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Cory DeWitt Meals

Questions of Gesture and Sound: Temporal Interactions in Conducted Ensembles

A Multiple Study Dissertation

Cory DeWitt Meals

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Reading Committee:

Steven J. Morrison, Chair

Patricia S. Campbell

Timothy Salzman

Geoffrey Boers

Program Authorized to Offer Degree:

Music

University of Washington

Abstract

Questions of Gesture and Sound: Investigations of Instrumental Ensemble Conducting

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Cory DeWitt Meals

Chair of the Supervisory Committee:
Steven J. Morrison
Music Education

Introduction: The purpose of this dissertation is to contribute to the body of research that has investigated conducting in musical contexts, especially instrumental ensembles. This dissertation contains three papers on the topic of conducting, including one literature review and two quantitative studies. While the central focus of this dissertation is instrumental ensemble conducting, the manifestations of entrainment and the performer's interactions with aural and visual stimuli emerge as consistent themes throughout. A brief summary of each paper in the dissertation is provided below.

Paper One: This review contextualizes empirical literature and existing conducting pedagogy, focusing on the role of the conductor in ensemble coordination and expressive communication. The paper organizes its findings thematically, highlighting the conductor's twin roles of coordination and expressivity through gesture. Through synthesis of research and pedagogical literature, I highlight that both conductor and ensemble are responsible for ensemble coordination and cohesion

through the interlinked processes of visual and aural entrainment. The paper also provides implications for conducting pedagogues, practitioners, and future music researchers.

Paper Two: The purpose of this study is to investigate the nature of ensemble response to conductor gesture from a temporal perspective. I examine the general tendencies of sonic offset from conductor gesture, as well as differences between ensemble type (orchestra, wind band), ensemble experience level (beginner, intermediate, advanced), and development over time. Findings reveal a general tendency for ensembles to lag behind the conductor's gesture, but I identify that this lag is dynamic and demonstrates change between ensembles, between experience levels, and over the course of a selected excerpt. Additionally, I identify performance tempo and phrase structure as contributing factors in the variance observed.

Paper Three: The dissertation author is the primary author of this paper, joined by co-authors Steven J. Morrison and Deborah H. Confredo. The purpose of this study is to investigate the role of action-sound congruence on perceptions of conductor efficacy. Through a quasi-experimental design, musicians ($N = 110$) evaluated ten videos of conductors during concert performance. Some of these videos were manipulated to offset audio and video by percentage of the ensemble's tempo (no offset, ±15%, ±30%) that would not register as unsynchronized with viewers. The videos appeared in one of five fully-crossed stimuli orders for evaluation. Participants evaluated offset of any kind as negative when compared with unaltered performance and identified greater offset values as more negative overall. Within this study conductor evaluations were generally more negative than ensemble evaluations.

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Dedication

To my students, who continue to be a source of inspiration, consternation, and motivation.

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To my daughter, Finley, may you know and embrace the pain and joy of growth and learning.

To my wife, Sarah, whose support, affirmation, motivation, and love nurtured me throughout.

INTRODUCTION

As a conductor, I strive to communicate in a clear and concise manner. My gesture provides a leading signal to the musicians, providing them with the information needed to coordinate activities in time, aesthetic, affect, and expressive intent at a group level. My physical placement, at a focal point between the ensemble and any audience, centralizes and requires my efficacy in that role. Deficiencies in my communication have a direct effect on their performance; an underdeveloped gestural vocabulary provides for an impoverished musical experience. These are lessons I have learned throughout my career, ones I give great value to, but the basis for much of this information is practice and anecdote. Passed to me by my teachers from their teachers who received them from their teachers, they link ever backward in time. This well-worn chain of beliefs and practices represents an intriguing area for systematic, empirical investigation of the complex and interactive nature of group musical performance.

Significance of the Topic

The persistence of these conducting paradigms suggests that in addition to representing pragmatic practice, they may also exploit features of human perception and communication to the ends of group coordination and musical performance. Where systematic, empirical research in music education has investigated the influence of visual features like facial expression and gesture on expressivity, examination of the temporal features within conducted ensemble performance is comparatively underrepresented. When considered alongside the implied centrality of the conductor's gestures to the ensemble itself, examination of temporal communication, response, and interaction highlights an interesting lacuna within music education research.

Gesture, sound, communication, and coordination within ensemble music combines to form a dense mesh of interaction weaving between, through, and around musician and conductor alike. This musical ecosystem pervades the experience of many musicians within Western settings and is the dominant musical experience available to developing musicians in middle- and high school settings. This collection of papers adds to the growing body of empirical research exploring this topic, with a focus on the temporal relationship between conductor gesture and ensemble response.

Contents of the Dissertation

The first of the three papers in this dissertation is an extensive review of literature examining conducting in ensemble music. This review combines empirical literature with the practice and pedagogy of conducting, examining themes that are in direct and tangential relation to the role and activity of the conductor in ensemble. Within this, I discuss topics of expressive gesture and ensemble coordination, with focus given to their broad overlap in both research and practice. Additionally, I investigate the ability of performers to extract and use temporal information in ensembles. This paper also establishes a framework of ensemble conducting and performance investigated by the other studies in this dissertation.

The second paper, “A Question of Lag: The Relationship Between Conductor Gesture and Sonic Response in Instrumental Ensembles,” is an investigation of temporal offset between conductor and ensemble in naturalistic performance settings. This study examines the delay between conductors leading orchestras and wind bands and the sonic response of those ensembles. To accomplish this, I examine differences in both the quantity and quality of temporal offset between ensemble types, between experience levels, and over time. Within this I identify ensemble

type, experience level, and ensemble development over time as important variables in lag quantity and quality differences. Additionally, I identify the influence of performance tempo and phrase construction as contributors to the variance observed.

The final paper, “The Effects of Temporal Action-Sound Congruence on Evaluations of Conductor Efficacy,” examines observer perception of conductor efficacy through the manipulation of the temporal relationship of conductor's gestures to the ensemble’s response. Stemming from the conductor lead / ensemble lag relationship assumed by much of conducting practice and pedagogy, performance video of five conductors was experimentally manipulated to shift the conductor’s gesture ahead of or behind the original, intact video. Participants evaluated one of five fully-crossed stimuli orders, evaluating conductor, ensemble, and the group's overall performance. I identify offset quantity (lead/lag) as an important variable in differences between evaluations of both conductor and ensemble and note the potential role of entrainment in judgements of quality and efficacy. The primary author of this paper is the dissertation author, joined by co-authors Steven J. Morrison and Deborah H. Confredo.

While the primary focus of this multiple study dissertation is the temporal interaction of conductor and ensemble, several other strands weave themselves through the papers presented. The role of entrainment within groups and the cross-modal fusing of sound and sight required in ensemble performance are both important themes within all three papers. These aspects of ensemble music-making was not central to the original focus of this dissertation, but emerged as an important, if underreported, consideration in ensemble-based musical performance. My aim is to contribute to the fields of music education and music perception through these three papers, bringing greater understanding of each to the other.

PAPER ONE

An Exploratory Review of Conducting in Ensemble Music

Abstract

Conducting is a complex and multivariate activity that takes place in the equally complex, multivariate, and multimodal setting of ensemble musical performance. While over a century of anecdotal and pedagogical texts exist describing the activities of the conductor and her relationship to the ensemble that she leads, empirical investigations have only recently begun to examine this aspect of musical performance in a systematic way. This review will highlight literature that examines the twin functions of the conductor – time-keeper and expressive communicator – through work in music perception, experimental psychology, entrainment, and conducting pedagogy. The larger question of the conductor's influence on the ensemble's function, both temporally and aesthetically, will be explored alongside related questions of individual musician time extraction and meaning formation co-occurrent within the ensemble's activity. Finally, further avenues for research of this complex system of communication and coordination are offered.

Introduction

As the hall lights dim, the once restive audience becomes still. The principal violin rises and offers the oboist's tone for final adjustments. The orchestra's sound trails off and the hall falls to hushed silence. From the wings, the conductor enters to rapt applause and muted affirmation via the tapping feet of musicians on stage. Soon atop the podium the conductor bows in acknowledgment, turns to the orchestra with outstretched arms, and begins the performance with a simple gesture. For the remainder of the performance, the conductor serves as a point of focus for both audience and ensemble, situated as an active participant in the "one-way system of communication, running from composer to individual listener through the medium of the performer and further mediated by the expressive motions of the conductor." (Small, 1998, p.6)

From figures like Gustav Mahler and Leonard Bernstein to contemporary conductors such as Marin Alsop and Alondra de la Parra, conductors enjoy a special and central status in the ensembles that they lead. Their gestures are seen to influence musicians in ways both direct and indirect, communicating through silent, prescribed motion. Despite the longevity of this practice, the perceptual and behavioral outcomes of these gestures are not commonly addressed or understood in a systematic way by conductors, musicians, or educators. Instead, the vast majority of conductors understand their contribution from the perspectives of received practice and pragmatic experience, imbuing meaning and causality in gesture through their own perception of musician and ensemble response. Conductor Erich Leinsdorf confirms this through his observation that "gesture is of crucial importance in conducting as long as it carries a message. But that message cannot be determined in advance. It is born out of a need that arises only during music making" (1981, p. 168).

Through this lens conductors and musicians understand that there is efficacy or impotence in conducting gesture. The prevalence of information beyond pragmatic verification of one gesture's quality over another, however, is vanishingly rare in conducting's practical or pedagogic literature. The majority of these sources are reliant on a long string of received practice, passed from teacher to student, branching only as needs arise. Conductor Alan Gilbert, formerly of the New York Philharmonic, situates this lens when he shares, "There is a connection between the gesture, the physical presence, the aura that a conductor can project, and what the musicians produce" (2012). Conducting literature is, by and large, built on anecdote culled from long-term observation (Green & Gibson, 2004; Labuta & Matthews, 2018), the lived experiences of successful conductors (Rudolf, 1980; Leinsdorf, 1981), or theoretical applications to gestural practice (Saito, 1988; Jordan, Wyers, Andrews, 2011). The absence of empirical research within conducting presents an opportunity to strengthen and amplify existing texts, practice, and pedagogy through the integration of these two areas, as well as help to extend existing practice.

To that end, I will explore the practice of instrumental conducting as it intersects with research investigating musical performance and coordination. There is much to be gained through this exploration, but many conductors and conductor-educators do not have a strong frame of reference outside of their existing literature. I have structured this review in three sections investigating conducting practice and pedagogy, gestural communication, and coordination through gesture respectively. Through consideration of these areas this review addresses the broad expanse of activity in instrumental conducting. Where present, hierarchical organization in aspects of conducting are examined in order to allow for a deeper understanding

of both existing practice and the implications of future research findings. Suggestions for future research and considerations for integration within music education are also discussed.

The Development of Conducting Practice and Pedagogy

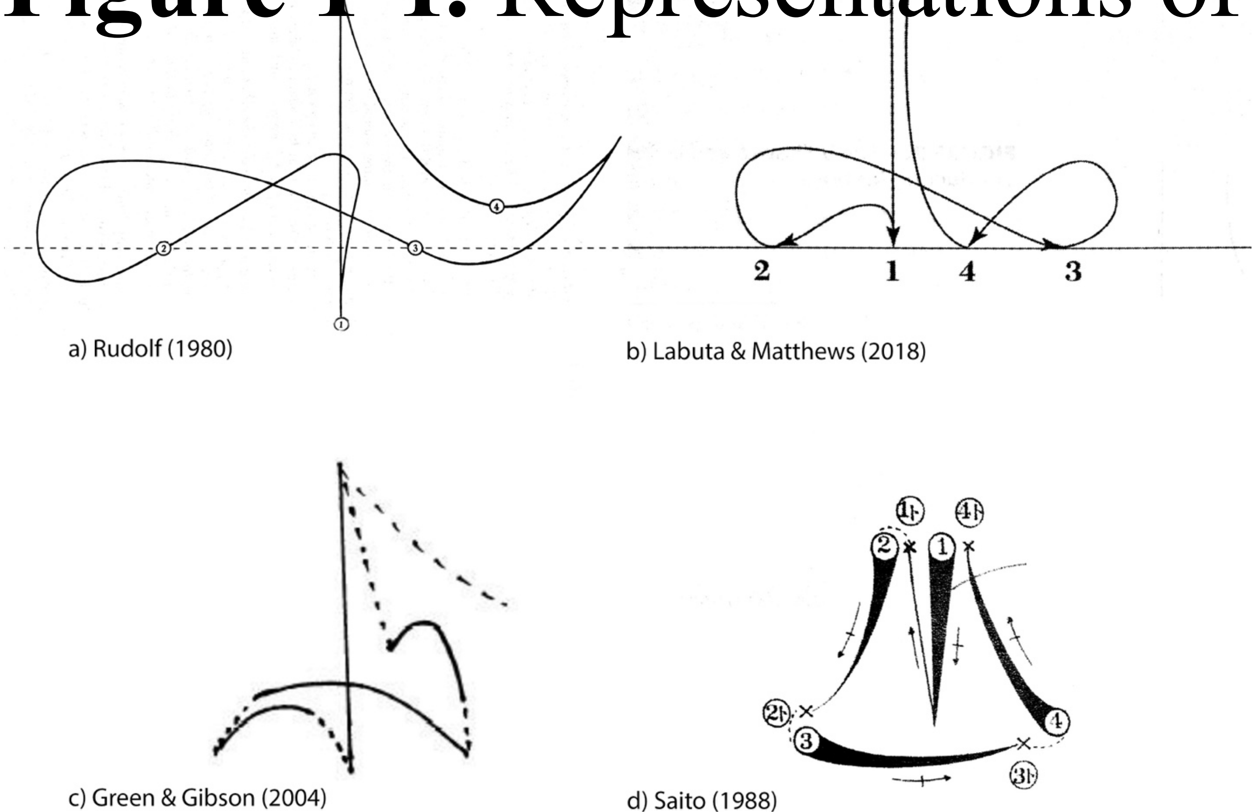
The specialized position of conductor grew out of the role of *kapellmeister*, in which an individual – most often the composer – served as coordinator of group musical activity during state functions and church services, a role held by both Bach and Haydn (Griesinger & Dies, 1968). This functional position gradually evolved into its current manifestation of conductor-as-interpreter through the concerted effort of composers and conductors in the middle 19th century (Galkin, 1988). First among these evolutionary voices was Hector Berlioz, who offered his thoughts as a remedy against unskilled conductors who were "selected from among the worst pianists to be found, or [those that] cannot play the pianoforte at all," (1855/2002, p. 257) in his treatise, *L'Arte du Chef d'Orchestre*. He was joined by Richard Wagner (1869) and Felix Weingartner (1896) in advancing the role of the conductor as a person who not only coordinates the activity of the ensemble, but also interprets the musical material under performance. Essentially, they envisioned an individual whose gesture balances communication of temporal signal and expressive intent, though disagreement over the importance of one gestural aspect or the other appeared not long after Berlioz's essay was published. Leonard Bernstein reflected on the early development of this disagreement thusly,

> The first real conductor in our sense of the word was Mendelssohn, who founded a tradition of conducting based on the concept of precision, as symbolized by the wooden stick that we call the baton. There soon arrived, however, a great dissenter named Richard Wagner, who declared that everything Mendelssohn was doing was

wrong and that any conductor worth his salt should personalize the score he was conducting by coloring it with his own emotions and his own creative impulse. (1954, p. 122).

This tension between coordination and expressivity remains a central consideration in conducting, as articulated by conductor Max Rudolf (1980), noting that "mere time-beating is not enough; the appropriate gesture for each musical expression must be mastered before we can speak of conducting" (p. xvi). Interestingly, popular conducting texts grant the majority of their page count to the topic of coordination, as their focus is largely on the instruction and refinement of gestural mechanics and conducting technique (Pasquale, 2008). This is presented as a

Figure 1-1. Representations of a Fo



collection of prescribed gestural patterns, each denoting a given number of beats, that the conductor performs to communicate time to the ensemble (see Figure 1-1). Information on expressive communication through these gestures is included, some incorporating observed practice (Green & Gibson, 2004; Labuta & Matthews, 2018) and others enlisting an external system of gestural communication (Jordan, Wyers, & Andrews, 2011), but the contrast of this material division when compared to the aims of Berlioz, Wagner, Weingartner, Bernstein, and Rudolf offers, if contrafactually, an insight into the difficulties of balancing these two aspects of conducting practice.

Further analysis of undergraduate conducting courses, where these ideas and books are most often found, highlights the imbalance of instruction prizing coordination over expressivity in curricula (Manfredo, 2008) and in the perceptions of students (Silvey, 2011b). Reporting on perception of conducting course outcomes among undergraduates, Silvey (2011b) found that students were more confident in their execution of conducting patterns than in their ability to communicate expressivity through those patterns. Similarly, university instructors reported a heavy focus on the mechanical aspects of conducting in their planning for these courses (Manfredo, 2008), revealing minimal time and focus on expressive communication within the gestures that were taught. Both studies cite a lack of instructional time as a limiting factor in providing access and experience in expressivity, but the hierarchical implication that mechanics must precede expressivity is, in itself, telling. Through this, the bifurcation suggested by Bernstein and reinforced by Leinsdorf's segmentation of gesture as "ranging from navigational to evocative" (1981, p. 169) is less as a continuum of aesthetic choice and more as a continuum of aptitude and skill-development. To wit, these practitioners believe that one must master the mechanical in order to access the expressive.

In this way, the treatment of gesture as a communicative channel is central to the study of conducting, but the specific content of that communication varies alongside experience and training. Several empirical reports note that experts demonstrate greater regularity and magnitude in expressive conducting than do novices (Bergee, 2005; Byo & Austin, 1994), and many of the aforementioned pedagogical texts are organized in a manner that presumes mechanical mastery of gesture before expressivity is meaningfully explored (Green & Gibson, 2004; Labuta & Matthews, 2018). A notable departure among these is the work of Japanese cellist and conductor Hideo Saito (1988), whose gestural vocabulary stands in contrast to that of his Western counterparts in that its progression through gesture synthesizes coordination-focused mechanics and expressivity in an array of prescribed, highly specific gestures intended to elicit equally specific responses from ensemble musicians. Additionally, the work of James Jordan and his collaborators in integrating existing practice with the movement-focused work of Rudolf von Laban is notable for its attempts to alleviate the paucity of expressivity in conducting (Jordan, 1985; Jordan, Wyers, & Andrews, 2011).

With this in mind, it is logical to infer that the development of conducting from its coordination-focused origins to its current manifestation as a means of simultaneously conveying musical intent and temporal signal is more accurately a transition from utilitarian gesture to abstract representation. In a similar way, conducting literature acknowledges the relationship between these elements and at the same time highlights their differences. Each represents an aspect of conducting that requires further independent examination, but consideration of the mechanisms by which gesture functions as a means of communication would assist in situating coordination and expression against and within one another.

Gestural Communication

Nonverbal gesture is powerful. It is foundational to the development of human communication across all cultures (Kita, 2003), and allows for the coordination of activity between individuals and within large groups (Sebanz, Bekkering, & Knoblich, 2006). The importance of gestures within conducting, then, is a subset of the larger set of meanings and outcomes in nonverbal gesture generally. The functional understanding of these two elements, communication and coordination, is important to the understanding of conducting as a means to both ends. Essentially, conducting is one example of many in which humans synchronize joint activity or convey meaning through visual means.

Where meaning is concerned, the development of gestural communication in children is closely linked to measurements of lexical and syntactic development (Iverson & Goldin-Meadow, 2005), but any parent will attest to the imprecision of a toddler's intent via their determined gesticulation. Similarly, among adults, gestural communication is mediated by culture and context but in most cases cannot be seen as an independent indicator of specified meaning (Hadar & Pinchas-Zamir, 2004). It has been shown to suffer from similar cross-cultural impediments to those found across verbal and lexical channels (Fay, Lister, Ellison, & Goldin-Meadow, 2014). As an aspect of cognitive function, gesture may be central to human communication — appearing even in interaction among individuals blind from birth (Iverson & Goldin-Meadow, 1998) — but its precision of meaning is "at best, only of incidental importance in communication" (Kendon, 1994, p. 192).

Music, however, is an inherently crossmodal experience. It integrates two streams of perception – sound and sight – into a fused experience where the absence of one impacts the perception and evaluation of the other (Godøy, 2003; Cohen, 2016). This crossmodal fusing does

not confer any greater clarity to the precision of either channel of communication, though. If we consider music as a functional subset of human communication that – similar to gesture – often lacks a direct semantic reference (Patel, 2008) it is unsurprising that researchers have noted a similarly powerful-but-imprecise specific, affective influence (Meyer, 1956; Sloboda, 1991; Juslin & Sloboda, 2001; Thoma et al., 2013). Additionally, music is similar to gesture in being mediated by a range of external factors, notably culture (Cross, 2008; Morrison & Demorest, 2009; Patel & Demorest, 2013) and presentation medium, which itself can shape the experience of music both aurally and visually (Thompson, Graham, & Russo, 2005). Through this, we can say that gesture joins sound in being a powerful but imprecise agent of communication.

It is useful to remember that both sound and sight serve multiple functions within music. The difference between a gesture that produces a sound and one that does not is highly consequential, as the former shares a causal relationship to the sonic result and the other does not. Conversely, visual communication of intent and the visual aspects of temporal coordination are both strongly supported by sonic information, and vice versa. Despite this, not all sound or gesture is meant to convey meaning, especially in group contexts. In contrast to the communicative expectation incumbent upon a soloist, the rhythm section of a jazz ensemble or the percussion section of a marching band is rarely called upon to convey specific musical intent through performed sound or gesture. Therefore, consideration of the multi- and crossmodal nature of music and conducting in an ensemble requires an extension beyond the general communicative power of gesture and sound, especially where the understanding of one's influence on the other is concerned. We must consider the role played by both aspects within the ensemble to fully appreciate the influence of each in our understanding of the whole.

The roles of gesture in music generally, and conducting specifically, do not cleanly divide between temporal and affect quality. There are many examples where one can find time within expressivity and expressivity within time, and for the purposes of clarity within this exploration we will address each as a separate area of musical communication. The predominance of instrumental performance research over conducting in both areas of gesture to be explored will guide the structure to follow, working from general reports to those that focus specifically on conducting.

Expressive Gesture in Music

There is evidence that a performer's physical movements bear consequence on an audience member's perceptions of her musical expressivity (Davidson, 1993; Juchniewicz, 2008), the formal structure of the piece being performed (Vines, Krumhansl, Wanderley, Dalca, & Levitin, 2005), and even the duration of individual tones within the performance (Schutz & Lipscomb, 2007). The breadth of gesture's impact on external perception of affect speaks to the quality of powerful imprecision discussed earlier, and further reinforces the power of sight within live musical performance. Indeed, even in the absence of sound, musically-focused gesture can significantly alter perceptions of a performance's general quality, even among untrained observers (Tsay, 2013, 2014; Rodger, Craig, & O'Modhrain, 2012)

The means by which these qualities manifest themselves require a dissection of gesture in music performance, however. Examining gestural affordances in musical sound, or the ways in which gesture interacts with music's creation, Godøy (2010) identifies a perception-action cycle underlying this activity in which the listener identifies and imagines the actions that produce the sound perceived or created. Godøy divides these into *sound-producing* and *sound-accompanying*

gestures, describing gestures that are and are not linked directly to a sonic result. The work of Wanderley (1999) allows for the subdivision of Godøy's sound-accompanying gesture into *accompanying* and *ancillary* gestures, wherein a gesture contains affective intent related to the music being performed or is simply co-occurent to the performance, respectively. This branching hierarchy allows for the disambiguation of activity that creates sound from other gesture, and the further classification of non-sound producing gestures by their relation to the expressive intent of the performer. It bears noting that these divisions are not clearly defined within observation, as many gestures can and do serve multiple functions within a performance (Godøy, 2010), but this classification of gesture by its relationship to a sonic consequent allows for the examination of the influence held by gestures on the perception of musical performance.

When we apply this classification structure to performance by examining variations in accompanying gesture's magnitude, the prevalence of its impact becomes clear. Davidson (1993) investigated expressivity in solo violin and piano performance by asking individuals to perform a selection at three levels of musical excitation - deadpan, projected, and exaggerated - which were captured in point light conditions (where reflective material highlighted major joints and bodily motion and video was modified to obscure all other visual markers). Video-only, audio-only, and audio-video conditions were created by the researchers and evaluated by trained musicians in a fully randomized order. Through this, the presence of visual information (in both visual only and audio-visual conditions) created the greatest change in the evaluation of expressivity across both instrumental contexts (violin and piano). Participants rated the video examples (both with and without sound) as more expressive than audio-only examples across all levels of excitation, thereby indicating the strength of the visual channel in conveying expressive qualities in performance.

The manner in which sound is created on violin and piano is readily apparent to even untrained observers, which could potentially blur distinctions between ancillary, accompanying and sound-producing gestures. Investigations by Vines and colleagues (Vines, Krumhansl, Wanderley, Dalca, & Levitin, 2005) examine the influence of expressive gesture in wind instrument performance where the creation of sound is mechanically obscured by the nature of the instrument's performance. This study, structured similar to Davidson's earlier work, asked evaluators to rate emotional experience across a randomized presentation of audio-video stimuli where a professional clarinetist performed musical excerpts at three levels of visual expressivity: immobile, standard, and exaggerated.

Their findings reveal that vision serves as "the primary channel through which variation in the clarinetist's performance intentions influence the emotions of the observers" (Vines et al., 2005, p. 465). Interestingly, the authors note a distinction between *structural* gesture, where a performer indicates a formal boundary such as a phrase ending or a cadence within the work, and *expressive* gesture, where musical intent is communicated. Their reported gestures do not cleanly align with the ancillary and accompanying gestures offered by Wanderley (1999), as structural, expressive, and accompanying gestures all contain meaningful information of differing kinds about the music or its performance, but ancillary gestures are simply co-occurrent to the performance. Vines and colleagues (2005) further reinforce the impact of the visual channel on perceptions of expressivity and communicated intent, but the expansion of gestural qualities from the findings of earlier researchers also adds credence to gesture's powerful-but-imprecise nature.

Beyond the buoying influence expressive gesture has on evaluations of musical performance is its ability to alter the viewer's perception of sound duration itself. Schutz and

Lipscomb (2007) highlighted the influence of expressive gesture in perceptions of tone duration in percussion performance. By pairing short and long duration notes performed on a marimba with similar long and short performance motions in a match-mismatch configuration they evaluated observer perceptions of note length. Across all conditions the visual channel (long / short) was significant in the evaluation of note length, even when paired with the opposite sound duration (short sound / long motion) and even after participants had been informed of the mismatch. Though there is evidence that this multimodal effect only exists in contexts where there is a causal link between action and sound (Schutz & Kubovy, 2009), it can be inferred that, even though long gestures cannot change the actual duration of tone on marimba, vision drives the perception of duration even in the presence of contrary indications. While this finding reveals further ambiguity in classifying some gestures as ancillary, accompanying, structural, or directly linked to the production of sound (as cases could be made for the presence of all in percussion performance generally), it does further illustrate the power of physical gesture in musical contexts.

The experience and evaluation of musical performance is strongly influenced by the visual component of human perception. Even in the absence of sound, visual information has been shown to communicate differences in expertise, skill, and competitive ranking at a level above chance in both individual (Tsay, 2013) and ensemble (Tsay, 2014) settings. While communication of specific meaning through these gestures is largely absent from findings, the influence held by the visual domain is pervasive throughout musical performance. In their metanalysis of research investigating the auditory and visual perception of musical performance, Platz and Kopiez conclude that “the visual component is not a marginal phenomenon in music perception, but an important factor in the communication of meaning” (2012, p. 75). Relatedly,

these same properties of visual influence on perception and evaluation of expressivity appear throughout investigations of ensemble conducting, as well.

Expressivity in Conducting

Nonverbal communication is central to conducting, as conducting is a musical activity without a direct sonic result. While all other instrumental performance contexts represent an action-sound relationship that feeds the perception-action cycle identified by Godøy (2010), conducting is alone in holding no direct, mechanical relationship to the sound being produced at its behest. If one were to imagine the rhythmic raising and lowering of hands and arms in any musical context, the expected percussive sound produced by that gesture is often quite different that the result of similar motion in a conducting context.

With this in mind and making use of the classifications provided by Godøy (2010) and Wanderley (1999), conducting is a kind of non-sonic gesture that, at various points, functions in an accompanying and/or structural role. This draws back to the observations offered by Bernstein (1954) and others, indicating a divide between precision and expressivity in conducting's fullest flowering. In this way, the activities of Mendelssohn and Wagner, as described by Bernstein, are examples of potential extremes between accompanying and structural gesture (though it is difficult to state definitively). More recently Leinsdorf observed a distinction between *navigational* and *evocative* conductors (1981, p. 169), where temporal coordination and expressive communication within conducting are positioned in manner similar to Mendelssohn and Wagner, via Bernstein (1954). This delineation complements the classification structure of Godøy (2010) and Wanderley (1999), especially when considered as a non-sonic form of gestural communication within music.

Investigations of expressive conducting's effect reveal findings that closely mirror those of existing instrumental performance research. When experimentally controlled by pairing video of high- and low-expressivity conducting with an identical audio track, participants rated the high-expressivity instrumental conducting as significantly more expressive (Morrison, Price, Geiger, & Cornacchio, 2009). Similarly, in a choral context, performance containing expressive conductor gestures are rated significantly higher than those containing inexpressive, or strict, gesture across both audio and audio-video contexts (Nápoles, 2013). This influence is seemingly training-independent, as it has also been noted among those with extensive or minimal formal musical training (Price, Mann, & Morrison, 2016). Even in less experimentally controlled settings, increased gestural quantity and variance is strongly correlated with increased musical expressivity, both in audio (Laib, 1993) and audio-video (Grechesky, 1985) conditions. In this way, the general mirroring of increased expressive motion or gesture contributing to increased perception of expressive performance holds true between instrumental performance and ensemble conducting.

In a departure from expressivity within instrumental performance, ensemble conductors are required to possess a wider vocabulary of gesture designed to indicate stylistic differences within a given piece. Expressive variance within these target areas follows a similar pattern of influence to more generalized expressivity evaluations, both in perception of performance quality (Morrison, Price, Smedley, & Meals, 2014) and in observer's evaluation of musical priority and salience within a given work (Kumar & Morrison, 2016). Morrison and colleagues (2014) varied both ensemble performance within dynamics and articulation (high- and low-contrast) and conductor gesture within those domains (high- and low-contrast), using a match/mismatch pairing to create fully crossed stimuli orders. Evaluations of high-contrast conducting along both

dynamics and articulation were rated more positively, even when paired with low-contrast ensemble performance.

Similarly, Kumar and Morrison (2016) found that the conductor's gesture serves as an aid to observer understanding of the work being performed. By varying the focus of the gestural vocabulary toward differing contrasts within a work (melody vs. ostinato, chords vs. interjections) they found that the conductor's gestural focus played a significant role in affective perception across a portion of the repertoire explored. This partial effect, seemingly mitigated by observer's preconceptions of the hierarchy of musical components within pieces in general, nonetheless points to a general relationship between conductor gesture and external evaluations of musical content. Findings investigating other features of ensemble conducting, such as a generally positive effect for baton use by the conductor in rhythmic and technical material (Silvey, Wacker, & Felder, 2017) as well as in conducting more generally (Nápoles, 2014), and the influence of conducting plane (or gestural height) on perceptions of expressivity (Silvey & Fisher, 2015) all reinforce the broader assertion of vision's importance in music perception (Platz & Kopiez, 2012).

It is important to note that the visual influence on musical performance, most often seen as a leavening agent to evaluations, is not universal. Morrison and Selvey (2014) found a lack of statistical significance in expressivity evaluations between audio-only and audio-video presentations of high-expressivity conducting (2014), though a significant difference was observed between audio-only and audio-video presentations of low expressivity conducting, with audio-only receiving higher expressivity evaluations. Similarly, Silvey highlighted the influence of an ensemble's expressivity and performance quality on perceptions of conductor expressivity (2011a), suggesting that expressivity itself may be a multi-directional property in ensemble

performance. These findings reveal the presence of variables within ensemble conducting that may additionally influence perceptions of expressivity.

