation has been created. She notes that the types of representational trajectories that emerge in these artistic practices are similar to those that emerge across disciplines; it follows from this that tracing musicians' evolving representations can reveal learning processes in both individual and group musical contexts, and that the representational trajectories of musical groups might resemble those in other collaborative processes.

2.3.2 Embodied Musical Interactions

In analyses of group learning, embodied and spatial cues can provide insight into the ways that representations are used to produce joint understanding, whether in classroom science talk (Nathan et al., 2007), narrative literacy performances (Leander & Rowe, 2006), or professional working contexts (Engestrom, 2008; Goodwin, 2010; Maitlis et al, 2013). These analyses hinge on the notion that spatial and physical relationships, rather than being incidental to or representative of an inner "knowledge," may actually embody that knowledge.

In musical contexts, physical motion mediates leadership roles (Wing, Endo, Bradbury, & Vorberg, 2014; Glowinski, Badino, Ausilio, Camurri, & Fadiga, 2012; D'Ausilio, Badino, Li, Tokay, Craighero, Canto, & Fadiga, 2012; Gilboa & Tal-

Schmotkin, 2010), as well as the relationships between gesture and listener perception (e.g. Kozak, 2015; Glowinski et al., 2013; Vines, Wanderley, Krumhansl, Nuzzo, & Levitin, 2004), and the ways that body movements in performance may be explicitly encoded for specific emotions (Tagg, 2004).

There is also evidence to suggest that embodied motion can help create an "internal pulse" (Gordy, 1999; Schutz & Lipscomb, 2007), which is one of the explicit tasks that musicians face in rehearsal. This "internal pulse" is instrumental in developing an external pulse or "groove," a phenomenon that has long been a subject of study by musicologists (e.g. Butler, 2006; Prögler, 1995). A groove constitutes a shared sense of time; this shared sense of time, or rhythm, is a key aspect of human intersubjectivity from an evolutionary standpoint. Rhythmic processing is a form of mimesis, which is a prerequisite not only of shared language but of tool use (Donald, 1991). Indeed, children who are better able to keep time with a beat demonstrate correspondingly better linguistic and cognitive capabilities (Tierney & Kraus, 2013). While gestures are critical to meaning-making in many kinds of problem-solving contexts (e.g. Singer et al., 2008), the primacy of body movement in musical performance make gesture analysis a particularly useful tool for studying musical interactions.

2.3.3 Gestural musical communication

One reason that gesture analysis is so critical to understanding musical interactions is the role of sound-accompanying gesture as a communicative tool in music. In ensemble musical performances, participants' visual perceptions of physical gesture contribute to the development of their shared understanding of events (e.g. Wanderley, Vines, Middleton, McKay, & Hatch, 2005;Vines et al., 2004; Dahl et al., 2009). Visual

and auditory cues, along with body movements, provide anchors for players' mutual understanding of events as they are happening (Schutz, 2008). These modes of perception combine in musical learning processes as musicians scaffold their "togetherness" via metronomes, body movements, and written scores (Hospelhorn & Radinsky, 2012).

Communication in music performance settings is explicitly embodied and spatial: management of the space between musicians' bodies has long been known to be a critical aspect of performance practice (Zvonar, 1999). Classical musicians are trained to read certain kinds of body movements as explicitly communicative. Studies of conductors working with singers have shown that the shape, timing and placement of a conductor's preparatory gesture can have a significant effect on a performer's body movement (Manternach, 2011), tone quality, and intonation (Brunkan, 2013). Musicians working without a conductor may use their bodies in space similarly, as a way to coordinate participation (Moran, 2013).

However, embodied motion in music is not just a tool with which to communicate with others; other strands of research point to ways that musicians' gestures may shape their own musical conceptions. A cue by a pianist that demarcates straight lines and points in space might elicit a more rough style of play, while a more flowing cue and subsequent swaying motion will both communicate and cause that pianist to play in a more flowing style (Gordy, 1999). Indeed, Davidson and Malloch (2009) argue that all musical meaning originates in the body, whether in visually perceived gestures or physically produced sounds, and that what we experience as "music" is a semantically and culturally modified instance of "gestural communication". In addition to explicitly agreed-upon gestures, musicians' embodied interactions often include emotive gestures

that may be both communicative and reflective of their conception of a piece.

gesture in musical learning contexts.

Critical to this understanding of musical meaning as being rooted in the body is the role that gesture plays in the enactment of musical structure. For example, Davidson (1993) studied the ways that individual musicians make non-essential gestures while playing that reflect their expressive intentions. A number of studies have attended to bodies in space and their relevance to musical learning situations: Vines et al. (2004), following Davidson (1993) and Wanderley (2002), determined that the visual experience of watching a musician's body movements conveys a great deal of information about musical structure, while Kurkul (2007) tracked the correlations of different teacher postures and attitudes to varying outcomes in instrumental instruction.

Davidson and Malloch (2009) used PEAK motion tracking software to generate graphs of a flutist and clarinetist rehearsing and performing, both apart and together, in order to document differences in individual gestures between musicians practicing alone versus with another performer. Their descriptive study concludes that the more "forceful leader," through motion, sound, and talk, influences the other performer's motion; expressive gestures by musicians change when they perform with other musicians. Their findings also suggest that musical structure is not a static entity to be "correctly" performed or communicated. Rather, it is negotiated and learned together.

bounding gesture in musical contexts.

Each musician's body, moving in time and space, reflects a physical enactment of a score-referenced movement through time. Musicians' performances of

abstract "musical gestures" bridge multiple types of representation, involve physical gestures, and consist of a multimodal enactment of an analogical musical process.

In research on language and gesture, McNeill (2002) analyzes gestures not as isolated communicative units, but rather as having a dialectical relationship with spoken utterances. While gestures linked with speech may occasionally emerge as discrete, easily bounded gesture objects, they can also blend into each other more fluidly. Musical "utterances," like the gestures which may accompany them, are more fluid than those of speech. It is notable that observers are able to point out qualitative musical differences when musicians gesture in a group (Glowinski, Mancini, Cowie, Camurri, Chiorri, & Doherty, 2013), suggesting a musical function of gesture. As in gestures that accompany speech, these gestures are emergent, analogical, and may assist in musical concept formation (Zbikowski, 2011).

Defining gestures in musical contexts is complicated by the fact that the physical movements that are used to bow a violin, to strum a guitar, or to operate a wind instrument are not gestures in McNeill's sense of the term. They are deliberate motions that execute a sound-producing function, rather than semi-conscious actions that elucidate meaning. However, musical performers often move in ways not critical to sound production; a "communicative" gesture may simply be a functionally unnecessary extension of a "sound producing" movement (Dahl et al., 2009). These types of gestures occur both in solo and group conditions. Jensenius, Wanderley, Godøy, and Leman (2009) identify gestures variously as "sound producing gestures," "communicating gestures" (intended for communication), "sound-accompanying gestures" (which may trace sounds that are created), and "sound-facilitating gestures," which may include

phrasing gestures. However, these categories are not cut and dried: sound-facilitating gestures, for example, may also be communicative.

Bounding these gestures with any clarity is a challenge; for this reason, the current study bounds gestures not based on their function, but on observable measures such as body part and temporal entrainment. In Indian Raga Performance, Clayton (2005) identifies “ideational” gestures as, for example, a singer’s hand following the contour of a melody; similarly, in a string quartet, Glowinski et al. (2012) studied “head and upper body sway” as motions “apt to express the phrasing and breathing" of the music interpretation “without being submitted to the constraints observed for other limbs such as the hands to produce the sound itself” (p. 3). Through these sorts of non-sound-producing movements, one can see glimpses of the aspects of a musical piece that are foregrounded for a particular person or group.

2.4 Gesture, Representation, and Talk as Learning Trajectories

The present study connects this conception of gesture as reflective of musical intention and process with an interactional view of musical learning, in order to show how joint musical concept formation emerges across “takes” in a rehearsal. In this, the study follows Leander, Phillips, & Taylor (2010) in conceiving of learning trajectories that are not linear through time, but consist of semiotic processes in space and time which make “particular forms of time visible and relevant” (p. 344). Non-sound-producing gestures occur on the microgenetic level in musical performance; meanwhile, rehearsal talk occurs *around* those performances. Written annotations change at a slower rate, but still may change in concert with changing talk and gestural representations.

In performance, the abstract ideas that may be worked out through musical

gestures are bridged with the practical considerations of how to make those abstractions happen. Each time musicians play a segment of music together, they negotiate and change the parameters that will constrain their final Performance. In this way they interpret the score, co-constructing a shared musical narrative as they perform. The group's assembly process, the "score-space" in which they move (Stefanou & Antoniadis, 2009), the musicians' respective roles within the group, and the story they are learning to tell become more coherent with each rehearsal. The analysis shows that performers' talk, written representations, and movements, when tracked over time in reference to a score, provide evidence of each performer's evolving conception of the piece of music, as well as the group's evolving cohesion around a shared interpretation.

2.5 Pilot Study

Prior to collecting data for this study, I conducted a pilot study on the embodied practices of a different professional string quartet, playing Bartok's String Quartet no. 2. Preliminary results of that study were published in *Discourse Processes* (Hospelhorn & Radinsky, 2016). The pilot study focused exclusively on the types of gestural communication that occurred across a single rehearsal of a single movement of a Bartok quartet. The rationale for that study was that careful attention to the ways embodied meanings develop and evolve among rehearsing musicians offers opportunities for conceptual and methodological insights that may have relevance for our understanding of discourse more broadly.

The constructs of Expressive Musical Gestures (EMGs) and Group Expressive Musical Gestures (GEMGs) were validated and used to analyze the string quartets' embodied discursive practices in rehearsal. In that analysis, briefly stated here, we

examined the ways that EMGs and GEMGs changed over time, and how those changes related to rehearsal talk.

Our analysis identified three functions of embodied gesture for score interpretation: (1) gestures served as a tool for group interpretation in passages that had previously been pointed to by verbal exchanges; (2) gestures served to fine-tune the location and enactment of dynamic markings in the score; and (3) group expressive gestures in the final "take" of the rehearsal incorporated group expressive gestures from other takes, constituting a negotiated set of score interpretations. GEMGs were identified as musico-gestural interactions that were comprised in part of musico-gestural actions (EMGs).

These findings provided insight into the ways that musicians use their bodies in the co-construction of group understandings, and highlighted the function of gesture as a representational practice that is foregrounded in conceptual work where talk may not be the primary form of discourse.

The current study builds on these preliminary findings about gestural communication in musical groups, expanding its analytical view to include other representational practices such as annotations and metaphorical talk, and focusing on a case group with a different rehearsal culture. One of the most salient differences between the two quartets is the amount of rehearsal-related talk in which they engage: while the pilot study quartet spoke minimally between takes, the quartet in this study engages in long discussions about musical interpretation as a matter of course. The gestural portion of this study focuses only on GEMGs, and locates those musical interactions in the context of talk and written representations. Thus, this study examines transformations not

just in gesture, but across representational practices.

3. METHODS

*portions of this chapter are reprinted in part from Hospelhorn & Radinsky, 2016. An Accepted Manuscript of an article published in *Discourse Processes* online [January 15, 2016] is available online: http://tandfonline.com/doi/full/10.1080/0163853X.2015.1137183 (see Appendix F).

3.1 Design of the study

The main question guiding this study was "How do musicians learn to construct a performance?" Two core assumptions drive the design of this study:

1. In expert musical groups, learning occurs through the negotiation and formation of shared musical concepts.
2. These musical concepts are reflected throughout the learning process through multiple modes of representation, including verbal representations, written representations, body movements, and sonic representations.

This study therefore examines the types of talk, annotation, and non-sound-producing motions that emerge across rehearsals, with the goal of finding out how these changing cross-modal representations reflect a musical group's learning processes. Non-sound-producing motions are of particular interest here, as they are foregrounded during performance when talk and annotation are unavailable as resources for the players. In order to examine this process, I designed a single case study that tracked a string quartet's embodied actions, along with verbal and written representations, over the course of several rehearsals and a Performance. Because I am primarily interested in tracking the learning process of a group, rather than any one individual, the unit of analysis for this study is located at the ensemble level. Specifically with regard to gestures, this study focuses on the *Group Expressive Musical Gestures* that emerged in rehearsal (discussed

in depth later in this section), along with annotations and rehearsal talk.

In order to track the way non-sound-producing motions and written representations change over time, it is necessary to relate those changes to musical events in the score. Therefore, the research questions that guided the data analysis are:

RQ1A: What group gestures are produced during rehearsals, and how do these gestures change across takes?

RQ1B: How do these gestures relate to the structural elements of the score?

RQ2: What kinds of written representations are produced during rehearsals, and how do those representations change across rehearsals?

RQ3: What kinds of talk are produced during rehearsals, and how does that talk change across rehearsals?

RQ4: How do changing patterns of group gestures, along with talk and written representations, reflect the group's learning process as they interpret the score together in rehearsal?

By answering these questions, the analysis will illustrate the ways gestures, talk, and annotations reflect a musical group's emergent, shared understanding of the musical structure of a composition.

3.2 Study Participants and Recruitment

This study examines a single case of a professional string quartet rehearsing a single piece of music over the course of several rehearsals and a concert. Criteria for recruitment were that the participant group be a professional chamber ensemble, working without a conductor, who had scheduled rehearsals for upcoming Performances.

Following an approved IRB protocol (Appendix E), I recruited a Chicago-based string quartet with an upcoming public Performance, who agreed to participate in interviews, have their rehearsals and Performance videorecorded, and share the written materials they used to rehearse.

At the time of data collection, the quartet was preparing a number of upcoming Performances, including a new commission by a living composer and an older work, Haydn's *Seven Last Words of Christ.* After collecting data on as many rehearsals as I could over the course of a month, I selected the third movement of *The Seven Last Words of Christ* as the focus of the case study, as I was able to collect the richest data set for that movement, and the challenges the group encountered in rehearsing it included the intonational, the annotational, and the metaphorical. The events documented in this case include three rehearsals, occurring over the course of two weeks, and one Performance. For a more in-depth description of the quartet's background and practices, as well as an overview of the piece they prepared for Performance, see Chapter 4: Case Overview.

3.3 Data Sources

The data collected for this case study consists of video of each rehearsal, field notes, written artifacts (scores, parts, annotated parts, and program notes), and interview data.

A. Video data

For each rehearsal, I placed two cameras in the room, so that the head and upper torso of each musician was visible. These two videos yielded gesture data, both from musical run-throughs and discussions that occur in between run-throughs, in which each

musician was clearly visible. The cameras were placed outside of the group, so that they capture expressive motions of each musician's head and torso without disturbing the natural flow of the group's working process.

B. Field notes

During each rehearsal, I took field notes in order to identify moments of interest for further examination in the interviews, as well as to provide additional information for the case study and inform my own understanding of the musical landscape (Titon,1996). While taking these notes, I referred often to my own copy of the score, so that I could take note of not only when an observation occurred, but where in the score it occurred, if the musicians were running through the piece at the time that the observation happened. I took note of musician annotations of their own parts as they happened. I also noted times when musicians use terms that are rich in metaphor or that I did not understand, for later explication in video-assisted interviews.

C. Written artifacts

In addition to the unmarked score and parts, I photographed copies of musicians' individual parts after each rehearsal. This allowed me to see which annotations had been created on each day, and to incorporate written annotations into my analysis of *representations*. See Appendix A for samples of these photocopied parts.

D. Interview data

After each rehearsal, I conducted an interview with multiple members of the group using interview protocol A (Appendix B). The purpose of this interview was to gain a greater understanding of the group's intentional actions for that session, including

rehearsal structure, and to generate narratives from the musicians that I could use in conjunction with gesture data, verbal data, and field notes to generate analyses of the group's changing musical conceptions.

After I had completed a first pass of all verbal transcriptions and begun to code for gestures, I conducted a final group interview where I asked participants to reflect on specific video segments from their rehearsals. For the interview protocol for this interview, see appendix C. I used this interview to check my emerging analysis of their evolving representations, as well as to clarify terms and iconic gestures that the musicians had used in discussion that were identified in field notes.

3.4 Data Selection and Initial Transcription

I collected video data and field notes for an entire rehearsal cycle, which included nine scheduled rehearsals and a Performance of Haydn's *Seven Last Words of Christ*, which is a multi-movement work consisting of eleven movements in total. Due to the group's practice of determining rehearsal needs in the moment, I was unable to predict which movements would be rehearsed when. There were also a few unscheduled rehearsals that I was unable to attend. I chose to analyze the third sonata, titled "Mulier, ecce filius tuus," because that was the movement that yielded the most complete data set, including rehearsal videos, annotated parts, and performer interviews. Sonata III also poses a valuable case for data analysis as it was the site of protracted negotiations about intonation, bowings, and metaphor. The group highlighted this movement as one of the more challenging sonatas for intonation work, and experienced a fair amount of frustration in their struggle to come to a shared conception of the piece that they felt was convincing.

Once Sonata III was selected as the case for analysis, videos were transcribed for talk and imported into Transana, where I applied thematic codes to rehearsal transcripts. This thematic coding process led to the identification of several excerpts to be highlighted at the video assisted group interview, which was also then transcribed and imported into Transana.

3.5 Mapping Research Questions to Data Sources

The following section identifies the constructs and analytical methods that were used to map research questions to data sources. Gestures were tracked in video using the constructs of *Expressive Musical Gesture* and *Group Expressive Musical Gesture*, and aligned with the score using both excel-generated graphs and score overlays (RQ1). Annotations were reproduced on copies of the score and tracked chronologically (RQ2). Rehearsal talk was coded using the construct of Idea Units (Jacobs & Morita, 2002) and tracked over five categories, including Rhythm-centered talk, Intonation-centered talk, and Metaphorical talk (RQ3). And interactions between gestures, annotations, and talk were tracked using multi-modal transcripts (RQ4).

Expressive Musical Gestures and Group Expressive Musical Gestures (RQ1A)

The present study employs the construct of *group expressive musical gesture* (GEMG) to track the ensemble's assembly of shared musical conceptions of two focal passages of *Mulier, ecce filius tuus*, in which a physical phenomenon – bodies moving in space – becomes a form of interactive musical score analysis. These constructs were initially developed in a pilot study tracking a different string quartet (Hospelhorn, 2012), and further refined in collaboration with Josh Radinsky as a method for tracking musical

gesture (Hospelhorn & Radinsky, 2016). GEMGs are an interactional outgrowth of a more basic construct of *Expressive musical gesture* (EMG). *Expressive musical gesture* (EMG) is operationalized as any movement of the head or torso during musical performance which is not necessary for sound production. Figure 3 shows a violinist making an EMG by moving his torso forward while playing.

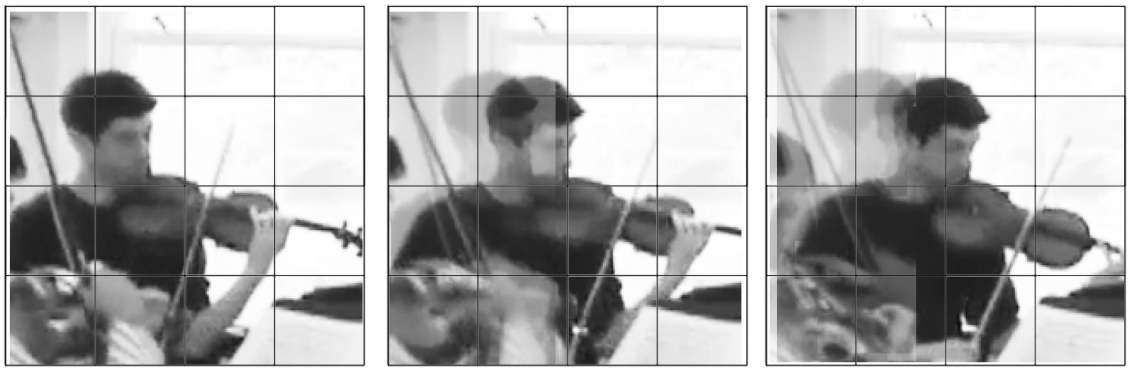

Figure 3. Violinist making an expressive musical gesture (EMG). (Reproduced from Hospelhorn & Radinsky, 2016)

The concept of *group expressive musical gesture* (GEMG) expands this construct to include multiple bodies, moving in a coordinated path through space. GEMG is operationalized as simultaneous EMGs by two or more players that share a physical form – e.g., swaying or nodding simultaneously in a coordinated direction (i.e., upward, downward, inward, outward, toward one another, or parallel to one another). These can take the form of "swirling" motions, where, in conjunction with a crescendo figure in the music, two or more musicians might lean forward with their torsos and back again in a single circular motion (see Figure 4 for an illustration), or both lean to their left and then right. EMGs that occur simultaneously but do not share a physical form (e.g., one player hunching shoulders while another leans inward) are not GEMGs.

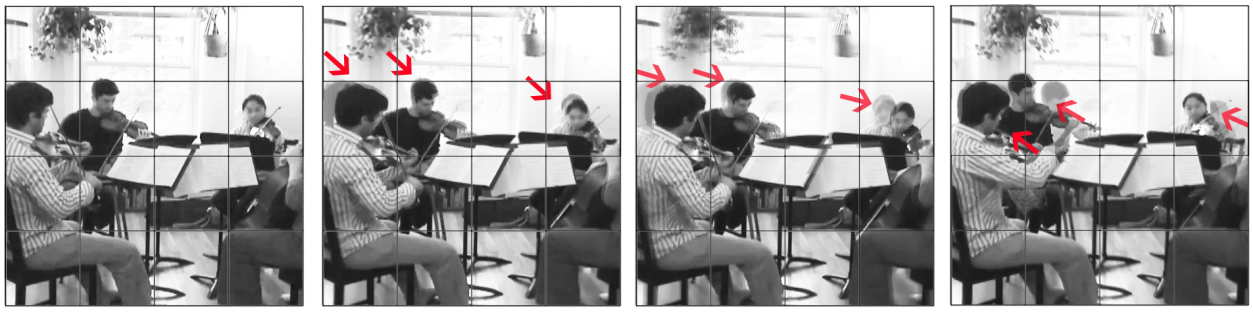

Figure 4. Violin 1, Violin 2 and Viola making a group expressive musical gesture (GEMG). (Hospelhorn & Radinsky, 2016)

The construct of GEMG is informed by Clayton's (2007) description of *temporal entrainment*, which emphasizes the ways players entrain to one another's timing by coordinating similar body motions. Unlike Clayton, though, the focus here is on co-construction of score interpretation rather than only temporal entrainment. Clayton's musicians' entrained motions tend to be rhythmic markers of the beat. These movements are similar to *interactive gestures* in the sense that Bavelas et al. (1992) identified in dyads of speakers, because they take place in a group musical context. At the same time, they have a referent in the score, similar to Clayton's *ideational gestures* (2005). When these interactive gestures become temporally entrained with co-gesturers, they can develop shared references to features of the score which can contribute to a process of group learning. While some researchers (e.g. Glowinski et al., 2012; Davidson & Malloch, 2009) have used gesture to study the development of *leadership* in musical groups, or relationships between gesture and audience perception (e.g. Kozak, 2015; Glowinski et al., 2013; Vines et al., 2004), the focus here is on the process of negotiation of meaning. As different configurations of EMGs and GEMGs emerge from take to take in a performance, these gestures are used here to track the group's evolving conception of the piece.

Transcription and Gesture Coding

Videos were transcribed for talk, and then coded for *expressive musical gestures* (EMGs) and *group expressive musical gestures* (GEMGs). The coding was done by hand using InqScribe™ transcription software. The video was played without sound, to mitigate bias that might be caused by the perception of sonic changes, with playback slowed to 40% in order to increase coding accuracy. Each code recorded the player by instrument (viola, first violin, second violin or cello), a brief description of the motion (e.g., lean forward, head nod, turn to left), and time codes marking the onset and release of the gesture. Although codes were applied to a single player at a time, this does not eliminate the possibility that their perceptions of player motion may have been influenced by movement from other players.

This kind of analysis requires the documentation of movements in space, indexed by time. Gesture analysts approach this challenge in different ways, some particularly relevant to studying musical movement. Zbikowski (2011) superimposes a grid onto multiple images of a musician (e.g., Fred Astaire at the piano, p. 94) in order to track the range of motion at different points in time. This use of "small multiples" communicates the passage of time visually (McCloud, 1993; Tufte, 1986), in Zbikowski's case with the lyrics of the song used as an approximate time index. A simplified silhouette and quadrant grid afford observation of motion in space between one time and the next. Zbikowski's approach affords detailed spatial observation, but depends on the inexact index of lyrics to document increments of time.

The approach used in the present study, adapted from Zbikowski, was used here to determine when movements of the head or torso occurred. Only one camera was used

in this study, though a more exact strategy would involve one camera per player to more clearly identify movements. Other analysts have used motion capture technologies for even finer-grained documentation of body movements, such as Kozak (2015) and Glowinski et al. (2012). These technological solutions (motion capture or multiple cameras) are more exact than the strategy used in this study, though they also are more invasive to the musicians being studied. This is a tradeoff of precision against ecological validity, as more invasive documentation is likely to change the ways players move their bodies and communicate with one another. Motion capture technology, as it becomes less intrusive, has great promise for this line of research, as it can document not only location but also velocity, precise direction, and quantified shape of each motion. Even with such approaches, though, the distinction between sound-producing and expressive gestures remains a qualitative judgment.

EMGs were recorded for each individual, following the protocol used in Hospelhorn & Radinsky (2016). GEMGs were then coded by examining each agreed upon EMG, for each player in turn, and looking for similar form factors in the motion of other players. These form factors could manifest in different ways – for example, a nod by one player might correspond to a full-body dip by another, if the velocity, direction, and acceleration were similar. These judgments of "similarity" were not quantified for the present analysis, though there are possibilities for instrumenting the documentation of gesture that could provide measures of velocity, direction and acceleration (see discussion of tradeoffs above). In and out times for EMGs were defined as starting from home base and returning to home base, but with GEMGs, "home base" was not used; onset was coded at the moment that two or more musicians begin to move in the same

shape (form factor) and ended when they diverged. This means that a GEMG may include multiple EMGS (if the same players locked in the same relative position to each other through a series of nods and swirls) or only part of one (for example, one player may start to lean and another player may join her halfway through).

Reliability

The gesture coding process used here was refined in an earlier study (Hospelhorn & Radinsky, 2016), in which two coders used the same coding scheme to identify EMGs and GEMGs in a string quartet rehearsal. In that study, a qualitative method was used to determine coding scheme reliability (see the paper for details). Although no second coder was used here, the coding scheme used was identical. Reliability was not calculated for the coding in this study.

Anchoring Gestures to the Score (RQ1B)

Each gesture was time-coded for onset and duration in terms of time, in minutes, seconds, and frames (30^{ths} of a second), e.g. 07:22.12. However, the relative onset and duration times of gestures cannot be compared across different takes of the same musical passage when those takes are played at different tempi (i.e., faster or slower). GEMGs were therefore translated into "score-time," using the protocol described in Hospelhorn & Radinsky (2016). This involved translating time-codes into measure numbers (e.g., a gesture that occurred the first time a segment was played, at minute 4 and a gesture that occurred during the second run of that segment, at minute 10, might both have onsets at measure 3.75).

Because of the slow pace of this sonata, measure numbers were spaced slightly

too far apart in the score to be used as an index of the relationship between gesture production and musical events in the score, or to compare relative gestural occurrences in multiple takes. Beats (subdivisions of measures), on the other hand, proved ideal for this purpose. The index of "score time" used here is therefore fractionally numbered *measures*, with each beat forming one quarter of a measure (e.g. measures 1, 1.25, 1.5, 1.75).

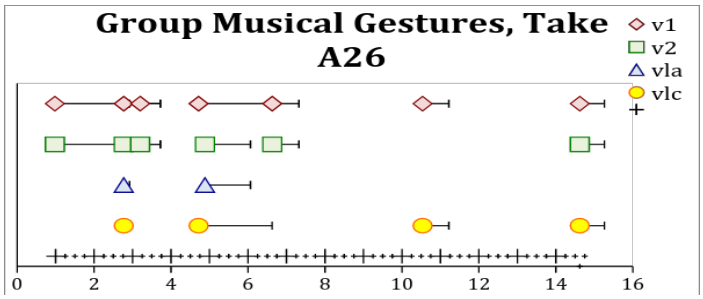

Figure 5. A graph of GEMGs in a single 14 measure take, indexed by measures and beats

Each gesture's timestamp was translated into "measure time" in order to track the evolution of a musician's gestures with respect to the score across takes. Measures and beats were time-coded and numbered in each video recording. The onset of each measure was plotted on the X-axis in timeline graphs of all gesture events. The temporal location of gesture events within measures was determined by dividing decimal minutes of timecoded events by the average number of decimal minutes per measure and beat in each take. This allowed for gestures to be referenced to musical events in the score, in order to inspect the group's negotiation of particular musical passages over the course of the rehearsal.

The time-coded gesture transcripts were used to generate motion graphs of each take, by importing codes into Excel™, translating timecodes to decimal measures, and assigning each player's codes to a horizontal row along a measure-indexed timeline.

Graphing each musician's GEMGs as a scatterplot against measures and beats in a single take yields the graph shown in Figure 5 (showing Take 26). Figure 5 shows this representation, with measures on the X-axis, and small "+" symbols along the X-axis marking individual beats.

Overlaying graphed gestures onto a Musical Score (RQ1B)

Graphing gestures in this way showed where gestures occurred in relation to each other over several takes and in relation to measures and beats, but conveyed no information about the musical materials corresponding to each gesture. Overlaying graphed gestures onto the actual musical score gives significantly more information about the musical materials co-occuring with each EMG, and allowed analysis of the relationships between rehearsal talk, score annotations, and EMGs. Overlays were done by hand in photoshop, using the excel-generated EMG graphs, and checked against the original start and stop times recorded in inqscribe (with sound on) for accuracy. Each GEMG was overlaid on the parts of the score corresponding to the players involved in that GEMG. In cases where multiple GEMGs happened simultaneously, each GEMG was assigned a separate color (see, for example, the short GEMG between V2 and Vla in Figure 6, which occurs simultaneously with a longer GEMG between V1 and Vlc. The shorter V2/Vla GEMG is highlighted in red). In the case of the very short 4-person GEMG that occurred at the end of measure 2 in this take, a band of purple extends downward through each line of the staff, symbolizing that it is shared by all four players.

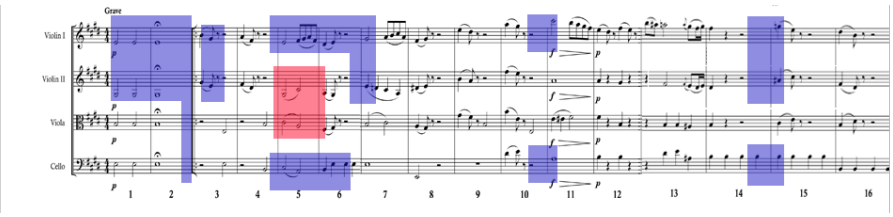

Figure 6. Graphed GEMGs overlaid onto a musical score.

Overlaying GEMGs onto score materials in this way gives much more information about where gestures occurred, and what kind of embodied score analysis those gestures might indicate. For example, whereas Figure 5 shows that a long initial GEMG between the two violins was followed by a shorter GEMG by the whole group, Figure 6 shows that the two violins moved together through three iterations of the opening E Major chord, and then were joined in the lead-up to measure 3, which is the start of the main thematic material of the piece. The fermata, or long held note, immediately preceding the four-person GEMG (purple bar extending across all four staff line sections) at the end of measure 2 strongly suggests that that GEMG is in fact a cue, setting up a shared time frame for the music to come.

Tracking Changing Annotations Across Rehearsals (RQ2)

Annotated parts were collected at the end of each rehearsal. In order to determine which annotations were produced when, videos were coded to identify moments where musicians marked their parts. These transcripts were used together with annotation photographs to align annotations to specific takes.

In order to track the way that annotations occurred and evolved over time, annotations were copied from individual parts onto score segments and laid out sequentially, with new annotation sets highlighted in different colors. Figure 7 shows

three annotation sets. The first score represents the state of the musicians' parts in measures 1-6 through the first 10 takes of segment A. Two annotations (in the violin and viola) occurred before take A11; the second score shows the state of the musicians' parts between take 11 and take A32. The first violinist annotated her part after the last take of the 3rd rehearsal, adding expressive marks to measures 3 and 4 and the words "warm and loving" to the top of her part; the score in take A33, which was the Performance take, shows the state of the musicians' parts at the Performance for those six measures.

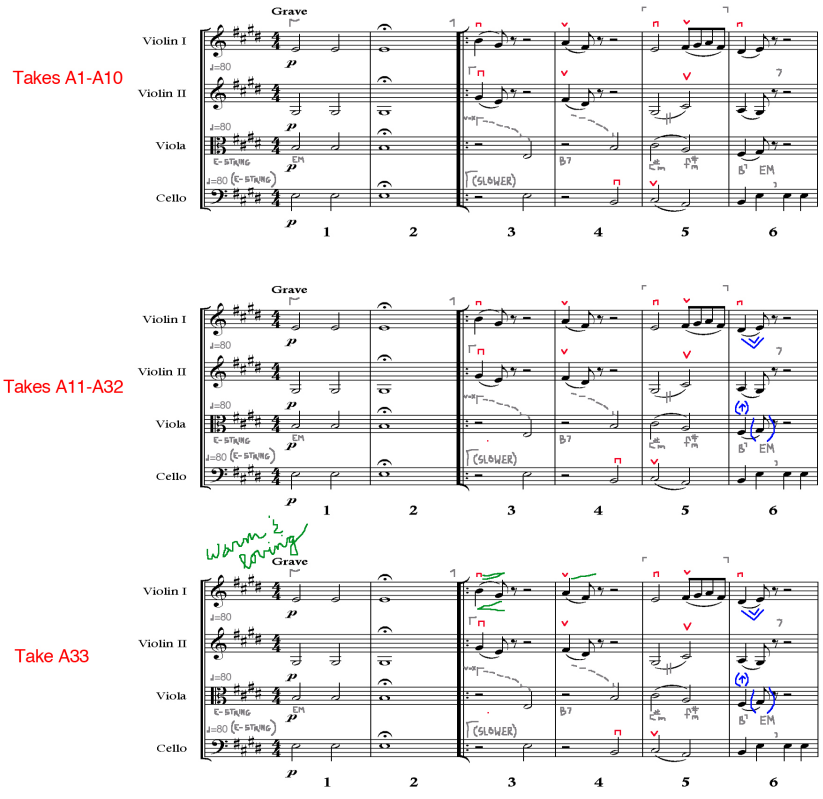

Figure 7. Combined annotation sets. Grey and black markings are pre-existing for this rehearsal cycle. Red markings are bowings and did not change from the first rehearsal to the last. Blue markings occurred between takes A10 and A11. Green markings occurred between takes A32 and A33.

Tracking Changing Talk Across Rehearsals (RQ 3)

In order to track changing patterns of talk in tandem with changing patterns of annotations and gestures, rehearsal talk was coded by content-type across rehearsals. Talk was coded as *Rhythm-centered, Intonation-Centered, Metaphor-Centered, Deciding Where to Rehearse Next,* or *Other.* These codes were applied not to entire turns, but to idea units (Jacobs & Morita, 2002) within turns, marked by shifts in emphasis, focus, gesture, or cadence of speech. Rhythm centered talk was determined by references to tempo and speed ("too fast," e.g.), or rhythms. (This code was originally "tempo or rhythm-centered," but was shortened to "rhythm-centered" for ease of reading). Intonation-centered talk contained references to pitch relationships ("where do I put this D#") as well as harmonic series ("B, centered around the E string" – for more on why this is classified as intonation-centered, see footnote 2 in literature review). Following Zbikowski's (2002) use of conceptual metaphors (Lakoff & Johnson, 2003) and conceptual blends (Fouconnier and Turner, 1998) as a way to synthesize the cultural theories and cross-domain mappings embedded in musical texts, Metaphor-centered talk was identified when musicians mapped musical materials to different conceptual domains (e.g. "warm," "it had a soaring feeling"). Deciding where to rehearse next was characterized by measure numbers ("can we do measure 96"?). Talk that did not fall into one of these categories was categorized as "other."

These idea units could contain combinations of speech, gesture, or singing. Idea units that consisted *only* of gesture or singing were coded as idea units only if they were produced in response to a previously categorized idea unit. For example, a singing and snapping response to the question "what's the tempo?" would be coded as a

rhythm/tempo centered utterance. Instances of coded talk were then compared across rehearsals in each category.

Generating Multi-Modal Rehearsal Transcripts (RQ 2, RQ3, RQ4)

This analysis assumes that talk, annotations, and non-sound-producing movements all contribute to the development of shared concepts in musical rehearsals. After transcribing talk, annotations, and GEMGs, I generated a series of multimodal rehearsal transcripts in order to track the interactions between these three modes of representation in rehearsal.

Initial transcripts consisted only of rehearsal talk and score-overlaid GEMGs:

Figure 8: segment of multi-modal transcript

I then highlighted *Annotations*, *Singing, Speech-related gestures,* and coded categories of *talk* in the multi-modal transcripts. Singing was highlighted as a representational mode similar to, but different from, both talk and performance: the players are incorporating pitches and rhythms, but not bowings or string-specific sound production into this representation.

Any annotations that were made immediately before a take were reproduced into that take's score segment and circled in red. In this way, it was possible to see whether, for example, the production of annotations corresponded with new GEMGs, or with the disappearance of pre-existing GEMGs (discussed in the analysis). Aligning annotations, metaphorical gestures, metaphorical talk, GEMGs, and rehearsal directions in this way allowed me to track the evolution *over time* of the group's changing conceptions of the piece.