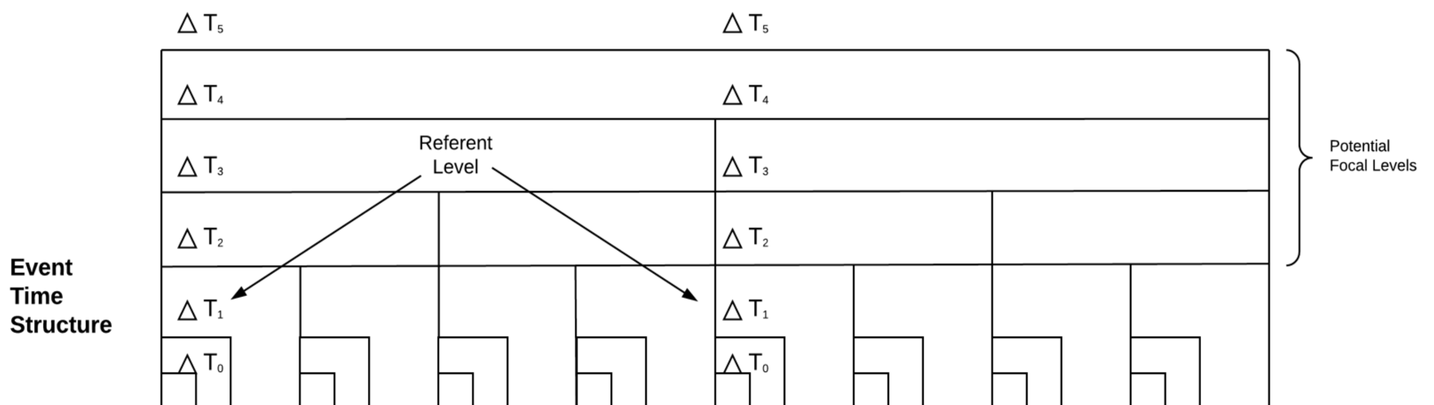
Examination of the influence played by static or idiosyncratic physical attributes doubtless play a role in the perception of affect and communication of intent in conducting. Included among those that have been investigated are physical attractiveness (Wapnick, Darrow, Kovacs, & Dalrymple, 1997) general appearance (VanWeelden, 2002), and facial expression (Mayne, 1992; Silvey, 2013). The impact of these variables is not fully understood, as metanalytic evaluations of conducting are largely absent from the literature and replication efforts have not yet extended these investigations to the level that theoretical frameworks can be distilled. Within and throughout these findings, however, the conclusions of Platz and Kopiez (2012) regarding the centricity of vision in the perception of music are further reinforced. Considering this within the crossmodal matrix of conductor and ensemble, it is important to consider the means by which observers, be they musicians and audience members, might extract salient information from the gestures presented to them.

Gestural Coordination in Music

Conducting is a non-sonic form of musical communication with the twin aims of conveying intent and coordinating action, and the means by which those signals are extracted owes much to the perceptual processes that underlie our ability to coordinate joint action between individuals. Potentially directed by the mirror neuron system, which is hypothesized to function as a portion of the brain that mirrors all perceived physical activity at the neuronal level (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Kohler et al., 2002; Overy & Molnar-Szakacs, 2009), it has been long noted that humans have a propensity toward coordinating physical

activities and emotional states with others (MacNeill, 1995). Within musical contexts, the coordination of joint physical activity is a much more clearly defined and studied aspect of this larger phenomenon, as the time provided by the conductor is highly consequential. In order to investigate this, we must consider the ability of humans to coordinate their activity with the activity of others through interaction with an external signal.

This property, entrainment, is the interaction of independent rhythmic systems with one another. In this relationship, the systems may showcase their own periodic, oscillatory activity as well as imitate the oscillations of other systems. This phenomenon is evident across nature, in both biological and non-biological settings, initially described in an inanimate setting via the 17th century experiments of Christiaan Huygens who found pendulum clocks to synchronize with one another when placed on a shared, flexible surface (see Ramirez, Olvera, Nijmeijer, & Alvarez, 2016, for a substantial discussion). In a similar way, biological entrainment is most often identified through synchrony, though observed examples suggest that synchrony may represent only a portion of the larger phenomenon of entrainment within human activity (Clayton, 2012).



In musical contexts, entrainment is observed in groups as small as a dyad and as large as hundreds, sometimes thousands, of performers. Within groupings, the entrainment activity observed may by symmetrical or asymmetric in nature, revealing that the coordinating signal is equal in influence across performers or highlights a singular focus from many performers to one source (Clayton, 2012). These examples of entrainment are fluid in their manifestation, shifting in character over time and between content and sometimes highlighting characteristics of multiple levels of rhythmic interaction through their activity (Phillips-Silver, Aktipis, & Bryant, 2010). According to Large (2000), entrainment requires interacting systems to be adaptable, able to align with other systems in a flexible manner, despite changes to the phase or period of the original signal. A system whose activity cannot accommodate these kinds of shifts may appear to be synchronized, but the rapid breakdown of coordination highlights a brittleness to this connection, one that indicates the incomplete overlap of entrainment and synchrony (Large & Palmer, 2001). Building on this, Levitin, Grahn, and London (2018) offer that humans are able to almost perfectly match movements to the beat rate and phase of music, but to do so they must create an internal representation of the beat to allow for synchrony with rather than reaction to the stimulus. These observations support the earlier work in hierarchical rhythmic attending done by Jones and colleagues (Jones, 1976; Jones & Boltz, 1989; Jones, Johnson, & Puente, 2006). These findings reflect a framework of rhythmic interaction that reveals itself when considering the propensity to "clap our hands, snap our fingers, stomp our feet, sway, dance or in some way coordinate our movements with the temporal structure that we perceive" (Large, 2000, p. 528) in individual and group level musical experiences.

Within the ability of an individual to coordinate musical activity in a complex environment is the means to detect the temporal signal amongst the noise. In her Dynamic

Attending Theory, Jones (1976) proposes that interaction with temporal information containing order or sequence is strongly influenced by the listener's attention to key features within the overall sonic signal. In contrast to theories linked to durational judgements of sound and silence, this theory posits that listeners perceive sound in a way that their attention is drawn to successive, invariant auditory markers that reveal understandable, hierarchical relationships within the temporal structure of that sound. Put another way, listeners hear regularly occurring features in a complex musical landscape and their attention is drawn to the aspects of those features that allow them to identify, predict, and synchronize with similar features in the future.

Jones and Boltz (1989) advance this further by offering that listeners entrain to a "…regular, prominently marked time period within an event" (p. 470). This referent level creates an auditory "home base" for listeners, giving their attending a clearer foundation from which to extrapolate shifting temporal activity and trajectory between hierarchical levels via changes in their individual focal attention. This shifting of focal attention is referred to as attunement, representative of not just the listener's recognition of the referent within the hierarchy but of their conscious diversion of attentional energy to other levels of temporal and metrical hierarchy. Essentially, the ability to recognize temporal coherence within any sound, including music, is expanded on by accessing related levels of organization within that sound in a manner not dissimilar to the shift from tapping one's foot to clapping a clave pattern in Latin music or switching one's attention from the snare to ride cymbal in swing music (see Figure 1-2).

Extending this, Jones and colleagues (Jones, Johnson, & Puente, 2006) expand on attunement by differentiating its underlying activity into *anticipatory* and *reactive* forms. They suggest that anticipatory attending is influenced by the larger time structure of the event being attended to, where reactive attending is influenced by temporally deviant, local, aspects of

temporal structure. According to the authors, both anticipatory and reactive attending are present during a listener's interaction with sound that contains a level of temporal coherence allowing for attending to take place. In this situation, anticipatory attending allows the listener to utilize the temporal hierarchy within the sound to predict longer-term patterns and improve accuracy in synchronization. During this, reactive attending engages in response to temporally deviant features in the signal, most often leading to decreased synchrony around the deviance in question. In this way, anticipatory and reactive attending provide the individual with information to identify aberrant temporal information and make better future-oriented judgements within and between the levels of temporal hierarchy.

Dynamic Attending Theory and its expansions focus on auditory stimuli, which are present in and consequential to the function of ensembles, but these stimuli represent half of the information channels available to musicians in conducted ensembles. The conductor's gestures provide the majority of temporally salient visual information, though in some ensemble settings other musicians can act as sources of time (Andai, 2011; D'Ausilio et al., 2012). The process of converting this visual information into a signal that allows for entrainment, synchrony, and attending is known as visual beat induction. Interestingly, the complexity of temporal information within these visual signals is relatively simple when compared to the auditory stream, but the ability of a performer to perceive, process, and utilize it is strikingly similar to the attending discussed by Jones (1976).

Luck and Sloboda (2009) found that visual beat induction was most strongly influenced by the rate of acceleration along a given trajectory within a conducting gesture. The authors note that, "…a visual beat is communicated by periods of acceleration or deceleration, and, as such, supports the theory that the percept of a visual beat is created by a variable which reflects a

change in the value of one of the parameters that defines a movement's trajectory" (p. 237). They take care to note that changes of direction or the rate of that directional change did not play a significant role in visual beat induction, only the rate of acceleration in the trajectory of a gesture contributed significantly to this effect. This suggests that beat induction to conducting stimuli is predictive in nature, rather than reactive, lending support to similar work by Luck and Toiviainen (2006), in which researchers identified that musicians tended to synchronize with periods of maximal deceleration along the trajectory of a conductor's gesture. Within the two-axis, horizontal and vertical vocabulary commonly found in instrumental conducting, the effect of regularity and smoothness across planes and within the conductor's gesture has also been shown to increase synchronization (Wöllner et al., 2012). Of these axes, vertical motion has been reliably found to coordinate musician's time-dependent activities as measured through maximal deceleration toward the lowest point of the trajectory (Clayton, 1986; Luck & Nte, 2008; Grady, 2014; Keller, 2014).

Building on findings pertaining to entrainment, attending, attunement, and visual beat induction, we are able to identify that the performer extracts information from conductors as they trace prescribed patterns of motion through the air, indicating a new beat, or onset, with every change of direction. Through this, performers note the time between these changes as a durational, or interonset, interval. This information allows performers to enlist both anticipatory and reactive attending, entraining to the rhythmic signal offered by the conductor in a flexible manner through these twin facets of temporal interaction. The beat is created by "the perception of a trajectory from which information about where to synchronize is extracted […] i.e. how a conductor communicates a single point in time at which everyone must play" (Luck & Sloboda, 2009). While we have seen that the visual representations of these patterns themselves may look

different (see Figure 1-1), each variation's intended function – temporal coordination by means of beat induction and entrainment – is invariant.

Group Musical Entrainment

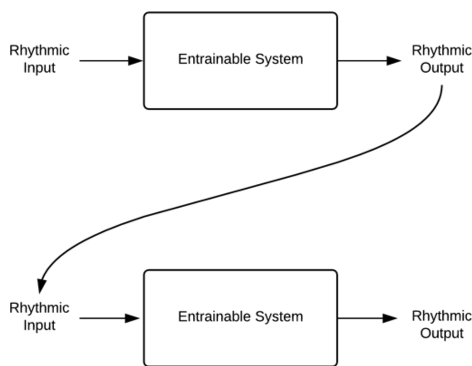
The ability of musicians to individually extract time-bearing information from both sonic and visual sources and apply that information is a fundamental aspect of music performance. Depending on their size and specific composition, ensembles introduce varying degrees of complexity to the sources of and relationships between each musician's aural attending, visual beat induction, and crossmodal combinations of these in entrainment. Consider the sources for aural attending between a pair of musicians and a quartet: Each member of the pair has one source of rhythmic information outside of themselves to entrain to, but quartet performers contend with the potential of three sources from individual colleagues as well as composite contributions from three potential pairs and a trio. A similar progression is observed in considering visual stimuli from other musicians, especially in conjunction with the conductor's gestures. Essentially, an individual's task becomes exponentially more complex as more ensemble members are introduced.

Through this we can see that large instrumental ensembles contain multiple individuals utilizing multiple modalities of communication who, in turn, serve as multiple transmitters and receivers within those modalities. This creates a dense, complex matrix of temporal information to be navigated, curated, and utilized by individual musicians toward the ends of their specific contribution to the music being performed. In order to understand beat induction, attending, and entrainment processes within this dense mesh of communication, we must consider entrainment's

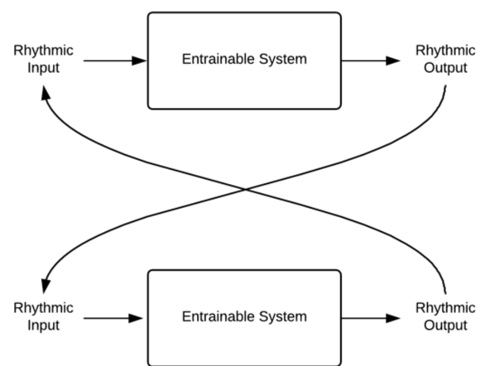
appearance and behavior within group and social settings (Clayton, 2012; Phillips-Silver, Aktipis, & Bryan, 2010).

The complexity of this group-level entrainment is directly affected by the group's scale, the number of musicians performing, as well as the role of each musician in the temporal function of the group or the music being performed. Clayton (2012) offers several interactive entrainment pathways within groups to address the issue of scale, ranging in connective complexity from one-to-one to many-to-many and in scope from inter-individual to intra-group.

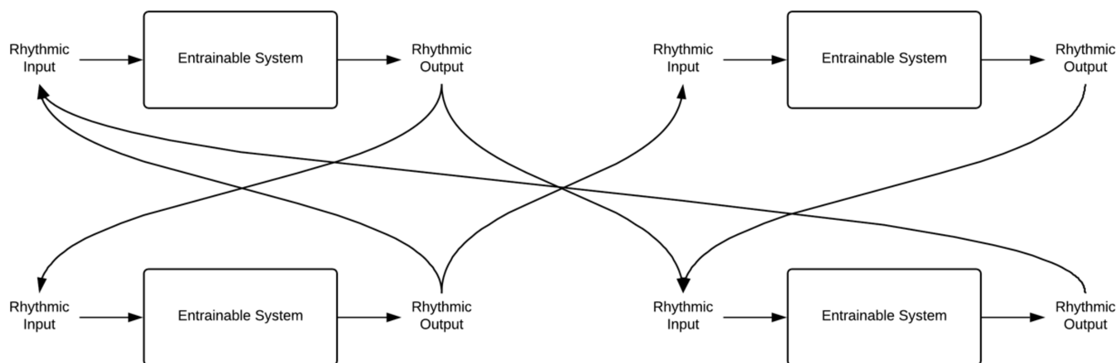
a) Social Entrainment



b) Mutual Social Entrainment



c) Collective Social Entrainment



Additionally, Clayton (2012) offers a view of temporal role within the group that treats the communication as symmetrical or asymmetric, where a single individual may communicate a rhythmic signal to many others, or the transmission and reception may be happening simultaneously between many individuals. Through this, we can see that an inter-individual relationship represents a symmetrical exchange of information if both individuals are serving as temporal transmitter and receiver of temporal information, and asymmetry in the same relationship is observed where one of the individuals acts as transmitter and the other as receiver. An inter-individual, many-to-many relationship similarly can manifest as symmetrical or asymmetric, depending on the relationship of transmission and reception within the group. With this in mind, conducting practice and pedagogy most often imply an asymmetric, one-to-many system of entrainment.

Phillips-Silver, Aktipis, and Bryant (2010) offer a more nuanced view of group entrainment, describing entrainment as "responsiveness to rhythmic information created by others" (p. 8), that they then extend into mutual- and collective-social manifestations of entrainment. These are organized along a line of increasing complexity with a baseline of social entrainment as the presence of a feedback loop from one system's output to another system's input. Mutual social entrainment deepens this interaction by both systems acting as transmitter and receiver, creating a loop in which one system can respond to variations in the signal of the other. Expanding further, collective social entrainment highlights a complex web of transmission and reception where multiple systems within the arrangement both provide and respond to changes in other systems (see Figure 1-3).

When considered alongside Clayton's scales of group-level entrainment (2012), the position of group-social entrainment (Phillips-Silver et al., 2010) within ensemble function adds

clarity to the potentially unruly complexity in musical ensembles. Ensembles, especially those that are conducted, represent an inter-individual system of entrainment that presents a range of possibilities for the directionality of an entraining signal. At the extremes of behavior these may appear as an asymmetric, one-to-many network of mutual social entrainment or as a symmetrical, many-to-many network of collective social entrainment. The former implies a monodirectional flow of transmission and reception, from the one to the many, while the latter highlights a bi-directional, continuous flow between individuals that creates a dense and complex web of time-oriented communication within the ensemble. Where conducting is concerned, practical and pedagogical resources support its classification as asymmetric entrainment and would likely support identification with the communication implied by mutual-social group entrainment offered by Phillips-Silver and colleagues (2010).

Though outward appearances conform to expectations of an asymmetric, one-to-many, mutual-social form of entrainment in conducted ensembles, evidence exists that creates a more complex and nuanced model of ensemble function, one which is not mentioned often in existing pedagogical or practical literature. An investigation of both conductor and violinist movement kinematics in a chamber orchestra reveals that increases in conductor-to-musician (and decreases in musician-to-musician) communication correlate to higher aesthetic evaluations of musical performance (D'Auslio et al., 2012). These findings, which utilized causal analysis of time series data to determine predictive relationships between multiple interacting systems (Granger, 1988), reinforce the view of asymmetric social entrainment between conductor and ensemble, but they also provide a view of entrainment within and between ensemble performers that suggests intermusician and intraensemble coordination at the level of individual musicians, lessening the weight of both the asymmetry and edging the interaction closer to a collective-social

manifestation of entrainment. Conforming to related findings observed in smaller, conductor-free settings such as string quartets (Wing, Endo, Bradbury, & Vorburg, 2014) and piano duos (Davidson & Williamon, 2002), these findings additionally support reports of large, conducted ensembles as a form of "chamber music on a grand scale" (McGill, 2007, p. 290) reported by many professional and amateur performers.

Similarly, but less quantifiably, influential in the behavior of ensembles is Dineen's "shadow ensemble," (2011) described as a group of prominent individuals within the group whose actions are consequential to the performance behaviors of other musicians through a combination of seniority, ability, or station (e.g. a first-chair or first-desk player). Dineen shares that practice and precedent render these individuals highly consequential to the performance function of the group, that they "assume some of the leadership roles normally assigned exclusively to the conductor." (p. 140) Within orchestras, a likely member of this elite group is the concertmaster. This individual serves as a primary referent for time and affect within the larger violin section, one whose responsibilities extend even into decisions of bow usage within individual pieces, a feature often passed down from one concertmaster to another (Andai, 2011). Within other sections of the orchestra, and other aspects of related instrumental groups like wind bands, principal players have been noted to serve similar roles. Though not always temporal in nature, the elevated responsibility and consequence of these individual's actions supports Dineen's identification of a group-within-a-group. Chris Martin, principal trumpet of the New York Philharmonic, confirms this in his observation of his role within the orchestra "in many cases you are the lead voice of the brass section. Your primary job is to dictate phrasing, expression, attacks, release(s) […] all the nuts and bolts of music." (New York Philharmonic, 2018).

These observations and findings suggest an impasse, or at least a compromise, between competing views of the conductor's gesture and its impact on the behavior and function of the ensemble. On one side rests pedagogy and practice, which centralizes the information offered by the conductor in both time (Rudolf, 1980; Saito, 1988; Green & Gibson, 2004; Labuta & Matthews, 2018) and expression (Leinsdorf, 1981; Jordan, Wyers, & Andrews, 2012). In studied opposition, empirical findings suggest a more nuanced and complex reality within ensembles (D'Ausilio et al., 2012; Dineen, 2011; Wing et al., 2014; Andai, 2011; Khodyakov, 2007) and appear to offer information that counterintuitively decreases clarity to assignments of both responsibility and communication within ensembles. While organizations that obviate this discussion do exist – conductorless ensembles such as the Orpheus Chamber Orchestra and Mercury Baroque Orchestra – they are often functionally restricted to a specific period or type of music, and therefore cannot be meaningfully generalized to satisfy the needs of rigorous investigation.

Regardless of where communicative responsibility is ultimately found to reside, the structure of instrumental ensembles still centralizes the conductor, both in location and in the execution of her duties. Due to this structural fact, combined with long-standing practice in musical performance and conducting (Galkin, 1988), this individual's activity still bears great consequence to the temporal and expressive function of the group. That is to say, conductors operate in a way that runs contrary to Frank Zappa's observation of their gestures as representing "…designs in the nowhere – with a stick, or with your hands – which are interpreted as instructional messages by guys wearing bow ties who wish they were fishing" (1989, p. 163).

Ensemble Conducting in Practice

The complexity of conducting's function within and effect on the ensemble are obvious, but the practical manifestation of these frameworks within performance and rehearsal have been largely neglected. As important as our understanding of what is occurring in the moments of gestural communication, how these interact with individual musicians, audience members, and conductors themselves are of great consequence as well. For conductors, choices to deploy expressivity, time, or combinations thereof may change based on literature, performers, or performance venue (Solti, 1998). For musicians, there may exist training or other contextual complications that inhibit full interaction with the conductor and ensemble. Audience members, too, may struggle in their interaction with the performance before them, whether through inexperience or other factors.

At the individual level, musicians are charged with the task of coordinating instrumental sound production with both temporal and expressive information offered to them by the conductor and that of their colleagues within the ensemble. Simultaneous to this process, in most cases musicians are also interpreting and synthesizing printed music (see Gundmundsdottir, 2010 for a review), as well as the management of any non-ergonomic encumbrance their instrument may introduce (as in the carriage of larger wind or string instruments). These challenges, while largely under-examined in instrumental ensemble settings, certainly play a role in the effect of any external stimulus.

Though their findings are restricted to violinists, Wurtz and colleagues offer that both experience and the structure of the music performed bear influence on the eye-hand span of the performer, as examined using eye tracking equipment and software (2009). Similar studies utilizing other instruments suggest a positive effect toward accuracy for experience, though

these are most often restricted to piano sight-reading (Truitt, Clifton, Pollatsek, & Rayner, 1997; Wristen, 2005; Drai-Zerbib, Baccino, & Bigand, 2012). Additionally, it can be inferred that visual attention to the conductor or other notable figures in the ensemble, as well as utilization of temporal and affective information gleaned there, exist in conjunction with more local efforts of sound production and adjustments to items like pitch, articulation, style, and phrasing. At high levels of expertise, these activities are being carried out simultaneously or in rapid succession, which Çorlu and colleagues share varies in quality in direct relationship to the cognitive load imposed by individual tasks onto the larger whole (Çorlu, Muller, Desmet, & Leman, 2015).

From the perspective of the audience member, the monodirectional flow of information from composer, through conductor and ensemble, is easily perceived (Small, 1998). We have seen that expressive qualities of the conductor's gesture, however, influence perception of the overall expressivity of the ensemble's performance (Price & Mann, 2011; Morrison, Price, Geiger, & Cornacchio, 2009; Morrison, Price, Smedley, & Meals, 2014), but one might consider that an untrained audience member might respond to this gesture in a different manner than a trained musician. Contrarily, findings suggest that there is likely little difference in overall aesthetic experience between those with musical training and those without (Madsen, Byrnes, Capparella-Sheldon, & Brittin, 1993). Even beyond the motions of the conductor, however, there is some evidence to suggest that the expressivity of an ensemble musician's physical gestures within the group may play a role in the overall perception of the performance's expressivity (Hamann, 2003), which would conform to the effect of expressive gesture in solo contexts explored by Davidson (1993) and others. Despite this, the vast majority of evidence offers that the variability of the ensemble's sonic output

and the conductor's gesture are the primary contributors to audience evaluations of performance quality.

In many ways, conductor and individual musicians both operate in a similar environment of temporal and affective musical information, though their responsibility to the musical ends before them are operationally different. It bears mentioning that conductors often monitor or respond to both aural and visual information from the ensemble, either gesturally and verbally, though a thorough investigation of this interaction falls outside the scope of this review. Both conductor and ensemble are awash in sound and sight, though from differing physical perspectives, and both must recruit attending and attunement to both provide and respond to the temporal signal and expressive range of the group's performance. The primary difference between conductor and musician is seen in the transmission strength of temporal and expressive information into the larger group communication matrix, a property whose rigorous examination is nascent but promising (D'Ausilio et al., 2012). Similarly, research has yet to fully investigate a conductor's *in vivo* attending, with literature exclusively addressing visual focus during performance (Bigand,et al., 2010). It is likely that the qualities of attending noted by Jones and colleagues (2006), as well as the cognitive load applied by the novelty or complexity of a given piece play a significant role in the conductor's deployment of expressive gesture and strength of temporal stability in a manner similar to musician's expressivity or accuracy (Çorlu et al., 2015), though current sources have only explored potential training effects in this area (Bodnar, 2017).

Limitations and Conclusions

The information reported in this review represents a brief summary of literature addressing conducting and its many dependent subcomponents. An exhaustive collection of research related to conducting would expand far beyond the already lengthy limits of this exploration, so curious readers are advised to seek further resources through related literature and authors. Additionally, it is important to note that investigations of ensemble-based phenomena, such as temporal action coordination or expressive gesture suffer from a distinct methodological bias as the computational means to track, measure, and analyze responses in a naturalistic setting have only recently become accessible and affordable (Davidson, 2014). Research in this area will doubtless produce keener insights into the interactive nature of ensemble performance as the means to observe, test, and record phenomena increase in accuracy and availability.

At the core of its function the image of a conductor mounting the podium and spurring an orchestra into performance has been borne out by findings investigating gestural communication, non-verbal expressivity, temporal coordination, and cognitive and perceptual processes recruited to the ends of musical performance, but only partially. Recent and mounting evidence highlights that the dense pathways of both time and musical intent found running throughout the ensemble flow as often between performers as they do from conductor to performer. Highlighted by the methodology and findings of D’Ausilio and colleagues (2012), this interior network of communication and coordination highlight an underexplored aspect of cognition, perception, and interaction within musical ensembles. Once fully mapped and understood, this mesh of information may reveal more than just an accurate model of musical performance. Its potential for improving music educational outcomes, as well as expanding a general understanding of human group interaction, make this a promising area of research.

Similarly, the influence of timing within a conductor's gesture to perceptions of conductor and ensemble quality are only loosely understood. With evidence to support dynamic variation as an element of entrainment in motor tasks (Jones & Boltz, 1989; Clayton, 2012; Merker, Madison, & Eckerdal, 2009), it stands to reason that the degree of congruence between conductor gesture to ensemble response is potentially a negotiated, or at least dynamic, property. When considered alongside findings suggesting that temporal variability as small as 30-50ms can be perceptually informative (Large & Palmer, 2001), the case for further investigation becomes stronger. Further, additional work is needed to explore effects that specific conducting gestures may have on an ensemble's sonic response, building on the nascent findings within choral literature (Madsen, 1991; Fuelberth, 2003; Daugherty & Brunkan, 2012).

In a space where both the presence and absence of organized sound is highly consequential, the figure of the conductor stands apart in their perpetual silence. This alone makes them a person of interest in musical contexts and focuses attention to their activity as a subject of investigation for researchers and practitioners alike. Considerable scholarship supports their function as a mediator and moderator of musical experience to both audience and musician alike, and research suggests that their temporal influence is central to the function of the groups they lead, though they are not the only transmitter of consequence within their ensembles. Evidence suggests that the conductor's expressive gesture is meaningful, though any specificity within this meaning may be overshadowed by the powerful-but-imprecise nature of its simple presence. Pedagogy and history offer practical guides to their development, some of which are reflected in the findings of empirical research, though others remain to be explored in a systematic manner. Centralized by the structure of the ensemble and performance space, the attention of audience and the ensemble alike, this contributor soundlessly communicates,

coordinates, and cajoles influence to and through musicians, adding silently to an experience that is otherwise awash with sound.

References

Andai, D. (2011). *A contemporary approach to orchestral bowings for the concertmaster* (Doctoral dissertation, University of Miami).

Bergee, M. J. (2005). An exploratory comparison of novice, intermediate, and expert orchestral conductors. *International Journal of Music Education*, *23*(1), 23-36. doi: 10.1177/0255761405050928

Bernstein, L. (1954). *The joy of music*. New York, NY: Simon and Schuster.

Bigand, E., Lalitte, P., Lerdahl, F., Boucheix, J. M., Gérard, Y., & Pozzo, T. (2010). Looking into the eyes of a conductor performing Lerdahl's "Time after Time". *Musicae Scientiae*, *14*(2_suppl), 275-294. doi: 10.1177/10298649100140S215

Bodnar, E. N. (2017). The effect of intentional, preplanned movement on novice conductors' gesture. *Journal of Music Teacher Education*, *26*(3), 38-50. doi: 10.1177/1057083716644651

Byo, J. L., & Austin, K. R. (1994). Comparison of expert and novice conductors: An approach to the analysis of nonverbal behaviors. *Journal of Band Research*, *30*(1), 11. Retrieved from http://search.proquest.com.ezproxy.lib.uh.edu/docview/1312127790?accountid=7107

Clayton, M. (1986). *Coordination between players in musical performance.* (Doctoral dissertation, University of Edinburgh).

Clayton, M. (2012). What is entrainment? Definition and applications in musical research. *Empirical Musicology Review*, 7(1-2), 49-56. http://hld.handle.net/1811/52979

Cohen, A. J. (2016). From auditory focus, to auditory influence, to multimodal experience in psychomusicological research. *Psychomusicology: Music, Mind, and Brain, 26*(2), 99-100.doi: 10.1037/pmu0000149

Çorlu, M., Muller, C., Desmet, F., & Leman, M. (2015). The consequences of additional cognitive load on performing musicians. *Psychology of Music*, *43*(4), 495-510. doi: 10.1177/0305735613519841

Cross, I. (2008). Musicality and the human capacity for cultures. *Musicae Scientiae,* 12(1_suppl), 147-167. doi: 10.1177/1029864908012001071

Daugherty, J.F., & Brunkan, M.C. (2012). Monkey see, monkey do? The effect of nonverbal conducting lip rounding on visual and acoustic measures of singers' lip postures. *Journal of Research in Music Education, 60*(4), 345-362. doi: 10.1177/0022429412464039

Davidson, J. W. (1993). Visual perception of performance manner in the movements of solo musicians. *Psychology of Music, 21*(2), 103-113. doi: 10.1177/030573569302100201.

Davidson, J.W. (2014). Implications for empirical expressive music performance research. In D. Fabian, R. Timmers, E. Schubert (Eds.), *Expressiveness in Music Performance: Empirical Approaches Across Styles and Cultures* (pp. 344-347). Oxford, UK: Oxford University Press.

D'Ausilio, A., Badino, L., Li, Y., Tokay, S., Craighero, L., Canto, R., Aloimonos, Y., & Fadiga, L. (2012). Leadership in orchestra emerges from the causal relationships of movement kinematics. *PLoS One, 7*(5), e35757. doi: 10.1371/journal.pone.0035757.

Drai-Zerbib, V., Baccino, T., & Bigand, E. (2012). Sight-reading expertise: Cross-modality integration investigated using eye tracking. *Psychology of Music*, *40*(2), 216-235. doi: 10.1177/0305735610394710

Fay, N., Lister, C.J., Ellison, T.M., Goldin-Meadow, S. (2014). Creating a communication system from scratch: Gesture beats vocalization hands down. *Frontiers in Psychology, 5*(354), 1-12. doi: 10.3389/fpsyg.2014.00354

Fuelberth, R. J. V. (2003). The effect of conducting gesture on singers' perceptions of inappropriate vocal tension. *International Journal of Research in Choral Singing*, *1*(1), 13-21.

Galkin, E. W. (1988). *A history of orchestral conducting: in theory and practice*. Pendragon Press.

Gilbert, A. (2012, April 6). Connecting music and gesture. *The New York Times,* online. Retrieved from: http://archive.nytimes.com/www.nytimes.com/interactive/2012/04/06/arts/music/the-connection-between-gesture-and-music.html

Granger, C. W. (1988). Causality, cointegration, and control. *Journal of Economic Dynamics and Control*, *12*(2-3), 551-559. doi: 10.1016/0165-1889(88)90055-3

Grechesky, R.N. (1985). An analysis of nonverbal and verbal conducting behaviors and their relationship to expressive musical performance. (Doctoral dissertation, University of Wisconsin – Madison).

Green, E.A.H., & Gibson, M. (2004). *The modern conductor: Seventh Edition*. New York: Pearson.

Godøy, R. I. (2010). Gestural affordances of musical sound. *Musical gestures: Sound, movement, and meaning*, 103-125.

Griesinger, G. A., & Dies, A. C. (1968). *Haydn: two contemporary portraits*. Madison, WI: University of Wisconsin Press.

Gudmundsdottir, H. R. (2010). Advances in music-reading research. *Music Education Research*, *12*(4), 331-338. doi: 10.1080/14613808.2010.504809

Hadar, U., & Pinchas-Zamir, L (2004). The semantic specificity of gesture: Implications for gesture classification and function. *Journal of Language and Social Psychology, 23*(2), 204-214. doi: 10.1177.0261927X04263825

Hamann, K. L. (2003). Identification of expressiveness in small ensemble performances by middle school students. *Bulletin of the Council for Research in Music Education*, 24-32. doi: http://www.jstor.org/stable/40319421

Iverson, J.M., & Goldin-Meadow, S. (1998). Why people gesture as they speak. *Nature, 396*(6708)*,* 228. doi: 10.1038/24300

Iverson, J.M., & Goldin-Meadow, S. (2005). Gesture paves the way for language development. *Psychological Science, 16*(5), 367-371. doi: 10.1111/j.0956-7976.2205.01542.x

Jones, M.R. (1976). Time, our lost dimension: Toward a new theory of attention, perception, and memory. *Psychological Review, 83*(5), 323-355. doi: 10.1037/0033-295X.83.5.323

Jones, M.R., & Boltz, M. (1989). Dynamic attending and responses to time. *Psychological Review, 96*(3), 459-491. doi: 10.1037/0033-295X.96.3.459.

Jones, M. R., Johnston, H. M., & Puente, J. (2006). Effects of auditory pattern structure on anticipatory and reactive attending. *Cognitive psychology*, *53*(1), 59-96. doi: 10.1016/j.cogpsych.2006.01.003

Jordan, J. M. (1985). The effects of information movement instruction derived from the theories of Rudolf von Laban upon the rhythm performance and discrimination of high school students. (Doctoral dissertation, Temple University).

Jordan, J., Wyers, G., & Andrews, M. (2011). *The conductor's gesture: A practical application of Rudolf von Laban's movement language.* Chicago, IL: GIA Publications.

Juchniewicz, J. (2008). The influence of physical movement on the perception of musical performance. *Psychology of Music*, *36*(4), 417-427. doi: 10.1177/0305735607086046

Juslin, P.N., & Sloboda, J.A. (2001). *Music and emotion: Theory and research*. Oxford: Oxford University Press.

Kendon, A. (1994). Do gestures communicate? A review. *Research on Language and Social Interaction, 27*(3), 175-200. doi: 101207/s15327973rlsi2703_2

Khodyakov, D. M. (2007). The complexity of trust-control relationships in creative organizations: Insights from a qualitative analysis of a conductorless orchestra. *Social Forces*, *86*(1), 1-22. doi: 10.1353/sof.2007.0100

Kita, S. (Ed.). (2003). *Pointing: Where language, culture, and cognition meet*. Psychology Press.

Kohler, E., Keysers, C., Umilta, M. A., Fogassi, L., Gallese, V., & Rizzolatti, G. (2002). Hearing sounds, understanding actions: action representation in mirror neurons. *Science*, *297*(5582), 846-848. doi: 10.1126/science.1070311

Kumar, A.B., & Morrison, S.J. (2016). The conductor as visual guide: Gesture and perception of musical content. *Frontiers in Psychology, 7*(1049), 1-11. doi: 10.3389/fpsyg.2016.01049

Labuta, J.A., & Matthews, W.K. (2018). *Basic conducting techniques*. New York: Routledge.

Laib, J. R. (1993). *The effect of expressive conducting on band performance* (Doctoral dissertation, University of Georgia).

Large, E.W. (2000). On synchronizing movements to music. *Human Movement Science*, 19, 527-566.

Large, E.W., & Palmer, C. (2001). Perceiving temporal regularity in music. *Cognitive Science, 26*(1), 1-37. doi: 10.1207/s15516709cog2601_1

Leinsdorf, E. (1981). *The composers advocate: A radical orthodoxy for musicians.* New Haven, CT: Yale University Press.

Levitin, D.J., Grahn, J.A., London, J. (2018). The psychology of music: Rhythm and movement. *Annu. Rev. Psychol., 69,* 51-75. doi: 10.1146/annurev-psych-122216-011740.

Luck, G. (2000). Synchronizing a motor response with a visual event: The perception of temporal information in a conductor's gestures. In *Proceedings of the 6th International Conference on Music Perception and Cognition (ICMPC6)(CDROM).*

Luck, G., & Nte, S. (2008). An investigation of conductors' temporal gestures and conductor—musician synchronization, and a fist experiment. *Psychology of Music*, *36*(1), 81-99. doi: 10.1177/0305735607080832

Luck, G., & Sloboda, J. (2009). Exploring the spatio-temporal properties of simple conducting gestures using a synchronization task. *Music Perception: An Interdisciplinary Journal, 25*(3), 225-239. doi: 10.1525/mp.2008.25.3.225.

Luck, G., & Toiviainen, P. (2006). Ensemble musicians' synchronization with conductors' gestures: An automated feature extraction analysis. *Music Perception: An Interdisciplinary Journal, 24*(2), 189-200. doi: 10.1525/mp.2006.24.2.189.

Madsen, C. K., Byrnes, S. R., Capperella-Sheldon, D. A., & Brittin, R. V. (1993). Aesthetic response to music: Musicians versus nonmusicians. *Journal of Music Therapy*, *30*(3), 174-191. doi: 10.1093/jmt/30.3.174

Madsen, M. K. (1991). *The effect of specific conducting gestures on vocal sound.* (Doctoral dissertation, Florida State University).

Manfredo, J. (2008). Factors influencing curricular content for undergraduate instrumental conducting courses. *Bulletin of the council for Research in Music Education*, 43-57. doi: http://www.jstor.org/stable/40319412

Mayne, R. G. (1992). *An investigation of the use of facial expression in conjunction with musical conducting gestures and their interpretation by instrumental performers* (Doctoral dissertation, The Ohio State University).

McGill, D. (2007). *Sound in motion: A performer's guide to greater musical expression*. Bloomington, IN: Indiana University Press.

Merker, B. H., Madison, G. S., & Eckerdal, P. (2009). On the role and origin of isochrony in human rhythmic entrainment. *cortex*, *45*(1), 4-17. doi: 10.1016/j.cortex.2008.06.011

Meyer, L.B. (1956). *Emotion and meaning in music.* Chicago, IL: The University of Chicago Press.

Morrison, S.J., & Demorest, S.M. (2009). Cultural constraints on music perception and cognition. *Progress in Brain Research, 178*, 67-77. doi: 10.1016/S0079-6123(09)17805-6

Morrison, S.J., Price, H.E., Geiger, C.G., & Cornacchio, R. A. (2009). The effect of conductor expressivity on ensemble performance evaluation.

Morrison, S.J., Price, H.E., Smedley, E. M., & Meals, C.D. (2014). Conductor gestures influence evaluations of ensemble performance. *Frontiers in Psychology*, *5*(806), 1-8. doi: 10.3389/fpsyg.2014.00806

Morrison, S.J., & Selvey, J. (2014). The effect of conductor expressivity on choral ensemble evaluation.

Nápoles, J. (2013). The influences of presentation modes and conducting gestures on the perceptions of expressive choral performance of high school musicians attending a

summer choral camp. *International Journal of Music Education, 31*(3), 321-330. doi: 10.1177/0255761411434823

Nápoles, J. (2014). The effect of baton use in fast and slow tempi on perceptions of choral conductor and ensemble performance. *International Journal of Research in Choral Singing*, *5*(1), 15-25.

New York Philharmonic. (2018, May 1). *On the cover: Christopher Martin Q&A.* [Video File]. Retrieved from https://www.youtube.com/watch?v=-U7pf7_huzA.

Pasquale, J.D. (2008). Directed listening for wind ensemble conductors: A pedagogy for developming aural analysis and effective rehearsal strategy. (Doctoral dissertation, University of Oklahoma).

Patel, A.D. (2008). *Music, language, and the brain.* New York, NY: Oxford University Press.

Patel, A.D., & Demorest, S.J. (2013). Comparative music cognition: Cross-species and cross-cultural studies, Chapter 16. In D. Deutsch (Ed.), *The psychology of music* (3rd. ed.)(pp. 647-681). San Diego, CA: Academic Press.

Phillips-Silver, J., Aktipis, C. A., & Bryant, G. A. (2010). The ecology of entrainment: Foundations of coordinated rhythmic movement. *Music Perception: An Interdisciplinary Journal*, *28*(1), 3-14. doi: 10.1525/mp.2010.28.1.3

Platz, F., & Kopiez, R. (2012). When the eye listens: A meta-analysis of how audio-visual presentation enhances the appreciation of music performance. *Music Perception: An Interdisciplinary Journal*, *30*(1), 71-83. doi: 10.1525/mp.2012.30.1.71

Price, H.E. (2006). Relationships among conducting quality, ensemble performance quality, and state festival ratings. *Journal of Research in Music Education, 54*(3), 203-214. doi: 10/1177/002242940605400304

Price, H.E., & Chang, C. (2001). Conductor expressivity and ensemble performance: An exploratory investigation. *Contributions to Music Education, 28*(2), 9-20. http://www.jstor.org/stable/24127033

Price, H.E., & Chang, C. (2005). Conductor and ensemble performance expressivity and state festival ratings. *Journal of Research in Music Education, 53*(1), 66-77. doi: 10.1177/002242940505400106

Price, H.E., & Mann, A. (2011). The effect of conductors on ensemble evaluations. Bulletin of the Council for Research in Music Education, 189, 57-72. http://www.jstor.org/stable/10.5406/bulcouresmusedu.189.0057.

Ramirez, J. P., Olvera, L. A., Nijmeijer, H., & Alvarez, J. (2016). The sympathy of two pendulum clocks: beyond Huygens' observations. Scientific reports, 6, 23580. doi: 10.1038/srep23580

Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. Cognitive brain research, 3(2), 131-141. doi: 10.1016/0926-6410(95)00038-0

Rodger, W.M.M., Craig, C.M., & O'Modhrain, S. (2012). Expertise is perceived from both sound and body movement in musical performance. *Human Movement Science, 13*(5), 1173-1150. doi: 10.1016/j/humov.2012.02.012

Rudolf, M. (1980). *The grammar of conducting (2nd ed.).* New York, NY: Schirmer Books.

Saito, H. (1988). *The Saito conducting method.* (tr. F. Torigai, ed. W.J. Toews). Tokyo, Min-On Concert Association & Ongaku No Tomo Sha Corp.

Schutz, M., & Kubovy, M. (2009). Causality and cross-modal integration. *Journal of Experimental Psychology: Human Perception and Performance*, *35*(6), 1791. doi: 10.1037/a0016455

Schutz, M., & Lipscomb, S (2007). Hearing gestures, seeing music: Vision influences perceived tone duration.

Sebanz, N., Bekkering, H., & Knoblich, G. (2006). Joint action: bodies and minds moving together. *Trends in cognitive sciences*, *10*(2), 70-76. doi: https://doi.org/10.1016/j.tics.2005.12.009

Silvey, B.A. (2011a). The effect of ensemble performance quality on the evaluation of conducting expressivity. *Journal of Research in Music Education, 59*(2), 162-173. doi: 10.1177/0022429411406173

Silvey, B. A. (2011b). Undergraduate music majors' perceptions of instrumental conducting urricula. *Journal of Music Teacher Education*, *21*(1), 27-38. doi: 10.1177/1057083710387521

Silvey, B.A. (2013). The role of conductor facial expression in students' evaluation of ensemble expressivity. *Journal of Research in Music Education, 60*(4), 419-429. doi: 10.1177/0022429412462580

Silvey, B.A., & Fisher, R.A. (2015). Effects of conducting plane on band and choral musicians' perceptions of conductor and ensemble expressivity. *Journal of Research in Music Education, 63*(3), 369-383. doi: 10.1177/0022429415597888

Silvey, B.A., Wacker, A.T., & Felder, L. (2017). Effects of baton usage on college musicians' perceptions of ensemble performance. *International Journal of Music Education,* 1-10. doi: 10.1177/0255761416667465

Small, C. (2011). *Musicking: The meanings of performing and listening*. Wesleyan University Press.

Solti, G. (1998). *Memoirs.* Chicago, IL: Chicago Review Press.

Thoma, M. V., La Marca, R., Brönnimann, R., Finkel, L., Ehlert, U., & Nater, U. M. (2013). The effect of music on the human stress response. *PloS one*, *8*(8), e70156. doi: 10.1371/journal.pone.0070156

Thompson, W.F., Graham, P., & Russo, F.A. (2005). Seeing music performance: Visual influences on perception and experience. *Semiotica, 2005*(156), 203-227. doi: 10.1515/semi.2005.2005.156.203

Truitt, F. E., Clifton, C., Pollatsek, A., & Rayner, K. (1997). The perceptual span and the eye-hand span in sight reading music. *Visual cognition*, *4*(2), 143-161. doi: 10.1080/713756756

Tsay, C.J. (2013). Sight over sound in the judgement of music performances. *Proceedings of the National Academy of Sciences of the United States of America, 110*(36), 14580-14585. doi: 10.1073/pnas.1221454110

Tsay, C.J. (2014). The vision heuristic: Judging music ensembles by sight alone. *Organizational Behavior and Human Decision Processes, 124*(1). 24-33. doi: 10.1016/j.obhdp.2013.10.003

Wagner, R. (1869). *Über das dirigieren.* Leipzig: Breitkopf & Härtel Verlag.

VanWeelden, K. (2002). Relationships between perceptions of conducting effectiveness and ensemble performance, *Journal of Research in Music Education, 50*, 165-176.

Vines, B.W., Krumhansl, C.L., Wanderley, M.M., Dalca, I.M., & Levitin, D.J. (2005). Dimensions of emotion is expressive musical performance. *Annals of the New York Academy of Sciences, 1060*, 462-466. doi: 10.1196/annals./1360.052

Wanderley, M.M. (1999). Non-obvious performer gestures in instrumental music. In: A. Braffort, R. Gherbi, S. Gibet, J. Richardson, & D. Teil (Eds.), *Gesture-based communication in human-computer interaction* (pp. 37-48). Berlin: Springer Verlag.

Wapnick, J., Darrow, A. A., Kovacs, J., & Dalrymple, L. (1997). Effects of physical attractiveness on evaluation of vocal performance. *Journal of Research in Music Education*, *45*(3), 470-479. doi: 10.2307/3345540

Williamon, A., & Davidson, J. W. (2002). Exploring co-performer communication. *Musicae Scientiae*, *6*(1), 53-72. doi: 10.1177/102986490200600103

Wing, A. M., Endo, S., Bradbury, A., & Vorberg, D. (2014). Optimal feedback correction in string quartet synchronization. *Journal of The Royal Society Interface*, *11*(93), 20131125. doi: 10.1098/rsif.2013.1125

Weingartner, F. (1896). *Über das dirigieren.* Berlin: J. Fischer Verlag.

Wöllner, C., Deconinck, F. J., Parkinson, J., Hove, M. J., & Keller, P. E. (2012). The perception of prototypical motion: Synchronization is enhanced with quantitatively morphed gestures of musical conductors. *Journal of Experimental Psychology: Human Perception and Performance*, *38*(6), 1390.

Wristen, B. (2005). Cognition and motor execution in piano sight-reading: A review of literature. *Update: Applications of Research in Music Education*, *24*(1), 44-56. doi: 10.1177/87551233050240010106

Wurtz, P., Mueri, R. M., & Wiesendanger, M. (2009). Sight-reading of violinists: Eye movements anticipate the musical flow. *Experimental brain research*, *194*(3), 445-450. doi: 10.1007/s00221-009-1719-3

Zappa, F. (1989). *The real Frank Zappa book*. New York, NY: Poseidon.

PAPER TWO

A Question of Lag: The Relationship Between Conductor Gesture and Sonic Response in Instrumental Ensembles

Abstract

In any ensemble performance, a lag exists between coordinating gesture and sonic response. The existence of this delay is a fact of human physiology, but its behavior within musical contexts can be influenced by an array of factors. Within large, conducted instrumental ensembles (e.g., orchestra and wind band) little is known about this lag beyond its existence, primarily in orchestral settings at that. Especially where a conductor is charged with the coordination of musical activity by gesture alone, it is hypothesized that the offset of gesture to sound will behave in related but similar ways to those reported in other, smaller ensembles. In this study I investigate the presence of this offset in orchestral and wind band settings, examining differences between groups, over time, and between experience levels. Results indicate a general difference in offset values between orchestra offsets (n = 825, Mdn = -133.2ms) and wind band offsets (n = 879, $Mdn.$ = 53.7 ms), U = 554740, Z = 225.58, p < .001, r = .46. Time series and relative phase analyses were also utilized to further explore these differences.

Introduction

The appearance of a sonic delay, or lag, between conductor and ensemble in orchestral settings is well known and much discussed among conductors and performers, though most often through anecdote (Bell, 2004; Johnson, 2014; Bennett, 2017). When I consider the view that instrumental ensemble music performance in orchestra (and by extension, wind band) represents "a one-way system of communication, running from composer to individual listener through the medium of the performer and further mediated by the expressive motions of the conductor" (Small, 1998, p.6), the paucity of research on the temporal relationship between conductor and ensemble presents an interesting context for investigation. Additionally, the physical configuration of orchestra and wind band are similar in many ways (i.e., number of performers, physical orientation of performers to conductor, performing venue), but discussions of "lag" appear primarily in orchestral settings (Bell, 2004; Johnson, 2014; Bennett, 2017). This reveals both that these ensembles may operate in different ways and that deviations are assessed from the perspective of the conductor's time only, indicating through omission that the interaction of ensemble performance in terms of time and synchrony within and between performers and conductors is not well understood. In this paper, I will examine temporally salient features of large instrumental ensemble performance, moving from individual musician and conductor activity to group-level coordination. We will then examine the appearance and behavior of temporal offsets within live orchestra and wind band performance.

Investigations of synchronized motor relationships like those in these large musical ensembles, have been explored in settings as diverse as spontaneous synchrony in audience applause (Néda, Ravasz, Brechet, Vicsek, Barabási, 2000), performance of Indian *tanpura* players (Clayton, 2007), within string quartets (Wing, Endo, Bradbury, & Vorberg, 2014), and

between performer and conductor in chamber orchestra settings (D'Ausilio et al., 2012; Luck & Toivianien, 2006), but the lack of investigation of the related area of temporal offset between conductor and performer in large-scale music ensembles like orchestra and wind band presents a gap in the literature. It is noted that differences in scale here also represent differences in data; that is, literature has been able to identify temporal deviations at the individual level, where an ensemble measurement creates the need for composite representation of group performance as individual performance. Within external perception, however, the ensemble's efforts are perceived as a singular composite of individual effort, with individuals drawing attention during solo passages or through individually identifiable error in performance.

In contrast to the composite effort of the ensemble, the conductor's gesture stands in perpetual isolation. Charged with both the coordination of musical activity and the communication of expressive intent, conducting serves multiple functions simultaneously (Leinsdorf, 1981; Rudolf, 1980). While some pedagogues offer a hierarchical relationship of these where temporal responsibilities dismissed are of lesser sophistication or value (Leinsdorf, 1981), all authors present communication of time as a basic requirement in the successful execution of the office (Rudolf, 1980; Green & Gibson, 2004; Labuta & Matthews, 2018; Saito, 1988). Some expand on this by offering that expressive conductor gesture builds upon a solid temporal basis by communicating musical intent through synthesis of time into gestural emblems (Green & Gibson, 2004; Labuta & Matthews, 2018) or specific, prescribed qualities of movement (Jordan, Wyers, & Andrews, 2011; Saito, 1988). Where differences in expressive gesture may exist, the centrality of the conductor's communication of time through gesture is omnipresent though discussions of any delay between that gesture and the ensemble's response

are all but absent from pedagogical texts. It can be inferred, then, that pedagogy is focused on the communication of time, leaving performer response and attending to other mechanisms.

Among support structures that foster attending to the gesture offered by the conductor is the physical organization of the ensembles in question. Both share a general configuration wherein the conductor stands at a focal point of ensemble and audience attention, creating a situation in which gestures are easily observed and interpreted. From Leonard Bernstein to contemporary figures like Marin Alsop and Alondra de la Parra, these individuals have enjoyed a special, often central, internal and external status in relation to the ensembles that they lead. As conductor Alan Gilbert notes, “There is a connection between the gesture, the physical presence, the aura that a conductor can project, and what the musicians produce” (2012). Within this, however, little is offered regarding temporal offset from conductor to ensemble save for noting its existence (Bell, 2004) and informal knowledge of differences across specific ensemble types (F. Krager, personal communication, February 2018).

Therefore, the existence of offset in these ensembles is strongly informed by musicians’ interpretation and use of the conductor’s gesture. From a temporal standpoint, extraction and subsequent application of information to periodicity in motor activity has been shown to occur in conjunction with the arrival to and departure from the lowest point of a given conductor’s videotaped motions in tapping tasks (Luck & Sloboda, 2008). Similarly, live performance and point light representations have been investigated to determine features of conductor gesture most associated with synchronization to that gesture, producing similar results (Luck & Toivianien, 2006; Luck & Nte, 2008). This process of beat extraction is robust in its persistence across contexts and serves as a continuous point of reference for individual musicians to coordinate activity within ensemble activity.

Entrainment, or the propensity toward synchronization that is robustly linked to rhythmic activity in human activity, is well documented in laboratory settings (Jones & Boltz, 1989; Repp & Penel, 2002; Keller, Knoblich, & Repp, 2007; Repp, 2010; D'Ausilio, Novembre, Fadiga, & Keller, 2015; Colley, Keller, & Halpern, 2017) and theoretical investigations (Jones, 1976; Clayton, 1986; Phillips-Silver, Aktipis, & Bryant, 2010; Clayton, 2012), with a relatively small percentage of the literature exploring the phenomena in naturalistic performance settings (Luck & Toivianien, 2006; Clayton, 2007; D'Ausilio et al., 2012; Hofmann, Wesolowski, & Goebl, 2017). Within this, fewer still examine synchronization in the large ensemble configurations traditionally found in Western instrumental music, such as orchestra (Luck & Toivianien, 2006; D'Ausilio et al., 2012) or wind band.

Entrainment is most commonly observed in groups of a dyad or larger, though it can manifest itself at the individual level in specific circumstances (Philips-Silver, Aktipis, & Bryant, 2010). Seen to operate in conducted contexts in an asymmetric, or one-to-many, manner, it may also occur in a symmetrical, or many-to-many, fashion in contexts of all sizes and compositions (Clayton, 2012). In this way, music offers a rich array of temporally salient information that is communicated both visually (Clayton, 2007), sonically (Nozaradan, Peretz, & Mouraux, 2012), or in combinations thereof (Jensenius, 2007; Williamon & Davidson, 2002; Luck & Toivianien, 2006), allowing for a great deal of interactive complexity within each performer's "rhythmic responsiveness to a perceived rhythmic signal" in a given performance context (Phillips-Silver, Aktipis, & Bryant, 2010, p. 5).

In this way, ensemble musicians utilize both visual and sonic information to coordinate their activities. The multimodal fusing of these two input sources likely recruits elements of the flexible and scalable attending found in the work of Jones and colleagues (Jones, 1976; Jones &

Boltz, 1989), though concrete evidence of this kind of individual activity within large ensemble settings is thus far missing. It is clear, however, that the asymmetric, conductor-to-musician link bears consequence in external perceptions of ensemble performance. Temporal deviation away from organic synchrony in either sight or sound appears to negatively impact external perception of conductor efficacy (Meals, Morrison, & Confredo, 2018). Similarly, increased synchrony with a conductor's temporal signal over those of co-performers was correlated with an increase in perceived quality of performance (D'Ausilio et al., 2012).

Given the multiple streams of communication flowing through a large instrumental ensemble, any offset is hypothesized to possess dynamic qualities within the ensemble's performance. Anecdote supports this, as Johnson notes "[t]he beat can occasionally elicit sound simultaneously […] it may also seem unnecessary once the danger is past, if the ensemble is satisfactory without the extra effort. The players' allegiance to the sound web reasserts itself quickly and returns the conductor to a more inspirational or decorative role" (2014, paragraph 12). Research investigating the interactions of co-performers additionally supports this this, (D'Ausilio et al., 2012; Dineen, 2011; Wing, Endo, Bradbury, & Vorburg, 2014) but authors do not directly address the audio/visual artefacts reported by observers (Bell, 2004; Johnson, 2014; Todes, 2015; Bennett, 2017). Based upon this, the presence of this offset or lag may be as strongly influenced by an interior "shadow ensemble" composed of consequential ensemble members whose visual and sonic contributions play a direct role in overall ensemble coordination (Dineen, 2011, p. 140). This, combined with the coordination-focused activities of the conductor and features of the musical content under performance will contribute to fluctuations within gesture-sound offsets during performance. The presence of and variability

between conducted gesture (entraining signal) and sonic offset (performer response) will establish the basis for further investigation of this hypothesis.

To this end, the following research question is proposed: What is the temporal relationship between visual gesture and sonic response in orchestral and wind band settings? Does an offset (lag or lead) exist, and does it vary between large instrumental ensembles? Within that, how does this lag or offset differ in degree or quantity between ensemble types, across experience levels, over the chronological development of an ensemble, and within each piece itself? Finally, does this lag or offset differ in its kind or behavior between ensemble types, experience levels, over time, and within a given piece of music?

Method

Audio and video from six different instrumental ensembles were recorded in rehearsal and performance (3 wind bands and 3 orchestras), recruited from college (*n* = 1) and secondary (*n* = 3) campuses located within the Southern United States (see Table 2-1). These campuses consisted of two junior high schools (grades 7-8), one high school (grades 9-12), and one university, each serving as a proxy for the ensemble's experience level (Beginner, Intermediate, and Advanced, respectively). Within this, Beginner ensembles represent performers with one to two full years of ensemble experience, Intermediate ensembles were comprised of performers with three to six full years of ensemble experience, and Advanced ensembles were comprised of collegiate performers with more than six years of ensemble experience. Campuses and ensembles were purposefully identified through consistent superior contest ratings (Beginner and Intermediate) and a history of critically acclaimed performance (Advanced). IRB permissions were secured at the university and secondary levels, allowing for direct recruitment of

appropriate conductors and ensembles by the researcher. Ensembles were selected from 'top' or premier groups where more than one ensemble existed on campus (*M* = 3 ensembles/campus), and conductors (*n* = 3 female) of these ensembles held greater than or equal to two years of experience with their groups (*M* = 10.8 years).

Table 2-1. Ensemble Location and Co

Ensemble	Campus Type	Grades Level	Ensembles per Campus	Conductor Experience (years)	Conductor Gender
Advanced Orchestra	Public University	Undergraduate & Graduate	2	26	Male
Advanced Wind Band	Public University	Undergraduate & Graduate	3	2	Male
Intermediate Orchestra	Public High School	Grade 9 - 12	3	6	Male
Intermediate Wind Band	Public High School	Grade 9 - 12	4	9	Female
Beginner Orchestra	Public Junior High School	Grade 6 - 8	3	9	Female
Beginner Wind Band	Public Junior High School	Grade 6 - 8	4	13	Female

The researcher and each conductor selected a work from their ensemble's current repertoire that fulfilled the following three criteria: the piece contained substantive segments of music (~30 seconds) with a consistent tempo, it contained contrasting styles or musical textures within those periods of stable tempo, and the preparation of the work had a definite goal orientation (i.e., an upcoming concert performance) (see Table 2-2). Capture took place three times over the course of four weeks. where capture periods conformed to ensemble availability within scheduled rehearsals (*M* = 12 days). To this end, the researcher and conductor created a schedule of ensemble availability reflective of conflicts with experimental capture (e.g. standardized testing, school holidays, off-site concert performances) that ensured regularly spaced intervals between captures.

Rehearsal and performance video were recorded on a Panasonic HC-VX981 4K camcorder (Panasonic, Inc.) placed at the rear of the ensemble from the conductor for video capture (*M* = 8.9 meters). The camera's viewable field was cropped to reveal only the conductor's gestures, omitting all individually identifiable performer features. Simultaneously,

audio was recorded with a Zoom H6 Handy Recorder audio recorder (Zoom, North America), placed approximately 2.5 meters behind the conductor, in front of the ensemble. After capture, the researcher and each conductor conferred to verify the quality of each performance. After capture, two specific segments reflecting musical contrast within the work performed were selected for extraction. Camera video and external audio were synchronized using PluralEyes (Red Giant, LLC) software, and the two aforementioned segments per ensemble (M = 38.52 s) were extracted and then modified into audio-only and video-only conditions for onset identification and analysis.

Stimulus orders were prepared by distributing audio-only and video-only stimuli in blocks of homogenous modality but alternating ensemble context (e.g. audio-only band followed by audio-only orchestra, video-only orchestra followed by video-only band), prefixing each sample with an eight second film-leader A/V synchronization countdown clip followed by four seconds of silence used to identify the beginning of each stimuli within the larger stimulus order. Onsets within each stimulus order (audio- and video-only conditions) were identified by the researcher tapping along with the synchronization signal and the audible or conducted pulse of the conductor or ensemble using a generic drum sound in GarageBand (Apple, Inc.) on an iPad.

These audio files were processed to identify onset location using the *aubio* onset detection module (Brossier, 2016) in Python 3.4.1 (http://www.python.org), which generates a frequency location value for each based the sampling range of the audio file (44.1kHz). Frequency values were then converted to timecode[1] and matched with their respective audio- and video-onset partners using the synchronization information that prefigured each excerpt. Each

[1] Each timecode value was calculated by dividing the frequency value by the audio's sampling frequency (e.g. location value ÷ 44100).

			Capture 1		Capture 2		Capture 3	
Ensemble	Work Performed	Composer	Excerpt A *Tempo (bpm)*	Excerpt B *Tempo (bpm)*	Excerpt A *Tempo (bpm)*	Excerpt B *Tempo (bpm)*	Excerpt A *Tempo (bpm)*	Excerpt B *Tempo (bpm)*
Advanced Orchestra	*Piano Concerto No. 3 in Bb Minor, Op. 23*	P. I. Tchaikovsky	82	85	80	92	72	92
Advanced Wind Band	*Bells for Stokowski*	M. Daugherty	70	152	88	128	108	164
Intermediate Orchestra	*Serende, Op. 6*	J. Suk	120	124	118	126	112	120
Intermediate Wind Band	"March" from *Symphonic Metamorphosis on Themes by Carl Maria von Weber*	P. Hindemith	144	144	152	152	148	146
Beginner Orchestra	*Sinfonia in A minor*	G.P. Telemann / arr. B. Mathews	100	98	102	104	98	100
Beginner Wind Band	*The Walking Frog (Two-Step March)*	K. L. King/arr. R. E. Foster	88	90	96	92	100	98

stimulus was separately evaluated three times by the researcher, with synchronization signal and onset reliability determined to be acceptable using Krippendorf's Alpha ($\alpha = .912$)[2] and mean values for all onsets were calculated ($n = 1704$ onsets across all excerpts). Audio-only and video-only onset locations were compared using the synchronization information as a zero point for both stimuli conditions. Offset values were calculated where video-only stimuli conditions were treated as the basis for comparison, creating a negative value for video-lead/audio-lag pairings, and a positive value for audio-lead/video-pairings.

Statistical Methods

The research questions under investigation dealt with both the presence of offset values in ensemble settings, as well as differences between these offset values within ensemble type, experience level, chronological capture period, and musical excerpt of a piece in repertoire. To investigate this, a combination of inferential and descriptive tools was employed that reflected the unique nature of the interaction between conductor and ensemble. To analyze differences in orchestra and wind band offset values by ensemble type, experience level, capture period, and excerpt I employed non-parametric methods, as offset values did not demonstrate appropriate homoscedasticity, indicated by the significance ($p < .05$) of Levene's test (1960). Due to this lack of homogeneity of variance within the data, combined with an unequal number of offsets across different ensembles and experience levels, Kruskal-Wallis tests, Wilcoxon-Mann-Whitney tests, and Kendall-Theil Sen Seigel nonparametric linear regression were utilized in analysis.