Tracking Learning Processes Across Talk, Annotations, and Gestures

Following Halverson (2013), these three strands of analysis were brought together to describe the learning trajectory that occurred across them. By tracking representational trajectories across annotations, across gestured representations of the performance that unfolded in time with sonic representations, and changing patterns of metaphorical talk between takes, the analysis and discussion construct a case of embodied, representational, and distributed processes learning that happened across rehearsals.

3.6 Summary

The central research question guiding this study is:

How does a musical group construct a shared conceptualization of a score through

rehearsal?

More specifically, this study examines the role of **Group Expressive Musical Gestures (GEMGs), Written Representations,** and **Talk** in the group's learning process. In order to examine the role each of these elements play in concept formation, it is necessary to document changes in the group's embodied actions over time, and to relate those changes to musical events in the score. Additionally, it is necessary to pinpoint the moment in time that written annotations appeared or disappeared, and to relate those changes to rehearsal talk and changing patterns of embodied actions. Therefore, the more specific questions guiding this analysis were:

RQ1: How do the group's GEMGs relate to the structural elements of the score?

RQ2: How do the group's written representations change across rehearsals?

RQ3: How does rehearsal talk change across rehearsals?

RQ4: How do changing patterns of individual and group gestures, along with talk and written representations, reflect the group's learning process as they interpret the score together in rehearsal?

Changing patterns of gestures were tracked over multiple takes at both individual and group levels of analysis. These gestures were then mapped to the musical score (RQ1), specific sections of which were highlighted as musically significant after analyzing the group's rehearsal process. Clear alignments of many of these patterns to elements of the musical score were identified in the graphed and score-overlaid data, often with explicit references to those score elements in the talk before and after rehearsal "takes," and sometimes immediately preceding or following the production of written

annotations (RQ4). Changing annotations were tracked in individual parts (RQ2), and located in relation to specific takes and rehearsal talk that co-occurred with them. Annotations produced during rehearsals fell into several different categories and, while they occasionally coincided with rehearsal talk (RQ4), did not always do so. Rehearsal talk was categorized and tracked across rehearsals (RQ3); changing patterns of rehearsal talk revealed an initial focus on rhythmic and intonational issues that moved to descriptive and metaphorical issues in later rehearsals.

The analysis tracks two main sections of the musical score (Segment A, consisting of measures 1-14, and Segment B, consisting of measures 86-114) and organizes these findings into three sections. The first shows how talk changed from rehearsal to rehearsal (RQ3). The second documents how the group's written annotations changed over time (RQ2). The third shows how particular patterns of gestures aligned with score elements (RQ1). The interactions between changing patterns of gestures, annotations, and talk reveal aspects of the group's development of a shared musical interpretation – i.e., an emergent group learning process (RQ4).

3. CASE OVERVIEW

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4.1 The Case: Learning Context

This string quartet participating in this study is, at the time of this writing, a professional group working in Chicago. The group formed in 2013, performs and teaches full-time, tours the United States often, and is well regarded in the American musical community, having won awards, released several recordings, and collaborated with a variety of other artists. They are particularly known for their somewhat unusual repertoire choices: while many chamber groups perform exclusively new music or older, classical "canon" music, this group regularly performs new commissions, experimental works, and famous classical works by Beethoven, Haydn, and others.

String Quartet Practices: General

Every string quartet consists of four members: two violinists, a violist, and a cellist. These musicians work within a specialized community of practice (Wenger, 1998) with shared tools (e.g. metronomes, musical instruments), documents (e.g. musical scores), routines (cues, slow practice, deliberate listening), vocabulary, and symbols. They belong to the community of classical orchestral musicians, but also to a more specialized community of string players. In a traditional string quartet, the first violinist is often given the most prominent and technically difficult music, and is the de facto leader of the group, with responsibilities including, but not limited to, giving starting and finishing cues.

String Quartet Practices: Current Case

Each member of the quartet in this study is a classically trained musician who has multiple advanced degrees from top-level music conservatories. At the time this study was conducted, three members of the quartet were founding members, and had been working together since attending the same graduate music program; the fourth member, who was also the only woman, had been with the group for less than a year at the time of data collection. The group's activities include, but are not limited to, presenting concerts both in their home town and across the country; rehearsing music for those concerts; commissioning and recording new works by living composers; coaching chamber music and overseeing other performance-related activities at a major university; and administrative activities including artistic planning, grant applications, maintaining donor relationships, marketing and publicity. During a concert cycle, the group may work together more than 40 hours per week, and their talk during rehearsals demonstrates a sense of almost sibling-like closeness, which vacillates between easy camaraderie, task-oriented focus, and tense negotiation.

The group rehearses at multiple locations depending on their daily schedule, including each others' homes and classrooms at the university where they teach. However, their primary rehearsal space is a dedicated chamber rehearsal room on the second floor of a building that was once a well appointed single-family home. The room is large and carpeted and houses a grand piano, busts and portraits of great composers, and various volumes of literature, both musical and otherwise. Windows look out onto a residential street, and let in substantial light during the day. The space comfortably seats four rehearsing musicians, and there is a couch by the wall where observers can sit.

During the data collection phase of this study, I was most often positioned on the couch, taking notes, while two cameras – one perched on the piano and one by the door – recorded the group's talk and movements. While the quartet did conduct some rehearsals of the larger Haydn piece at other locations during this cycle, all of their rehearsals of Sonata III (the movement of interest for this study) happened at this rehearsal space.

Sonata III from Haydn's "Seven Last Words of Christ"

The Seven Last Words of Christ was originally an orchestral work written by Franz Joseph Haydn. At the request of his publisher, Haydn produced a reduced version for string quartet (op. 51) in 1787. It is often performed at Christian churches during Holy Week, and consists of seven central movements, or "sonatas," each in a different key and each tied to one of the last sayings of Jesus Christ as reported in the gospels, as well as an introduction and concluding sonata. Sonata III, in the key of E Major, is titled "Mulier, ecce filius tuus," (translation: "Mother, behold your son") and bears a tempo marking of "Grave" (translation: "Slow").

Many musicians believe that the reduced string quartet version was not actually produced by Haydn himself, but rather one of his students, and they consider that version of the score to be deeply problematic, with voice-leading mistakes and awkward harmonies. The string quartet in this study therefore commissioned a composer to create another version for them that "fixes" some of the problems inherent in the famous Opus 51. It is that version that they rehearse and perform, and that version that this case study examines.

The great majority of the group's rehearsal time was spent on two segments of the score: the beginning (measures 1-20) and a selection at the end (measures 87-113). The

two segments that comprise the bulk of the group's investigation are shown in Figures 9 and 10.

Segment A

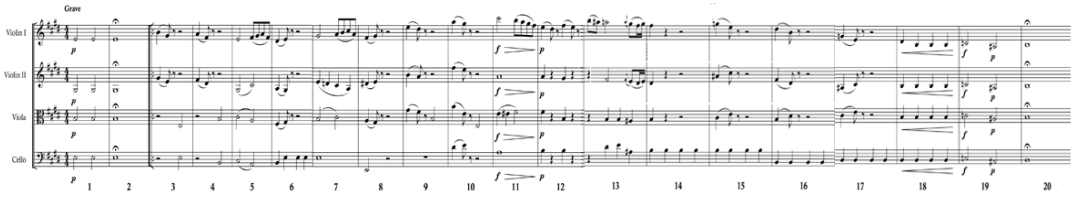

Figure 9: Segment A, or measures 1-14 of score

In this segment, the piece begins with a sustained E major chord, repeated three times slowly with the third chord held indefinitely in a fermata. Time, thus stopped, starts again in bar 3, which is arguably the start of the sonata proper, as the main thematic motive of a falling third establishes the rhythm that will prevail for the rest of the piece.

Segment B

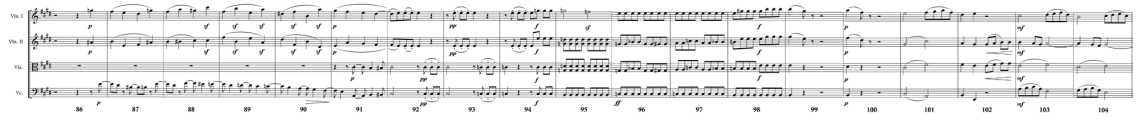

Figure 10. Segment B, or measures 86-104

Segment B occurs well into the development, at the onset of a new rhythmic relationship between the two violins, in rhythmic unison but with varying chromatic slides and leaps, against the cello, who is offset against them by one eighth note, creating a syncopated rhythm that pushes the chromatic harmonic motion further and further until, in bar 92, it comes to rest in C# minor. The upper and lower instruments then trade motifs until the segment's climax, at bar 95, which is the start of a long cadence that arrives,

finally, at the recapitulation of the main falling-third theme in bar 99.

4.2 Data overview

The video data for this case includes three rehearsals and the corresponding Performance, as well as three post-rehearsal interviews and one video-assisted group interview. I also collected annotated parts after each rehearsal.

4.3 Case Timeline

Rehearsal 1

On this date, the group got together to do an initial run-through of the piece. Three members of the group had played the piece together multiple times, and in multiple formats; the newest member had not played it with this group before. They played each movement once, from start to finish.

Before beginning Sonata III, the group briefly discussed the English translations of the names of each movement, along with their feelings about abstracting the religious nature of the piece. The three senior members of the group explained to the first violinist that they normally do the first two bars "out of time," and then come back into tempo for bar three. After a brief discussion of the possibility of baroque tuning, they set the tempo and began the run-through:

V2: yeah. but we'll, so, what was the main tempo?

V2: (singing) durrrr, durrrr, (conducting, snapping) burrr, durrrr. Something like that?

Vla: (singing, conducting) maybe just slightly just slower than that?

<Full Run Through of Sonata III>

Once the run was completed, members of the group made a few self-evaluative comments before moving on to the next Sonata:

V2: sorry {I played} flat a bunch of times in the opening

V1: ah me too

Vla: this one's tough for tuning

V2: it didn't go too bad for the first time.

Vla: no, not at all.

Vlc: sorry {I kinda} pushed a little too hard there at 97 and 8

V2: (looking at music, singing to himself)

Vlc: ah, it was too loud at {102}

V2: and just one thing I wanted to point to you, is, is like, a rhythmic thing that, it's like intuitive the way you did it, but it's... or maybe…hmm. (singing) yaa dadeedada yaaa, dada- oh, just, (pointing to his own part) you.. did those as 16th notes everywhere so I just wanted to /point that out

V1: /right (annotating)

Vla: more?

Vlc: yeah

Vla: mulier

V2: we're gonna sort it.

Vla: yeah, absolutely.

<rehearsal moves to another piece>

Rehearsal 2

On this date, the group got together to work more in-depth on individual movements. Rather than planning which sonatas to work on in advance, they have a practice of deciding in the moment what to work on. After some discussion, they chose to work on Sonata 3 on this date because of its intonation challenges. After deciding which sonata to do, there was a brief discussion about the first violinist's part, which had been given to her by the previous first violinist:

Vla: there are zero key areas in that part?

V1: (shakes head) no. I mean, "yes, there are zero key areas."

V2: I actually didn't write in that many either cause I just, I remember what they are

Vla: so, E major, B string is based around E string, as per us(ual)

The group then began to play, getting only through one measure before stopping to tune the opening chord. The rest of the rehearsal consisted of extremely small chunks of playing, alternating with "tuning sessions," where a single player would hold a note and the other players would tune to that note, listening and adjusting.

Table 1 represents an overview of the session. There are three types of activities: playing, tuning, and talking. Tuning consisted either of multiple players holding long notes simultaneously, while one player adjusted their pitch or the pegs of their instrument, or of a single player playing multiple notes on their instrument simultaneously, and adjusting the instrument. Each box in Table 1 represents a shift in the

type of activity. Segments of talk are summarized by content (e.g., "intonation talk" or "deciding what to do next." As this is an overview designed to give a general sense of the rehearsal process, talk segments are marked only when talk extended past a single sentence (e.g., "can we tune measure 10?" followed by a tuning segment is marked below as a tuning segment, rather than a talk and tuning segment).

Table 1: Overview of Rehearsal 2

Play M1	tune	Play M1	Tune M1	Play M1-8 (Take A2)	Talk: decide to play bland, without expression, at tempo	Play M1-8 (Take A3)	Tune M7	Play M7-8 (Take A4)	Play M8 (Take A5)	Talk about next step
Play mm 3-10 (Take A6)	Talk about next step	Play mm 3-12 (Take A7)	Tune mm 10	Discuss intonation	Tune mm 10	Talk about next step	Play mm 3-6 (Take A8)	Talk about intonation	Play mm 3-5 (Take A9)	Play mm 3-6 (Take A10)
Tune mm 5	Slow play/ tune mm 5	Annotations and discussion about annotating intonation	Play mm 3-14 (Take A11)	Play mm 11-12 (no V1) (Take A12)	Play mm 11 (no V1) (Take A13)	Slow play mm 11-14 (Take A14)	In-depth intonation discussion	Play mm 11-14 (no V1) (Take A15)	Play mm 13-14 (no V1) (Take A16)	
In-depth intonation discussion	Play mm 11-16 (no V1) (Take A17)	Play mm 11 (no V1)	Evaluative discussion	Intonation Discussion	Play mm 11-15 (Take A18)	Tune to V1 E string	Intonation Discussion			
Play mm 13 with cello pedal (Take 19)	Intonation discussion	Play mm 13 with cello pedal (Take 20)	Intonation discussion	Viola jokes	Discuss what to do	Play mm 11-20 (Take A21)	Discuss what to do			
Tune to viola	Play mm 1-20 (Take A22)	Play mm 18-19, evaluate	Play mm 18-20	Discuss what to do/ intonation	Play mm 1-3 (Take A23)					
Tune mm 1	Play mm 1 (abort)	Play mm 1-5 slowly (Take A24)	Discuss what to do/ problem solving	Play mm 1-6 (Take A25)	Tune mm 6 downbeat	Rehearsal end				

Rehearsal 3

At this rehearsal, the group started with a run-through of the piece. They then had an extended discussion for about ten minutes regarding metaphors, intonation, and bowing strategies in various sections of the piece, before beginning rehearsal on the second half of the sonata. Table 2 shows an overview of rehearsal 3:

Table 2: Overview of Rehearsal 3

Play mm 59-110 (Take B02)	Evaluation, long discussion of balance/ metaphor/ meaning/ planning	Play mm 87-104 (Take B03)	Discussion of part interaction, metaphor, strategy, meaning behind dynamics	Brief break	
Play mm 87-93 (Take B04)	Bowing discussion and annotations	Play mm 87-88 (violins only) (Take B05)	Play mm 87-92 (violins only) (Take B06)	Metaphorical discussion of sound quality	Play 87-92 (violins only, no sforzandos) (Take B07)	Play mm 87-92 (Take B08)
Bowing discussion and annotation (violins)	Play mm 87-93 (violins only) (Take B09)	Bowing discussion and annotations	Play mm 87-113 (all players) (Take B10)	Discussion, evaluation, annotations	Play mm 87-end (Take B11)
Discussion, evaluation, planning	Metaphorical score analysis	Jokes	Play mm 99-103 (Take B12)	Discussion, evaluation, metaphorical score analysis	
Play end of previous Sonata, mimic interstitial speech, play mm 1-20 (Take A26)	Discussion, evaluation	Play mm 1-3 (Take A27)	Discussion, problem solving	Play mm 3 (Abort)	Play mm 3-6 (vlns only) (Take A28)
Bowing discussion, problem solving	Play mm 3-4 (vlns only) (Take A29)	Discussion, metaphorical bowing analysis	Play mm 3-4 (vlns only) Take A30)	Play mm 3-6 (vlns only) (Take A31)	Play mm 1-58 (all) (Take A32)	Discuss, rehearsal ends

4.4 Rehearsal Map

Combining the takes from the case timeline with the score yields a map of the group's rehearsal process in the two in-depth rehearsals they conducted. Figure 11A, shown in Appendix G, shows the distribution of takes across the score for the second rehearsal. Figures 12A and 12B (shown in Appendix H) show the take distribution for the third rehearsal. Each take is marked by a red line that aligns it with the music it covered. Takes that cover some part of mm1-14 are marked as A takes. Takes that cover some part of measures 96-114 are marked as B takes. Takes outside of the scope of these segments are noted but not assigned a take number.

As these maps make clear, the group rehearsed certain sections much more than others, and seemed to follow a pattern of "zooming in" on smaller sections before playing longer segments that included those sections. For example, Takes A6-A11 focus on the musical material between measures 3 and 6. In take A6, the group played from measures 3-12. They then ran a much smaller segment, from m3-m6, several times before running the slightly larger segment again. The group's overwhelming focus on measures 1-14 and 86-114 drove the selection of these segments for analysis.

The following chapter analyzes talk, annotations, and gestures that occurred across these three rehearsals. The analysis focuses on the two sections, identified as Segment A (Figure 9) and Segment B (Figure 10), that the quartet focused on during the majority of their rehearsal time on this piece. Rehearsed takes of segment A are numbered A1 through A33. Rehearsed takes of segment B are numbered B1 through B13.

5. ANALYSIS AND FINDINGS

This chapter is divided into three main sections that track conceptual change across the three modes of this study: Rehearsal Talk, Written Representations, and Group Expressive Musical Gestures. The section concludes with a summary of the findings.

5.1 Rehearsal Talk

Over the course of three rehearsals, the content of musician talk changed around repeated enactments of the piece. In general, rehearsal talk in this group started with ideas about tempi and togetherness, centered for a long time around intonation, and began to get more conceptual and metaphorical as rehearsals went on. This progression is consistent with the construction of an increasingly rich conceptual model of the piece. Table 3 tracks the numbers of utterances of each types in each rehearsal:

Table 3: Types of utterances in each rehearsal

Rehearsal	Deciding where to rehearse next	Intonation -centered talk	Rhythm-centered talk	Metaphor-centered or descriptive talk	Other (balance, dynamics, bowings)
1	0	6	13	0	1
2	57	82	15	5	8
3	46	10	28	66	35

The first rehearsal contained the least amount of total talk, with twice as many rhythm-centered utterances as intonation-centered utterances, and no metaphoric talk at all. There were increases in all three types of talk in the second rehearsal, but the rehearsal overall was overwhelmingly centered around tuning and intonation. In the final rehearsal, the majority of utterances were metaphorical, in a stark departure from the first two rehearsals. Section 1.1 analyzes rhythm-centered utterances, section 1.2 tracks

intonation-centered utterances, and Section 1.3 analyzes metaphor-centered talk. The section concludes with a summary of the ways that between-take rehearsal talk changed over the course of the cycle.

5.1.1 Rhythm-centered utterances

There were 13 rhythm-centered utterances (out of 21 total utterances) in rehearsal one, 15 (out of 162 total utterances) in rehearsal two, and 28 (out of 185 total utterances) in rehearsal three. This means that while 61.9% of the group's coded talk was rhythm-based in the first rehearsal, the percentage went down to 9.2% in the second rehearsal, and 15.1% in the third.