The nature of the interaction between conductor and ensemble, as seen through offset

[2] Krippendorff's Alpha, a test of inter-rater reliability (Krippendorff, 2012), is utilized here for its robust reliability across multiple coders and the nonbinary manner in which it deals with disagreement between (*m*) coders. The data being evaluated (individual onsets, $SD = 183$ ms) combined with computationally generated factor weights and a conservative lower bound ($\alpha = .800$) all contribute to its use in this investigation.

values within each sample, necessitated the use of analyses designed to showcase these processes over time. As the variable of interest was the variance of offset values between ensembles, captures, experience levels, and within each excerpt, both time series analysis and phase relationship analysis were utilized to illustrate this activity in a clear and descriptive manner. Autocorrelation between offset values, or the analysis of correlation and directional relationship in a time series, were utilized to illustrate the behavior of offset values within each sample. The phase relationship between conductor and ensemble, where the periodicity of each component in the conductor-ensemble relationship is compared at each onset location, was employed to describe changes in the lead/lag relationship across all conditions.

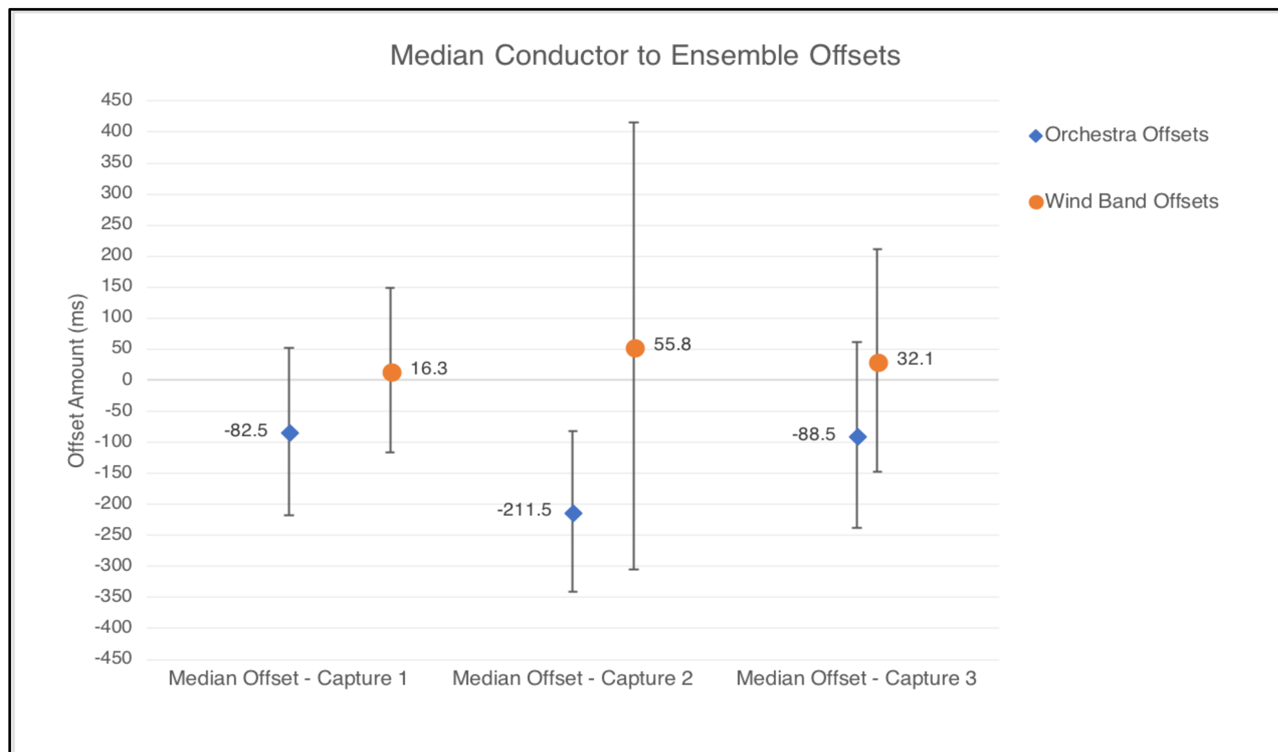
Results

Examination of median offset values between ensemble types across captures confirms the presence of the expected, anecdotally documented, offset between conductor and ensemble (Bell, 2004; Johnson, 2014; Bennett, 2017) where negative values indicate a conductor-lead relationship and positive values indicate an ensemble-lead relationship (see Figure 2-1). Additionally, a Kendall-Theil Sen Siegel nonparametric linear regression suggests that excerpt tempo significantly predicted the offset value quantity, $b = -.15$, $t(1702) = -6.90$, $p < .001$. Excerpt tempo also explained a significant proportion of variance within offset values, $R^2_{CoxAndSnell} = .02$, $F(1, 1702) = 25.68$, $p < .001$. This suggests that a small but significant portion of the variation observed within offset values is attributable to the tempo of the excerpt being performed.

To investigate differences in offset values between wind bands and orchestras a Wilcoxon-Mann-Whitney test was performed on offsets across all captures with ensemble type

as the grouping variable. This revealed significant differences between ensembles in terms of the amount of offset observed ($U = 554740$, $Z = 225.58$, $p < .001$). Wind band offset values ($n = 879$, $Mdn = 53.7$ ms) were significantly higher than orchestra offset values ($n = 825$, $Mdn = -133.2$ ms), indicating both an audio-lead orientation within band and further suggesting a general difference in each ensemble's interaction with the coordinating signal of the conductor's gesture. These findings were accompanied by a large effect size ($r = .46$), additionally suggesting that differences are robust and bear further investigation.

A Kruskal-Wallis analysis of variance (ANOVA) was used to determine if significant differences exist among offset values at the Beginner, Intermediate, and Advanced experience level, the presence of which suggests differences in ensemble/conductor interaction across experience levels. Significant differences in offset values were found between all groups, accompanied by a modest effect ($H = 80.18$, $df = 2$, $p < .001$, $r = .22$). To investigate further, a post-hoc test of offset values between Beginner ($n = 504$), Intermediate ($n = 687$), and Advanced

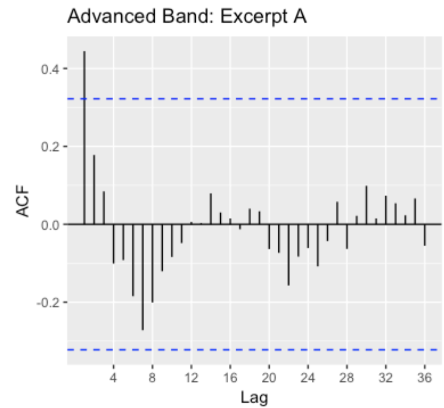


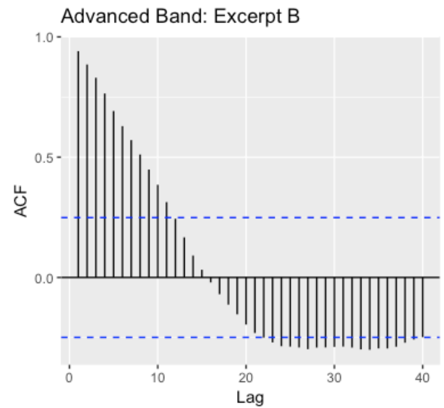
($n = 513$) ensembles were compared using Dunn's multiple comparison procedure, revealing a significant difference ($p < .05$) in offset values between Advanced ensembles and all other experience levels.

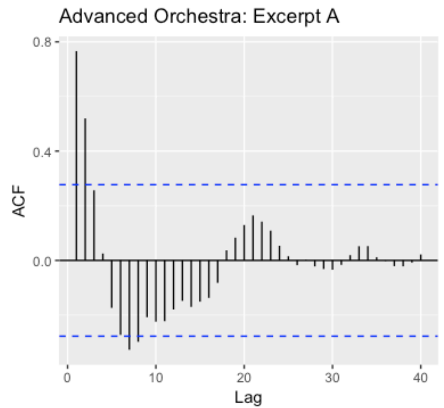
Similarly, a Kruskal-Wallis analysis of variance (ANOVA) was used to determine if significant differences exist across capture periods, which would indicate a change in offset values over the development of the ensemble on a given piece of music. Significant differences in offset values were found between all captures, accompanied by a modest effect ($H = 70.17$, $df = 2$, $p < .001$, $r = .20$). Dunn's multiple comparison procedure was used to determine that a significant difference ($p < .05$) in offset value exists between Capture 2 and all other captures. This suggests that offset quantities are different between captures in a way that highlights changes in the interaction between conductor and ensemble.

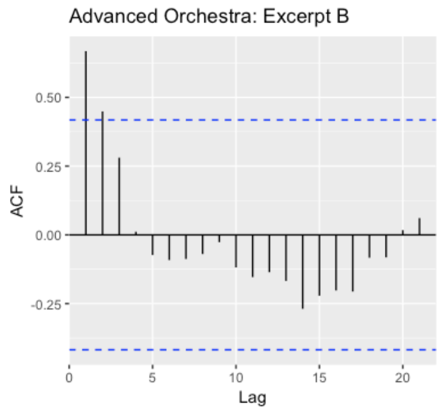
A Wilcoxon Signed-ranks test indicated that offset values were lower for Excerpt 1 ($Mdn = -44.0$ ms) than for Excerpt 2 ($Mdn = -41.0$ ms), $Z = 35.75$, $p < .001$. Additional Wilcoxon Signed-rank tests revealed a similar difference within Wind Bands between Excerpt 1 ($Mdn = 54.6$ ms) and Excerpt 2 ($Mdn = -10.2$ ms), $Z = 25.68$, $p < .001$, and within Orchestras between Excerpt 1 ($Mdn = -132.1$ ms) and Excerpt 2 ($Mdn = -96.0$ ms), $Z = 24.88$, $p < .001$. A uniformly large effect size ($r = .87$) across all tests indicates the robustness of these differences.

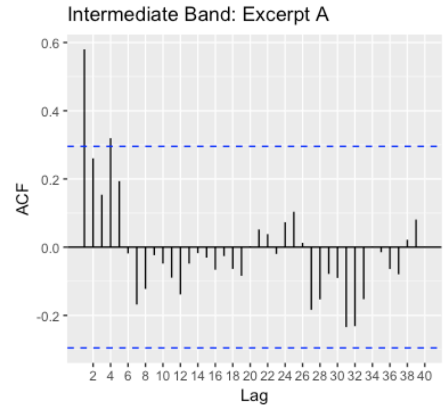
With the presence of an offset between conductor and ensemble confirmed, and differences in offset values identified between all variables of interest, the question of differences in the behavior of these offsets remains to be addressed. Variability has been anecdotally noted in the relationship between a conductor and ensemble (Johnson, 2014), and detection of differences of quantity and degree do not fully describe this phenomenon. To investigate these

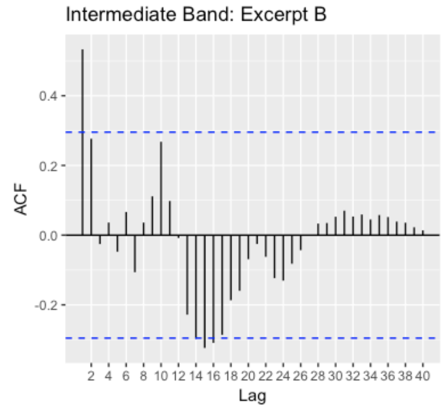

Advanced Band: Excerpt A
ACF
Lag

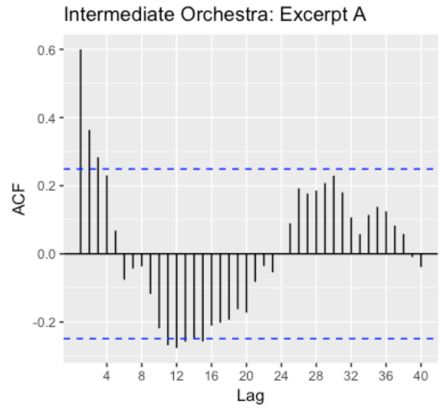

Advanced Band: Excerpt B
ACF
Lag

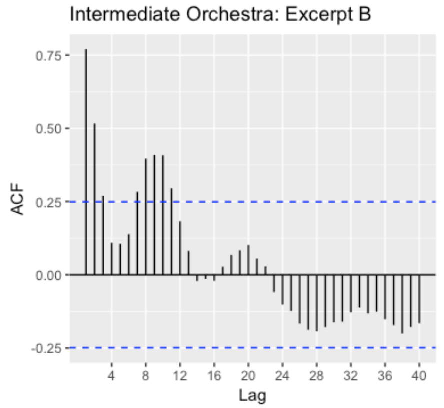

Advanced Orchestra: Excerpt A
ACF
Lag

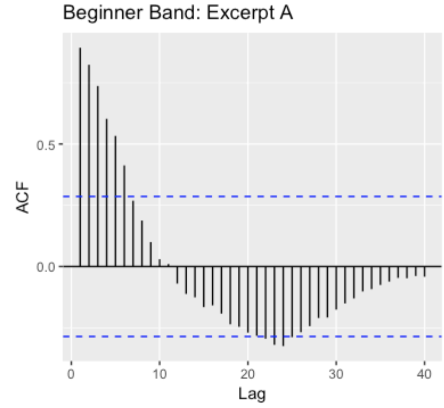

Advanced Orchestra: Excerpt B
ACF
Lag

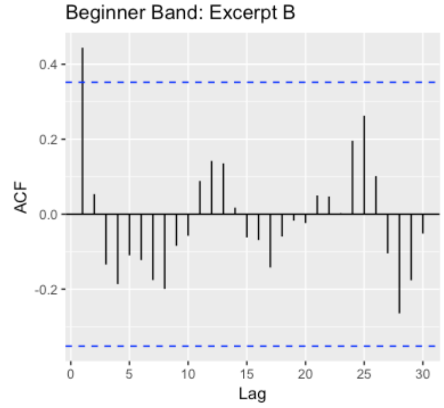

Intermediate Band: Excerpt A
ACF
Lag

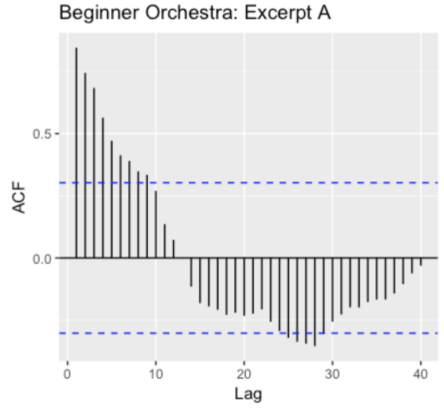

Intermediate Band: Excerpt B
ACF
Lag

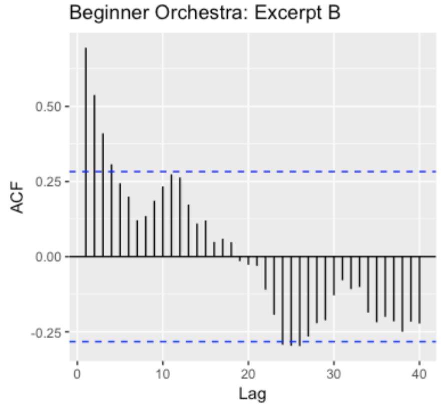

Intermediate Orchestra: Excerpt A
ACF
Lag


Intermediate Orchestra: Excerpt B
ACF
Lag


Beginner Band: Excerpt A
ACF
Lag


Beginner Band: Excerpt B
ACF
Lag


Beginner Orchestra: Excerpt A
ACF
Lag


Beginner Orchestra: Excerpt B
ACF
Lag

differences in kind, patterns of change in offset value and interaction between conductor and ensemble were examined within each ensemble type, across captures, by experience level, and by excerpt by transforming these values into time series and phase relationship datasets, respectively.

Offset behavior within ensembles and excerpts was explored through serial dependence or autocorrelation (ACF) analysis of time series data (see Clayton, Sager, & Will, 2005, p. 41-42 for a detailed explanation and examples). The presence of serial correlation indicates that potential future values in the time series could be predicted by preceding values, which in some settings reveals a violation of independence in observations. In this setting, however, serial correlation within offset values highlights patterns of temporal push and pull between conductor and ensemble that suggest an adherence to and interaction with hierarchical aspects of musical structure indicated by Jones (1976), Clayton (2012), Phillips-Silver and colleagues (2010) among others.

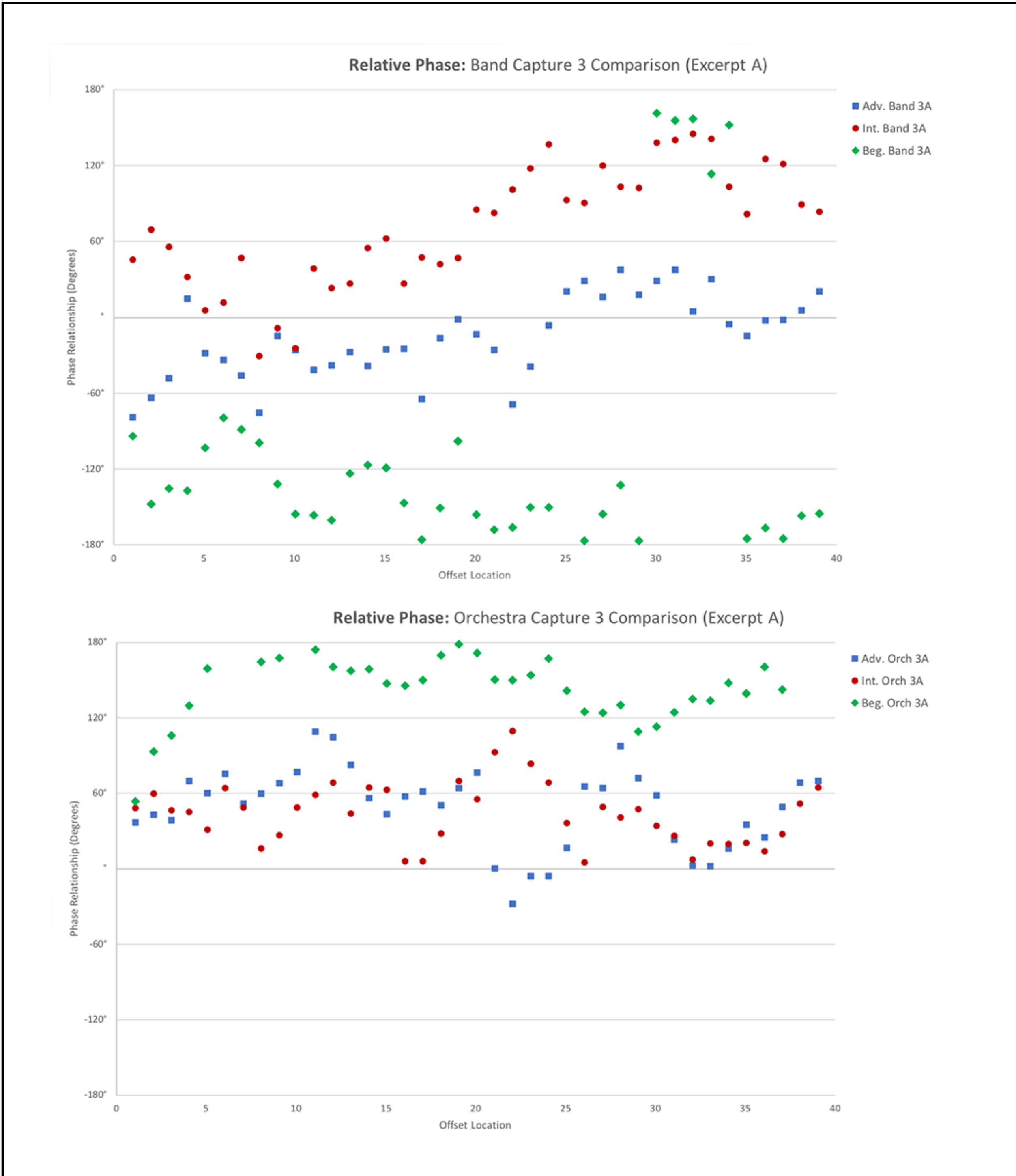
The presence of serial correlation was confirmed by the significance ($p < .05$) of Durbin-Watson tests performed on mean offset values across all excerpts. ACF plots, or correlograms, of mean values by ensemble and excerpt reveal patterns of regularly varying correlation in offset values, though there is no clear pattern presented by ensemble type (see Figure 2-2). What is notable, however, is that the patterns of increase and decrease indicated by the side lobes of each plot broadly conform to musical phrases within each excerpt, though it may suggest as much about musician's performance of each phrase as it does the formal structure of the work itself. What is clear, however, is that offset value quantity is not a fixed property of conducted ensemble performance, but instead a regularly varying and dynamic property of the interaction of ensemble and conductor.

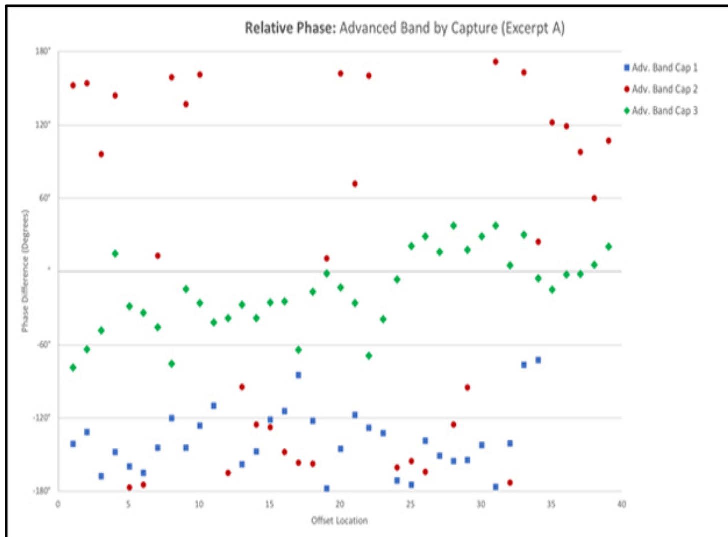
Extending this, changes in offset value and orientation (conductor- or ensemble-lead) were investigated through calculation and comparison of relative phase of conductor and ensemble onsets. This analysis compares the relationship of video (conductor) and audio (ensemble) streams, treating onsets within each as waveform peaks and the interonset interval as the period of that signal[3]. This method, adapted from Clayton's 2007 study of entrainment within Indian *tanpura* performers, compares the phase differences between conductor and ensemble over the course of each excerpt, generating a sequence that reveals the synchrony or asynchrony present within the performance (see Figures 2-3a & 2-3b). Phase relationships have been organized between ±180° via *modulo* to highlight their relationship to phase alignment (0°). Additionally, Rayleigh's Test was found to be significant ($p < .05$) across phase differences in all excerpts, indicating that phase relationships were non-uniform in their distribution, indicating organized coordination within phase values.

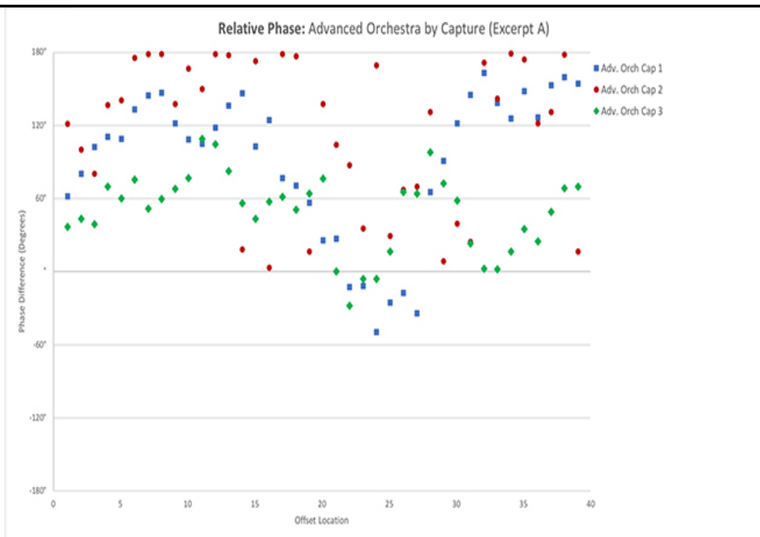
To illustrate the phase relationships between ensembles, across experience levels, and between captures, each ensemble's Excerpt A was selected as the clearest illustration of interactions within ensembles (see Appendix A for complete data). The relative phase relationships of all ensembles in their final capture of Excerpt A highlight a clear difference between bands and orchestras (Fig. 2-3a). The clustering of phase values across positive and negative within wind band highlights the lead and lag of the conductor, where the largely positive values found in orchestral phase values indicates a clear skew toward conductor-led ensemble performance. In application, this indicates that the temporal aspects of performance within wind bands tends to drift slightly ahead and behind the conductor's time

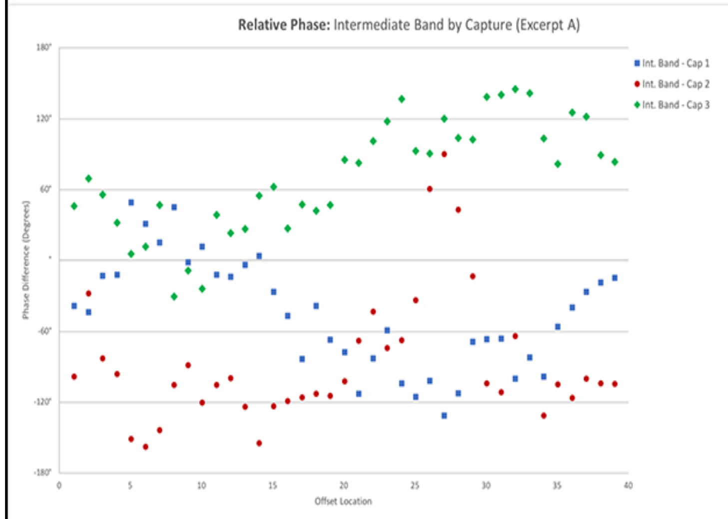
[3] The relative phase of Video (V) to Audio (A) is calculated using the formula (A1-V1)/(V2-V1)x360 for each excerpt. A relative phase of 0° indicates exact phase alignment, where ± 180° indicates antiphase alignments corresponding to audio lead/video lag (-) or audio lag/video lead (+).

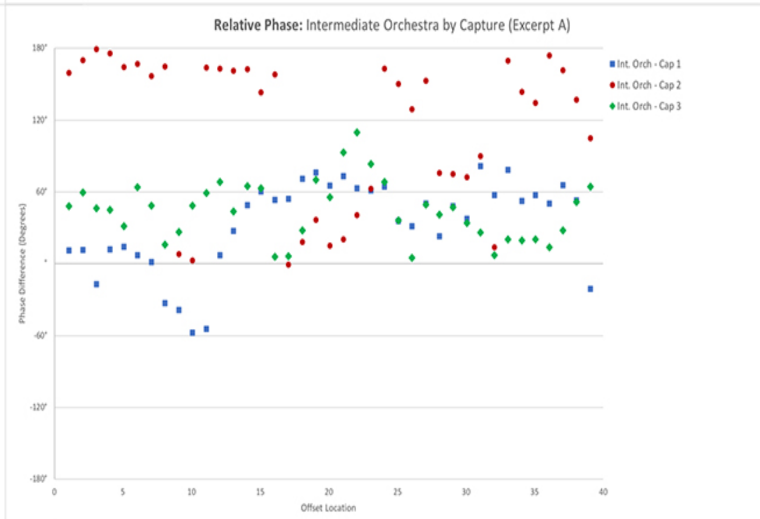
($Mdn_{BandExcerptAOffset}$ = -88.6 ms, SD = 163.4 ms), where orchestras are almost exclusively behind the conductor's temporal signal ($Mdn_{OrchestraExcerptAOffset}$ = -137.3 ms, SD = 91.0 ms).

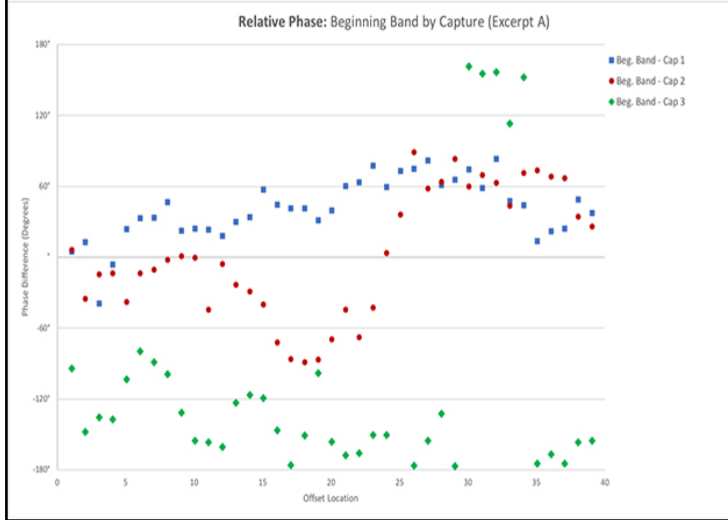


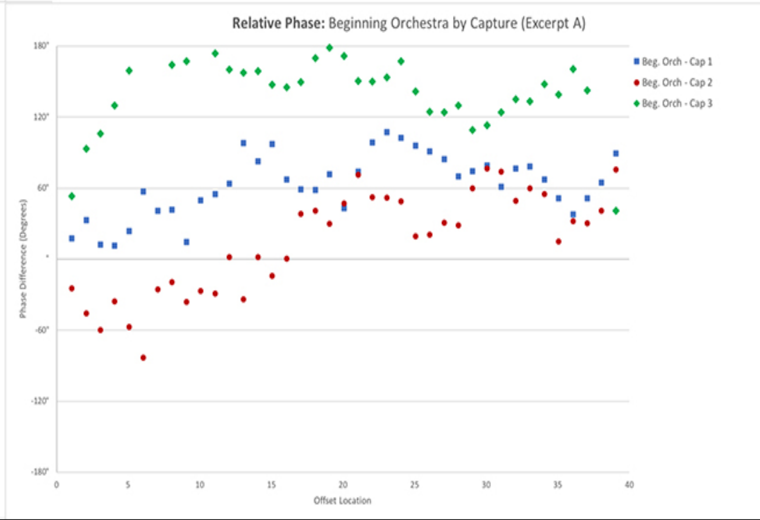

Relative Phase: Advanced Band by Capture (Excerpt A)
Adv. Band Cap 1
Adv. Band Cap 2
Adv. Band Cap 3
Phase Difference (Degrees)
Offset Location


Relative Phase: Advanced Orchestra by Capture (Excerpt A)
Adv. Orch Cap 1
Adv. Orch Cap 2
Adv. Orch Cap 3
Phase Difference (Degrees)
Offset Location


Relative Phase: Intermediate Band by Capture (Excerpt A)
Int. Band - Cap 1
Int. Band - Cap 2
Int. Band - Cap 3
Phase Difference (Degrees)
Offset Location


Relative Phase: Intermediate Orchestra by Capture (Excerpt A)
Int. Orch - Cap 1
Int. Orch - Cap 2
Int. Orch - Cap 3
Phase Difference (Degrees)
Offset Location


Relative Phase: Beginning Band by Capture (Excerpt A)
Beg. Band - Cap 1
Beg. Band - Cap 2
Beg. Band - Cap 3
Phase Difference (Degrees)
Offset Location


Relative Phase: Beginning Orchestra by Capture (Excerpt A)
Beg. Orch - Cap 1
Beg. Orch - Cap 2
Beg. Orch - Cap 3
Phase Difference (Degrees)
Offset Location

Relative phase relationships for each ensemble's Excerpt A across capture periods reveal distinct differences over time, though the collected data do not allow for the determination of a direct developmental effect. What can be observed is the change over time either toward or away from an in-phase relationship between ensemble and conductor (Fig. 2-3b). For instance, the high degree of positive and negative anti-phase variability within Advanced Wind Band Captures 1 and 2 gives way to a clearly phase-centric relationship in Capture 3, where the Advanced Orchestra maintains a similar quantity of anti-phase to phase-centric activity, though almost wholly positive/conductor-led in its appearance.

Discussion

The presence of a perceptible offset between conductor gesture and the orchestra's response is present in anecdotal accounts (Bell, 2004; Johnson, 2014; Todes, 2015; Bennett, 2017), but is largely absent from empirical literature. Expanding this question to encompass the two large instrumental ensembles of wind band and orchestra, findings highlight differences in degree, here the quantity of offset observed, as well as differences in kind, here the behavior and location of offsets between ensemble types, experience levels, and the chronological development of ensemble and conductor within a given piece of music. These six ensembles, equally balanced between orchestra and wind band and across experience levels from Beginner to Advanced, reveal that the observed offset in these settings are not a static property of ensemble function, but are in fact a dynamic property of internal interaction that indicates a more flexible temporal relationship between conductor and ensemble, where designations of "leader" and "follower" may shift or invert in certain circumstances.