The first rehearsal consisted of a run-through with brief pre- and post-playing discussions. It therefore had the fewest utterances of any rehearsal, with mostly rhythm-centered exchangers to set tempi, as in this brief exchange preceding the run-through:

V2: yeah. but we'll, so, what was the main tempo?
durrrr, durrrr, (conducting, snapping) burrr,
durrrr. Something like that?

Vla: (singing, conducting) ladadeedadaaaa, daaa….
maybe just slightly just slower than that?

These utterances could contain references to tempo, "pushing" or "waiting," or gestures, singing, and snapping. While the rhythm-centered talk in the first rehearsal appeared to have an orienting function globally - that is, the players were deciding on overall tempi for the piece – rhythm-centered utterances in later rehearsals worked slightly differently. In the second rehearsal, for example, rhythm-centered utterances were either requests for slow practice of specific sections, or other types of requests:

V2: can we be a little more, like, easygoing with the time? I feel like I'm like waiting for things and that makes it really hard to feel like I'm (gesturing)

The rhythm-centered utterances in the third rehearsal were more evaluative, and centered around more specific segments of music. For example:

V1: I also, like, did kind of a thing getting into 95, that I don't think really worked this time. Like I tried to put a little bit of time there so that, like, the tempo doesn't feel like it really goes until like 95 and I don't think it

Vlc: didn't work

V2: didn't bother me. I thought it was/ a good idea

Vlc: /it could certainly work. like

V1: it was too much I think

Rhythm-centered utterances had multiple functions, from task-orientation ("so what's the tempo") to more interpretive requests and evaluations. Although the request to be easygoing with the time by the 2nd violin in the second rehearsal seems, on the surface, similar to V1's comment about adding time in rehearsal three, the subject of V2's comment is the ensemble playing and his ability to fit into the group, and the subject of the later discussion is the group's interpretation of the flow of time at measure 96. This indicates that the overall function of rehearsal talk changed over time, from a focus on coordination in early rehearsals to a focus on interpretation in later rehearsals.

5.1.2 Intonation-centered utterances

There were six intonation-centered utterances (out of 21 total) in the first rehearsal, 82 (out of 162) in the second rehearsal, and 10 (out of 185) in the third. The percentages of intonation-centered talk in each rehearsal were 28.5, 50.6, and 5.4, respectively. Intonation-centered talk in the first rehearsal consisted solely of evaluative comments after the run. However, the second rehearsal focused much more on intonation, with a wider variety of intonation-centered utterances.

In that second rehearsal, the majority of talk centered around intonation, with talk around deciding the next rehearsal segment coming in second place with 57 utterances. Utterances classified as intonation-centered either involved the relevant overtone series for certain key areas (and therefore involved some level of theoretical analysis of the score) or centered around an individual "finding" their place in a chord. When speaking in this way, musicians tended to classify pitch in terms of location on a spectrum or map, with phrases like "where [is it]" or "I'm not finding it." Consider this fragment of a rehearsal transcript:

Vla: (to V1) sorry, could I, could I get it without
you once, just to make sure I know where it is?

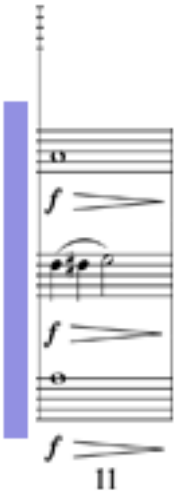

Figure 13. Measure 11, Take A13, Rehearsal 2: three-person GEMG precedes start of measure

`V2: weird`

Here, the antecedent of "it" is the violist's F# pitch in measure 11, just before take A13 in the second rehearsal. He asks to play the segment without the violinist, who also has a F#, to make sure that he is placing his own pitch correctly. The question is not where a theoretical F# is on an abstract scale, or what the fingering is for a F# on a viola, but where *this* F# is/will be relative to the other players' pitches when they simultaneously play bar 11. The use of the static present tense "is" to refer to this kind of pitch relationship assumes that these relationships will be the same each time the group plays this bar. By asking the other players to play the bar without him, the violist establishes that those players *create* a specific "place" for the F#, regardless of whether that pitch sounds or not. The F# must relate both to the pitches before and after it, and the pitches sounding simultaneously with it. The violist here is thus not only working out

logistics of his performance, but also making explicit an emerging conception of the musical passage through verbal negotiation with the group.

Intonation-centered utterances in the third rehearsal, like rhythm-centered utterances, were more evaluative and interpretive:

> V2: and, one way we did it before, I'm not a hundred percent sure, I think it still makes sense, um, C, we've been keeping that E as it was, the E string E, you know, the Major E, through 93 and then we thought of it as a modulation into C major when they played the C, and lowered the E in 94 to be in tune with the C. And you did it with me that time, I don't know if you liked it or not.

While conversations about "finding it" centered around the need for the ensemble to play in tune with each other, the second violinist's third-rehearsal intonation comment above highlights the interpretive possibilities of intonation: the group chooses to "think of it" as a modulation into C major, meaning that the pitch of the violin E in measure 94 was different than the pitch of that same note in measure 93. They could also have chosen not to "think of it" as a modulation, keeping the two Es the same.

5.1.3 Metaphor-centered utterances

Metaphor-centered utterances showed the starkest shift in numbers across rehearsals: there were none in the first rehearsal, five (out of 162 total) in the second rehearsal, and 66 out of 185 in the third. Metaphoric talk constituted 0%, 3%, and 35.6%

of the 1st, 2nd, and 3rd rehearsals, respectively.

The vast majority of metaphor-centered utterances occurred in the third rehearsal. These utterances made up the bulk of between-take talk for that rehearsal, whereas they had been in short supply in the second rehearsal and nonexistent in the first. In the third rehearsal, metaphors were used freely, as in the following exchange:

> Vlc: /before it, and then all of a sudden, C Major. And I think that that shift around your E natural
>
> V1: mhmm
>
> Vlc: is, um, is a striking color change. And to me the change is one that is, um, ...it's somehow, um, ... I don't know if I can put my words to it. Anybody else have any thoughts?
>
> V2: I feel {that right now the music is} getting, like, right. Super blissed out or something for a second. Right? And then, kinda like regai- like suddenly things go kind of like, "oh" (gestures) and then it kinda like regains its focus or something.

The cellist starts with intonation-centered talk ("that shift around your E natural") that then moves quickly into more semantic territory. The key shift is described as "a striking color change," which is in itself a metaphor (keys are not colors). The cellist opens up the discussion to other descriptions, and V2 meets the request by characterizing the key shift/ color change as a place where the music moves from "super blissed out" to

"regain[ing] its focus." This metaphoric language centers less on issues of placement (where does this pitch go?) and more on defining either end of a trajectory (what set of concepts is this music moving from, and what set of concepts is it moving towards?). Whereas in the previous, intonation-centered example, the players identified with pitches which they needed to "find" or "place" in a shifting landscape of pitch centers and key areas, the subject of these metaphorical discussions zooms outward to be, not a single musical element, but the music itself.

Summary: Between-Take Talk as a Medium of Group Learning

The changing distributions of rhythm-centered, intonation-centered, and metaphor-centered talk in these three rehearsals outline a clear trajectory from rhythm to intonation to metaphorical concerns. Additionally, a similar trajectory, from a focus on coordination to a focus on interpretation, can be seen in deepening subject matter in rhythm-centered, intonation-centered, and metaphor-centered talk both within and across rehearsals. Sections 2 and 3 will show that this trajectory mirrors the change in GEMGs, which centered around barlines in the first rehearsal and reflected a metaphorical conception in the final Performance, and annotations, which expanded from tempo markings and bowings in the first rehearsal to pictoral and written metaphors (e.g. squiggly rising lines, "warm and loving" (an annotation that originated as a written reflection of a spoken statement) at the end of the third rehearsal.

5.2 Written Representations

Analysis of changing rehearsal talk is one way to represent a group's changing conception of a piece of music over time; annotations created by the group as they

rehearse constitute a parallel representational trajectory that can also be analyzed on a per-take basis. The evolution of annotations over time followed a similar pattern to the evolutions of rehearsal talk patterns, as more metaphor-based annotations occurred in later rehearsals. Section 2.1 analyzes the development of annotations in measures 1-6 over the course of three rehearsals. Section 2.2 zooms in on the generation of one particularly idiosyncratic annotation. The section ends with a discussion of the role of annotation as a medium for group learning.

5.2.1 Annotations elaborate musical context in measures 1-6

Written parts changed slowly over time, but they did change as the group negotiated various parameters of interpretation, intonation, and balance. Before this rehearsal cycle began, the musicians' parts already had markings in them: bowings, tempi, key areas, and some interpretive markings carried over from previous Performances of the piece, which had featured a different first violinist. Even among players who had previously performed the piece, new annotations emerged.

Figure 14 shows three iterations of the same six measure segment as the first violinist and violist annotated their parts. Each successive set of annotations is highlighted in a new color:

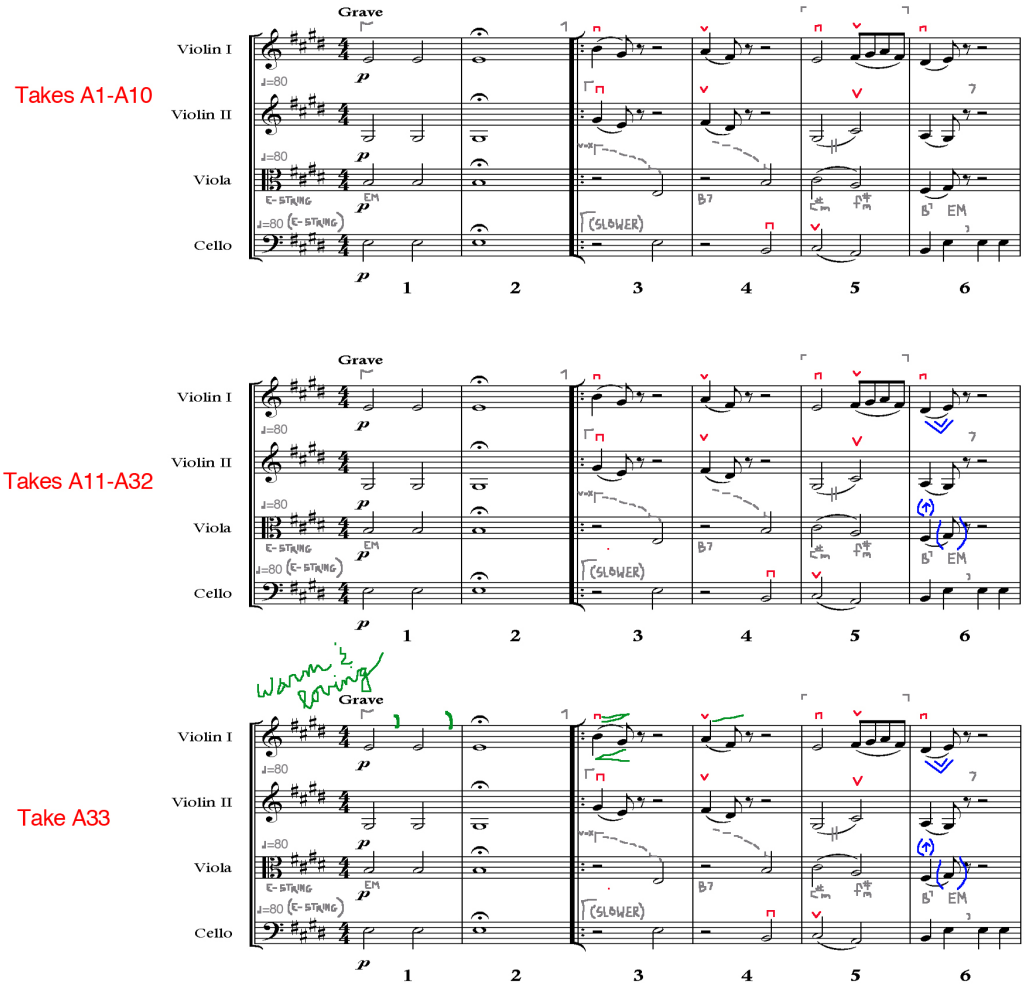

Figure 14. Annotations in Segment A over three rehearsals

Each successive set of annotations enriches the musical context for the pitch and rhythm information contained in each part. The key areas marked in the viola part give contextual information for each pitch, allowing the violist to place that pitch appropriately for each chord (e.g. slightly flat for a 3rd or 7th scale degree, perfectly in tune for a unison or 5th). Between takes A10 and A11, the group discussed the need for the violin's D# in measure 6 to be lower (see section 2.4.1). This resulted in a "wide half

step" marking in the violin part (a non-standard annotation, seen below in Figure 16, or in the V1 part of measure 6 in the second and third rows of Figure 14), as well as an up arrow in parentheses in the viola part in the same rows, indicating the viola's willingness to raise his part of the chord relative to the first violin so that the interval is smaller, regardless of whether she sounds lower or he sounds higher.

The markings in both parts are relative to different parameters: the first violin's "wide half step" places the two notes in relation to each other, while not illuminating which of the two is stable, pitch wise, relative to the music around it. Meanwhile, the violist's upward arrow is surrounded by parentheses, which may be musician code for "maybe" – a conditional warning sign that allows the violist to know what kind of pitch correction he is likely to need to make.

Additionally, the viola marked parentheses around the final note of the phrase after deciding to "be less" relative to the second violin:

V2: which one of us should make sure to be less
because we're like hanging out doubling 3rd notes
in a weird way

Vla: I'm going from the 7th {...} while you're
following the shape of the first violin ANNOTATES

V2: yep

Vla: so I'll, I'll be less.

V2: okay

This parenthesis has a different meaning than the one above; rather than marking

a conditional, it is a mark of erasure, indicating that the final note is a mere echo of the "real" pitch being played by the second violin.

In annotation set three, the violinists have come to a shared interpretation of the opening phrase: they have an agreed-upon tempo range, the violinists share "open" bowstrokes in the opening falling third theme in measure 4, and the falling third in the violins "passes off" the melody line to the lower strings in the second half of the bar. V1's addition of long, upward trending lines over the quarter-note pairs in bar 3 indicate this elongation of each phrase; the crescendo marking below the B-G in bar 3 likely means not a literal crescendo, but a cancellation of the violinist's previous tendency to diminuendo.

Taken together, annotations found in the violin and viola parts in later versions give increasingly explicit information regarding intonation relative to the group. Additionally, the dotted line in measure 5 in the viola part, annotated for a previous Performance but still in play for this one, indicates an extended musical metaphor much richer than the information contained in the original printed score, which says merely to rest for two beats and then play a half note; the dotted line evokes the concept of "passing" a sound from one part to another, and the directionality of the line evokes floating.

Annotations by individual group members ranged from conventional (bow markings, dynamics) to unconventional (invented symbols for a "wide half step," dotted lines symbolizing a conceptual "falling" metaphor, the first violinist's language of "warm and loving" at the beginning of the piece. Each of these annotations was made in an individual part, but in all cases, these annotations reflect broader-scale information about

what is going on musically in the group as a whole.

Bow markings reflect shared decisions that were tried and evaluated as a group; the "wide half step" marking marks an attempt to negotiate the changing pitch centers caused by the group's just-intonation traversal of a chord progression that moves continually from tonic to dominant tonal areas. The violist's dotted line situates the half notes in measures 4 and 5 in relation to the falling quarter note motif in the violins that precedes those half notes; the violinist's note of "warm and loving," added midway through the rehearsal process, reflects a group understanding of this sonata as "warm and loving," in terms of Christ's relationship with his mother, in relation to the other sonatas in this large work, which connote other emotions.

By tracking the evolution of these annotations over time in the crucial first six measures of this Sonata, we see annotation as a medium in which individual sense-making interacts with the negotiation of a group understanding of a musical passage. As in rehearsal talk, annotations shifted in from intonation-centered in Takes 1-22 (arrows and half-step markings) to more phrase-based (squiggly lines in V1 part) and metaphor-centered ("warm and loving") in Takes 32-33.

5.2.2 An invented annotation fails as a learning mechanism

The annotations that players used to construct and document their changing plans for execution of their parts varied in terms of conventionality. While markings for upbows and downbows are a matter of strict convention, dynamic, timbral, and text-based markings tended towards more individualized meanings. For example, in the second rehearsal, V1 attempted to invent a new annotation when she could not think of a conventional way to write down a piece of new information. Figure 15 shows the initial

form of this marking (reproduced from half-erased markings on her part), while Figure 16 shows its final form:

V1: what would be the symbol for like a wide half step. Or a narrow half step.

V2: you could do, (gestures) so you draw the half step thing and one could be a slash though it and the other one could be like a half step thing with like a circle or a half circle around it?

V1: hm

Vla: you're talking about a stacked half step, or (gesturing) ... like a vertical half step or a, uh, a C? horizontal half step?

V1: (nodding) mhmm

Vla: a double line for a big one and a single line (gesturing)

V1: ah, good one, good one. I like that better. ANNOTATES

Figure 15. V1's initial attempt at an annotation for a "wide half-step" in measure 6 (see Figure 14 for context).

V2: the oold double stack. (chuckling) to me that looks like just some kind of hilarious accent though. I would, I'd be like (plays sharp accent)

V1: yeah, actually it'd be better.. do you have an eraser?

Vla: here

V1: ANNOTATES

Figure 16. V1's final attempt at an annotation for a "wide half-step" in measure 6 (see Figure 14 for context).

Here, the violinist invents a notation that attempts to convey the increased distance between two pitches required to play in "just" intonation in the key of E Major, where the D# (the 7th scale degree) is lower than normal. Her initial attempt (Fig. 15) looks too much like the conventional notation for an emphasis marking, so she erases it and flips the direction of the notation (Fig. 16).

In fact, there is a way to annotate this part using more conventional notation that will achieve the same result: inserting a downward pointing arrow over the D# would indicate that the D# should be played lower in pitch, thus increasing the distance between the two pitches. However, the violinist's focus on the interval between her own two pitches, rather than each pitch's relationship to the group's center as a whole, may have caused her to invent a notation that attempted to reflect that relationship.

In a later, video-assisted interview, V1 was initially unable to interpret this marking. After re-watching the video and discussing the different kind of half step

markings possible, she speculates that the mark has a highlighting function:

V2: you wanted it wider, right?

V1: ahhhh, that's what we were talking about

V2: yeah

V1: that's probably why I did a double line. But I've never used that again before or -- like, before or since. (laughter)

V1: like, like the reason that I /

V2: /{welp} experiment left in the dust. (laughter)

V1: like, I mean-- no, I mean, it's so slow, it's not a place where I'd forget that I have a half step. You know what I mean? Like the only reason that I would use that to, like, remind myself to pay attention to it

Vlc: cause that's a special kinda half step

V1: right. it's just a special half step and like, ... I, I think I usually use it to mean that it's a smaller one.

researcher: yeah. and that's why/

V1: /so that's, I was like, (dramatically) "hhhow do I do this"

Vla: I guess the way more typically that we've done that is just like, if that... D# is gonna be

closer to the E we would use an arrow of some kind above the D sharp to show that it's tighter.

researcher: yeah.

Vla: that'd be the kind of more normal way I think we would normally do that (laughter)

In this interview, which takes place three months after the Performance of this piece, V1 is initially unable to recognize her marking and points to "drawing attention to it" as a reason for the annotation of something so slow. The group's inability to recognize the marking points to the marking's failure as an annotative innovation. If the annotation had been successful, it would be recognizable out of context.

The violist's mention of the "more normal" way references a type of marking that would be instantly readable by most musicians. However, V1's attempt at this, and subsequent failure, points to a tension between horizontal relationships (between subsequent notes) and vertical relationships (between simultaneous notes). While the more "typical" annotation of an upward arrow over a note implies a relationship between simultaneous pitches, it makes invisible the intervals between pitches unfolding horizontally across time. The violinist's failure to innovate a new annotation norm points to the role of conventional annotations in the group's negotiation of a shared interpretation of musical passages – as a way to make more permanent decisions that have been negotiated. However, the above analysis shows that the violinist's invention of a new annotation might reflect the beginning of a shift in the group's focus of negotiation from intonation work to interpretive work.

Summary: Annotations as a Medium of Group Learning

Both between-take talk and between-take annotations served as modalities in which shared interpretations were introduced, made explicit for joint attention, and problematized for individuals in the group. However, both of these representational modalities were engaged only when the group was not actually playing, and marked opportunities for post-hoc reflection and future planning. In the following section, I examine the more fluid modality of expressive musical gestures as a parallel trajectory on which these interpretations were worked out and negotiated over each rehearsal take.

5.3 Group Expressive Musical Gestures (GEMGs)

While the representations and patterns of rehearsal talk changed relatively slowly, patterns of Group Expressive Musical Gestures (GEMGs) changed in visible ways from take to take, with slightly different patterns emerging every time the musicians performed a segment of music. Patterns of change in sequential GEMGs followed a similar trajectory to patterns of change in talk and annotations: early GEMGs were more centered around barlines between measures, suggesting a focus on rhythm/ temporal entrainment, while later GEMGs seemed to reflect more nuanced score analyses. Section 3.1 discusses larger patterns of GEMGS across rehearsals. Section 3.2 zooms in on the evolution of specific GEMGs, and ties them to talk and annotations that occurred around them.

5.3.1 GEMGs accumulate and expand with repetition over time

Segment A and Segment B were each played five times in their entirety. Table 4 and Table 5 track the number of GEMGs that occurred in each full take as well as the

number of measures of music that were covered by GEMGs for each full take, and the average length (in measures) of each GEMG. These have been calculated from more extensive GEMG graphs, which are shown in Figure 17 and Figure 18. Rehearsal take A1, for example, contained 14 GEMGs, averaging less than two beats in length, covering almost six measures in total (out of 14 measures, which is the length of the segment). In contrast, Take A26 (third full take) contained just 8 GEMGs but these were on average over twice as long, and covered more total measures of the segment than the first take had. This means that musicians' movements of the head and torso were entrained with each other for twice as much of the performed take, which contained the same music.

Note that only full segments are included here; between Take A1 (the first full take) and take A22 (the second full take), for example, the musicians rehearsed smaller portions of the segment 21 times.

Table 4: Number, Coverage, and Average Length of GEMGs in full Segment A Takes

Rehearsal	**Take**	**# of GEMGs**	**Measures covered**	**Avg GEMG length (in measures)**
1	A1	14	5.9	.42
2	A22	15	8.6	.57
3	A26	8	8.5	1.06
3	A32	9	8.2	.91
Performance	A33	22	14	.63

Table 5: Number, Coverage, and Average Length of GEMGs in full Segment B Takes

Rehearsal	**Take**	**# of GEMGs**	**Measures**	**Avg GEMG**

			covered	**length (in measures)**
1	B1	10	3.3	.33
3	B2	24	11.7	.48
3	B10	25	18.9	.756
3	B11	27	20.5	.75
Performance	B13	31	26.1	.83

The number, length, and overall coverage of GEMGs increased significantly between the first and final takes in both analyzed segments. Fourteen GEMGs covered 5.9 measures in A1, and 22 GEMGs covered 14 measures in A33 (Performance/fifth full take). Meanwhile, 10 GEMGs covered 3.3 measures in B1, while 31 GEMGs covered 26.1 measures in B13 (Performance/ fifth full take). While the number of GEMGs went down in middle takes, the total number of measures covered by GEMGs in each segment stayed steady or increased, suggesting that more frequent, smaller GEMGs in earlier takes expanded and melded into each other in later takes. This increase in entrainment between musicians' body movements may suggest a coming together of a shared gestural conception of the music.

Table 6 and Table 7 show that GEMGs were not only more frequent and of longer duration between the first and last takes, but also involved more participants:

Table 6: Number of players involved in Segment A GEMGs

Rehearsal	**Take**	**2 person GEM Gs**	**3 person GEMGs**	**4 person GEM Gs**
1	A1	12	2	1
2	A22	11	4	0
3	A26	6	1	1
3	A32	7	2	0
Performance	A33	11	7	4

Table 7: Number of players involved in Segment B GEMGs

Rehearsal	Original Take	2 person GEMGs	3 person GEMGs	4 person GEMGs
1	B1	7	3	0
3	B2	14	7	3
3	B10	17	7	1
3	B11	17	9	1
Performance	B13	21	6	4

In both segments, there was a significant increase in GEMGs that involved all four participants between the final rehearsal and the Performance. However, GEMGs did not expand gradually to more participants over time. For example, the Performance segment included more total GEMGs, more two-person GEMGs, and more four-person GEMGs than any previous take. Additionally, the three four-person GEMGs that occurred in take B2 decreased to a single four-person GEMG in the next full take of that segment (B10). Possible reasons for this decrease might be that the group deliberately disrupted an interpretation that had emerged through entrained body movements.

Graphing takes against each other in segment A and segment B shows gives a visual representation of changes in GEMG coverage (both participants and measures) over time:. In the graphs for both segments, there is a shift from short, sparse GEMGs in the first take to longer GEMGs in later takes. For example, in bars 9-11, a number of brief (<1 beat) two person GEMGs outline a series of congruencies around the barline:

Figure 17: GEMGs in all full A Segment Takes, with highlighted section showing measures 9-11, where take A1 GEMGs center around barlines, and take A33 GEMGs combined into a single, two bar motion

This graph only notes GEMGs rather than EMGs, so it gives no information as to the length of each person's individual gesture; however, in the final take, the separate GEMGs by V1 and V2 that emerged in earlier iterations of measures 9-11 have combined into one extended GEMG, where the two violins share an entrained trajectory over the course of three measures.

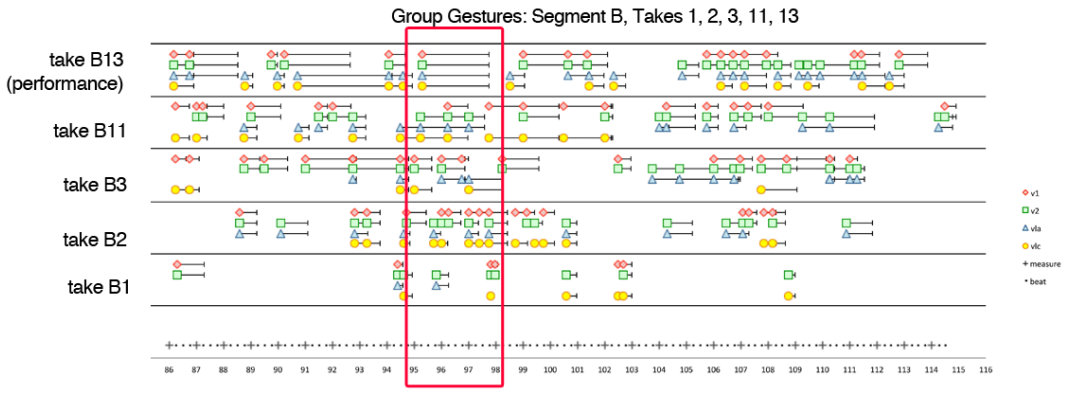

Figure 18: GEMGs in all full B segment Takes, with highlight showing measures 95-98, where brief GEMGs in B1 expand to longer, 4-person GEMG in B13

A similar pattern can be seen in bars 95-98. The number, but not the length, of GEMGs increases between takes one and two; between takes three and 11, these agglomerate into longer, multi-beat GEMGs. In the Performance, a single GEMG by all four performers covers the entire three-bar segment. Note that different types of group gestures emerge: takes 1-3 contain a variety of two-person GEMGs between violins, violin/viola, or violin/cello. The violin/viola GEMG in measure 96 stays consistently present, expanding in both length and participants, until it blends into the four-person extended GEMG in the Performance take.

These findings showed three ways that GEMGs expanded and accumulated across takes. (1) In the rehearsed segments, the number of measured "covered" by GEMGs increased across takes, with a significant jump in the Performance. (2) The number of GEMGs in which all four musicians participated increased across takes. (3) More frequent, separated GEMGs became subsumed into longer and more continuous GEMGs. These patterns suggest that entrained movement may have served as a mode of coordination, especially in earlier takes where smaller GEMGs around barlines may have

served as cues. Additionally, the expansion of GEMGs to cover longer segments of music suggests an embodied group understanding of the music that increased from take to take.

5.3.2 GEMGs as a medium for an emerging shared interpretation

Closer examination of the ways that GEMGs lined up with the score shows that the group's emerging joint understanding was not simply a matter of increased coordination, but that GEMGs were a medium for interpretive work. While the number, duration, and number of participants in GEMGs increased between the first run-through and the Performance, the increases were not linear from take to take. GEMGs emerged and disappeared between larger takes, as quartet members worked intensely on smaller segments of music. Additionally, the placement of those GEMGs changed significantly over time.

Cohering gestures in measures 1-6

For example, GEMGs in the initial run-through (Fig. 19) were smaller, more numerous, and, in several cases, ended at bar lines:

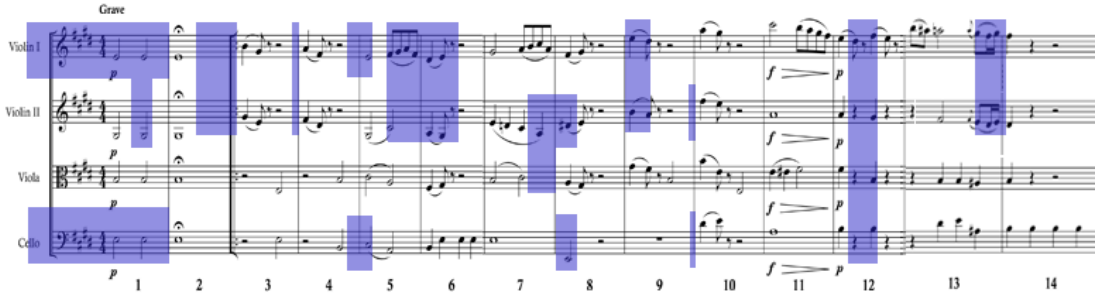

Figure 19: GEMGs in Take A1, Rehearsal 1

This convergence around metrical beats (e.g. GEMGs that ended on the downbeat of bars 2, 3, 4, 10, and 14) suggests either that GEMGs here might have been a scaffold

for temporal entrainment, as well as a reflection of the group's focus on staying together in tempo. As early as the start of the second rehearsal, GEMGs began to cover larger portions of music. Figure 20 shows GEMGs in the first take of the second rehearsal:

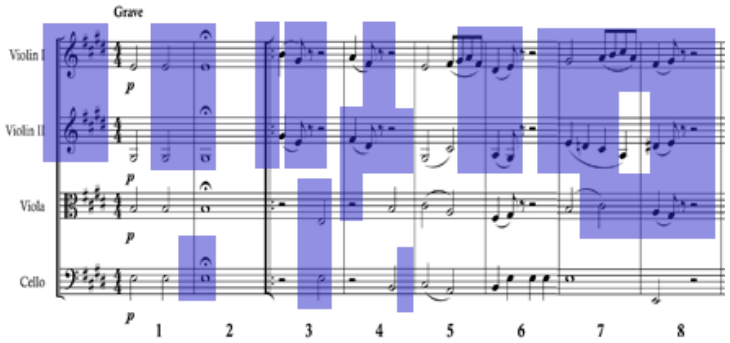

Figure 20: GEMGs in Take A2, Rehearsal 2

Here, the violin GEMG in bars 5-6 remains, but the figure immediately after it, in measures 7-8, has grown a new series of GEMGs between the violins and viola. This take constitutes the first enactment of music in the second rehearsal of this piece, before the group has verbally decided on a rehearsal strategy. Immediately after this take, the second violin asks for clarification on the focus of the rehearsal:

> V2: could we just do that beginning again? I just need a little clarity on what we're doing. Are we playing just for intonation, are we shaping some with vibrato, I'm just confused.

Here, the violinist acknowledges the lack of a preconceived plan for the initial take; his request for a more explicit rehearsal plan, along with the preponderance of GEMGs in the take before this statement, suggests that interpretive work was happening, albeit tacitly, through non-verbal modes. This interpretive work was not made explicit verbally; hence the violinist's request.

Later, after the group intensively drilled down into much smaller sections of the score over the course of the second rehearsal, GEMGs in the opening segment of music shifted beyond simple expansion, into what seemed to be a reflection of a coherent musical concept. Between takes A22 (2nd full A segment) and A26 (third full A segment), GEMGs cohered into a pattern that suggested a musical interpretation. Figures 21 and 22 show the difference in the GEMGs that occurred in these takes, which occurred weeks apart from one another (with three takes of smaller sub-segments taking place immediately after Take A22).

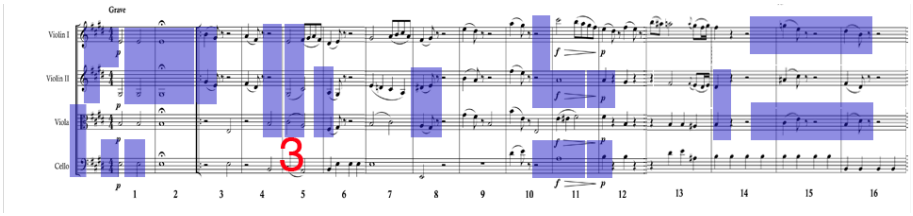

Figure 21. GEMGs in Take A22, Rehearsal 2

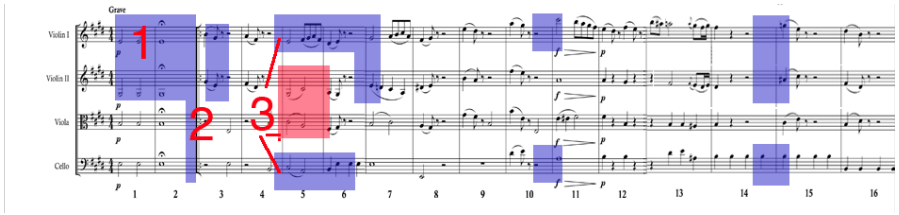

Figure 22. GEMGs in Take A26, Rehearsal 3 (three weeks later)

While there were more GEMGs in take A22 than Take A26, the GEMGs aligned with the score in A26 show a much clearer relationship to musical elements of the score. In Take A26, the violins share an extended GEMG that covers the entire "introductory" set of three E Major chords (number 1, Figure 22). A short GEMG shared by all four players before the onset of the theme in bar 3 indicates a rhythmic cue as the tempo is set for the main form of the sonata (number 2, Figure 22). Meanwhile, number 3 in Figures

21 and 22 shows a GEMG that was shared between the upper three voices in bars 5 and 6 has been split into two GEMGs that indicate separate "teams:" the inner voices (V2 and Vla), with slurred half notes over a large interval, form one pair while the outer voices (V1 and VLC) are similarly entrained, as each has a smaller slur from the initial half note, into material that drives the melody forward (in beats 3 and 4 of bar 5 for the violin, and in the continuing quarter notes of bar 6 for the cello).

Cohering gestures in measures 87-90

After playing through it in the additional run-through, the quartet did not revisit any part of Segment B until the third rehearsal, which was the last rehearsal before the Performance. During that rehearsal, they played music from Segment B a total of 11 times, focusing in particular on the 7-bar section between measures 86 and 93. This 7-bar section is characterized by rhythmic-unison quarter note slurs in the violins, offset by an offbeat counterpoint in the cello. The segment comes immediately after a grand pause, which, during the third rehearsal, the musicians characterized as "spacious," "plangent," "a moment to consider what is being said," and "room for the holy spirit."

Over the course of the third rehearsal, the group sometimes talked a lot between takes, and other times decides simply to "try again" without direction. Figure 23 shows the GEMG that emerged in take B3 between the first two violins. The text that follows details the type of work that took place between Take B3, which contains only a single GEMG at the start of the bar, and Take B9 (Figure 24), where GEMGs have significantly expanded to cover the majority of the passage.

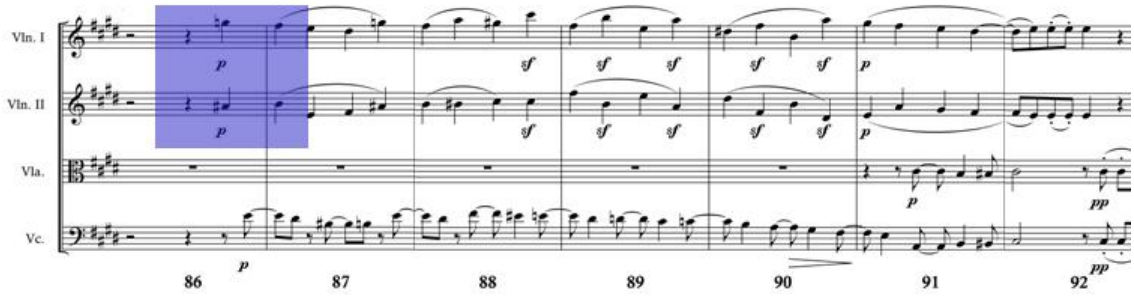

Figure 23. GEMGs in Take B1

Between takes B3 and B4, the group's evaluative comments conflate sound producing motions, conceptual metaphors, musical gestures, and sonic output:

V2: how'd you feel about, ah, the phrase at 87 that time?

V1: I felt good about it. Oh, 87. Do you mind if we do that again actually?

Vla: do you mind if I make one comment about that? ... um, just because this part is so rhythmic, I just wonder if, like, without changing the articulation or anything, if the beginning of each of your guys notes as you go down could get, not {..} but just a little bit more focused so that we hear that (gesturing) back and forth a little bit more?

V1: yeah. I think (gesturing) the tone is a little bit too forced from both of us

V2: yeah yeah we're a little too, like, slowbow
(gesturing)

V1: it's big sforzandos yeah

The two violinists then rehearse this segment by themselves several times. After take B8, the violinists mark bowings that they like and agree to try one more time:

V1: ANNOTATES okay. I'm gonna try something else.

V2: sweet. Should I know about it ahead of time?