The offset between conductor gesture and ensemble response in observed ensembles supports anecdotal accounts while partially subverting the expectation of the conductor-as-leader implied by terms like "orchestral lag" (Bell, 2004; Bennett, 2017). Offset values for wind band (*Mdn* = 53.7 ms) and orchestra (*Mdn* = -133.2 ms), where negative values indicate a sight before sound (here, conductor before ensemble) relationship, suggest a general tendency toward conductor-led interactions in orchestras over bands. This difference in degree is reinforced by the difference in kind indicated by comparison of phase relationships between ensemble types (Fig. 2-3a) and over time (Fig. 2-3b). In these, wind band phase values are roughly distributed between conductor- and ensemble-lead and orchestral phase values indicate conductor-led performance almost exclusively. This finding further confirms long-standing anecdote and broadly conforms to the experiences shared by one of the collaborating conductors with experience across both ensemble contexts, who noted that "The [wind] band just has more immediacy to it, [it's] a more impatient thing. The orchestra takes its time … it waits to see what you're going to do and then decides to go along with you … or not." (personal communication, February 2018).

Differences in offsets across experience levels and captures also indicate differences in degree but fail to conclusively demonstrate differences in kind. By this I mean that the overall differences in offset value quantity and behavior found between secondary (Beginner, Intermediate) and tertiary (Advanced) ensembles suggest the possibility of an effect based on long-term ensemble experience, though no clear linear relationship presents itself in the available data. Additionally, differences found between capture in these ensembles support changes due to short-term ensemble development, but there is insufficient evidence to reveal if the groups are simply changing through exposure or if there is a trajectory to the quantity and behavior of their

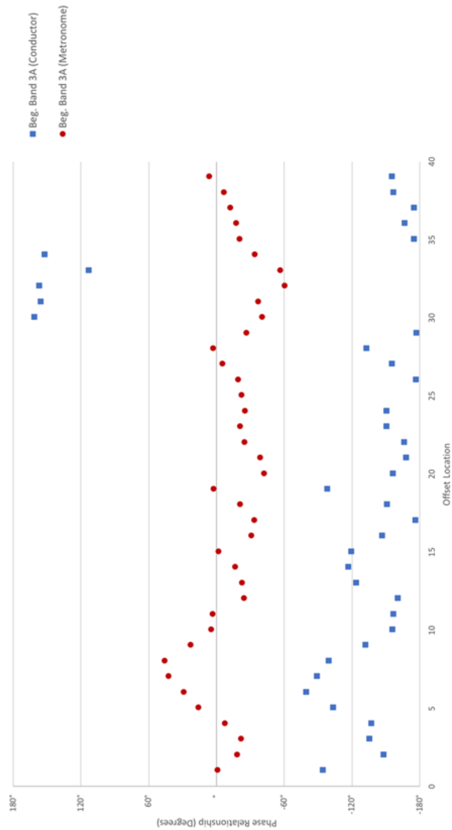
offset values. These are buoyed by the visual investigation of phase relationships observed over time that appear to trend toward phase alignment and synchrony, especially in Advanced ensembles (Fig. 2-3b), though Clayton (2012) notes that not all entrainment is observed as synchronized phase alignment. A stabilization of phase relationship, as seen through the reduced phase variability in the third capture of each ensemble, may represent the stable but flexible, mature relationship of conductor and ensemble within a group's development noted by Clayton (2012) and others (Phillips-Silver, Aktipis, & Bryan, 2010; Levitin, Grahn, & London, 2018), though further research is required in this specific setting.

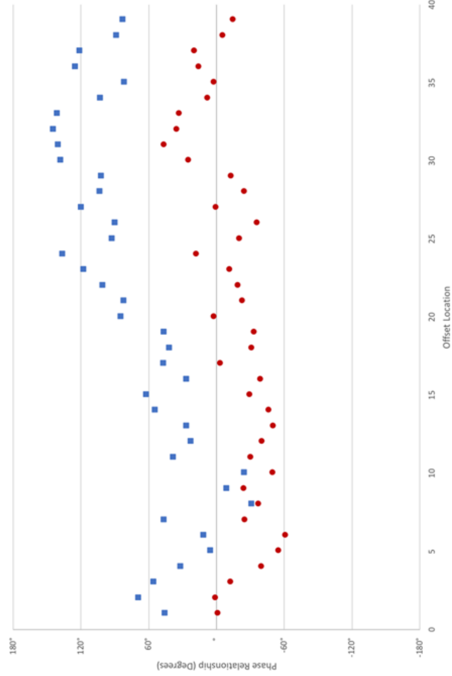
Of interest within these differences, however, is the behavior of phase relationships within secondary ensembles, especially wind bands. The presence of an asymmetric entrainment relationship (Clayton, 2012), in which the conductor's time is the only time-bearing signal coordinated with, is assumed to an almost foundational level in conductor-led ensembles (Leinsdorf, 1981; Rudolf, 1980; Green & Gibson, 2004; Jordan, Wyers, & Andrews, 2012). Interestingly, two of the ensembles included in this study (Beginner Wind Band and Intermediate Wind Band) frequently make use of an audible metronome for group coordination in rehearsal (though they did not during performance captures for this study). The behavior of phase relationships in these ensembles reveal the widest variance of all ensembles, often moving between conductor-lead and ensemble-lead orientations both within and between captures. This volatility could suggest that students are attempting to balance a form of self-entrainment (Phillips-Silver, Aktipis, & Bryant, 2010) with the asymmetric entrainment offered by the conductor, highlighting that affordance through their vacillation between leading and following the visual signal presented. A cursory analysis comparing the phase relationship of conductor to

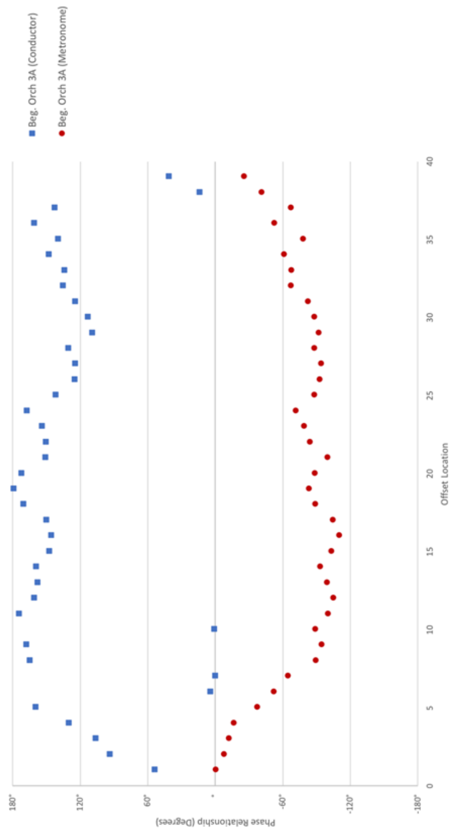
ensemble and metronome to ensemble reveals a potential for this affordance to be operating within ensembles that rehearse with an audible metronome (see Figure 2-4).

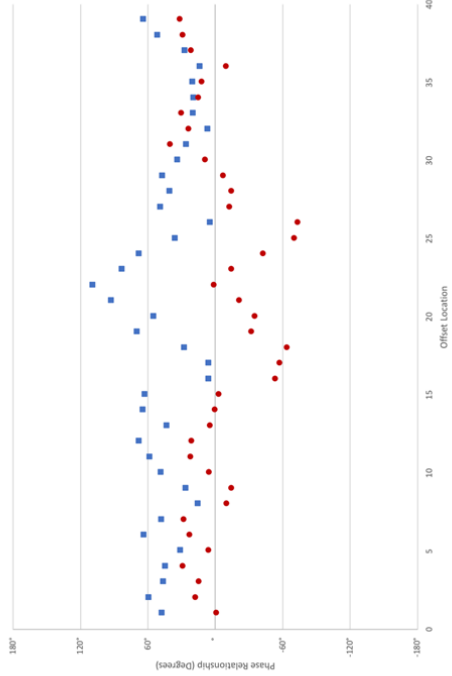
Findings reported within investigations of inter-musician (Davidson & Williamon, 2002; Wing et al., 2014) and intra-ensemble (D'Ausilio et al., 2012) coordination provide further confirmation of the entrainment observed within these ensembles. The presence of coordinated activity, confirmed both through visual inspection of ACF and phase relationship analysis as well as the significance of post-hoc tests of serial correlation and non-uniformity, conforms to definitions of entrainment offered by Clayton (1986, 2012), Phillips-Silver and colleagues (2010), Levitin, Grahn, and London (2018), and numerous others. Interestingly, the internal processes of entrainment within ensembles are obscured from this analysis and present a level of complexity that exceeds most experimentally confirmed instances of entrainment, demonstrating a clear need for continued research in this area.

The presence and influence of time sources within the ensemble beyond the conductor's gesture has been investigated in a limited, laboratory-focused manner (D'Ausilio et al., 2012) and in observational settings (Dineen, 2011), indicating that consequential amounts of variance in entrainment may flow from other members of the ensemble. Work investigating causal relationships between performers (Wing et al., 2014) as well as between conductors and performers (D'Ausilio et al., 2012) provides a useful framework for investigations of similar processes on a larger scale, especially as it may reveal the persistence, boundaries, and specific function of the "shadow ensemble" observed by Dineen (2011) or confirmation of latent influence by rehearsal procedures reported in this study. Investigations that extend this line of inquiry serve to increase understanding of both the conductor-ensemble relationship and how the


Relative Phase: Beginner Wind Band Capture 3, Excerpt A Comparison
Phase Relationship (Degrees)
Offset Location
Beg. Band 3A (Conductor)
Beg. Band 3A (Metronome)


Relative Phase: Intermediate Wind Band Capture 3, Excerpt A Comparison
Phase Relationship (Degrees)
Offset Location
Int. Band 3A (Conductor)
Int. Band 3A (Metronome)


Relative Phase: Beginner Orchestra Capture 3, Excerpt A Comparison
Phase Relationship (Degrees)
Offset Location
Beg. Orch 3A (Conductor)
Beg. Orch 3A (Metronome)


Relative Phase: Intermediate Orchestra Capture 3, Excerpt A Comparison
Phase Relationship (Degrees)
Offset Location
Int. Orch 3A (Conductor)
Int. Orch 3A (Metronome)

constituent skills of musical performance (attending, coordination, executive skills, interpretation) develop in an ensemble setting.

These findings are limited in several ways that bear discussion and consideration in the final interpretation of the results. The broad nature of the audio data analyzed (group onset) does not allow for the consideration of temporally consequential aspects of wind and string instrument performance, where differences in frequency propagation and response time between woodwind, brass, string, and percussion instruments present a wide range of affordances to be considered in future investigations (Rossing, 2010; Benade, 1969). Additionally, the sample size of recruited ensembles ($N = 6$) coupled with the significance of the findings and size of effects between ensembles, experience levels, and chronological development demonstrates the need for further research in this area.

For many outside of ensemble music, the complex and dynamic ecosystem inside these groups appears to be dominated and guided by the interaction of sound and the conductor's baton. Great amounts of responsibility and power have been ascribed to the individual atop the podium, but an emerging body both of practice and research calls into question the singularity of this individual's role in the coordination of the ensemble's musical efforts. Their contribution as a source of entrainment is clear, but the findings of this study suggest support for the larger body of research indicating the presence of other time-bearing actors within the ensemble, even if only by describing the outlines of their effects.

The differences described here – between ensemble types, experience levels, and chronological growth – remain persistent throughout all groups and time periods sampled. These differences – both in degree through onset quantities and in kind through relative phase between ensemble types over time – present a fruitful avenue for future investigation where the

mechanics of each ensemble’s instrumentation combine with both conductor-to-musician intra-ensemble and musician-to-musician inter-performer communication. An increase in our understanding of the dense web of entrainment and communication in ensembles will have numerous benefits in both music performance and music education, allowing for the creation of a more comprehensive, nuanced, and accurate model of ensemble performance.

References

Bell, L. (2004). Conducting: When orchestras are used to playing behind the beat. [Online forum thread]. Retrieved from http://www.choralnet.org/view/221793

Benade, A.H. (1969). Effect of dispersion and scattering in the startup of brass instrument tones. *The Journal of the Acoustical Society of America, 45*(1), 296-297. doi: 10.1121/1.1971279

Bennett, J. (2017, September 17). Why do orchestras seem to play behind the beat? *WQXR Blog.* Retrieved from https://www.wqxr.org/story/why-do-orchestras-play-behind-beat/

Cofer, R. S. (1998). Effects of conducting-gesture instruction on seventh-grade band students' performance response to conducting emblems. *Journal of Research in Music Education*, *46*(3), 360-373. doi: 10.2307/3345548

Clayton, M. (1986). *Coordination between players in musical performance.* (Ph.D. Thesis). University of Edinburgh, Scotland.

Clayton, M. (2007). Observing entrainment in music performance: Video-based observational analysis of Indian musicians’ tanpura playing and beat making. *Musicae Scientiae, 11*(1), 27-59. doi: 10.1077/102906490701100102

Clayton, M. (2012). What is entrainment? Definition and applications in musical research. *Empirical Musicology Review*, 7(1-2), 49-56. http://hld.handle.net/1811/52979

Clayton, M., Sager, R., & Will, U. (2005, January). In time with the music: the concept of entrainment and its significance for ethnomusicology. In *European meetings in ethnomusicology.* (Vol. 11, pp. 1-82). Romanian Society for Ethnomusicology.

Colley, I. D., Keller, P. E., & Halpern, A. R. (2017). Working memory and auditory imagery predict sensorimotor synchronization with expressively timed music. *The Quarterly Journal of Experimental Psychology*, 1-49. doi: 10.1080/17470218.2017.1366531

D'Ausilio, A., Badino, L., Li, Y., Tokay, S., Craighero, L., Canto, R., Aloimonos, Y., & Fadiga, L. (2012). Leadership in orchestra emerges from the causal relationships of movement kinematics. *PLoS One, 7*(5), e35757. doi: 10.1371/journal.pone.0035757

D'Ausilio, A., Novembre, G., Fadiga, L., & Keller, P. E. (2015). What can music tell us about social interaction? *Trends in cognitive sciences*, *19*(3), 111-114. doi: 10.1016/j.tics.2015.01.005

Dineen, P. M. (2011). Gestural economies in conducting. In A. Gritten & E. King (Eds.), *New Perspectives on Music and Gesture*, 131-157. Farnham, Surrey: Ashgate Publishing, Ltd.

Gilbert, A. (2012, April 6). Connecting music and gesture. *The New York Times,* online. Retrieved from: http://archive.nytimes.com/www.nytimes.com/interactive/2012/04/06/arts/music/the-connection-between-gesture-and-music.html

Green, E.A.H., & Gibson, M. (2004). *The modern conductor: Seventh Edition*. New York: Pearson.

Hofmann, A., Wesolowski, B. C., & Goebl, W. (2017). The tight-interlocked rhythm section: production and perception of synchronisation in jazz trio performance. *Journal of new music research*, *46*(4), 329-341. doi: 10.1080/09298215.2017.1355394

Jensenius, A. R. (2007). Action-sound: Developing methods and tools to study music-related body movement. (Ph.D. Thesis) University of Oslo, Norway.

Johnson, E. (2014, August 28). Why do so many orchestras lag behind the beat? *The Strad.* Retrieved from http://www.thestrad.com/cpt-latests/why-do-so-many-orchestras-lag-behind-the-beat/.

Jones, M.R. (1976). Time, our lost dimension: Toward a new theory of attention, perception, and memory. *Psychological Review, 83*(5), 323-355. doi: 10.1037/0033-295X.83.5.323

Jones, M.R., & Boltz, M. (1989). Dynamic attending and responses to time. *Psychological Review, 96*(3), 459-491. doi: 10.1037/0033-295X.96.3.459

Jordan, J., & Lauridsen, M. (2009). *Evoking sound: Fundamentals of choral conducting* (2nd ed.). Chicago, IL: GIA Publications.

Jordan, J., Wyers, G., & Andrews, M. (2011). *The conductor's gesture: A practical application of Rudolf von Laban's movement language.* Chicago, IL: GIA Publications.

Keller, P. E. (2001). Attentional resource allocation in musical ensemble performance. *Psychology of Music*, *29*(1), 20-38. doi: 10.1177/0305735601291003

Keller, P. E., Knoblich, G., & Repp, B. H. (2007). Pianists duet better when they play with themselves: on the possible role of action simulation in synchronization. *Consciousness and cognition*, *16*(1), 102-111. doi: 10.1016/j.concog.2005.12.004

Krippendorff, K. (2012). *Content analysis: An introduction to its methodology*. Thousand Oaks, CA: Sage.

Labuta, J.A., & Matthews, W.K. (2018). *Basic conducting techniques*. New York, NY: Routledge.

Leinsdorf, E. (1981). *The composers advocate: A radical orthodoxy for musicians.* New Haven, CT: Yale University Press.

Levitin, D.J., Grahn, J.A., & London, J. (2018). The psychology of music: Rhythm and movement. Annual Review of Psychology, 69. doi: 10.1146/annurev-psych-122216-011740

Luck, G., & Nte, S. (2008). An investigation of conductors' temporal gestures and conductor—musician synchronization, and a first experiment. *Psychology of Music*, *36*(1), 81-99. doi: 10.1177/0305735607080832

Luck, G., & Sloboda, J. (2008). Exploring the spatio-temporal properties of simple conducting gestures using a synchronization task. *Music Perception: An Interdisciplinary Journal, 25*(3), 225-239. doi: 10.1525/mp.2008.25.3.225

Luck, G., & Toiviainen, P. (2006). Ensemble musicians’ synchronization with conductors’ gestures: An automated feature extraction analysis. *Music Perception: An Interdisciplinary Journal, 24*(2), 189-200. doi: 10.1525/mp.2006.24.2.189

Meals, C.D., Morrison, S.J., Confredo, D.H. (2018). *The effects of temporal action-sound congruence on evaluations of conductor efficacy.* Manuscript submitted for publication.

Néda, Z., Ravasz, E., Brechet, Y., Vicsek, T., & Barabási, A. L. (2000). Self-organizing processes: The sound of many hands clapping. *Nature*, *403*(6772), 849. doi: 10.1038/35002660

Nozaradan, S., Peretz, I., & Mouraux, A. (2012). Selective neuronal entrainment to the beat and meter embedded in a musical rhythm. *Journal of Neuroscience*, *32*(49), 17572-17581. doi: 10.1523/JNEUROSCI.3203-12.2012

Phillips-Silver, J., Aktipis, C. A., & Bryant, G. A. (2010). The ecology of entrainment: Foundations of coordinated rhythmic movement. *Music Perception: An Interdisciplinary Journal*, *28*(1), 3-14. doi: 10.1525/mp.2010.28.1.3

Repp, B. H. (2010). Sensorimotor synchronization and perception of timing: effects of music training and task experience. *Human movement science*, *29*(2), 200-213. doi: 10.1016/j.humov.2009.08.002

Repp, B. H., & Penel, A. (2002). Auditory dominance in temporal processing: New evidence from synchronization with simultaneous visual and auditory sequences. *Journal of Experimental Psychology: Human Perception and Performance, 28*(5), 1085-1099. doi: 10.1037/0096-1523.28.5.1085

Rossing, T.D. (2010). *The science of string instruments.* New York, NY: Springer.

Rudolf, M. (1980). *The grammar of conducting (2nd ed.).* New York, NY: Schirmer Books.

Saito, H. (1998). *The Saito conducting method.* (tr. F. Torigai, ed. W.J. Toews). Tokyo, Min-On Concert Association & Ongaku No Tomo Sha Corporation.

Small, C. (2011). *Musicking: The meanings of performing and listening*. Wesleyan University Press.

Todes, A. (2015, October 5). View from the viola front desk. *Elbow Music*. Retrieved from https://www.elbowmusic.org/single-post/2015/10/05/View-from-the-viola-front-desk.

Williamon, A., & Davidson, J. W. (2002). Exploring co-performer communication. *Musicae Scientiae*, *6*(1), 53-72. doi: 10.1177/102986490200600103

Wing, A. M., Endo, S., Bradbury, A., & Vorberg, D. (2014). Optimal feedback correction in string quartet synchronization. *Journal of The Royal Society Interface*, *11*(93), 20131125. doi: 10.1098/rsif.2013.1125

PAPER THREE

The Effects of Temporal Action-Sound Congruence on Evaluations of Conductor Efficacy

Cory Meals, primary author

Steven J. Morrison, co-author

Deborah H. Confredo, co-author

Abstract

Vision serves a fundamental role in the human experience of musical performance. This particular heuristic influences both expressive and coordinational aspects of musical activity, involving the audience and the performers in distinctly different but equally impactful ways. While prior research has demonstrated the influence that vision holds in evaluations of musical expressivity in individual and ensemble conditions, less attention has been paid to possible influence of temporal distance between action and sound in these contexts. Conductors are often observed to be both ahead of and behind ensembles, sometimes within the same piece, and few conducting texts provide a prescriptive rationale for such behavior. Especially in ensemble performance, where conductor gesture coordinates musical activity in both time and affect but has, at best, an indirect sonic result, alteration of temporally bound action-sound relationships is likely to be of consequence.

Our goal in this study is to investigate influence played by temporal congruence of conductor gesture to ensemble sonic output through experimental manipulation of intact performance video of instrumental ensembles. Naturalistic performance video of five conductors was collected and excerpts were identified representing both highly lyric and highly rhythmic musical content. Video and audio were offset by a percentage of excerpt tempo (±30%, ±15%)

and five fully crossed stimuli orders were created. Participants were asked to rate the performance of the conductor, ensemble, and composite on a Likert-type scale bound by "*poor*" and "*excellent*." Our results indicate that any offset value, whether audio or visual, is evaluated to have lower levels of conductor efficacy than intact, unaltered performance, though the effect size in our analysis is moderate ($\eta_p^2 = .037$). We examine the variables that may impact our results and link our findings to both human beat entrainment and the theory of dynamic attending proposed by Jones and collaborators (1976, 1989).

Introduction

Vision serves a fundamental role in the human experience of musical performance. Visual information has been shown to have a significant impact on the perception, experience, and subsequent evaluation of musical performance (Shove & Repp, 1995; Platz & Kopiez, 2012; Boltz, Ebendorf, & Field, 2009; Dahl & Friberg, 2007). Contributing factors to this relationship are primarily kinematic in nature, exposing the role of both sound-producing (Davidson, 1993; Schutz & Lipscomb, 2007) and expressive, non-sound-producing (Vines, Krumhansl, Wanderley, Dalca, Levitin, 2006; Davidson, 2008) performance gestures. The importance of visual information in musical judgments has even been demonstrated to overshadow the aural in solo (Tsay, 2013) and ensemble (Tsay, 2014) settings, in seeming defiance of the perceived sonic core to evaluations in these contexts.

Consideration of the intimacy inherent in musical performance may suggest a measure of vision's outsized influence in evaluations of musical performance. Details as specific as facial expression (Thompson, Graham, & Russo, 2005; VanWeelden, 2002; Silvey, 2013), stage behavior and attire (Wapnick, Mazza, & Darrow, 1998), race (Elliott 1995/1996; VanWeelden & McGee, 2007) and physical attractiveness (Wapnick, Darrow, Kovacs, Dalrymple, 1997) have been shown to influence musical judgments in both solo and group performance. While the impact of visual information in a live performance setting falls within expectations for basic human perception, the presumed primacy of sonic information in Western music, especially art music (which serves as stimuli in the vast majority of reported studies), stands at odds with the seeming universality of these findings.

This is not to say that aural information is of no consequence in musical judgments. Research has shown the significant impact of aural performance quality on visual judgments,

indicating influence that is bidirectionally crossmodal (Silvey, 2011). Similarly, the manipulation of both temporal and affective sonic information in film has been shown to create a host of alterations to judgments of both quality and efficacy (Dallinger, 2013). While a qualitatively different context than musical performance, the influence played by sound in film serves as an interesting comparison. While sound producing activities showcased in film may be either organically captured or added in post-production, existing scholarship (Donnelly, 2014, p. 18-19) provides evidence that perception of both musical performance and film/sound synthesis is strongly influenced through the combination of visual and sonic information, most notably the relationship of action to sound.

Within music, as with film, the actions of sound production are often explicitly or implicitly tied to a sonic result. Be it striking, plucking, vibrating, or blowing, each sound produced is seen to have a kinematic correlate. One notable exception to this can be found in the case of the ensemble conductor, an individual whose role is ostensibly that of a soundless contributor who nonetheless bears great consequence to the function of the group before which they stand. Corollary to the long-held belief that, "… an incapable or malevolent conductor ruins all," (Berlioz, 1926, p. 1) this individual's gesture is seen by audiences and used by performers to coordinate individual activity into a group-level composite that, in its best form, represents the artistic intentions of the composer, the performers, and the conductor themselves.

The influence of the conductor can be bisected into two broadly overlapping domains of gestural communication: temporal alignment and expressive intent. The influence of expressive gesture has been thoroughly examined (Price & Chang, 2005; Morrison, Price, Geiger, Carnacchio, 2009; Price & Mann, 2011; Silvey, Wacker, & Felder, 2013; Napoles, 2013) and has been found to conform to the reported influence of expressive gesture in solo musical

performance. Dividing this influence even further, researchers have examined the role of these gestures on audience perception of expressive performance (Morrison, Price, Smedley, Meals, 2014; Morrison, Price, Geiger, & Carnacchio, 2009; Morrison & Selvey, 2014; Silvey, 2011) as well as the impact of gesture on specific performance behaviors in musician's sonic output (Fuelberth, 2003; Napoles, 2013; Skadsem, 1997). Despite the lack of a direct sonic consequent, the conductor's gestures impact the experience and perception of both musician and audience in significant ways.

What remains less clearly understood is the role played by temporally bound action/sound congruence in the perception of efficacy within conducting. The kinematic nature of the activity lends itself to both latent and active evaluation of its spatiotemporal features, an element that some musicians recognize as a highly variable element within and between conductors (Johnson, August 28 2014; Bell, 2004). Referring to the orchestral setting, Johnson (2014) portrays the delay between conductor and ensemble as an accepted feature of the conductor's gestural vocabulary within the musical activity of the ensemble. Similarly, Bell (2004) identifies this delay as a variable property that can be manipulated at the discretion of either or both the ensemble and conductor. Johnson goes on to provide several hypotheses for this perceived lag in ensemble sonic response, comparing the ensemble's response to "… cars at a traffic light. The light turns green, but we cannot move until the cars in front of us have reacted one by one […] orchestras have the advantage of a preparatory gesture but are still often late to the downbeat." (2014, paragraph 2) A later, and more robust, hypothesis by Johnson points to the primacy of in-group bonds and focus of attention found within ensembles.

Similar properties were explored by D'Ausilio and colleagues (2012), where inter-musician influence within an ensemble was compared to conductor-driven influence using

Granger Causality method for kinematic quantification. Musician-to-musician influence was seen to have an expectedly inverse relationship with conductor-to-musician influence, but the latter was more strongly correlated with increased quality of execution in expert evaluations of an audio-only condition. Similarly, Dineen (2011) identified a “shadow ensemble” within the orchestra comprised of a small number of highly visible and influential performers whose musical leadership is often exhibited through their physical movement and gesture, at times superseding the direction of the conductor (p. 138).

The action of conducting creates a predictive cycle of expectation and response leading to kinematic synchronization. The mechanics of simple conducting patterns have been explored in laboratory settings using point-light stimuli and were found to engage musicians and non-musicians alike in motor synchronization in single beat-point (Luck & Nte, 2007) and multiple beat-point (Luck & Sloboda, 2007; Su, 2014) conditions. Within the examined conducting patterns, a consistent spatial point of isochronous, regular signaling was identified by participants at the elision of two opposing vectors of motion. Referred to within conducting pedagogy as the *ictus* (Rudolf, 1980; Green & Gibson, 2004; Labuta, 2004; Jordan & Lauridsen, 2009), this feature of conducting appears to be central to the temporal congruence observed across conducted ensembles. Indeed, the importance and coordinational value of visual signaling between performers has been documented in chamber settings (Williamon & Davidson, 2002; Goebl & Palmer, 2009), with similar features identified in conductor’s gestural communication within ensemble contexts (Luck & Toivianen, 2006). The majority of conducting texts imply synchrony between conductor and ensemble but are not explicit in their suggestion of a consistent relationship between beat placement and ensemble response. Notable among texts is the work of Saito (1988), who does offer clear and prescriptive thoughts on beat placement

through premeditated variation of velocity and assignment of a spatial focal point to all temporal information conveyed by the conductor's gesture (p. 8-12), but these thoughts are in the clear minority.

With this noted, it is reasonable to define conducting's central goal as the coordination of each performer's individual-level musical activity toward a coherent group-level musical communication. Gesture's affective influence within this channel of information is highlighted by the pervasive role its presence plays in evaluations of music performances but the impact of temporal congruence to elements beyond synchronization is not clear. External (i.e., non-performer-based) perception of music performance is strongly influenced by visual information, as noted by Tsay in her investigation of amateur and expert evaluations of prize-winning pianists (2013). In the same way, audience perception of conducted ensembles is strongly influenced by the expressive quality of the conductor's gesture, as explored by Morrison and colleagues across instrumental (2009) and choral (*with* Selvey, 2014) contexts. The affective content of conducting gestures themselves has even been shown to influence perception of elements as removed from the visual channel as specific musical content (Kumar & Morrison, 2016). Where some practitioners offer that the conductor is both a navigator of time and the visual embodiment of musical affect (Leinsdorf, 1981) it would seem that the temporal distance of action to ensemble sound would bear consequence, all other things being equal.

The ability of humans to coordinate and synchronize actions between individuals and across groups is representative of the larger biological principle of entrainment. Defined as the "spatiotemporal coordination resulting from the rhythmic responsiveness to a perceived rhythmic signal," (Phillips-Silver, Aktipis, & Bryant, 2010, p. 3) this property of biological behavior is central to a wide range of activities and species (Patel, Iversen, Bregman, Schulz, & Schulz,

2008), music being one of the most idiosyncratically human. The propensity of individuals to coordinate their actions to a central, isochronous signal has been noted throughout human history (McNeill, 1995, p. 6) and has been empirically investigated within sonic (Nozaradan, Peretz, & Mouraux, 2012) and visual (Clayton, 2007) modes of transmission. Clayton (2012) further offers that entrainment can be subdivided into symmetrical and asymmetrical, with the former occurring in a complementary fashion between two responsive rhythmic systems (e.g., walking in step in a social setting) and the latter occurring in a setting where a more responsive rhythmic system's behavior becomes subsumed within the signaling of a stronger system (e.g. individual response to circadian rhythms while traveling). While research suggests that performer coordination occurs through the cross-modal integration of both information streams (Clayton, 1986; D'Ausilio et al., 2012; Williamon & Davidson, 2002), both the asymmetric organization of the one-to-many communication within ensemble music, as well as the primacy of visual information in any example of externalized evaluation, highlights the potential importance of temporal congruence in the context of conducted ensembles.

The phenomenon of visual congruence with an acoustic signal is most salient within temporal order judgments. Though facial gestures and temporally-bound aspects of conducting activity doubtless play a significant role in overall performance (VanWeelden & McGee, 2007), the temporal order of gesture to sound can be seen to stand – among practitioners and participants alike – as a quickly ascertainable signifier of a conductor's competence or lack thereof. In other words, the degree to which a conductor's time-coordinating gestures fall ahead or behind of the aurally-perceived beat of the musical presentation is often an indicator of conductor efficacy. The quality of synchronicity that is most preferred by observers in an ensemble setting has yet to be measured, but the predictive nature of kinematic responses to

conducting (Luck & Toivianen, 2006) and the entrainment of motor activity to a visual signal (Luck & Nte, 2007; Su, 2014; Luck & Sloboda, 2007) strongly suggest that temporal order is of no small consequence. Though recent studies have highlighted performer-to-performer influence -- both from perspectives of interpersonal/political interaction (Dineen, 2011) and interperformer entrainment (D'Ausilio et al., 2012) – the value given to temporal placement and congruence is substantial.

If there exists an automatic cross-modal recoding of temporally significant visual stimuli, then the practice-based evaluation of visual congruence in conducting practice may rest on a biological, or at least neurocognitive, foundation. Considering that there is a point of synthesis in similar cross-modal activities, this could also shed light on the variance within conducting tasks as they relate to the auditory output of a musical ensemble. In order to test the anecdotal construct of conductor efficacy, we pose the research question, "Does the temporal distance of conducting gesture to sound consequent have any bearing on evaluations of conductor efficacy and quality in a large ensemble setting?"