V1: no. (laughter) no, I don't think so.

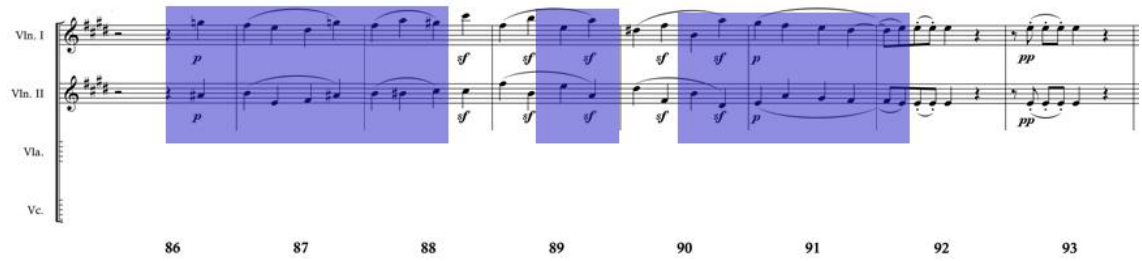

Figure 24. GEMGs in Take B9 (violins only, no lower strings playing)

Vlc: it had more of a soaring feeling.

V2: is it alright that we don't match?

V1: I think it's kinda nice actually. I think it/

Vlc: /buuuttt I would, I would, (moves) I think that you should match. but/

In take B9 (Figure 24), three GEMGs appear that cover much more of the score segment than has previously occurred. The group evaluates this performance much more positively, and while the group rehearses two more times in order to match bowings, the extended GEMG remains in the final Performance:

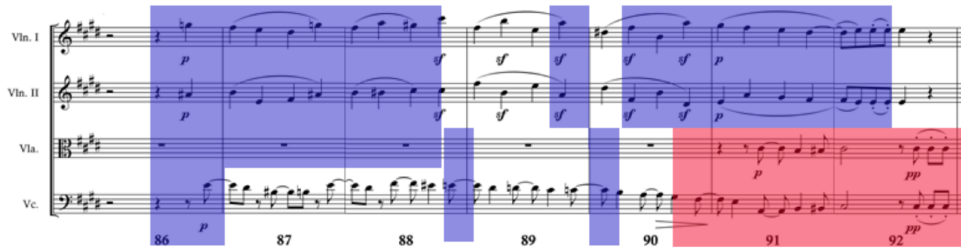

Figure 25. GEMGs in Take B13 (Performance)

In the final Performance, the GEMGs reflect a coherent interpretation of the score: the group moves together at the start of the segment, regardless of whether they have notes to play or not. At the start of measure 87, Figure 25 shows that the cello leaves the group gesture as his musical materials oppose the shared violin line. The violins, meanwhile, continue to gesture together. The viola moves with the violins for the first three bars even though he has no music to play; his movements join the cello movements half a measure before he plays in rhythmic unison with the cello. The GEMGs then show two separate "teams" starting just before measure91, as the viola joins the cello in rhythmic unison on the offbeats of the violin line (marked in red in Figure 25). Over the course of 11 takes, the group's GEMGs in this passage grow from a single orienting GEMG at the beginning of the new material (bar 86) to a coherent interpretation of a musical phrase. Figure 26 shows this progression, by aligning gesture maps of measures 86-93 from all five full B segments.

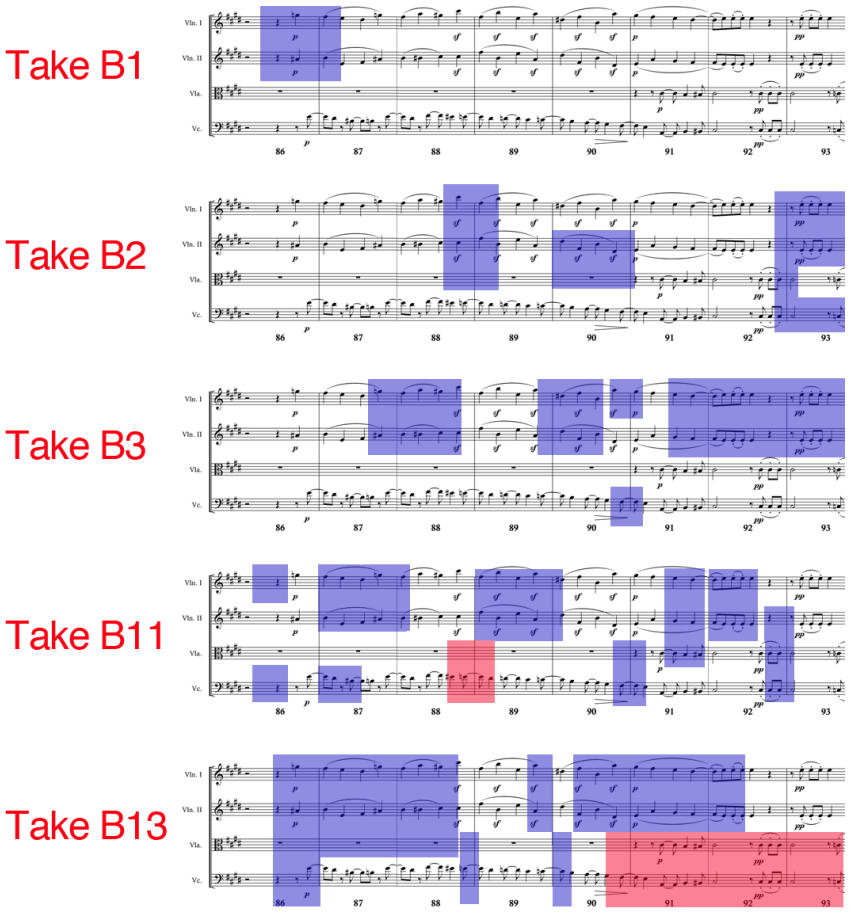

Figure 26. GEMGs in all full B takes, aligned next to each other.

In focused detail work between the two violins, as well as in whole group enactments of the piece, the gesture space functioned as a medium for emerging shared interpretation, working in concert with, but not dependent on, other modes of interpretation such as annotation and talk. The analyses of GEMGS in alignment with score elements in this section show that the gesture space was a site not simply of increasing cohesion, but of successful group interpretation of structural score elements over time.

5.3.3 Disruption and re-assembly of GEMGs

The presence of a GEMG in a musical take did not always correspond to a satisfactory performance. In several cases, the group arrived at a shared gestural interpretation that was deemed sonically unsatisfactory. Sometimes in these cases, a GEMG that had emerged was subsequently disrupted in rehearsal when musicians agreed to try something different, or when a part was annotated, changing the written representation of a segment of music. Often, a musician's statement of intent to change something about their part – whether verbally or in writing - would immediately precede the disappearance of a GEMG in that segment, which would then re-appear in changed form in subsequent run-throughs.

Interpretive work disrupts a GEMG in measures 3-5

Figure 27 shows the violin GEMG that emerged in take A29 after the cellist suggests that the violinists think about "releasing with the same type of gesture." In this context, physical gestures and score-implied musical gestures may in fact be conflated. Regardless, after the violinists agree to "release with the same type of gesture," a GEMG emerges across the full take. Although the violinists arrived at a shared interpretation of that segment in that take, the cellist evaluated that shared interpretation as needing work. Figure 28 shows the much smaller GEMG that occurred in the next take, after the group had the following evaluative discussion:

Vlc: see the, the second [falling third] seems more unified to me. Like, the first one, it seems like, the first one's open (SINGS) (moves hands

apart from each other) and then it gets like (moves hands together in shutting motion}

PLAYING - V1, V2

Vlc: so I, I feel like it's too much -- personally, I feel like it's too differential between, like, three quarters of the bow and like smaller upbow on the last note. I would even let it out just a bit more.

After this comment, the violinists attempted the phrase again, with a different bow distribution, and the GEMG in measure 3 became much smaller. In Fig. 29 below, contrast Take A30 with the fuller GEMG both immediately preceding and following it.

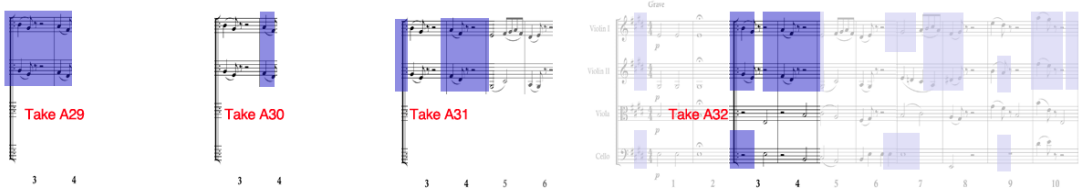

Figure 27. GEMGs in Takes A29-A30. Discussion about shared interpretation occurs between Takes A29 and A30.

In doing the interpretive work to get a bow distribution and action sequence that was musically satisfying, the violinists disrupted and then slowly reassembled the GEMG that first appeared after their discussion about the need to think gesturally (Fig. 27). This GEMG slowly reemerged, becoming fuller in Take 32 and finally becoming a 3-person GEMG in the Performance take (see figure 37).

Tuning work disrupts a GEMG in measures 4-6

Earlier in the rehearsal process, this same passage posed intonation problems for

the group. In Take A8 (Fig. 28), an extended GEMG emerged at the first cadential phrase. Although the players moved in unison in Take A8, the cadence in the first two beats of measure 6 did not sound in tune. The group discussed having the first violinist place the D# appoggiatura at a lower pitch within the B7 chord on the downbeat of measure 6. Take A9 was aborted; in Take A10 (Fig. 29, shown next to Fig. 28 for comparison), the GEMG around the cadential phrase has disappeared.

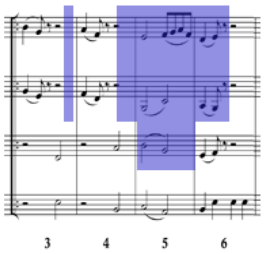

Figure 28. GEMGs in Take A8

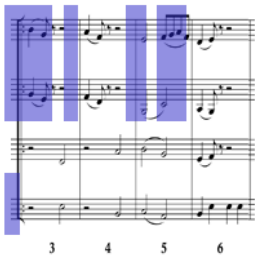

Figure 29. GEMGs in Take A10

The full transcript of the group's verbal exchange between these two takes is below. Implicit in the following exchange is the fact that the players are working within a just intonation system. This means that the D#, as the third of a B7 chord, needs to be played several cents lower relative to the other pitches in order to ring in tune in this chord.

V2: try again?

V1: yeah. I don't know where to put that D#.

Vlc: (downward pointing gesture) (laughter)

Vlc: (repeats downward pointing gesture)

```
V1: (laughs) well definitely more so than what's been
      happening, but like...
V2: let's do it again.
```

The first violinist annotated her part for a "wide half step" (see Fig. 16) after Take A10, while V2 and Vla discussed the balance between their instruments in bar 5. After the group made a decision that the viola would play more quietly on their unison note, the GEMG in bar 5 disappeared as well:

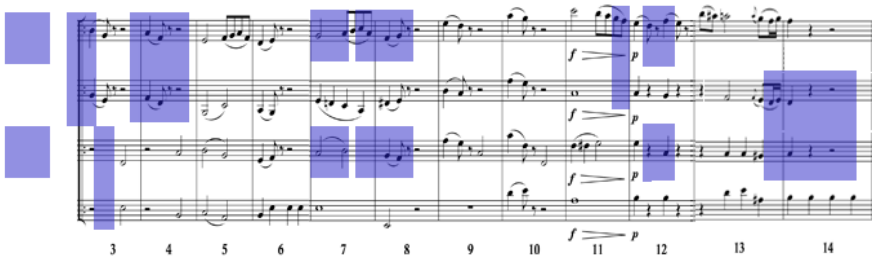

Figure 30. GEMGs in Take A11, Rehearsal 2

After this, the quartet left off rehearsing bars 5 and 6 for some time. When they finally came back to it, the GEMG in bar 5 partially re-emerged, and remained in one form or another in almost all subsequent takes (see figs 21 and 22).

Bowing work disrupts a GEMG in measures 86-90

The construct of Group Expressive Musical Gesture involves "expressive motion of the head and torso." This type of motion may be intentional or incidental but is not necessary to sound production. The act of moving a violin bow across a string, however, *is* crucial to the sound, and the way players distribute bow direction (up or down) has a significant effect on phrasing and sound quality. In rhythmic unison passages, string players plan their bowings so that they go in the same direction at the same time. During

the third rehearsal, the two violinists tried several different bowings for the passage between measures 86 and 90. Eventually, in the first take that the group evaluated as interpretively successful, three large GEMGs emerged between the two violins:

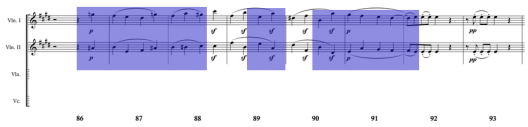

Figure 31. GEMGs in Take B09, Rehearsal 3

While this take was evaluated as musically successful, the violinists' bow strokes did not match. After deciding to match bow strokes, and annotating their parts with the newly decided-on bowings, the violinists played the segment with the whole group. Just as before, when a pitch annotation preceded the disappearance of a GEMG, the GEMG in measures 86-88 disappeared. Figure 32 shows the absence of this GEMG in Take B10.

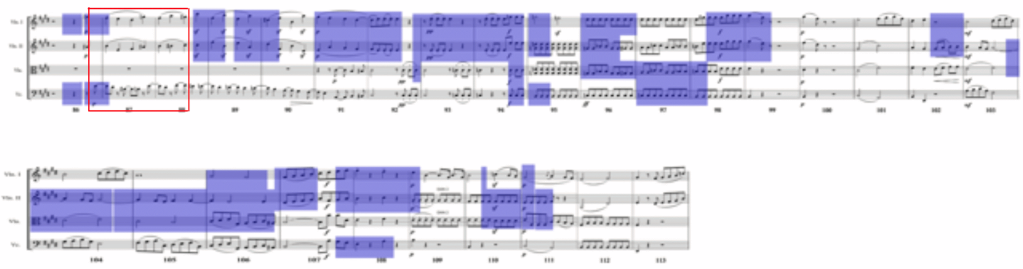

Figure 32. GEMGs in Take B10, Rehearsal 3

Although the GEMG that emerged through intensive repetitions of violin takes disappeared after the violinists annotated their parts with changed bowings and played the segment through with the group for the first time, it reappeared in a slightly altered form in subsequent takes (see, e.g., Fig. 25). It is not surprising that an overt physical change might impact work in the gesture space; the re-emergence of the GEMG with the changed bowings after the initial disruption indicates that it may have been the players' attention

on a new challenge (i.e. new bowings) that disrupted their shared gestural interpretation after it had emerged. Overall, GEMGs that emerged in the shared gesture space were occasionally disrupted and restructured as players directed their attention to various other strands of work, including intonation, shared articulation, or bowings.

5.3.4 From verbal mention of "gesture" to gestured interpretation

The claim that musicians' physical gestures reflect their conceptions of the score is supported by the relationship between musicians' explicit references to "playing the gesture" and their subsequent patterns of physical gesture. Patterns of GEMGs, once formed, did not stay static. In some cases, the group pointed to a segment verbally which had failed to satisfy them sonically in the previous take; over the course of working on those more specific sections, some tacitly agreed-on GEMGs disappeared, while others, more directly related to the issue the group had talked about, emerged. On three separate occasions, members of the group pointed to the need to think "more gesturally." Although thinking "more gesturally" ostensibly refers to implied musical gestures in the score, rather than physical gestures, non-sound-producing movements of the head and torso seemed to cohere into GEMGs after these musical gestures were invoked. Overall, the act of pointing to something verbally, THEN engaging in a GEMG, and then annotating that segment of music, seemed to be a better indicator that something would stay steady.

From "gesture" to GEMG in measures 1-3

The first verbal mention of "gesture" occurred at the end of Rehearsal 2, after three takes in which there had been no GEMG connecting measures two and three. The

group evaluated all three of these takes as musically unsatisfactory, at least partially because of unsatisfactory intonation, which was the main focus of the rehearsal. Below is the complete transcript for the work that occurred between Takes 24 and 25. Below that, Figure 33 and Figure 34 show the difference in GEMGs between those takes.

V2: Dammit

V1: Let's just play downbeats. Let's play, downbeat of 3, downbeat of 4, and then downbeat of 5.

V2: I mean it's already so simple I'd love to ..not think we need to do that. It’s like, for me it's like the gesture as much as anything. Like it's not just being able to hear which I don't think is so hard, it's like, following the gesture and doing everything and (gesturing)

Vlc: yeah.

V2: if that makes sense. We can just do downbeats once if that's/

V1: Do you wanna just, I mean... I don't know. I just, I’m trying of something else to do because I don't think this is working.

V2: Can we be a little bit more, like, easygoing with the time? I feel like I'm like waiting for things and that makes it really hard for me to like feel like I'm (gesturing)...just like a little more

free with our gestures even though we're playing abstract sound

V1: ok

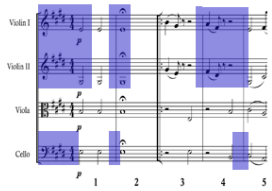

Figure 33. GEMGs in Take A24,

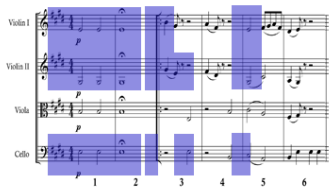

Figure 34. GEMGs in Take A25

Before V2 suggests "following the gesture" and "being free with our gestures," there are two distinct GEMGs in bars one and three. However, in the take after that discussion, a shared GEMG develops between V1, V2, and Vlc that encompasses the entire first two bars, while another GEMG between V1 and V2 extends into the beginning of the theme in bar 3 (Figure 34). This take was the last take played during rehearsal 2. Two weeks later, when the group touches the same segment of music again, the violin GEMG extending across that barline had disappeared (see Figure 22, Take A26). Once again, the group pointed to a gestural conception in their talk before playing the segment through again:

V2: Yeah, we're just behind, because we're being so careful with our ... yeah it should, (gestures) let it start, like let it be easygoing, like, connection.