Method

Participants

Participants (*N*=112) were recruited from the graduate and undergraduate populations of two music schools located in the Eastern and Midwestern United States. All participants had one or more years of instrumental ensemble performance experience (*M*=6.10 years, *SD*=6.28 years); data collection was conducted through an online platform (Psychdata.net) and was carried out using university-based computer networks in accordance with Human Subjects protocols[4].

4 Psychdata.net collects IP address information from all participants, but anonymity was achieved via blanket IP address assignment within university networks utilized.

Participants who did not complete the survey instrument (n=2) were omitted from analysis. Remaining participants (*Female* = 56) reported more instrumental/band performance experience (M = 8.35 years, SD = 6.04 years) than choral (M = 6.48 years, SD = 7.00 years) and orchestral (M = 3.46 years, SD = 4.54 years). Additionally, participants reported fewer years of conducting experience than performance experience across all ensemble types (M = 4.54 years, SD = 1.27 years).

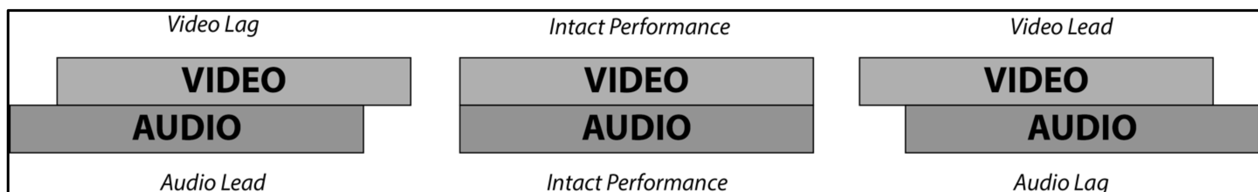
Stimuli

Stimuli were taken from intact performance videos collected from five experienced conductors (*2 female*). In all videos, conductors appeared from the perspective of the performers, with a variance of approximately 15 degrees to the right or left of ensemble center. The similarity of evaluations of conductor gesture from the performer's perspective to the audience's perspective has been demonstrated in similar studies (Price & Mann, 2011). Across all videos, performing musicians and audience members are viewable in the fore- and background, respectively. Video quality across collected samples met or exceeded baseline requirements for High Definition (720p HD, 720 x 480 pixels). Video artifacts were addressed using color correction and cropping where they did not detract from the focus of attention (e.g. automatic white balancing and cropping to center conductor in viewable field). Audio resolution for all videos was determined to be 16-bit WAV (CD quality) or better and represented professionally recorded audio captured during the performance in question.

From the collected videos, we chose two musically cohesive excerpts per conductor, one fast and one slow, each demonstrating a consistent tempo throughout the excerpt (fast: M_{fast}=142.4 beats per minute (BPM), SD_{fast} = 8.32 BPM; slow: M_{slow} = 73.0 BPM, $SD_{slo\ w}$= 30.54

BPM). These ten samples were selected for the balanced presence of consistent and clear gestural communication within a fully intact and coherent musical phrase, though tempo variance among slow excerpts was greater than that of fast. Consideration was also given to the presence of contextually-appropriate, expressive gesture shown by each conductor. Excerpt length (M_{length} = 29.2 seconds) was sufficiently short to allow close attention throughout the task and to avoid participant fatigue.

Intact stimuli videos were manipulated within Adobe Premiere Pro (Adobe, Inc.). Identified excerpts were extracted and manipulated to conform to experimental conditions through the separation and adjustment of audio and video tracks. This created a set of excerpt iterations encompassing an intact sample with no manipulation, a ±30% audio/visual offset condition, and a ±15% audio/visual offset condition for a total of fifty manipulated stimuli. These manipulations did not alter content quality or speed, but rather shifted the audio to either a lead (-) or lag (+) condition as compared to the intact video (see Figure 3-1). The temporal distance, measured in milliseconds (ms), was determined by analyzing the tempo of each excerpt ($M_{fast_excerpts}$= ±138ms (±30%), ±69ms (±15%); $M_{slow_excerpts}$= ±262ms (±30%), ±131ms (±15%)). In this way, we made the conductor seem either ahead of or behind the performing ensemble's acoustic output as compared to the naturalistic intact performance. For clarity, we labeled stimuli



by using the position of the audio stream related to the video where 'minus' indicated audio positioned before video and 'plus' indicated audio positioned after video.

The degree of offset reflected consideration of previous research highlighting offsets in conducting task synchronicity (Luck & Toiviainen, 2006), synchrony in music performance (Vatakis & Spence), and error detection (Danz & Janyan, 2009). Additionally, Fendrich and Corballis (2001) found that there is a natural tendency for sound and sight to fuse, becoming perceptibly synchronized, even in experimental conditions. In their study a cross-modal, temporal "locking" was observed below a threshold of 50 ms when applied to combinations of visual flashes and auditory clicks and flutters presented in close temporal proximity to one another. The mean offset values across all stimuli in the present study fell outside of this range, suggesting that participants would be capable of discerning some degree of "distance" between the audio and video components of the stimuli. The ±15% and ±30% offsets are theorized to provide a variance that is meaningful enough in audio/visual congruence to elicit a significant effect in participant's evaluations yet not so severe that participants interpreted them as a product of mechanical difficulties attributable to bandwidth, hosting service, browser, or playback. In contrast with fixed offset values reported in other investigations, the offset mechanism in the present study was designed for adaptation across a wide range of tempi, style, texture, or meter. In other words, the offset values generated here were reflective of the musical context rather than a static value.

A 45-second "Please Respond" prompt was added to the end of each excerpt and each was rendered with high definition audio and video (H.264, Apple, Inc.). From these stimuli five fully crossed orders were organized where no conductor, offset value, or excerpt condition (fast,

slow) was seen consecutively. Stimuli were individually uploaded to YouTube (Alphabet, Inc.) as unlisted videos[5].

Procedure

Via Psychdata.net, respondents viewed an instructional video and were asked to complete a sample evaluation of a conductor not included in the created stimuli. Each embedded video included three Likert-type scales anchored by *poor* (1) and *excellent* (5), asking the participant to rate the conductor, ensemble, and overall performance (see Appendix F). The survey instrument allowed for the tracking of elapsed and active time by each participant ($M_{elapsed}$ = 20.52 minutes, $SD_{elapsed}$ = 4.85 minutes), which was used to identify participants who did not complete their session or presented an elapsed time well outside the overall mean (n = 2). Participants were assigned to each condition randomly after indicating agreement to the IRB protocols, and completed the survey on desktop or laptop computers within each university's computer lab. As YouTube (Alphabet, Inc.) is a web application that renders equally well on the vast majority of available browsers and systems, hardware or software information was not collected for analysis.

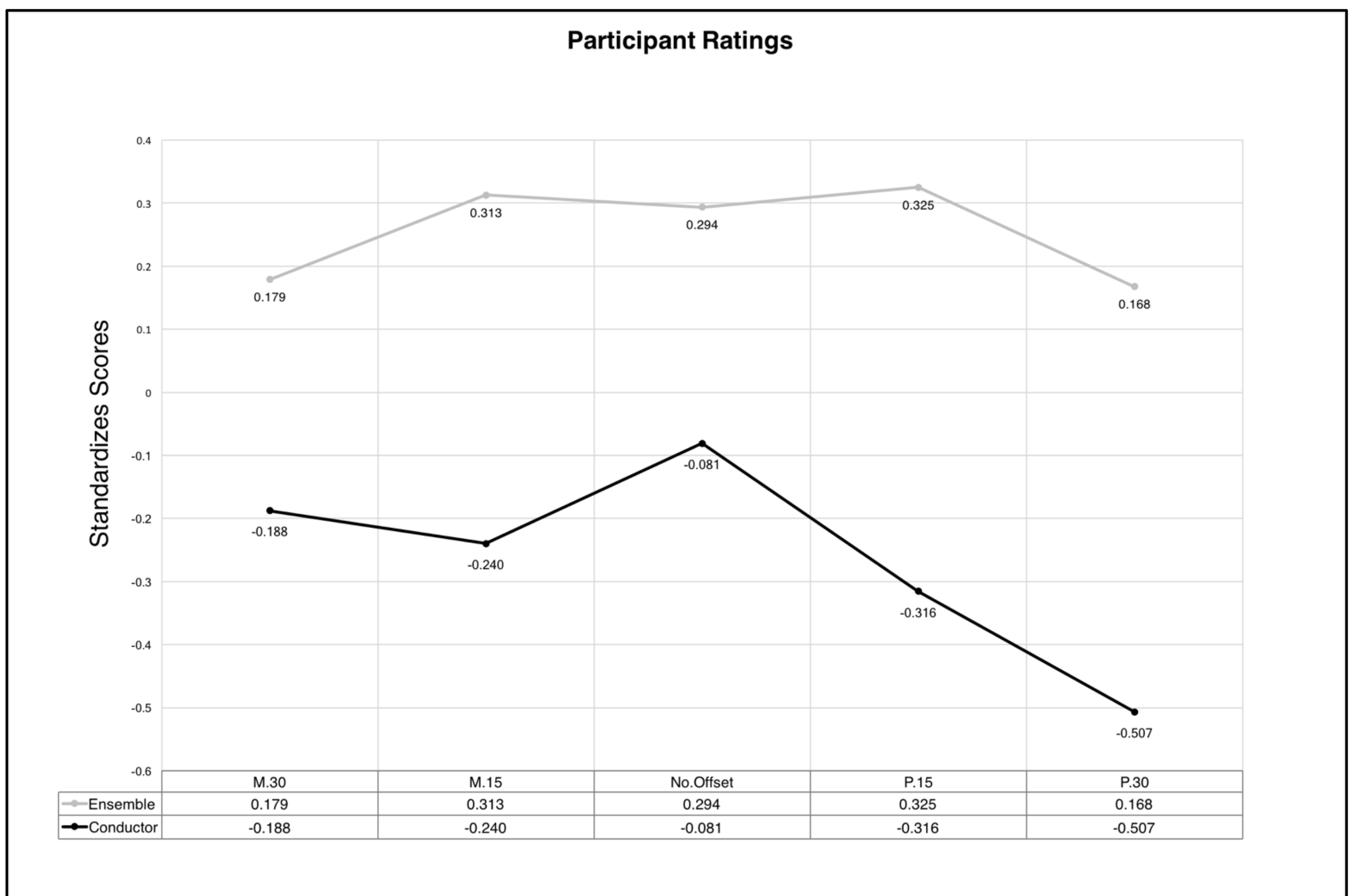
Results

Upon completion of data collection, we standardized participant ratings to account for individual variance in scale usage, and we grouped ratings by offset condition (e.g., -30%, -15%, no offset, +15%, +30%). Analysis of both mean conductor and ensemble ratings across excerpt

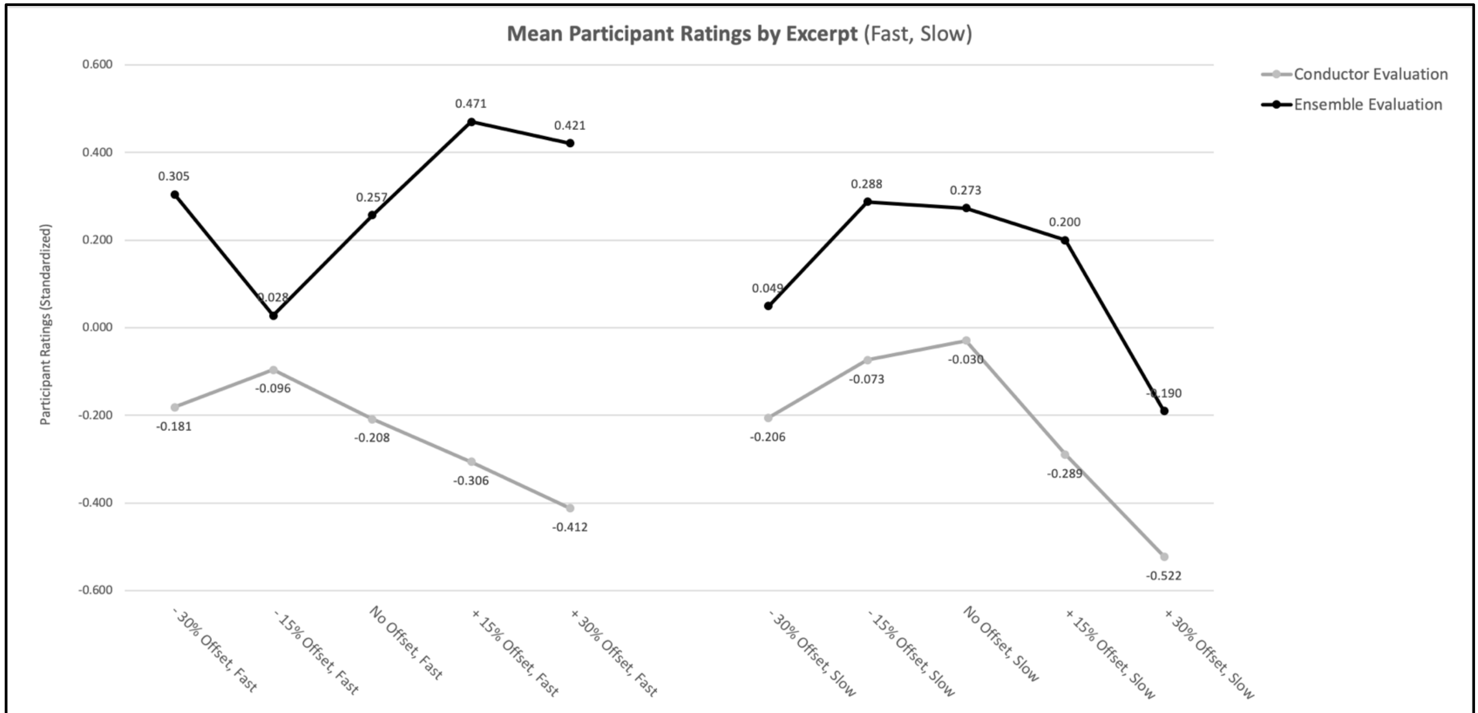
5 The nature of unlisted videos on media platforms such as YouTube restricts access to only those with a direct link to the media. This differs significantly from private videos that, while essentially invisible to web searches, are often password protected, un-embeddable, and therefore inappropriate for use through online survey forms such as those available through Psychdata.net.

condition (fast, slow), as well as analysis of mean ratings within each by tempo condition, were calculated in order to determine differences within participant ratings of conductor efficacy.

A within-subjects analysis of variance revealed significant differences in conductor evaluations across offsets $F(4, 436) = 3.236$, $p = .012$, $\eta_p^2 = 0.029$. Using Bonferroni correction for multiple comparisons, we found a significant difference between the no offset condition (M = -.081, SE = .082) and the +30% condition (M = -.507, SE = .088). No significant differences were found across ensemble evaluations. As can be seen through mean participant ratings across offset conditions (see Figure 3-2), a generally inverted-U shape exists in both evaluations of conductor and ensemble, where conductor ratings were overall lower than those of the ensemble.



	M.30	M.15	No.Offset	P.15	P.30
Ensemble	0.179	0.313	0.294	0.325	0.168
Conductor	-0.188	-0.240	-0.081	-0.316	-0.507



Analysis of conductor evaluations across slow and fast excerpts revealed significant differences in participant evaluations of slow excerpts $F(4, 436) = 4.237$, p = .002, $\eta_p^2 = .037$. Using Bonferroni correction for multiple comparisons, significant differences were found to exist between the +30% condition (*M* = -.611, *SE* = .109) and the -15% condition (*M* = -.084, *SE* = .108) as well as the no offset condition (*M* = -.024, *SE* = .106). Similar analysis of fast excerpts revealed no significant differences. Within the distribution of these scores, the inverted-U shape noted in the mean ratings discussed earlier is clearly visible within the slow excerpt condition (see Figure 3-3).

Due to the naturalistic source of collected stimuli, as well as reported effect sizes, consideration of potential confounds within stimuli was included in our analytic plan. Factors such as differences in quality of gesture (Morrison et al., 2009, 2014a, 2014b), ensemble performance level (Silvey, 2011), and each conductor's physical appearance (VanWeelden & McGee, 2007; Elliott 1995/1996) were not systematically controlled in the present design. Each

performance captured an advanced college-level ensemble following several weeks of rehearsal preparation; as such, the demonstrated level of accuracy and technical proficiency was comparable across excerpts. Likewise, because the videos were taken during concert performances, each conductor appeared in formal concert attire within an appropriate and professionally lit music performance venue. In terms of differences in quality of gesture, the aforementioned findings of Morrison and colleagues, as well as those of Napoles (2013) and Price et al. (2009), suggest that quality and variance of expressive gesture significantly influences overall perception of expressivity in ensemble performance, possibly leading to an influence in participant ratings within the present study. With this in mind, a review of stimuli revealed observational differences in the range of gestural expressivity among conductors in both slow and fast conditions.

To examine potential differences by conductor, standardized conductor ratings were reorganized by conductor and averaged. A within-subjects analysis of variance was performed on averaged participant ratings grouped by conductor in which Mauchly's test indicated that assumptions of sphericity had been violated ($\chi^2(9) = 20.59$, $p = .015$); degrees of freedom were corrected using Huyhn-Feldt estimates of sphericity ($\varepsilon = 0.95$) (Girden, 1992). Using this correction, a significant difference was found across conductors $F(3.8, 414.2) = 43.68$, $p < .001$, $\eta_p^2 = .286$. Using Bonferroni correction for multiple comparisons, significant differences were found between averaged evaluations of Conductor Four ($M = .648$, $SE = .057$) and all other conductors (see Table 3-1).

Table 3-1. Pairwise Comparisons: A

	n	*Mean*	*(SE)*	1	2	3	4	5
Conductor 1	218	-.095	.066	-				
Conductor 2	198	-.460	.074	-.185 (.069)	-			
Conductor 3	220	-.413	.067	-.201 (.082)	-.016 (.071)	-		
Conductor 4	220	.270	.086	.702* (.094)	.887* (.084)	.903* (.082)	-	
Conductor 5	244	-.431	.069	-.047 (.082)	.138 (.069)	.154 (.082)	-.749* (.079)	-

** Mean is significant at < .001*

Additional analyses of variance were performed examining standardized ensemble evaluations organized by conductor. Significant differences were found within ensemble evaluations $F(4, 436) = 55.4$, $p < .001$, $\eta_p^2 = .337$. Using Bonferroni correction for multiple comparisons, significant differences were found between averaged ensemble evaluations of Conductor Four ($M = .969$, $SE = .049$) and all other conductors. An analysis of variance examining standardized conductor evaluations was performed in which Mauchly's test indicated that assumptions of sphericity had been violated (χ^2 (9) = 21.12, p = .012); degrees of freedom were again corrected using Huyhn-Feldt estimates of sphericity ($\varepsilon = 0.95$) (Girden, 1992). Using this correction, significant differences were found across conductors $F(3.77, 410.66) = 16.374$, $p < .001$, $\eta_p^2 = .131$. Using Bonferroni correction for multiple comparisons, significant differences were found between evaluations of Conductor Four ($M = .299$, $SE = .096$) and all other conductors. These results broadly support findings that indicate a cross-modal relationship between expressive gesture and overall evaluations of ensemble expressivity (Morrison et al.,

2009; Morrison & Selvey, 2014; Morrison et al., 2014), appearing here as a measure of ensemble (and conductor) quality.

Discussion

Conducting is a multivariate and cross-modal activity that, while it straddles many related perceptual and mechanical boundaries in its function, primarily exists as a process whose goal is the coordination of human musical activity. Various strands of ensemble performance have been found to operate independent of the conductor, be they temporal alignment (Bishop & Goebl, 2017; Ross, 2014; Jones, 2015) or expressive intent (Hamann, 2003), but all have been shown to bear the influence the conductor's activities. Though there is considerable evidence to the limits of this influence (i.e., D'Ausilio et al., 2012; Dineen, 2011), the centrality of an otherwise soundless contributor's influence on both temporal congruence and expressive communication is inescapable.

In the current study we highlighted the importance of congruence between participants in ensemble music contexts, demonstrating that alterations within the perceptual envelope create deleterious effects on evaluations of both conductor and ensemble. While this further reinforces the perceived role of the conductor as a central, entraining figure within the dynamic interaction of ensemble music, our results do not fully explain the presence of this response among experienced musicians. With the power of gesture in music well documented regarding conveying emotion (Davidson, 1993), delineating musical structure (Vines et al., 2006), or even communicating musical ideas and timing (Williamon & Davidson, 2002; Goebl & Palmer, 2009), one would expect that the seeming global effect of gesture on evaluations of musical performance to appear more strongly in this context. The impact of alterations to temporal

congruence on these evaluations is a useful finding when considered alongside the existing literature; nevertheless, the minimal amount of variance explained by our findings requires further exploration.

Music produces a complex and dynamic sonic mesh of interaction that both performers and audience members must process, often in a holistic manner. With this cross-modal nature of musical performance, especially where performer gesture is involved, it is reasonable to infer that elements of one modality (i.e., aural) will influence perception of the other (i.e., visual). Dynamic Attending Theory (Jones, 1976, Jones & Boltz, 1989) addresses the auditory properties of temporal congruence and its alterations by highlighting the manner in which individuals interact with the auditory signals woven throughout complex sonic streams. The attending described by Jones and colleagues spans the range of periodic rhythmicity from hierarchical and highly coherent to unstructured and minimally coherent but is rooted in the human propensity toward synchronizing or entraining with external temporal signals. Where attending becomes interactive, it is referred to as attunement, which is divided into the two functions of *analytical* and *future-oriented* (Jones & Boltz, 1989, p. 470). These vary in their robustness but allow for the flexibility between the placement of a given beat and the accessing of the larger hierarchical structures within the music.

As demonstrated by Luck and Toiviainen (2006), there is a predictive bias to performer response in ensemble conducting, indicating that this action is future-oriented in a similar manner to that described by Jones and Boltz (1989). Highly coherent events (e.g., successful ensemble performance) afford future orientation to attending, essentially focusing on aligning activity with “what-comes-next,” a factor especially salient in performance contexts where inter-performer synchrony is highly valued. With this in mind, consideration of the negative influence

played by alterations to temporal location in a pitch comparison task (Jones, Moynihan, MacKenzie, & Puente, 2002) yields interesting parallels to the findings of the present study. Jones and colleagues found that any alteration to expected temporal location (both leading and lagging) had a deleterious effect on the focal task in a very similar manner to the quality and efficacy judgments in our study. This is further reinforced the findings of Reeves and Nass (1996) who reported that video stimuli whose sound preceded paired visual speech were seen as less effective or desirable in general, regardless of their content.

Where the measure of temporal distance appears most salient, however, is in the consideration of offsets in slow excerpts. With a much wider maximum variance of temporal offset in slow ($M = \pm 262$ ms, $SD = \pm 81$ms) versus fast ($M = \pm 138$ ms, $SD = \pm 31$ms) excerpts, the striking differences between responses to the two sets of stimuli suggest that an absolute rather than relative interval in temporal offset may be a driving factor in evaluations. In other words, despite the fact that both slow and fast excerpts exhibited enough video lag or lead to discern them from the corresponding audio (Fendrich & Corballis, 2001), it may be that participants were better able to accommodate the dissociation among the faster excerpts. Slower material may be perceived as simpler, leaving participants able to direct attention to more discrete aspects of the conductor's gesture. In considering that all participants were ensemble performers to whom synchrony is a highly valued aspect of music performance, Vatakis and Spencer's observation that "… perception of synchrony may be affected by the complexity of the particular stimuli being judged," (p. 141) bears further consideration. Taken along with the negative impact of offset reported by Jones and colleagues (2002), this potentially suggests a range of expressive temporal affordance within ensemble conducting that is perceptually fixed rather than dynamically linked to the musical content. Once violated, any temporal alterations to action-

sound congruence degrade the externally perceived efficacy of a conductor's communication with the ensemble. In other words, conductors can only be so far ahead or behind the ensemble before their gestures become sharply less efficacious.

This raises two critical questions. First, would the response profile between slow and fast excerpts be more similar if each was adjusted using the same absolute (rather than relative) magnitudes of deviation? If so, this would reveal either (1) a potential duration-general window of "affordance" within which observers reconcile disjunct audio and video music performance information or (2) a "blind spot" that lies outside the range of discernment of decontextualized stimulus but may be facilitated by a more content-rich perceptual environment, an eventuality supported by work in the area of crossmodal perceptual binding (Engel, Roelfsema, Fries, Brecht, & Singer, 1997).

Second, given a direct comparison between intact and adjusted excerpts, would a more apparent positive response to intact performances emerge for fast excerpts? Likewise, would a correspondingly more pronounced positive response emerge for slow excerpts? Such a finding would confirm that the adjustments used in the present study were sufficiently discernable and that the responses observed reflect an active accommodating of temporal misalignment.

Though it is premature to hypothesize beyond the data and results at hand, it stands to reason that an individual's propensity toward entrainment, a quality present across culture and context (Patel et al., 2008), combined with the asymmetric nature of the entrainment paradigm presented in the stimuli of the present study, would place an entraining system (here a conductor) demonstrating a signal that falls outside the expected pulse (here the conducted beat of a musical group) would be seen negatively by experienced evaluators. Though this does not specifically address the negative human-computer video offset findings of Reeves and Nass (1996), the

overarching idea of entrainment as a significant factor in the decreased preference and lower evaluation across modalities bears further consideration in future investigations.

In tandem with the detrimental effect of alterations to temporal congruence in conducting tasks, our results further suggest that the quality of the expressive quality of the conductor's gesture may play a role in evaluations of efficacy. The one conductor whose gestures were noted as being more expressive than other conductors was rated higher across all offsets and in both fast and slow conditions. This further supports earlier findings that expressive gesture in conducting tasks serves to alter perception of the performance overall (Morrison et al., 2009; Morrison et al., 2014; Morrison & Selvey, 2014; Price & Mann, 2009; Silvey, 2011; Napoles, 2013).

Another potential explanation for the differences between all offsets and the intact video could be an effect of ensemble conducting experience or training on the part of the participants. Luck and Sloboda (2007) found that participants with conducting tutelage synchronized more readily with experimental stimuli, leading them to offer that these subjects', "superior performance may be explained by their better understanding of what exactly characterized a visual beat, and an increased sensitivity to the kinematic information contained in the gestures of other conductors" (p. 42). While the ensemble performance ($M = 6.10$ years) and conducting ($M = 4.54$ years) experience of participants in this study lends credence to a potentially higher sensitivity to temporal congruence, as noted by Rammsayer, Buttkus, & Altenmuler (2012), the marked impact of visual information on evaluations of performer quality (Tsay, 2013) and performance quality (Davidson, 1993), as well as the overlapping findings of deleterious offset (Jones et al., 2002) and just noticeable difference (Vatakis & Spencer, 2006), all strongly point to the potential for broader generalizability in more systematically controlled settings. What

remains less clear, however, is the overall negative trend in conductor evaluations when compared to those of the ensemble. While Silvey (2011) revealed the influence of ensemble performance on evaluations of conductor quality, the question of training- and context-specific effects on evaluations still remains to be investigated in this context.

Ensemble performance is a multivariate and multimodal communication network in which conductors are a critical and influential node. The results of this study suggest that the temporal congruence of the gesture offered by these otherwise soundless contributors bears consequence not only in their coordinational role, but in evaluations of their efficacy and the quality of the ensemble's performance. Additionally, these results reinforce existing findings within entrainment and temporal discrimination research, highlighting an understudied extreme in perceptual attunement between conductor and ensemble. Though this study adds broad support to the cross-modal influence of sight and sound in musical contexts, further research is needed to foster a more robust understanding of the multiple interactions that create the dense mesh of communication and congruence within ensemble music.

References

Bell, L. (2004). Conducting: When orchestras are used to playing behind the beat. [Online forum thread]. Retrieved from: http://archive.choralnet.org/view/221793

Bishop, L., & Goebl, W. (2017). Beating time: How ensemble musicians' cueing gestures communicate beat position and tempo. *Psychology of Music, 37(5)*, 1578-1594. doi: 10.1037/a0024323

Berlioz, H. (1926). *The orchestral conductor: Theory of his art.* New York: Carl Fischer, Inc.

Boltz, M., Ebendorf, B., & Field, B. (2009). Audiovisual interactions: The impact of visual information on music perception and memory. *Music Perception, 27* (1). 43-59.

Clayton, A.M. (1986). *Coordination between players in musical performance.* (unpublished doctoral dissertation) Edinburgh University, UK.

Clayton, M. (2007). Observing entrainment in musical performance: Video-based observational analysis of Indian musicians' tempura playing and beat making. *Musicae Scientiae, 11*(1), 27-59.

Clayton, M. (2012). What is entrainment? Definition and application in musical research. *Empirical Musicology Review, 7* (1-2). 49-56.

Danz, A. D., & Janyan, A. (2009). Detecting audio-video tempo discrepancies between conductor and orchestra. In *Proceedings of the 31st Annual Conference of the Cognitive Society* (pp. 3064-3069).

D'Ausilio, A., Badino, L., Li, Y., Tokay, S., Craighero, L., Canto, R., Aloimonos, Y., & Fadiga, L. (2012) Leadership in orchestra emerges from the causal relationships of movement kinematics. *PLoS ONE, 7*(5). e35757.

Davidson, J. (2008). Qualitative insights into the use of expressive body movement in solo piano performance: A case study approach. *Psychology of Music, 35* (3). 381-401.

Davidson, J. (1993). Visual perception of performance manner in the movements of solo musicians. *Psychology of Music, 21*. 103-113.

Dineen, P. M. (2011). Gestural economies in conducting. In A. Gritten & E. King (Eds.), *New Perspectives on Music and Gesture*, 131-157. Farnham, Surrey: Ashgate Publishing, Ltd.

Donnelly, K.J. (2014). *Occult aesthetics: Synchronization in sound film*. Oxford, UK: Oxford University Press.

Elliott, C.A. (1995/1996). Race and gender as factors in judgments of musical performance. *Bulletin of the Council for Research in Music Education,* 127 (The 15th International Society for Music Education: ISME Research Seminar), 50-56. doi: http://www.jstor.org/stable/40318766

Fendrich, R., & Corballis, P. M. (2001). The temporal cross-capture of audition and vision. *Perception & Psychophysics*, *63(4)*, 719-725.

Fuelberth, R.V. (2003). The effect of left hand conducting gesture on inappropriate vocal tension in individual singers. *Bulletin of the Council for Researching Music Education, 157.* 62-70. doi: http://www.jstor.org/stable/40319187

Girden, E.R. (1992). *ANOVA: Repeated measures*. Newbury Park, CA: Sage.

Goebl, W., & Palmer, C. (2009). Synchronization of timing and motion among performing musicians. *Music Perception, 26* (5). 427-438.

Green, E.A., & Gibson, M. (2004). *The modern conductor* (7th ed.). New Jersey: Pearson.

Johnson, E. (2014, August 28). Why do so many orchestras lag behind the beat? *The Strad.* Retrieved from: http://www.thestrad.com/cpt-latests/why-do-so-many-orchestras-lag-behind-the-beat/

Jones, M.R. (1976). Time, our lost dimension: Toward a new theory of perception, attention, and memory. *Psychological Review, 83(3),* 323-355. doi:10.1037/0033-295X.83.5.323.

Jones, M.R., & Boltz, M. (1989). Dynamic attending and responses to time. *Psychological Review, 96(3),* 459-491. doi:10.1037/0033-295X.96.3.459

Jordan, J., & Lauridsen, M. (2009). *Evoking sound: Fundamental art of choral conducting.* Chicago: GIA Publications.

Kelly, S. (2008). Effects of conducting instruction on the musical performance of beginning band students. *Journal of Research in Music Education, 45* (2). 295-305.

Kumar, A.B., & Morrison, S.J. (2016). The conductor as visual guide: Gesture and perception of musical content. *Frontiers in Psychology,* 7. doi:10.3389/fpsyg.2013.01049.

Labuta, J. (2004). *Basic conducting techniques.* Upper Saddle River, New Jersey: Pearson & Prentice Hall.

Leinsdorf, E. (1981). *The composer's advocate: A radical orthodoxy for musicians.* New Haven, Connecticut: Yale University Press.