Vla: Or really considering it as a composite gesture rather than, gesture -- gesture –

After this exchange, the group plays the first three bars of the piece again. GEMGs are shown in Fig. 27:

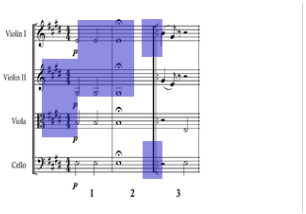

Figure 35. GEMGs in Take A27, Rehearsal 3

In this take, the GEMG connecting the opening chords to the theme in bar 3 occurs for the first time since the previous rehearsal, this time between the cellist (who had first called attention to the segment) and the first violinist. This cueing gesture, which connects the end of bar 2 through the barline into bar 3, stays present in its over-the-barline form from the next time the musicians play that segment of music to the Performance itself:

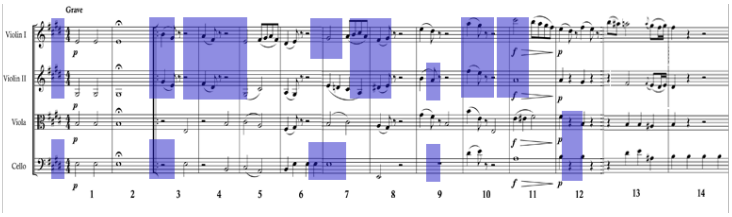

Figure 36. GEMGs in Take A32, Rehearsal 3

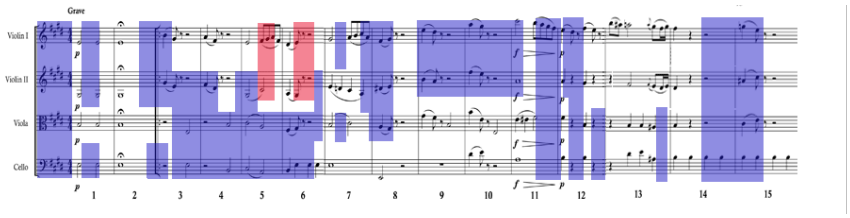

Figure 37. GEMGs in Take A33, Performance

In both of these instances, a GEMG emerged that highlighted a connection between measure 2 and measure 3 after group members pointed to a need to "be free with our gestures" or think of something as "a composite gesture". However, these brief discussions about time and gestural thinking were followed by gestural interactions (GEMGs) that accompanied changes in the group's performance of this passage. The shape and location of the GEMGs correspond to a particular set of performative decisions; the GEMGs in takes 25, 27, 32, and 33 reflect a group understanding of the space between the last note of measure 2 and the first few notes of measure 3 as a bridge between two contrasting sets of musical material.

From "gesture" to GEMG in measures 3-4

Once the interstitial gesture between bars 2 and 3 was established in take A27, the group pivoted to a discussion of the violinists' shared theme in bars 3 and 4:

> Vlc: ah, downbow feels different than the upbow. The upbow actually feels more - maybe it's because you already played one of them and so it's easier to play the second one? I don't know. But the downbow feels like, um, the first note there's a different amount of bowspeed being used. You use a little faster, a little slower. And then the

end of the note feels -- the end of the second note feels different, um, um, maybe just think about trying to release with the same (gesturing) type of gesture off of, off of, once the notes finish.

V2: once it's finished. yeah

V2: could we try it once where we don't start right at the frog? so we do like, half, half a bow or something? Is that gonna be awkward? I don't know. just

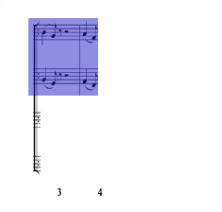

Figure 38. GEMGs in Take 29, Rehearsal 3

Again, pointing to the need for a shared gesture in explicit rehearsal talk immediately precedes the emergence of a GEMG. It is worth noting that the musicians did not verbally specify the *type* of gesture they planned to do; they specified a different starting point on the bow, and a different amount of bow to be used, but the musical gesture at the end is specified only as "the same type of gesture," and is reflected in a shared movement of the head and torso. Much of the interpretive work is happening in the gesture space, first in the cellist's speech-accompanying gesture, and then in the GEMGs produced by the violinists. The discussion about "releasing with the same type of gesture" was followed by an extended GEMG that again corresponded to a particular

set of performative decisions of much more complexity than just "releasing with the same type of gesture." Beyond an emphasis on shared releases at the ends of each two-note slurs, the GEMG in this passage reflects a group understanding of that two-bar passage as a single continuous line, connected through motion in space even when no sound is being produced.

The analysis in this section showed the accumulation and agglomeration of GEMGs over time, the gradual cohering of those GEMGs with musical elements of the score, and the ways that other kinds of interpretive work impacted interpretive work that occurred in the gesture space. The relationship between musicians' explicit discussions of music-as-gesture and subsequent GEMGs points to the primacy of gesture in the formation of a group's shared conception of a work of music. This claim is explored further in the discussion.

Summary

This analysis showed that group learning occurred through the mediums of between-take rehearsal talk, annotations, and non-sound producing gestures. Finding set 1 showed a trajectory from rhythm-centered rehearsal talk, focused on temporal entrainment, to intonation-centered rehearsal talk, focused on elaborating context, to metaphor-centered rehearsal talk. Finding set 2 showed that this trajectory was reflected in the annotations that the musicians produced, albeit at a slower rate, over rehearsals. Finding 2.2 showed that the spatial mappings between group musical conceptions and written annotations are non-obvious: V1's improvised, idiosyncratic notation demonstrated an attempt to synthesis "horizontal" aspects of musical flow with "vertical" aspects of intonation. Finding set 3 showed the ways that musicians' group gestures

constitute an additional medium for group learning. The analysis of evolving GEMGs as a learning trajectory resonates with the analysis of learning trajectories across other modalities, as smaller, separate GEMGs around barlines agglomerated into longer GEMGs that seemed to reflect more coherent musical concepts. In the Discussion, I unpack these findings in relation to each other across modes, and relate them back to discussions in the literature about sensemaking across modes, distributed practices in groups, and the development of conceptual metaphors in music.

6. DISCUSSION

*portions of this chapter are reprinted in part from Hospelhorn & Radinsky, 2016. An Accepted Manuscript of an article published in *Discourse Processes* online [January 15, 2016] is available online: http://tandfonline.com/doi/full/10.1080/0163853X.2015.1137183 (see Appendix F).

Overview

These findings provide an initial set of insights into the various roles played by gesture, representation, and talk in the learning processes of rehearsing musicians. (1) Gestures, annotations, and talk shared the burden of aligning decisions among musicians. (2) These three modes reflected conceptual change on different timescales. (3) All three were sites of a process of conceptual spatialization, wherein the group's enacted pitches, rhythms, and musical gestures were mapped in relation to each other, both structurally and through time. (4) This process occurred in a similar sequence across gestures, talk, and annotations: a focus on tempi, shared rhythms, and staying together in the first rehearsal moved to a focus on intonation and developing a 3-dimensional conceptual landscape of chords and pitches in the second rehearsal. Finally, in the third rehearsal, the group worked more explicitly in metaphor, constructing a coherent sequence of events that evoked a musical story. I will discuss each of these four points in the sections that follow, showing how they build on current theories around group cognition and learning.

6.1 Learning Processes Across Modes in Rehearsals

The group problem-solving task in this study – the collective interpretation of a musical score – offers particular analytical challenges and insights that can inform the larger project of studying multimodal sense-making in groups. Movement, talk, and written representations all work together in this learning process, as the group develops a

shared concept of the piece, where pitch relations, rhythm relations, and musical concepts coalesce into a shared narrative that can be transmitted to an audience. As in Goodwin (2007), or Radinsky et al. (2012), group members used embodied moves along with speech and written artifacts to co-construct shared spatial representations. These shared spatial representations ultimately worked together to constitute a "four-dimensional score space" like that described by Stefanou & Antoniadis (2009), where elements determined by the printed score are reified into sonic objects interlinked with each other and unfolding across time.

This process of musical conceptualization and negotiation takes place across multiple modes simultaneously, as the group continually switches between different representations – written, sonic (playing or singing, alone or together), and embodied (speech-accompanying gestures, EMGs, and GEMGs). Although the written representations, in the form of annotated parts, evolve at a different timescale than musical representations in other modes, each of these modes of representation contributes to the group's learning process, in which musical concepts are repeatedly enacted, revised, and re-enacted. The work that these musicians do takes place in a discursive context that is mediated by the shared interpretation of a text as it simultaneously mediates the physical form of that text.

6.1.1 Learning trajectories in rehearsal talk

Finding set 1 showed the way that rehearsal talk shifted over the course of three rehearsals from a focus on tempo and entrainment, to intonation and pitch, to more metaphorical and phrasing concerns. This talk occurred between musical takes and tuning sessions, and linked segments of the score to both evaluations of musical enactments of

that score, and potential changes in those enactments. Additionally, talk co-occurred with singing, snapping, and gesturing, and switched often between these modes outside of musical takes. The analysis of between-take talk found that broad-scale shifts in group concepts around musical segments were linked to shifts in gestural and written conceptual modes at scales of seconds, minutes, hours, and days. Additionally, across rhythm-centered, intonation-centered, and metaphorical talk, subject matter shifted from a focus on ensemble playing, or being together, towards a focus on interpreting the music as a group.

6.1.2 Annotations as a reflection of group sensemaking

Finding set 2 shows how annotations evolved over the course of three rehearsals. These evolving annotations constitute a representational trajectory similar to those described by Halverson (2013). The musicians are annotating a pre-existing written score, which Stefanou & Antoniadis characterize as an "interstructure" that links multiple performances across time. Looking at the evolving set of representations shown in finding 2.1, we can posit the evolution of the interstructure as a learning process: the group's evolving conception of the piece is reflected in a series of documents that contain increasingly rich information about an abstract composition, and which function as a way to orient the group to the decisions they have made over the course of rehearsal.

6.1.3 Gesture space as a site of group problem-solving

Finding set 3 shows how GEMGs evolved over the course of several rehearsals. Finding 3.1 suggests a transition in attention from individual parts to the group, as gestures cohered into progressively longer GEMGs across takes. The gradual increase in

the group's number and duration of GEMGs over time indicates that some of the group's learning process takes place within the gesture space, as distinct instances of brief periods of entrainment between bodies agglomerate into longer GEMGs.

While it is not surprising that group gestures would cohere more over time, the main point of interest here is that the GEMGs evident in later takes constitute de facto score analyses. Finding 3.2 illustrates the types of ephemeral score analyses that were enacted in the gesture space. The musicians' gestural "score analyses" are at once ephemeral and increasingly stable; while some GEMGs emerged and then dissipated, others emerged and remained relatively constant. Eventually, isolated GEMGs that occurred in small takes agglomerated into a relatively stable set of GEMGs that aligned with specific structural and musical elements in the score.

Some of these GEMGs emerged in the gesture space alone; others were preceded by related rehearsal talk. In the pilot study, talk consisted mainly of brief verbal exchanges between takes that often contained only shorthand pointers to problem areas. In this study, between-take talk was significantly more involved; in addition to pointing out problem areas, players offered multiple possible musical interpretations and problem solving techniques. One of these problem-solving techniques involved "thinking gesturally," and variants of this phrase often directly preceded the expansion of a GEMG. GEMGs that appeared immediately following verbal discussions about "following gestures," as well as GEMGs that appeared in earlier takes with no related discussion at all, appear to indicate musically structural points, rather than simply tempo markings. These musically structural points emerged increasingly over takes. Musicians were able to align detailed decisions about musical structure with little to no verbal negotiation,

suggesting that the gesture space was used at least in part to carry out more detailed alignments than talk alone.

I do not assume that there is a simple, causal relationship between these changes in gesture and any accompanying changes in musical performance. The primary communication among the musicians was sonic, not embodied or visual. Nonetheless, correspondences of changes in gesture with changes in score interpretation suggest that the gesture space is one medium in which the emergent learning process is carried out, and point to particular roles that gesture may play in this complex interactive process.

Following Hutchins (2010), the claim is not that the GEMGs of the musicians simply *reflect* a new interpretation (after the fact), or *cause* a new interpretation (prior to conceptualization of it). Rather, the interactions among their bodies in space constitute a medium in which the new interpretation is realized. While Hutchins' examples are people plotting points on a chart with tools, or Watson and Crick thinking through the double helix with cardboard, the examples of "enaction" here are musicians jointly conceptualizing and negotiating a musical narrative with their bodies.

6.2 Learning processes across scales of time in musical rehearsals

The Introduction mentioned several unusual aspects of musical rehearsals as a context for studying gestural and embodied communication. As the analysis shows, one unique aspect of this context is the close temporal coordination that is required for the group to accomplish its task, constrained by the musical score. Communication through EMGs and GEMGs was accomplished across multiple repeated performances of the same portion of the score – i.e., multiple opportunities to interpret the same text. In this work, as in Leander et al. (2010), or Lemke (2000), multiple scales of time become visible and

relevant. The methods developed for this study enabled the analysis of embodied communication to align closely to the text (using units of measures and beats). That text itself slowly changed as individual parts were annotated in response to other modes of negotiation, including score-referenced talk.

Because the processes of annotation and enacted group gesture were analyzed on different timescales, attention to the places where they intersected revealed a process where one mode of conceptual change might disrupt another. Finding set 3.3 showed that some shared interpretations that emerged in the gesture space were evaluated critically, based on sonic feedback, and then broken down through a process of verbal negotiation, annotation, and enaction. Shared concepts were occasionally arrived at in the gesture space without co-occuring talk or writing, but GEMGs sometimes broke when a tacitly arrived at interpretation was changed. Rather than a learning process that consists merely of increasing "togetherness," this sequence of disruption and reassembly reflects a much more complex group learning process, in which shared conceptions undergo continual evaluation and renegotiation.

This kind of disruption has been shown to play a similar role in other learning contexts: in the pilot study, a different string quartet came to a shared gestural musical conception that broke down when one person called the group's attention to a decrescendo in the score (Hospelhorn & Radinsky, 2016). Hall et al. (2010) note that "when a group's conventional thinking is disrupted…discovery or innovation at the microgenetic level can produce new ways of accomplishing that work." (p. 229) Attending to these processes of disruption in the context of a musical rehearsal, where the concepts being disrupted are not primarily visible through language, highlights the fact

that the group's learning trajectory does not involve a single, constantly changing shared concept; rather, processes of conceptual change may occur simultaneously across modes, and those processes may come into conflict. The alignment of group concepts across modes was, then, a key part of this group's learning process.

Though measures and beats are unique to music, this analytical process may have analogs in the study of other discourse processes that are also tightly temporally constrained, subject to repetition, and constrained by a text. In teaching contexts, we can imagine that interactions of talk, written representation, and gesture might trace the development of metaphorical concepts in a classroom, or across classrooms, or even across multiple years of teaching a given class (cf. Amaya Becvar, Hollan & Hutchins, 2005; Hall, Wright & Wieckert, 2007; Hospelhorn & Radinsky, 2016). Thus the methods for documenting musicians' emergent gestural interpretations in "score time" along with score-referenced talk and annotations might point us to valuable ways to deepen our understanding of discourse as it plays out in other contexts.

6.3 Processes of Contextualization and Spatialization

The group's work on intonation in the second rehearsal resulted in a set of individual parts that expanded and enriched contextual information about sounding pitches in relation to each other. Taken together, intonation-centered talk (finding set 1) and intonation-centered annotations (finding set 2) reflected an ongoing group analysis of the piece that was at once both structural and process-based. This analysis explicated structural musical elements of key areas, chordal relationships, and harmonic progressions. Additionally, the analysis took into account the way this process would unfold in time in a musical enactment: i.e., analyzing not only what the chordal

relationships should be, but how they would line up relative to real-world pitches (perfect or imperfect as they might be) when they were enacted in real time.

6.3.1 "Vertical" and "Horizontal" pitch relationships

This process of contextualization is also a process of spatialization: a pitch resonating at 440 khz has no inherent two-dimensional spatial relationship with a pitch resonating simultaneously resonating at 880 khz. Following Isaacson (2005), these pitch relationships are metaphorically spatialized through musical notational conventions on a score:

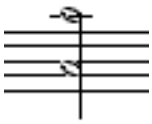

Figure 39. A standard representation of two simultaneous pitches, depicted in vertical relation to one another.

This kind of representation locates these pitches on an abstract vertical plane. However, the players do not work from a score, but from individual parts; for them, the vertical plane is implied. Written up or down arrows on top of pitches, such as those in figure 14, function to locate these abstract pitches within a conceptual model of the piece that has a vertical dimension (pitch) as well as a horizontal dimension (time); additionally, these arrows relate not simply to abstract ideas of pitch, but to spatial representations of *enactions* of those pitches in the real world, where they must be played together with other enacted pitches, which will differ in some way from the "ideal" pitch represented on the page. These differences can result from tuning systems (just vs. even-tempered) or from habit (a given player might have a tendency to play a given pitch low,

and their partner might write an arrow to compensate for this fact). Whatever the cause, the evolution of these types of annotations in a score reflects an evolution in the spatiality of musicians' conceptions of those pitch relationships.

Performers' intonation-centered talk, as well as their notational practices around intonation, further deepened the spatialization process in the second rehearsal. Intonation-centered utterances like "just so I know where it is" highlighted the *place* aspect of the group's intonation work, as they co-constructed a score-space in which individual pitches could be located.

6.3.2 Creating and Traversing a Musical Map

In finding 2.2, V1's attempt at an invented notation for a "wide half step" illuminates this tension between structure and flow. The wide half step marking is, again, a disruption of group conventions ("an arrow above the D#....would be the more normal way we would normally do that"). And, following Hall et al. (2010), her invented notation constituted an invention at the microgenetic level. While the annotation did not succeed as an inscription that was interpretable in future contexts, the question of whether it succeeded in facilitating a group learning process in the moment is murkier.

V1's description in the interview of her annotation as highlighting "a special kind of half-step" reveals a temporary identification with her melodic line, rather than with the placement of a discrete pitch in relation to other simultaneously sounding pitches. Like the scientists in Ochs, Jacoby et al (1996) who identify themselves variously as observers or players in chemical processes, group members shifted their identities in similar ways: they identified variously as observers of their own melody, players of melodies, map readers ("I'm following the shape of the first violin"), or map

creators ("where should I put this D#"). The musicians alternately traversed and created a musical landscape through multiple modes of negotiation. This pattern of quickly shifting relationships to an evolving shared concept is similar to patterns found by Ochs et al. (1996), or Nathan et al (2007) in the learning processes of scientists and classroom students, respectively. Perhaps, then, we might expect to see these shifting relationships in analyses of shared sensemaking across contexts.

6.4 Conceptual Change Across Modes: Developing Coherent Conceptual Metaphors

The group's shared musical conception of this sonata changed dramatically over the course of the rehearsal period. Taken together, their composite rehearsal talk, annotated part composite, and group gesture graph all reflect a shift from an emphasis on rhythm and chordal alignment in early rehearsals to thinking more gesturally/ conceptually in later rehearsals. Finding 3 synthesizes learning processes that occurred through textual, gesture, and talk spaces, and shows a group whose conception of the work required to play this sonata evolves from a focus around playing in time and in tune with each other to a more internalized understanding of those requirements, and a higher level shared understanding of the musical and structures at work in this piece. In the second rehearsal, emphasis in talk and annotations shifted to intonation and to placing pitches in a three dimensional context that related to other players' simultaneous pitches and to their own previously placed pitches in time, as well as in the broader chordal context of the piece. The creation of this pitch-world is not simply a process of learning to play in tune, but a process of concept development, where pitch relationships in different harmonic contexts constitute a musical "color palette" which is deliberately unfolded in time by the group in performance. Finally, in the third rehearsal, themes in

rehearsal talk shifted significantly towards the metaphorical: for example, a moment of silence were characterized as “room for the holy spirit” rather than in terms of duration, and musical phrases were characterized as “warm and loving” rather than in terms of bow strokes or pitch centers.

Although an in-depth study of the conceptual metaphors at play here is outside the scope of this analysis, finding sets 1 and 2 show the ways that conceptual metaphors in measures 1-6, for example, became gradually deeper and richer. Characterizations of measures 1-6 as “B string, centered around the E string” and as at a given tempo deepened into characterizations that highlighted “composite gestures” and a sense of being “warm and loving,” for example. These characterizations were supported and reflected in GEMGs that evolved from short, disparate shared motions to continual entrained gestures, the shape of which reflected a slow, calm unfolding in space. It is important to note that the group did not move from *no* understanding to an understanding of a static information set. Rather, the group moved from one type of shared understanding that highlighted temporal entrainment and depended on barlines as scaffolds, to another type of shared understanding that was more embodied and more metaphorical.

Summary

This discussion showed how the learning practices of the string quartet analyzed here are similar to learning practices that have been studied in other disciplines, particularly mathematics and science, both professionally (Ochs et al., 1996; Hall et al., 2010, Hutchins, 2010) and in the classroom (Radinsky et al., 2012; Goodwin et al., 2007; Leander et al., 2010, Nathan et al., 2007; Halverson, 2013). The depth and breadth of the

metaphorical and spatial mappings that the group achieved indicate that robust shared musical concepts may share much in common with similarly robust shared concepts across contexts. This musical group's learning process, like that of successful groups both musical and non-musical, was spatial, embodied, and mapped consistently and with a variety of perspectives between multiple modes of representation.

7. CONCLUSION AND FUTURE WORK

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Over the course of three rehearsals and a Performance, the quartet in this case engaged in an ever-deepening process of sensemaking and spatialization. Tracking the group's talk, annotations, and shared movements revealed similar trajectories across all three modes of representation. A focus on shared rhythms and "staying together" in the first rehearsal was followed by deep intonation work in the second rehearsal, where the quartet's relentless focus on building a shared landscape of related pitches resulted in a continuing tension between the "vertical" plane (playing simultaneous pitches in tune) and the "horizontal" (playing melodies that flow coherently through time). Finally, in the third rehearsal, the group began developing the metaphorical mappings of their shared musical conception, using words like "spacious," "warm," "nurturing," and "soaring" to describe larger musical concepts.

This progression – from a focus on entrainment to the development of an increasingly rich and metaphorical set of shared concepts – may be representative of a broader set of processes that occur in sensemaking in both musical and non-musical contexts. Participants in successful group interactions must orient to each other and to a shared conceptual framework before enriching and deepening their group conceptions. This process is distributed across participants and across representational modes, and changing group conceptions are worked out in part through embodied interactions.

Much of the analysis in this paper revolves around a few opening bars of a much larger work. This is because the vast majority of the group's rehearsal revolved around those opening bars. A likely explanation for this phenomenon is that the majority of the challenges of the work were broad-scale enough that once they had been resolved for those few measures, they could be applied to the rest of the work. It is important to note that the group's learning process is both tied to specific moments of a specific score, and to broader musical concepts at play in the score.

The analysis of written representations points to a tension between conventional score annotations and invented score annotations. While conventional annotations were more often effective, the production of invented annotations pointed to a shifting of perspective on the part of the annotator, and a tension between musical structure and musical flow, which may have been indicative of a deepening of musical understanding. While the annotations produced by these musicians were occasionally non-conventional, the score itself was written in conventional western notation. Many contemporary musical works are written in non-conventional notation, as composers invent new ways to express different kinds of sound. How do these representational trajectories change when the central representation – the score – is itself unconventional?

The gesture analysis attended only to the frequency, location in the score, and cohesion of gestures, leaving out much richer information that could be obtained by more detailed analysis of the content of the gestures (e.g., amount and direction of movement, distinct kinds of movements of head and torso, or repetitions of particular movements). Nonetheless, these findings offer valuable guidance in interpreting the processes by which gesture mediates the learning of a coherent shared interpretation in collaborative

music-making, as well as in other collaborative contexts.

The discussion of spatial mapping processes did not account for the spatial transliterations that occur in the *shape* of musicians' gestures. The current study did not focus on Expressive Musical Gestures (EMGs), choosing instead to analyze the more obviously interactive Group Expressive Musical Gestures (GEMGs); however, preliminary work in the data transcription phase suggested the possibility that, just as cohering group concepts can be seen in evolving patterns of GEMGs, the evolving shapes of EMGs might be another representational trajectory through which individual musical conceptions might be tracked. A central part of the group's learning process was the gradual establishment of a multidimensional score-space – that is, a network of relationships between pitch centers, individual musical lines, and chord areas – that was mapped out across representations: on paper, through spoken negotiation, through musical performance, and through the physical relationships between multiple bodies moving in space. Closer study of the evolving shapes of individual musicians' movements through space as their musical conceptions develop will provide further insight into the spatial learning processes at play in group interactions.

The relationship of verbal exchanges to gestural communication is different in this context from that of gesturing *speakers*, for whom gesture and speech are often analyzed together as a single unit of analysis. The more direct analog in this context would be analysis of the relationship between gesture and the contents of the sonic performance. This is mainly backgrounded in the present study, in order to highlight relationships between gesture and features of the score. Future work might combine more in-depth gestural analysis, score analysis, and analysis of the sonic aspects of the

performance. For example, if the large, shared gesture that evolved over the first three bars of the piece had a general circular shape, might that shape be reflected in the wave form generated by the piece – or, in other words, the dynamic shape of the opening phrase? Further study is warranted to examine the ways that gestures, annotation, and talk mediate the development of particular musical phrasing. The ways gestures interrelate to auditory perception and musical expressiveness undoubtedly mediate the group's shared sense-making processes.

Additionally, the space that the performers play in itself would appear to have an effect on the group's learning processes. In the group interview after the Performance, the first violinist, after watching a video clip of the Performance, made an observation about the way the resonance of a given Performance space affects the sound of the group:

V1: it's really interesting to me, having not thought as much about this idea [of harmony] as these guys have, watching that performance....yeah, like the color of the key is so clear to me. That, like, in the reverb of that space, I wish we weren't vibrating. (To rest of group) Or I wish we were barely vibrating. Because it distorts that color.

Vlc: oh yeah.

Vla: mhmm

Vlc: yeah. That's, that's.... it could be even purer sounding.

In this conversation, the violinist noted that she uses extra vibrato at the end of notes to simulate the effect of reverb in a large hall. However, the group's extensive work on intonation over the course of their rehearsal process had succeeded to such a degree that the group could hear shifting "colors" in the shifting tonalities of their performance; their vibrato, which serves the function of simulating reverb, consists of very slight deviations in pitch. In a large hall where this compensation was unnecessary, the violinist was able to hear that it was not only unnecessary, but perhaps undesirable. Shortly following this discussion, the group discussed the possibility of finding a way to rehearse in large halls on a more regular basis. This analysis does not touch on the ways that the spaces in which a musical group rehearses and performs interact with their learning processes; this aspect of spatial learning presents an enticing opportunity for future study.

The analyses presented here offer some insights as to the ways that multi-modal representational processes contribute to the development of group concepts, which emerge over time on multiple trajectories, and which may come into conflict or reinforce one another. The approach taken here may similarly be suited to examining emerging multi-modal coordination where a complex joint performance, linked to a text and dependent on precise timing, is learned over multiple group enactments or performances. In this way, musical learning situations might be similar to other contexts which share these characteristics, including theatrical rehearsals with screenplays, spoken presentations around slideshows, sports plays from playbooks, or scientific experiments from written protocols.

Tracking the trajectories of talk, annotations, and group gestures in rehearsals provides a useful tool for documenting the process that a group goes through as it learns

to construct a Performance. By showing the ways that emerging group gestures over time interact with and support changing representations in talk and written artifacts, these methods show promise for examining interlinked verbal and non-verbal coordination of nuanced, shared decision-making.

Musical contexts are not simply sites of "creativity" or "art," but sites of intensely complex trajectories of shared understanding, where participants build off of pre-existing concepts verbally, in writing, and with embodied communication to achieve complex insights and increasingly rich shared concepts. This research provides a new context for looking at the role of multimodal representations not just in musical interactions, but in any group sensemaking process.

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APPENDICES

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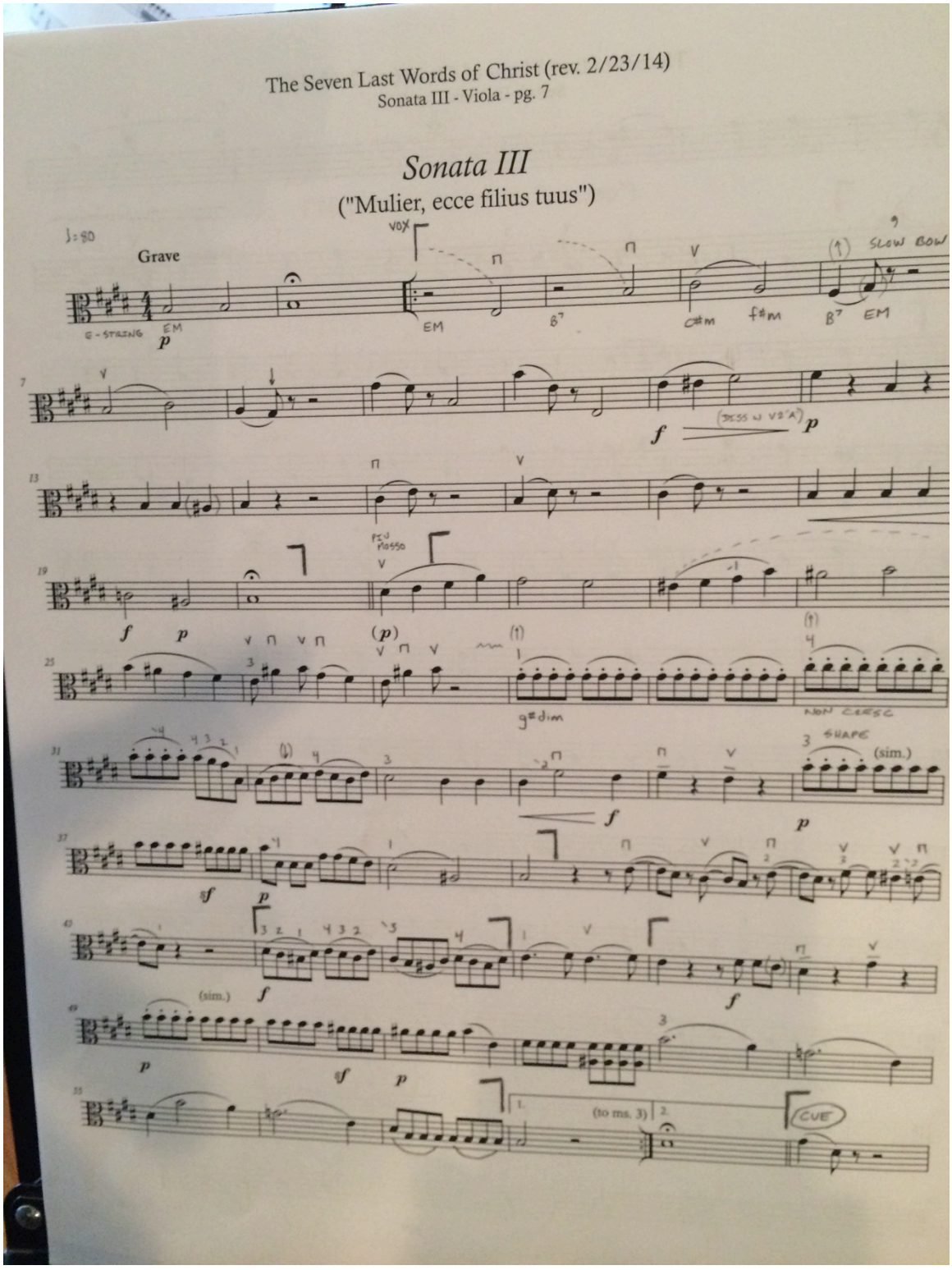
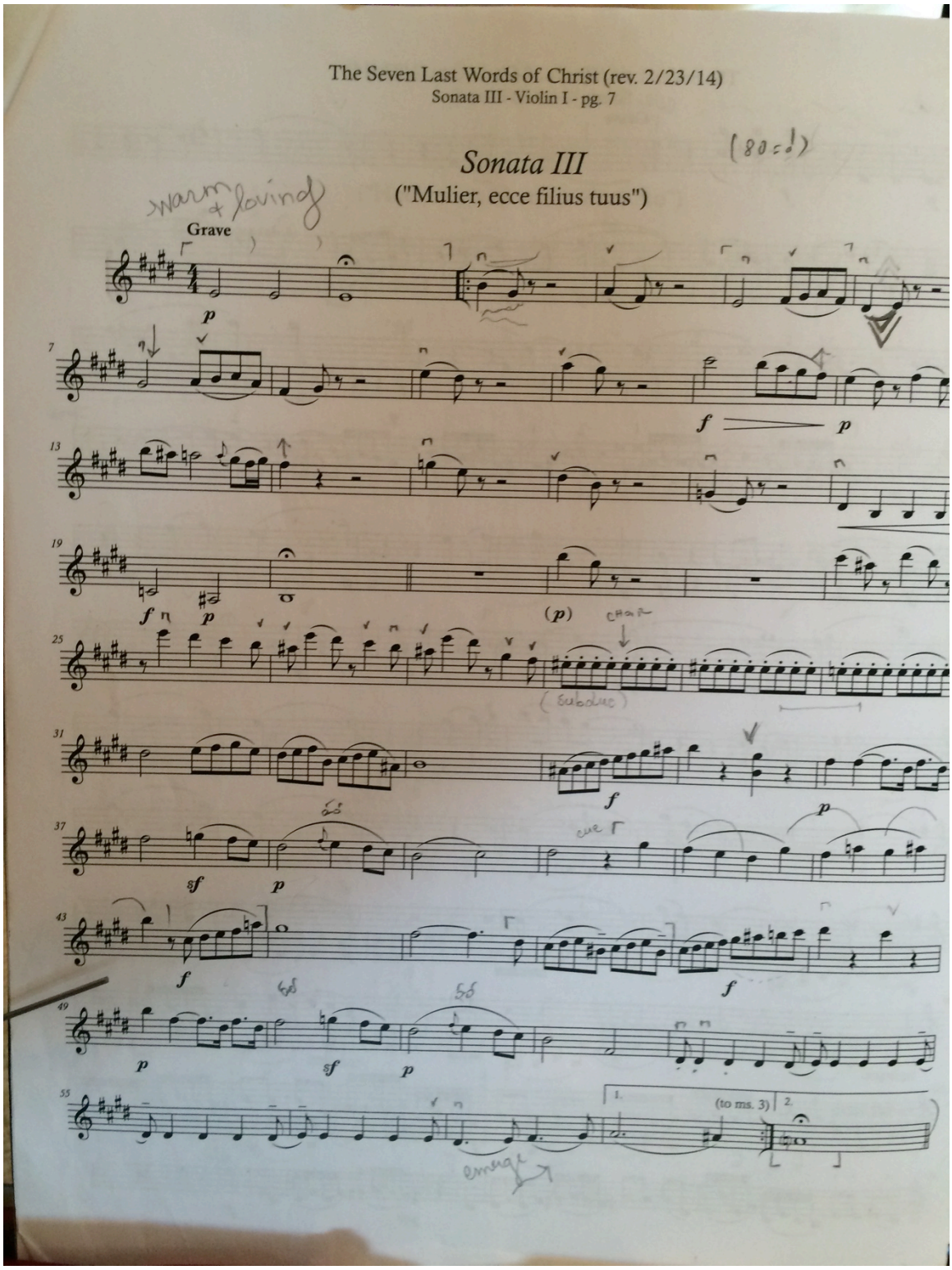
APPENDIX A: SAMPLES OF ANNOTATED PARTS



Viola part page 1, collected after 2nd Rehearsal



Violin 1 page 1, collected after 3rd rehearsal

APPENDIX B: INTERVIEW PROTOCOL FOR POST-REHEARSAL INTERVIEW

1. How would you describe this piece of music?

2. How did you prepare for this rehearsal?

3. Did you have any specific goals coming into this rehearsal? If so, what were they?

3a. What were you focusing on in this rehearsal?

1a. PROBE: is there anything you found particularly challenging about that? Why?

3b. How did this rehearsal go?

4. What is your next step with this piece of music?

e.g. practice at home (what and why?)/work on something specific with the group (what & why?)/prepare for performance/ etc

6. At one point, I saw you make a note in your music at [movement/measure number]. What did you write and why?

[REPEAT AS NECESSARY]

APPENDIX C: INTERVIEW PROTOCOL FOR GROUP INTERVIEW

(To be conducted with scores)

I'm going to show you some clips of your rehearsal that I've taken over the past few days and I'd love you to tell me what is going on here.

[Musical clip protocol]

Ok, this is you playing the section at [mm. xx- mm. xx] [SHOW VIDEO CLIP 1]

How would you describe this section of music?

What do you think of this performance?

How does this section of music relate to the rest of the movement?

[Discussion clip protocol]

What does [term] mean? (Use this to clarify any unclear abbreviated terms, e.g. "Comma" "rit")

What were you referring to here? (Use this to clarify unclear references, e.g. "Bartok pizz.," "Sciarrino vibe")

[Probe] how is this piece like [referent]?

7. What is your group's general process for learning a piece of music?

8. How did you become a part of this group?

9. How does the culture of this group compare to other groups you've played in?

APPENDIX E: IRB APPROVAL LETTER

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Exemption Granted

March 5, 2015

Emma Hospelhorn, BA
Learning Sciences Research Institute
3312 W. Pierce Ave, 1st Flr
Chicago, IL 60651
Phone: (917) 415-9189

RE: Research Protocol # 2015-0236
"Learning and Interaction in Musical Groups"
Sponsors: None

Dear Ms. Hospelhorn:

Your Claim of Exemption was reviewed on March 5, 2015 and it was determined that your research protocol meets the criteria for exemption as defined in the U. S. Department of Health and Human Services Regulations for the Protection of Human Subjects [(45 CFR 46.101(b)]. You may now begin your research.

Exemption Period:	**March 5, 2015 – March 5, 2018**
Performance Site:	UIC
Subject Population:	Adult (18+ years) subjects only
Number of Subjects:	15

The specific exemption category under 45 CFR 46.101(b) is:
(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

You are reminded that investigators whose research involving human subjects is determined to be exempt from the federal regulations for the protection of human subjects still have responsibilities for the ethical conduct of the research under state law and UIC policy. Please be aware of the following UIC policies and responsibilities for investigators:

1. Amendments You are responsible for reporting any amendments to your research protocol that may affect the determination of the exemption and may result in your research no

APPENDIX F. REUSE PERMISSIONS FOR HOSPELHORN & RADINSKY (2016)

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10/25/2016

Emma Hospelhorn
hospelhorn@gmail.com

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> *Discourse Processes* (Online) 1-20.
> DOI: 10.1080/0163853X.2015.1137183

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