Luck, G., & Nte, S. (2007). An investigation of conductors' temporal gestures and conductor musician synchronization, and a first experiment. *Psychology of Music, 36*(1), 81–99. doi: 10.1177/0305735607080832

Luck, G., & Sloboda, J. (2007). An investigation of musicians' synchronization with traditional conducting patterns. *Music Performance Research, 1*(1), 26-46.

Luck, G., & Sloboda, J. (2008). Exploring the spatio-temporal properties of simple conducting gestures using a synchronization task. *Music Perception, 25*(3), 225–239. http://doi.org/10.1525/mp.2008.25.3.225

Luck, G., & Toiviainen, P. (2006). Ensemble musicians' synchronization with conductors' gestures: An automated feature-extraction analysis. *Music Perception, 24* (2), 189-200. http://www.jstor.org/stable/10.1525/mp.2006.24.2.189

Madison, G., Gouyon, F., Ullén, F., & Hörnström, K. (2011). Modeling the tendency for music to induce movement in humans: First correlations with low-level audio descriptors across music genres. *Journal of Experimental Psychology: Human Perception and Performance,* 37 (5). 1578-1594.

McNeill, W.H. (1995). *Keeping together in time: Dance and drill in human history.* Cambridge, MA: Harvard University Press.

Morrison, S., Price, H., Geiger, C., & Carnacchio, R. (2009). The effect of conductor expressivity on ensemble performance evaluation. *Journal of Research in Music Education, 57* (1). 37-49.

Morrison, S., Price, H., Smedley, E., & Meals, C. (2014). Conductor gestures influence evaluations of ensemble performance. *Frontiers in Psychology*. doi: 10.3389/fpsyg.2014.00806

Morrison, S., & Selvey, J. (2014). The effect of conductor expressivity on choral ensemble evaluation. *Bulletin for the Council of Research in Music Education, 199*, 7-18. doi: http://www.jstor.org/stable/10.5406/bulcouresmusedu.199.0007

Napoles, J. (2013). The influences of presentation modes and conducting gestures on the perceptions of expressive choral performance of high school musicians attending a summer choral camp. *International Journal of Research in Music Education, 31* (3). 321-330.

Nozaradan, S., Peretz, I., & Mouraux, A. (2012). Selective neuronal entrainment to beat and meter embedded in a musical rhythm. *Journal of Neuroscience, 32*(49). 17572-17581. doi: 10.1523/JNEUROSCI.3203-12.201

Patel, A.D., Iversen, J.R., Bregman, M.R., Schulz, I., & Schultz, C. (2008). Investigating the human-specificity of synchronization to music. *Proceedings of the 10th International Conference on Music Perception and Cognition, Sapporo, Japan.*

Phillips-Silver, J., Aktipis, C., & Bryant, G. (2010). The ecology of entrainment: Foundations of coordinated rhythmic movement. *Music Perception, 28* (1). 3-14.

Platz, F., & Kopiez, R. (2012). When the eye listens: A meta-analysis of how audio-visual presentation enhances the appreciation of music performance. *Music Perception, 30*(1). 71-83.

Price, H. & Mann, A. (2011). The effect of conductors on ensemble evaluations. *Bulletin of the Council for Research in Music Education, 189.* 57-72. doi: http://www.jstor.org/stable/10.5406/bulcouresmusedu.189.0057

Price, H.E. & Chang, E.C. (2005). Conductor and ensemble performance expressivity and state festival ratings. *Journal of Research in Music Education, 53*(1). 65-77. doi: 10.1177/0022429405058300106

Rammsayer, T., Buttkus, F., & Altenmüller, E. (2012). Musicians do better than nonmusicians in both auditory and visual timing tasks. *Music Perception, 30*(1). 85-96.

Reeves, B., & Nass, C. (1996). *The media equation: How people treat computers, television, and new media like real people and places.* New York: Cambridge University Press.

Rudolf, M. (1980). *The grammar of conducting.* New York: Schirmer.

Saito, H. (1988). *The Saito conducting method.* (W. Toews & F. Torigui, trans.). Tokyo: Min-On Concert Association.

Schutz, M., & Lipscomb, S. (2007). Hearing gestures, seeing music: Vision influences perceived tone duration. *Perception, 36*. 868-897. doi: 10.1068/p5635

Silvey, B. (2011). The effect of ensemble performance quality on the evaluation of conducting expressivity. *Journal of Research in Music Education, 59* (2). 162-173.

Silvey, B. (2013). The role of conductor facial expression in students' evaluation of ensemble expressivity. *Journal of Research in Music Education, 60(4)*, 419-429. doi: 10.1177/0022429412462580

Silvey, B., Wacker, A.T., Felder, A. (2016). Effects of baton usage on college musicians' perceptions of ensemble performance. *International Journal of Music Education,* 1-10. doi: 10.1177/0255761416667465

Skadsem, J.A. (1997). Effect of conductor verbalization, dynamic markings, conductor gesture, and choir dynamic levels on singers' dynamic responses. *Journal of Research in Music Education, 45*(4), 509-520. doi: 10.2307/3345419

Su, Y.H. (2014). Audiovisual beat induction in complex auditory rhythms: Point-light figure movement as an effective visual beat. *Acta Psychologica, 151.* 140-150. doi: 10.1016/j.actpsy.2014.05.016

Thompson, W.F., Graham, P., & Russo, F.A. (2005). Seeing music performance: Visual influences on perception and experience. *Semiotica, 156(1),* 203-227. doi: 10.1515/semi.2005.2005.156.203

Tsay, C.J. (2013). Sight over sound in the judgment of music performance. *Proceedings of the National Academy of Sciences of the United States of America, 110(36),* 14580-14585. doi: 10.1073/pnas.1221454110

Tsay, C.J. (2014). The vision heuristic: Judging music ensemble by sight alone. *Organizational Behavior and Human Decision Processes, 124*. 24-33. doi: 10.1016/j.obhdp.2013.10.003.

VanWeelden, K. (2002). Relationships between perceptions of conducting effectiveness and ensemble performance. *Journal of Research in Music Education, 50(2)*, 165-176. doi: 10.2307/3345820

VanWeelden, K., & McGee, I. R. (2007). The influence of style and conductor race on perceptions of ensemble and conductor performance. *International Journal of Music Education, 25*(1), 7-17. doi: 10.1177/0255761407074886

Vatakis, A., & Spence, C. (2006). Audiovisual synchrony perception for music, speech, and object actions. *Brain Research, 1111*(1). doi: 10.1016/j.brainres.2006.05.078

Vines, B.W., Krumhansl, C.L., Wanderley, M.M., Dalca, I.M., & Levitin, D.J. (2006). Dimensions of emotion in expressive music performance. *Annals of the New York Academy of Sciences, 1060*, 462-466. doi: 10.1196/annals.1360.052

Williamon, A., & Davidson, J.W. (2002). Exploring co-performer communication. *Musicae Scientiae,* 1(1), 53-72.

Wöllner, C., Deconinck, F.J., Parkinson, J., Hove, M., & Keller, P.E. (2012). The perception of prototypical motion: Synchronization is enhanced with qualitatively morphed gestures of musical conductors. *Journal of Experimental Psychology: Human Perception and Performance, 38*(6), 1390-1403. doi: 10.1037/a0028130

Wöllner, C., & Auhagen, W. (2008). Perceiving conductors' expressive gestures from different visual perspectives: An exploratory continuous response study. *Music Perception, 26* (2). 129-143.

Appendix A. Human Subjects Approvals, Paper Two

NOT HUMAN RESEARCH

January 23, 2018

Cory Meals
3333 Cullen Blvd.
Room 134
Houston, TX 77204-4017

7137435389
cdmeals@central.uh.edu

Dear Cory Meals:

On 1/23/2018, the IRB reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	A Question of Lag: The Relationship Between Visual Gesture and Sonic Response in Instrumental Ensemble Settings
Investigator:	Cory Meals
IRB ID:	STUDY00000723
Funding/proposed funding:	Name: Music, Moores School of
Award ID:	
Award Title:	
IND, IDE, or HDE:	None
Documents Reviewed:	• HRP-503 MEALS Winter 17.18.docx, Category: IRB Protocol; • HRP-416 MEALS Winter 17.18.docx, Category: Consent Form; • Temporal Latency/Lag Consent Form, Category: Consent Form;
Review Category:	
Committee Name:	Not Applicable
IRB Coordinator:	Sandra Arntz

The IRB determined that the proposed activity is not research involving human subjects. IRB review and approval is not required. The described research activities involve the analysis of onset differences, rather than human subjects data.

UNIVERSITY of
HOUSTON
DIVISION OF RESEARCH
Institutional Review Boards

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are being considered and there are questions about whether IRB review is needed, please submit a study modification to the IRB for a determination. You can create a modification by clicking **Create Modification / CR** within the study.

Sincerely,

Research Integrity and Oversight (RIO) Office
University of Houston, Division of Research
713 743 9204
cphs@central.uh.edu
http://www.uh.edu/research/compliance/irb-cphs/

From: **Jean E. Stewart** jestewart@conroeisd.net
Subject: RE: Request for Research - Conroe ISD
Date: March 8, 2018 at 12:07 PM
To: Meals, Cory D cdmeals@Central.UH.EDU
Cc: Gregg A. Colschen gcolschen@conroeisd.net, Donny J. Daw ddaw@conroeisd.net, Curtis Null cnull@conroeisd.net

Mr. Meals,

I have met with the Research Committee and spoken to the principals regarding your request to conduct research at Knox Junior High and The Woodlands High School. The principals and instructors at both campuses are willing to participate in the study. Your request to conduct research is approved as submitted with the following parameters:

1. There will be no *identifiable* student voices or images in the video. Parents will be notified by the campus of the research and that the instructors will be filmed during class. If a parent has a concern, he/she is to contact the instructor at the campus.
2. Participation by the teachers is strictly voluntary;
3. The day, date, and time of filming will be mutually agreeable to CISD staff and the researcher; and
4. Any contact with staff in CISD regarding the study will be conducted outside of school hours.

I wish you the very best in your educational pursuits

Regards,
Jean Stewart, Ed.D.

From: Meals, Cory D [mailto:cdmeals@Central.UH.EDU]
Sent: Tuesday, March 06, 2018 2:50 PM
To: Jean E. Stewart <jestewart@conroeisd.net>
Subject: Re: Request for Research - Conroe ISD

Good afternoon, Dr. Stewart,

Thank you for the prompt reply, I apologize that I wasn't able to find your contact information on the district site!

Regarding your provisions, those all fit within the dictates of my study save for the recording of ensemble performance, which (as my proposal indicates) is designed to present no disruption to normal classroom function, instructional time, or student activity.

I look forward to hearing back from you, thank you again!

Cory Meals

Cory Meals I Music Education, Instrumental
University of Houston

Appendix B. Consent Forms, Paper Two

Consent to Take Part in a Human Research Study

Title of research study:

A Question of Lag: The Relationship Between Conductor Gesture and Sonic Response in Instrumental Ensemble Settings

Principal Investigator: Cory Meals, University of Houston Music Education Faculty

Why am I being invited to take part in a research study?

We invite you to take part in a research study because you are the primary conductor of a high school or middle school band or orchestra.

What should I know about a research study?

- Someone will explain this research study to you.
- Whether or not you take part is up to you.
- You can choose not to take part.
- You can agree to take part and later change your mind.
- Your decision will not be held against you.
- You can ask all the questions you want before you decide, and can ask questions at any time during the study.

Why is this research being done?

This study seeks to investigate and analyze the time-based relationship of music conductor gesture and ensemble sonic response along several parameters: between orchestras and wind bands, between developmental levels (beginner, intermediate, advanced), and over a set period of time (4 weeks).

How long will the research last?

We expect that you will be in this research study for four weeks, comprising a total of 3 visits by the Primary Investigator over that time.

How many people will be studied?

We expect about 2 people on your campus (1 band, 1 orchestra) will be in this research study out of 6 people in the entire study.

Consent to Take Part in a Human Research Study

What happens if I say yes, I want to be in this research?

Tertiary (2 College) and secondary (2 HS, 2 JH) ensemble conductors representing an equal distribution of band and orchestra (1 each) will be video and audio recorded in naturalistic rehearsal settings, taking care to omit individually identifiable student information. Before class begins a video camera will be set up at the rear of the classroom, approximately 10 meters from the conductor. Similarly, an audio recorder set up in front of the ensemble, approximately 2 meters from the ensemble. This equipment will remain in place throughout the class period, being put away during the following passing period. The camera angle will be zoomed/cropped in such a way that only conductors will be identifiable, and care will be taken to omit all identifying information from the frame (e.g. school name, student information).

This research study includes the following component(s) where we plan to audio record/video record you as the research subject:

I agree to be audio recorded/video recorded during the research study.
- I agree that the audio recording/video recording can be used in publication/presentations.
- I do not agree that the audio recording/video recording can be used in publication/presentations.

I do not agree to be audio recorded/video recorded during the research study.

What happens if I do not want to be in this research?

You can choose not to take part in the research and it will not be held against you. Choosing not to take part will involve no penalty or loss of benefit to which you are otherwise entitled.

What happens if I say yes, but I change my mind later?

You can leave the research at any time it will not be held against you.

If you stop being in the research, already collected data will be removed from the study record.

Is there any way being in this study could be bad for me?

There are no foreseeable risks related to the procedures conducted as part of this study. If you choose to take part and undergo a negative event you feel is related to the study, please inform your study team.

Will I get anything for being in this study?

No compensation will be provided for participation in this study.

Will being in this study help me in any way?

There are no known benefits to you from your taking part in this research.

What happens to the information collected for the research?

Efforts will be made to limit the use and disclosure of your personal information, including research study and medical records, to people who have a need to review this information. Each subject's name will be paired with a code number, which will appear on all written study materials. The list pairing the subject's name to the assigned code number will be kept separate from these materials. We cannot promise complete secrecy. Organizations that may inspect and copy your information include the IRB and other representatives of this organization, as well as collaborating institutions and federal agencies that oversee human subjects research.

We may publish the results of this research. However, unless otherwise detailed in this document, we will keep your name and other identifying information confidential.

What else do I need to know?

You will be informed of the results of this research within 2 months of the final performance capture, and the final write-up will be shared with you prior to publication.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, you should talk to the research team at Cory Meal**s (cdmeals@central.uh.edu)** – 713.743.7359 (office)

This research has been reviewed and approved by the University of Houston Institutional Review Board (IRB). You may also talk to them at (713) 743-9204 or cphs@central.uh.edu if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

Consent to Take Part in a Human Research Study

Signature Block for Capable Adult

Your signature documents your consent to take part in this research.

Signature of subject	Date
Printed name of subject	
Signature of person obtaining consent	Date
Printed name of person obtaining consent	

Consent to Take Part in a Human Research Study

Signature Block for Adult Unable to Consent

Your signature documents your permission for the named subject to take part in this research.

____
Printed name of subject

____ ____________________
Signature of legally authorized representative Date

____
Printed name of legally authorized representative

____ ____________________
Signature of person obtaining consent Date

____
Printed name of person obtaining consent

Appendix C. Human Subjects Approval, Paper Three

11/25/2014

PI: Dr. Steven Morrison, Professor
School of Music

Re: Human Subjects application #48706
"Temporal Congruence Influences Evaluations of Conductor Efficacy"

Dear Dr. Morrison,

Thank you for submitting the above-referenced Human Subjects application for review and approval. During screening, we discovered that your project may qualify for a determination of exempt status. Projects qualifying for determination of exempt status are determined to be of marginal or of no risk to subjects, and fall within certain regulatory guidelines.

The administrative review process for exempt projects differs from Minimal Risk or Full Committee review. In general, the review process does not usually take as long. In addition, the determination period is for 5 years, rather than for a one year period. However, the determination has some limitations. For example, the project cannot be amended or changed, and the project's determination cannot be renewed. Instead, a new Exempt Status Request must be reviewed by the departmental chair, dean, or director, and then the signed request needs to be forwarded to the Human Subjects Division for a determination.

Please respond to the following questions so that we may determine the appropriate level of review for your project:

1. Please note that a determination of exempt status does not allow for revisions to the protocol; the determination is only for those activities outlined in the Human Subjects application. Please confirm that there will be no changes made to this protocol. Should revisions be necessary, then please confirm you will provide a new determination request for departmental review, and then send the signed copy to the Human Subjects Division for administrative review.

   Once approved, there will be no revisions made to the protocol. Should revisions prove necessary, we will provide a new determination request for approvals at the departmental and Human Subjects Division levels.

2. Please confirm that this project will be completed within 5 years of approval. In the event that the project continues after the 5 years, you will provide a new exempt status request for departmental review, and then send the signed copy to the Human Subjects Division for administrative review.

   This project will be completed within five (5) years of approval.

3. Based on my pre-review of your application, it appears that all of the procedures you have described may qualify for exempt status under category 7. Please consult our SOP on Exempt Determination and review the criteria for category 7. If you do not feel that your activities meet these criteria, please explain.

4. Section VII.1 in the application was left blank. Please confirm my understanding that there is no funding for this project. If this is incorrect, please list the funding below and provide a copy of the grant or proposal along with your response to this letter.

   We confirm our understanding that there is no funding for this project.

5. Please clarify the role of Temple University in this research. Will individuals from Temple be interacting directly with subjects? Obtaining consent? Analyzing data? Please specify below. Will individuals from Temple be obtaining separate IRB review? Please explain.

   Temple University's role will be primarily that of data collection. They will interact directly with subjects, obtain consent, and facilitate access to computer workstations for survey data collection. Our collaborators at Temple will be obtaining separate IRB review, contingent on UW IRB approval.

6. My understanding is that the only procedures involved in this study are task completion (video viewing) and surveys with adults. If this is not accurate, please explain.

   This is correct.

7. Only a single page instrument was submitted and it does not appear to represent the complete range of questions that will be presented to subjects. Please attach a comprehensive set of measures/questions with your responses.

   The instrument is a twelve-page website, the first page of which is demographic information collection (attached), and the same survey form (referenced above) linked to eleven different videos (one familiarization page, ten survey pages).

8. No consent materials were provided with the application. Please submit a copy of the consent form(s) that will be used with subjects who complete this research.

   We apologize, and have added language to our script to remedy that oversight.

9. You indicated (per item H.6) that FERPA regulations will apply to this project. Will you be directly accessing academic records for research purposes? Please clarify how FERPA applies to this research.

   That was a typographical error. Academic records will not be accessed for this research, only self-reported demographic information from subjects.

10. Many internet survey sites collect identifiers (including IP address) even though they may not release this information to researchers. Please confirm that the survey site that will be used to collect study data will not collect any identifiable information about users.

Psychdata.com allows for the collection of IP addresses, and through this the tracking of survey duration (which is needed to help ensure the durational integrity of subject's viewing task). As subjects will be using a university computer lab for viewing and feedback, the IP addresses will only reflect which individual machine is used, rather than identify an individual user.

11. Please review the criteria for exempt category 7 outlined in section 8.1 of our SOP on Exempt Determination. Confirm that the proposed procedures meet the specified requirements.

    We confirm that our proposed procedures meet specified requirement for exempt category 7.

12. In order to qualify for exempt category 7, the proposed research must **not** be federally funded, supported, or regulated. You indicated in the application that there is no current funding for this project. Please respond to the questions below to clarify the funding status of this project.

    a. Is this research funded by a grant or contract awarded directly or indirectly (i.e., through a sub-contract) from a federal agency to the University of Washington? If yes, provide the name of the federal funding agency.

       No, this research is in no way funded (directly or indirectly) by a federal agency.

    b. Is there involvement of federal personnel?

       No federal personnel will be involved.

    c. Are any research team members (including students) paid or supported by any federal award, including federal training, program, or center grants?

       To the best of our knowledge, no research team members fit the above stipulations.

    d. Are there any contractual obligations to follow federal research requirements?

       No.

13. If the research is determined to qualify for category 7 exempt status and later becomes federally funded, supported or regulated, please confirm that you will immediately cease research activities until IRB approval is obtained.

    We confirm our understanding that should this research become federally funded at any point, we will cease research activities until IRB approval is obtained.

14. Could disclosure of the subjects' responses outside the research reasonably place them at risk of civil or criminal liability, or be damaging to their financial standing, employability or reputation? Please explain your answer. Note this question is about the risks to subjects if accidental disclosure were to occur, and not about how you will maintain confidentiality.

In no way could the disclosure of the subjects' responses outside the research place them at any risk of liability or damage. Video stimuli used in this study have been experimentally manipulated, making evaluations by subjects reflective of the manipulation rather than reality. This alleviates the already minimal risk to employability or reputation that might exist from accidental disclosure.

Please embed your answers using italics or a contrasting font (not a different color) in a copy of this letter. ***Send the response letter as an e-mail attachment.*** In addition to the response memo, please forward of the following documents as attachments to your response e-mail.

- Funding, if applicable
- Instruments
- Consent Materials

Be sure to reference the Human Subjects application number in the subject line of your e-mail message and on all communications with our office. Please note that you may not recruit subjects or conduct this activity until you have received notification of final determination or approval. Additionally, if we do not receive a response to this letter within sixty (60) days, the application will be returned.

If you have further questions or concerns, feel free to contact me.

Best regards,

Bailey Bell
Human Subjects Administrator
(206) 221-7918
bbell3@uw.edu

1 PURPOSE

1.1 This document describes the procedures for determining whether a human subjects research project qualifies for exempt status.

2 POLICY

2.1 Applicability of federal regulations. When determining whether UW human subjects research is exempt, the University of Washington (UW) applies the federal Common Rule (45 CFR 46.101(b)) and related guidance to research that is federally funded, supported, or regulated. The regulations of the Food and Drug Administration (FDA) about exemption are applied only to FDA-regulated human subjects research.

2.2 Non-federal research. For non-federal research, the University of Washington IRB has created an additional exempt category, called Category 7. All procedures, requirements, and responsibilities described below in Sections 3 through 6 apply to all exempt research, regardless of category. See Section 8.1.2. for information on the disqualifying criteria for this category.

2.3 Additional requirements. It is UW policy that, in addition to other specified criteria, research qualifies for exempt status only if it involves no more than minimal risk.

2.4 Who determines exempt status. Per UW policy, the staff of the Human Subjects Division (HSD) are the only individuals authorized to determine that research is exempt. Researchers do not have the authority to determine that their own research qualifies for exempt status.

2.5 All or nothing. All of the proposed research activities of a **federally-funded** study must fit into one or more of the six exemption categories defined by federal regulations. Parts of the research cannot be considered exempt when other parts are not.

2.5.1 **Federal opinion**: When different institutions are conducting portions of a single research study: the entire study must meet one or more of the exemptions in order for the exemptions to apply to the portion of the study occurring at a single institution. This applies even when the components of the study are being conducted by different institutions under subcontracts. (See reference 10.5)

2.6 Prospective determination required. The research may not begin until the investigator has received notification from HSD that the research qualifies for exemption.

2.7 Duration of exempt status. It is UW policy that exempt status is granted for a 5-year period. Exempt studies are automatically closed by HSD; researchers do not need to submit a closure request. If the research will continue past the 5-year period, the researcher is required to obtain a new exempt determination from HSD before the determination expires

3 DEFINITIONS

3.1 Deception means deliberately misleading subjects about some aspect of the research. The omission of minor factors is not equivalent to deception. Examples of deception include:

- 3.1.1 Misinforming participants about the research
- 3.1.2 The use of fake or rigged instruments or procedures
- 3.1.3 Misleading play-acting in experimental design
- 3.1.4 The use of covert procedures

3.2 Exempt. Research that is found to be "exempt" is still considered to be human subjects research. However, it is exempt from meeting the requirements of the federal human subjects regulations, including the requirement for initial and continuing IRB review.

3.3 Incomplete disclosure means deliberately withholding certain information regarding certain aspects of the study. Examples include:

- 3.3.1 Withholding specific information about the true purpose of a study.

3.4 Interview refers to a meeting (in person or by phone or video conference or similar technology at which people talk to each other in order to ask questions and get information. Per guidance from the federal regulatory agency OHRP, an interview does not involve a task completion, role play with other individuals, an intervention of any kind, response to a stimulus, or engaging in any activity (e.g. "priming") before the interview is conducted (reference 10.7).

3.5 Minimal risk. The UW applies the definition of minimal risk provided in federal regulations (45 CFR 46.102): The probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than that ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.

- 3.5.1 Prisoners: Minimal risk is defined by federal regulation as the probability and magnitude of physical or psychological harm that is normally encountered in the daily lives, or in the routine medical, dental, or psychological examination of a healthy person.
- 3.5.2 Research involving the Department of Defense (funding, subjects, facilities, resources). Per DOD regulations (reference 7.8), the phrase "ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests" must not be interpreted to include the inherent risks certain categories of subjects face in their everyday life. For example, the risks imposed in research involving human subjects focused on a special population should not be evaluated against the inherent risks encountered in their work environment (e.g., emergency responder, pilot, soldier in a combat zone) or having a medical condition (e.g., frequent medical tests or constant pain).

3.6 Public behavior refers to behavior in which the subject does not have a reasonable expectation of privacy (e.g., a public plaza or park, a street, a building lobby, a government building). If subjects have a reasonable expectation of privacy at the location where the researcher is conducting the observation, the project does not qualify for exempt status.

3.7 Survey refers to the act of gathering data on attitudes, impressions, opinions, satisfaction level, etc. by polling a section of the population. Per guidance from the federal regulatory agency OHRP, a survey does not involve a task completion, role play with other individuals, an intervention of any kind, response to a stimulus, or engaging in any activity (e.g. "priming") before the survey is conducted (reference 10.7).

3.8 Task is defined as an activity or piece of work to be done or undertaken. Tasks disqualify a federally-supported project for Category 2 exempt status when they are part of a survey or interview, but not when they are part of an educational test. However, non-federal research involving a task that would otherwise not qualify for Category 2 may qualify for Category 7 exempt status.

3.8.1 Examples of tasks include: (1) asking subjects to physically manipulate an object; (2) asking subjects to play a game: (3) asking subjects to complete a specific physical action; (4) asking subjects to read something and then answer questions about it.

3.8.2 **Some educational tests, including cognitive, diagnostic, aptitude and achievement tests, involve task completion. The inclusion of a task under these types of tests is permissible and may still qualify for exempt review**. For example, most intelligence ("IQ") tests have the individual perform visual-spatial tasks.

4 PROCEDURES: Investigators

4.1 Requesting an exempt determination. Investigators request an exempt status determination from HSD by submitting a completed **APPLICATION: Determination, Exempt Status**. Before applying for exempt status, investigators should confirm that their study is, in fact, considered research with human subjects. For example, some research involving the use of coded private information or specimens is not considered human subjects research and therefore requires no HSD review. See the **SOP Human Subjects Research**.

4.2 Requesting a continuation of exempt status. When the exempt research will continue beyond the five-year determination period, the investigator must repeat the exempt determination process before the expiration of the determination. HSD does not provide a reminder prior to the expiration of an exempt determination.

4.3 Modifications to the research. Any substantive change to the exempt research may invalidate the exempt determination. The researcher is responsible for consulting with HSD when substantive changes are planned, to ascertain whether a new exempt determination, IRB review, or no action, is required.

4.3.1 Minor modifications are allowable without an HSD re-determination, when they do not change the nature of the research or research risks. Examples of minor changes include:

4.3.1.1 Changes in co-investigators or research staff

4.3.1.2 Minor revisions to any consent process or form

4.3.1.3 Minor revisions to the survey, interview, or focus group instruments that do not fall outside of the scope of the original instruments

4.3.1.4 Changes to funding

4.3.2 Substantive changes that are likely to require a re-determination include (but are not limited to):

4.3.2.1 Change of principal investigator

4.3.2.2 Change to risks, especially if the risks will no longer be minimal

4.3.2.3 New study procedures (e.g., new data collection; increased scope)

4.3.2.4 Change in study population

4.3.2.5 Changes in the identifiability of the data to be received or recorded

4.4 Standards of conduct. It is UW policy that, although research that qualifies for exempt status is not governed by federal regulations, investigators remain responsible for protecting the rights and welfare of their subjects by conducting the research in accordance with:

4.4.1 The ethical principles of **Respect for Persons**, **Beneficence**, and **Justice** as described in the Belmont Report;

4.4.2 Other applicable federal and state laws;

4.4.3 UW policies; and

4.4.4 Relevant professional standards and codes of conduct as generally accepted in the investigator's academic and/or professional discipline.

4.5 Voluntary participation. The Belmont principle of **Respect for Persons** states that subjects should be given the opportunity to choose whether to participate in research. For this reason, HSD expects that investigators will generally obtain some type of consent from subjects for any exempt research where the investigator will collect data through interaction (in-person or otherwise) with the subjects.

4.5.1 If the research involves children, it is almost always appropriate to inform parents of their child's participation in the research. (Note that there may be other federal regulations that require parental permission, such as the COPPA regulation from the federal Department of Commerce about collecting identifiable information through a website from children under the age of 13.)

4.5.2 Per UW policy, any consent process or materials for exempt research are not reviewed by HSD. The consent process need not include all of the federally-required consent elements. HSD encourages investigators to provide subjects with, at a minimum, the information listed below in the consent process and before any data collection begins. Additional information may be appropriate in some cases.

4.5.2.1 The identity/affiliation and contact information of the investigator

4.5.2.2 A statement that indicates that the activity is research and that participation is voluntary

4.5.2.3 A brief description of the study procedures

4.5.2.4 Contact information for HSD, to respond to complaints or concerns about subject rights

5 PROCEDURES: Human Subjects Division

5.1 Overall process. HSD staff assess the materials provided by the investigator. They apply the criteria and guidance described in this document to determine whether a human subjects research project qualifies for exempt status. If necessary, they obtain additional information from the investigator.

5.1.1 Uncertainty or disagreements about eligibility for exempt status are adjudicated by an Assistant or Associate Director of Operations.

5.1.2 If necessary, another member of the HSD management team is also consulted. If the two managers do not agree, the item will be considered not exempt.

5.2 Routine assessment. HSD routinely determines whether an item is exempt for all of the following items as part of the pre-review process, whether or not the researcher has explicitly requested it.

5.2.1 Initial applications of all types (except Center/Training/Program grant applications).

5.2.2 Any formal request for a Human Subjects Research determination (if the determination is positive) and Exempt Status Requests.

5.3 Documentation. Exempt determinations are documented on the application form and/or in correspondence to the investigators. Determinations are considered HSD records and are appropriately tracked and filed.

6 SPECIFIC ISSUES

6.1 Greater than minimal risk. Per UW policy, research involving greater than minimal risk to subjects does not qualify for exempt status.

6.2 Specific protected populations. Federal regulations provide additional protection for some specific vulnerable populations, and therefore certain activities with those populations are not eligible for exempt status:

6.2.1 Research involving interactions with prisoners can only be exempt when:

6.2.1.1 The research is not supported by the federal Department of Health and Human Services (HHS) or the other federal agencies that apply the HHS prisoner regulations (called Subpart C; the other agencies are Defense; Homeland Security; Central Intelligence Agency; Energy); and

6.2.1.2 The research does not involve the Bureau of Prisons (BOP) – for example, the research does not involve collecting data from any BOP facility, staff, or inmates; and

6.2.1.3 The research involves no interaction or intervention with prisoners; and

6.2.1.4 The research meets all of the criteria for exempt Category 4 (see below).

6.2.2 Research involving children does not qualify for Category 2 exempt status when it involves:

6.2.2.1 Surveys or interviews of children that do not fall into exempt Category 1, or

6.2.2.2 Observation of the public behavior of children when the investigator interacts with the children.

6.3 Food and Drug Administration (FDA). Research regulated by the FDA qualifies for exempt status only if it meets the criteria described for Category 6 of the six federally-described categories of exemption (see Section 7, below). Moreover, FDA-regulated research does not qualify for exempt status under Category 6 if there have been food or color additives incorporated into the food product and those additives are used in research with the intent to apply to the FDA for marketing of the additive(s).

6.4 Health care information maintained in Washington State. The use of identifiable health care information for research use without the consent of the patients requires IRB review, per Washington State law (RCW 70.02.05), even when the research may qualify for exemption under federal criteria.

6.5 Use of certain state-owned records, including UW records. The use of identifiable records from certain state agencies for research use without the consent of the individuals requires IRB review, per Washington State law (RCW 42.48), even when the research may qualify for exemption under federal criteria. (See Sections 7.1 and 7.4, below).

6.6 Involvement of third party subjects. Third party subjects are individuals about whom the researcher is obtaining private identifiable information from someone else. For example, an individual might be asked to provide private identifiable information about the medical history of a relative. The relative would be considered a third party subject. **Involvement of third party subjects does not disqualify a project from exempt status.**

6.6.1 Federal regulations do not allow research involving surveys and interviews with children subjects to qualify for exempt Category 2 (surveys, etc.). This means that research involving children as third party subjects and surveys/interviews does not qualify for exempt Category 2.

6.6.2 **Consistent with recommendations to the federal regulatory agency (see reference 9.6), it is UW policy that studies using deception or concealment may qualify for exempt status when all applicable exempt criteria are met and when:**

6.6.2.1 The deception or incomplete disclosure is necessary to ensure valid results. For example, withholding or misinforming subjects about the true purpose of a study may be important to reduce biased responses (i.e., “demand” characteristics). Research findings suggest that such deception is not harmful to subjects.

6.6.2.2 The deception or incomplete disclosure is not being used to get subjects to do something that the majority of them would not do *if the information was fully disclosed to them*; and

6.6.2.3 The conditions of the deception pose no more than minimal risk of physical or emotional distress. “Conditions” include: the nature of the deception or concealment; how likely it is that subjects will learn of the deception or concealment; the nature of any de-briefing; how likely it is that anyone besides the research team and the subject would learn results about a subject that would be distressing to the subject.

6.6.3 A debriefing of subjects after they complete the procedures may be appropriate and may be required (but is not necessary) to obtain exempt status. The need for a de-briefing does not necessarily exclude a project from exempt status; the key issue is whether the project overall (including the de-briefing) involves no more than minimal risk to subjects.

6.6.4 An example of survey research involving deception that would qualify for exempt status is when a researcher doesn't tell the subjects that she plans to see if their answers to demographic questions (e.g., gender, age, socio-economic status, family size, etc.) predict their responses to questions about the value of a college education.

6.7 Granting exempt status to previously non-exempt research. HSD staff have the authority and discretion to grant exempt status to UW research with a current IRB approval, as described here.

6.7.1 Criteria. The following criteria must be met:

6.7.1.1 The research is not federally funded (now or in the past).

6.7.1.2 The reason for the reclassification of the research is one or more of the following:

6.7.1.2.1 It was reviewed at a time when the appropriate exempt category did not exist (for example, exempt Category 7).

6.7.1.2.2 The UW interpretation of specific exempt eligibility criteria has changed.

6.7.1.2.3 Its eligibility was overlooked (not noticed) at initial review.

6.7.1.2.4 There was a mistake in how exempt eligibility criteria were interpreted or applied.

6.7.1.3 The researcher agrees to the re-classification.

6.7.2 The reclassification process is performed by HSD staff.

6.7.2.1 The eligibility for reclassification is determined, including communication with the researcher.

6.7.2.2 Communication with the researcher (phone or email) should include information about the advantages and disadvantages of reclassification.

6.7.2.2.1 Primary advantage: No need for continuing review.

6.7.2.2.2 Primary disadvantage: Modifications to the research may require submission of a new application. Retaining IRB approval as a non-exempt study may provide more flexibility with respect to modifications.

6.7.2.3 The reclassification, the rationale for it, and the researcher's concurrence are documented in a Note to File and a letter to the researcher (copied to the file).

6.7.2.4 The study information in the HSD database is revised, following the specific instructions for this process in the DORA Manual.

6.7.2.5 The study file is consolidated and organized as needed, and moved to the appropriate exemption filing place.

7 CRITERIA: The Federal Exempt Categories (1-6)

7.1 Category 1: **Educational Practices**

7.1.1 Criteria for this category: Research conducted in established or commonly accepted educational settings, involving normal educational practices such as:

7.1.1.1 Research on regular and special educational instructional strategies; or

7.1.1.2 Research on the effectiveness of, or the comparison among, instructional techniques, curricula, or classroom management methods.

7.1.2 Commonly accepted educational settings include but are not limited to K-12 schools and college classrooms. They may also include after-school programs, preschools, vocational schools, alternative education programs, and other sites where educational activities regularly occur.

7.1.3 Normal educational practices include established or innovative teaching methods (not considered to be experimental) or curriculum, and commonly accepted classroom management techniques that are planned and implemented by the classroom teacher. Normal educational practices are activities that could occur regardless of whether the research is conducted.

7.1.4 Per Washington State law RCW 42.48, records from the following state agencies cannot be used for research purposes without the subjects' written consent unless there has been an IRB review (which means that the activity does not qualify for exempt status):

7.1.4.1 WA Department of Social and Health Services;

7.1.4.2 WA Department of Health;

7.1.4.3 WA Department of Corrections;

7.1.4.4 WA Department of Early Learning;

7.1.4.5 Any Washington State public institution of higher learning, including: the state universities, regional universities, the Evergreen State College, community colleges, and technical colleges.

7.1.5 Examples

7.1.5.1 A study that evaluates a new instructional strategy or curriculum, or that randomly assigns students to different instructional strategies/curricula for comparison that would create inequity, would probably not be exempt since these are not "normal educational practices".

7.1.5.2 Studies that involve surveys and interviews with minors that are outside of "normal educational practices" also do not qualify for this category of exemption.

7.2 Category 2: **Educational Tests (Cognitive, Diagnostic, Aptitude, Achievement), Survey Procedures, Interview Procedures, or Observation of Public Behavior**

7.2.1 Criteria for this category: Research involving the above-listed procedures is exempt unless:

7.2.1.1 The information obtained is recorded in such a manner that subjects can be identified, directly or through identifiers linked to the subjects, **AND**

7.2.1.2 Any disclosure of the subject's responses outside of the research could reasonably place the subject at risk of criminal or civil liability or be damaging to the subject's financial standing, employability, or reputation.

7.2.1.3 Research involving surveys or interviews with children, or observation of public behavior when investigators interact with children, does not qualify for exempt status under this category.

7.2.1.4 The research involves a task (except when the task is part of an educational test such as an intelligence test).

7.2.2 Definitions. See Section 3 (above) for definitions of "survey", "interview", "public behavior", and "task".

7.2.3 Interpretation of the "Identifiability" criterion (Section 7.1.2.1.1). This criterion means that the data are collected/recorded anonymously – which means that no identifiers can be connected to the data, either directly or through a coding system.

7.2.3.1 Videotapes and photographs are usually considered to be identifiable. Therefore any data collection that involves video recordings or photographs of subjects would not be considered anonymous.

7.2.3.2 It is also possible that multiple pieces of information, none of which are identifiable on its own, may identify a person when brought together. Under such circumstances, the data would be considered identifiable.

7.2.4 Interpretation of the "risk of disclosure" criterion (Section 7.1.2.1.2). This criterion means that there would be no significant detrimental consequences to the subject if identifiable information were disclosed outside of the research. Whether "consequences" would be significant and detrimental depends in part on context. For example, including a question about sexual identity in an interview study that investigates adults' plans to change careers could be non-controversial – and exempt – in some locales, but highly sensitive – and therefore non-exempt – in other places.

7.2.5 Examples of research likely to be exempt under Category 2.

7.2.5.1 A study involving an anonymous survey regarding workplace satisfaction at area firms.

7.2.5.2 A study involving interviews with college seniors (age 18 and older) about their plans after graduation. The answers to the questions would present no risks to subjects if divulged outside of the research.

7.3 Category 3: **Educational Tests, Survey Procedures, Interview Procedures, or Observation of Public Behavior**

7.3.1 Criteria for this category: Research involving these procedures that is NOT exempt under Category 2 can be exempt if:

7.3.1.1 The subjects are elected or appointed public officials or candidates for public office; **OR**

7.3.1.2 Federal statute requires without exception that confidentiality of the personally identifiable information will be maintained through the research and thereafter.

7.3.2 Interpretation of the "public officials" criterion (Section 7.3.1.1). This category is for the same procedures as in Category 2, but holds public servants to a different privacy standard by not requiring that the collected data be anonymous and is not concerned with any risks that may result from disclosure of the data. This category does not apply to public employees such as managers and staff in public agencies or offices. Federal guidance provides the following non-inclusive list of examples of public officials:

7.3.2.1 Mayors, governors

7.3.2.2 School superintendents, school board members

7.3.2.3 Police chiefs

7.3.3 Interpretation of the "federal statute" criterion (Section 7.3.1.2). This part of the category applies only to research on specific programs conducted or supported by the federal Department of Justice or the federal National Center for Education Statistics.

7.3.4 Examples of research that is considered exempt under this category.

7.3.4.1 A study that includes interviewing town mayors about their religious beliefs and views on the separation of church and state.

7.3.4.2 A study of candidates for the state legislature that includes interview questions about their finances and state employment.

7.4 Category 4: **Existing Data or Specimens**

7.4.1 Criteria for this category: Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens if:

7.4.1.1 These sources are publicly available; or

7.4.1.2 The information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

7.4.2 NOTE: many projects involving the use of existing data/specimens do not meet the definition of "human subjects" research. Investigators may use the **APPLICATION: Specimen or Data Use, Non-Identifiable (and self-determination)** and the **SOP Human Subjects Research** to self-determine whether their activity is considered human subjects research.

7.4.3 Definition of "existing". The materials or data to be used in the research must be existing or "on the shelf" at the time the research is proposed to HSD on the **APPLICATION: Determination, Exempt Status.** This category does not apply to the prospective collection of data or specimens.

7.4.4 Research can qualify for this category of exemption if the investigators initially have access to identifiable private information, but abstract the data needed for the research in such a way that the information can no longer be connected to the identity of the subjects. This means that the abstracted data set does not include direct identifiers (names, social security numbers, addresses, phone numbers, etc.) or indirect identifiers (codes or pseudonyms that are linked to the subject's identity).

7.4.5 Use of records from certain state agencies. Per Washington State law RCW 42.48, records from the following state agencies cannot be used for research purposes without the subjects' written consent unless there has been an IRB review (which means that the activity does not qualify for exempt status). If written consent is obtained as described in RCW 42.48 and all other criteria for this category are met, the activity can be exempt.

7.4.5.1 WA Department of Social and Health Services;

7.4.5.2 WA Department of Health;

7.4.5.3 WA Department of Corrections;

7.4.5.4 WA Department of Early Learning;

7.4.5.5 Any Washington State public institution of higher learning, including: the state universities, regional universities, the Evergreen State College, community colleges, and technical colleges.

7.4.6 Health care information (PHI) maintained in Washington State. The use of identifiable health care information for research use without the consent of the patients requires IRB review, per Washington State law (RCW 70.02.05), even when the research may otherwise qualify for exemption under federal criteria.

7.4.7 Examples of research exempt under Category 4.

7.4.7.1 A study of treatment outcomes for a drug that involves the review of patient charts at a non-UW and non-Washington State HIPAA-covered medical facility, unless the investigator wants the UW IRB to grant a waiver of HIPAA authorization. The investigator records patient age, sex, diagnosis, and treatment outcome in such a way that the information cannot be linked back to the patient.

7.4.7.2 A graduate student has access to identifiable data from a study previously conducted by her faculty advisor and she records the information she needs in a way so that the data being analyzed for her research cannot be traced back to individual subjects.

7.5 Category 5: **Research and Demonstration Projects Conducted by or Subject to the Approval of Department or Agency Heads:**

7.5.1 Criteria for this category.

7.5.1.1 The program under study must deliver a public benefit (e.g., financial or medical benefits as provided by Social Security) or service (e.g., social, supportive or nutrition services as provided under the Older Americans Act).

7.5.1.1.1 The research may be designed to study, evaluate, or otherwise examine: the program; procedures for obtaining benefits or services under those programs; possible changes in methods or alternatives to those programs or procedures; or possible changes in methods or levels or payment for benefits or services under those programs.

7.5.1.2 The research or demonstration project must be conducted pursuant to specific federal statutory authority. [That is, the research is required by a federal law or regulation.]

7.5.1.3 There must be no statutory requirement that the project be reviewed by an IRB.

7.5.1.4 The project must not involve significant physical invasions or intrusions upon the privacy of the subjects.

7.5.2 This category applies only to federally-supported projects examining federal public benefits programs. It is extremely rare for research to meet the criteria of this category.

7.5.3 Example of research in this category: The federal Department of Housing and Urban Development Agriculture is charged by Congress with providing periodic reports about effectiveness of a federal housing subsidy program, as indicated by perceptions of individuals about the procedures and time required to qualify for the program. The Department contracts with a UW researcher to collect the data for the report.

7.6 Category 6: **Taste and Food Quality Evaluation and Consumer Acceptance Studies**

7.6.1 Criteria for this category.

7.6.1.1 Involves the consumption of wholesome* foods without additives; or

7.6.1.2 A food is consumed that contains a food ingredient at or below the level and for a use found to be safe by the FDA or approved by the Environmental Protection Agency (EPA) or the Food Safety and Inspection Service (FSIS) of the US Department of Agriculture (USDA); or

7.6.1.3 A food is consumed that contains an agricultural chemical or environmental contaminant at or below the level found to be safe by the FDA or approved by the EPA or the FSIS of the USDA.

7.6.1.4 For FDA-regulated research: there can be no food or color additives incorporated into the food product if those additives are used in research with the intent to apply to the FDA for marketing of the additive(s).

7.6.2 The research may not involve the consumption of any type of food, or volume of food, that would present any risk to the subjects. The research must involve what would be considered reasonable eating behaviors by the subject.

7.6.3 *Definition of "wholesome": means that the food ingredients have not been manipulated by the investigator, and that the content of the food will not be detrimental to the health of the subjects. If the research involves plants or animals raised for food products, the level of chemical additives or environmental contaminants must be at or below the levels approved by the FDA, EPA, or USDA.

7.6.4 Studies involving the consumption of alcohol, vitamins, and nutritional supplements do not qualify for exempt status.

7.6.5 Examples of research that qualifies for exempt status in this category:

7.6.5.1 A taste test on different varieties of a fruit to determine consumer preference, when the fruits do not have any additives and subjects are asked to indicate which fruit they prefer.

7.6.5.2 A study that involves taste testing of various beef products from cattle that have been given feed with a chemical additive, if the investigator can document that the amount of the additive was at or below the levels approved by the USDA.

8 CRITERIA: Non-Federal Exempt Category 7

8.1 Category 7: **Minimal Risk, Non-Physically Invasive, Interventions or Interactions Associated with Educational Tests (Cognitive, Diagnostic, Aptitude, Achievement), Survey Procedures, Interview Procedures, or Observation of Public Behavior**

8.1.1 Criteria for this category. Research involving the above-listed procedures is exempt if the interaction or intervention (1) involve no more than minimal risk to subjects or others; and (2) is non-physically invasive.

8.1.1.1 Examples may include (but are not limited to):

8.1.1.1.1 Reading/writing tasks;

8.1.1.1.2 Computer tasks or using a computer program;

8.1.1.1.3 Playing a game;

8.1.1.1.4 Viewing media;

8.1.1.1.5 Doing Internet searches;

8.1.1.1.6 “Think aloud” or “imagine” tasks;

8.1.1.1.7 Asking subjects to physically manipulate an object;

8.1.1.1.8 Asking subjects to complete a specific physical or mental action;

8.1.1.1.9 “Priming”;

8.1.1.1.10 Role play with other individuals;

8.1.1.1.11 Response to a non-physically invasive stimulus.

8.1.2 Disqualifying criteria for this category. Research involving the above-listed procedures is NOT exempt if:

8.1.2.1 It is subject to FDA regulations.

8.1.2.2 It is federally funded, supported, or regulated. In addition to federal funding, this also means any of the following:

8.1.2.2.1 Involvement of federal personnel;

8.1.2.2.2 Any research team member (including students) who is paid or supported by any federal award, including federal training, program, or center grants;

8.1.2.2.3 Contractual obligations to follow federal research requirements;

8.1.2.2.4 Involvement of the Department of Veterans Affairs;

8.1.2.2.5 Conducted under a federal Certificate of Confidentiality or federal Certificate of Privacy.

8.1.2.3 The information obtained is recorded in such a manner that subjects can be identified, directly or through identifiers linked to the subjects, **AND** any disclosure of the subject’s responses outside of the research could reasonably place the subject at risk of criminal or civil liability or be damaging to the subject’s financial standing, employability, or reputation.

8.1.2.4 It involves surveys or interviews with children, or observation of public behavior when investigators interact with children.

8.1.3 Interpretation of the "Identifiability" criterion (Section 7.1.2.1.1). This criterion means that the data are collected/recorded anonymously – which means that no identifiers can be connected to the data, either directly or through a coding system.

8.1.3.1 Videotapes and photographs are usually considered to be identifiable. Therefore any data collection that involves video recordings or photographs of subjects would not be considered anonymous.

8.1.3.2 It is also possible that multiple pieces of information, none of which are identifiable on its own, may identify a person when brought together. Under such circumstances, the data would be considered identifiable.

8.1.4 Interpretation of the "risk of disclosure" criterion (Section 7.1.2.1.2). This criterion means that there would be no significant detrimental consequences to the subject if identifiable information were disclosed outside of the research. Whether "consequences" would be significant and detrimental depends in part on context. For example, including a question about sexual identity in an interview study that investigates adults' plans to change careers could be non-controversial – and exempt – in some locales, but highly sensitive – and therefore non-exempt – in other places.

8.1.5 If the research is determined to qualify for Category 7 exempt status and later becomes federally funded, supported, or regulated, the researcher must immediately cease research activities until IRB approval is obtained. **This will require submission of a new application.**

9 MATERIALS

9.1 APPLICATION: Determination, Exempt Status

9.2 SOP Human Subjects Research

9.3 APPLICATION: Specimen or Data Use, Non-Identifiable (and self-determination)

10 REFERENCES

10.1 45 CFR 46.101

10.2 21 CFR 56.104

10.3 The Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research. Office of the Secretary of Health and Human Services; National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. April 18, 1979.

10.4 OHRP, "Guidance on 45 CFR 46.101(b)(5) Exemption for Research and Demonstration Projects on Public Benefit and Service Programs", March 1983.

10.5 IRB Forum, January 20, 2013. Communication from Edward Bartlett, Office of Human Research Protections. "Review of protocols for tasks done by a subcontractor".

10.6 Secretary’s Advisory Committee on Human Research Protections (SACHRP), Meeting Minutes, from meeting held on March 8-9, 2011; Attachment E, “The Use of Deception in Research”.

10.7 Department of Health and Human Services, Advance Notice of Proposed Rulemaking, “Human Subjects Research Protections: Enhancing Protections for Research Subjects and Reducing Burden, Delay, and Ambiguity for Investigators”. Federal Register volume 76, number 143, July 26, 2011. Re exempt category 2, see page the top of page 44519.

Appendix D. Recruiting and Consent Script, Paper Three

Consent Agreement
(Verbal Read, Signed Consent)

Hello!

My name is <*full name and title here*>, and I am here to recruit you for a study examining conductor gestures in an instrumental ensemble setting.

This study involves the evaluation of performance video featuring conducting activities, and you are being recruited due to your recent or current membership in an instrumental performing ensemble.

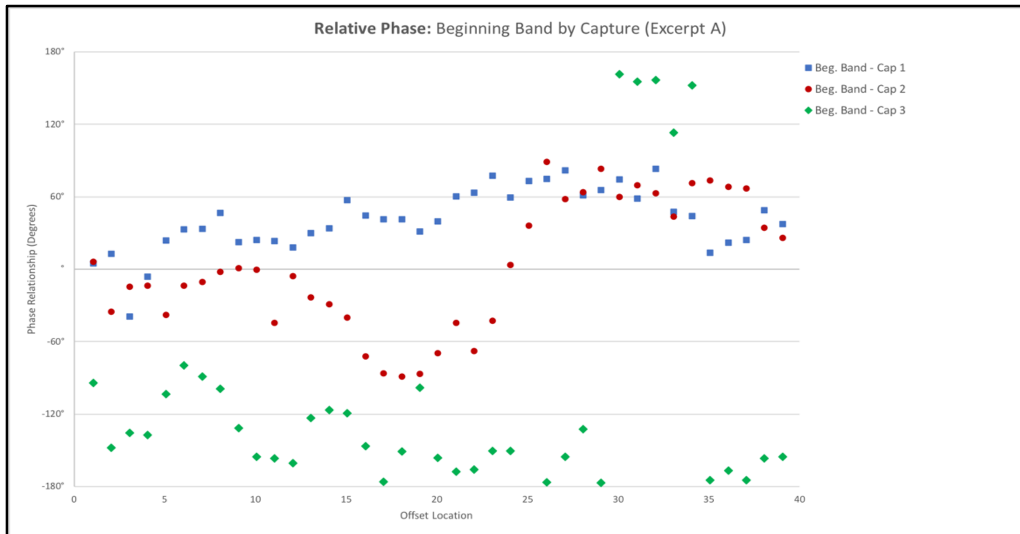
Participation in this study is completely voluntary, and your choice whether or not to participate will have no effect on your academic outcomes or standing in this course or any other. The study will take approximately 20-25 minutes of your time, and you will not be compensated in any way for your participation.

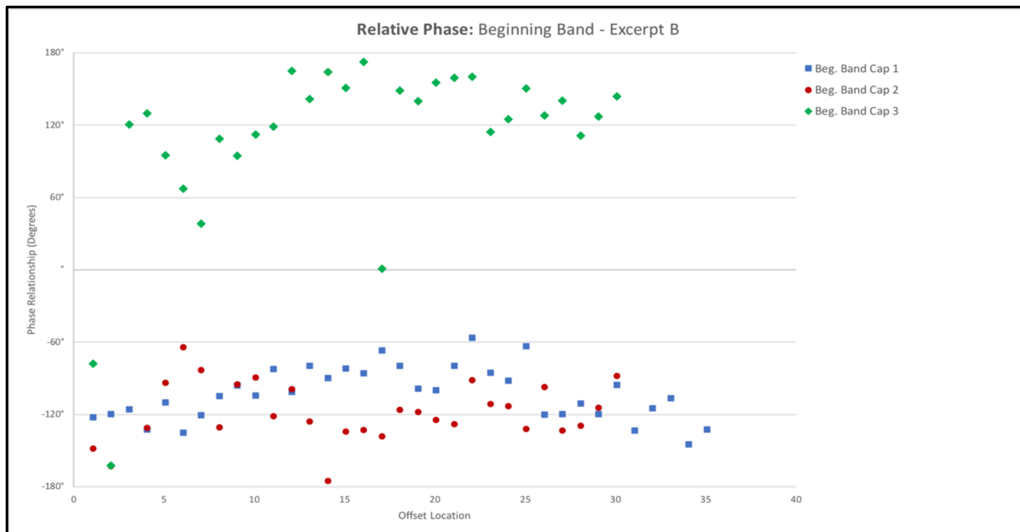
There is a sign-up sheet that will be passed around the group momentarily, please provide your name and email address so that we can add you to our list of participants. Video evaluation sessions will occur in < *computer lab(s)* >, and you will be allowed to select the session that best fits your schedule.

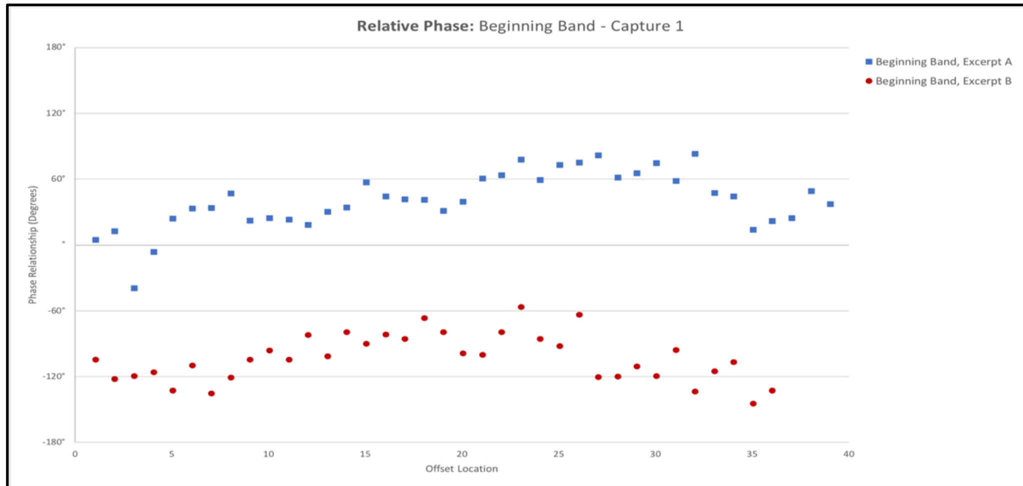
Agreement to participate in this study constitutes consent for data collected to be utilized in our study. Thank you in advance for considering participation in this study and helping to further our understanding of gesture in musical performance!

Appendix E. Complete Phase Relationships, Paper Two

Figure A.1.a-b. Beginning Band Phase Relationships, Excerpt A & B
Figure A.2.a-c. Beginning Band Phase Relationships, Capture 1-3
Figure A.3.a-b. Beginning Orchestra Phase Relationships, Excerpt A & B
Figure A.4.a-c. Beginning Orchestra Phase Relationships, Capture 1-3



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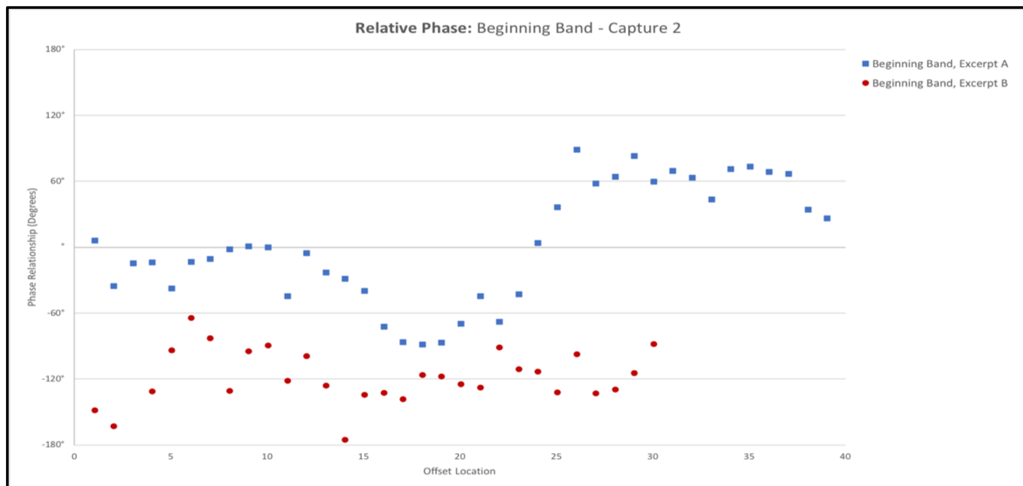
Beginning Band, Excerpt A
Beginning Band, Excerpt B
Phase Relationship (Degrees)
Offset Location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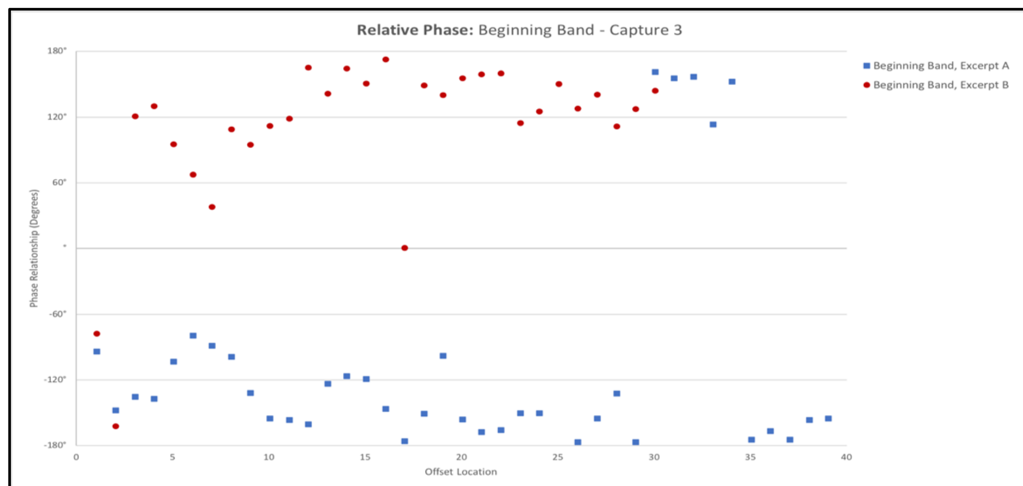
Beginning Band, Excerpt B
Phase Relationship (Degrees)
Offset Location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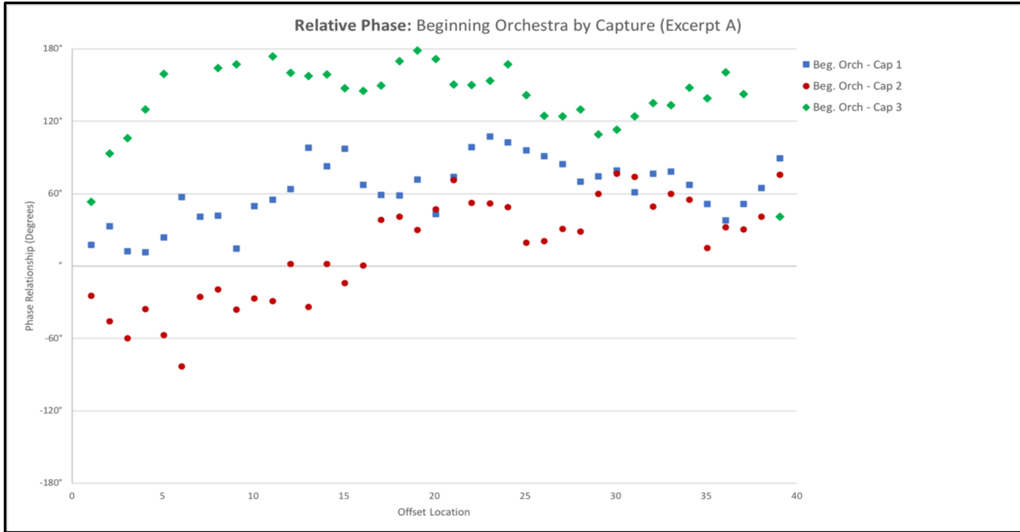
Beginning Band, Excerpt A
Beginning Band, Excerpt B
Phase Relationship (Degrees)
Offset Location


Relative Phase: Beginning Orchestra by Capture (Excerpt A)
180°
120°
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-60°
-120°
-180°
Phase Relationship (Degrees)
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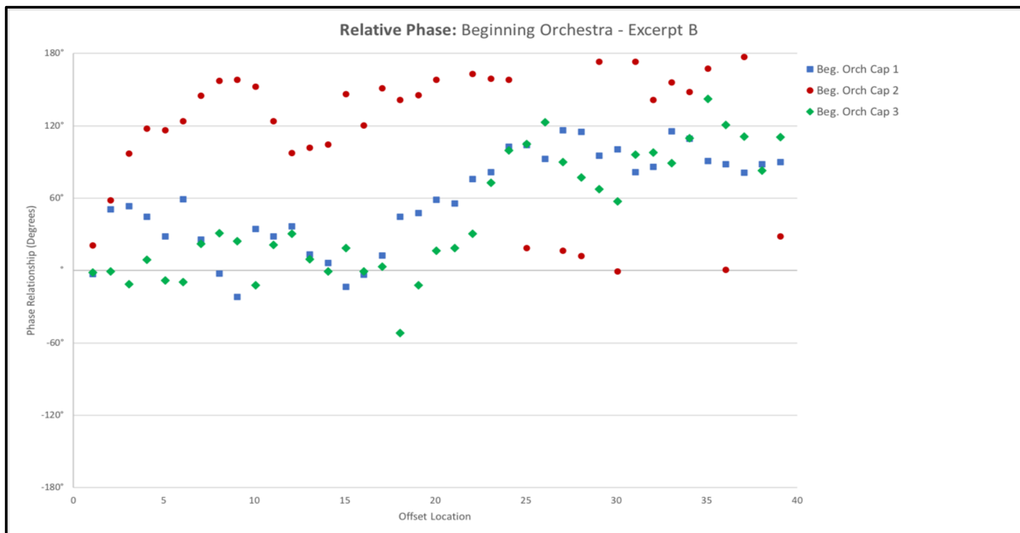
40
Offset Location
Beg. Orch - Cap 1
Beg. Orch - Cap 2
Beg. Orch - Cap 3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-120°
-180°
Phase Relationship (Degrees)
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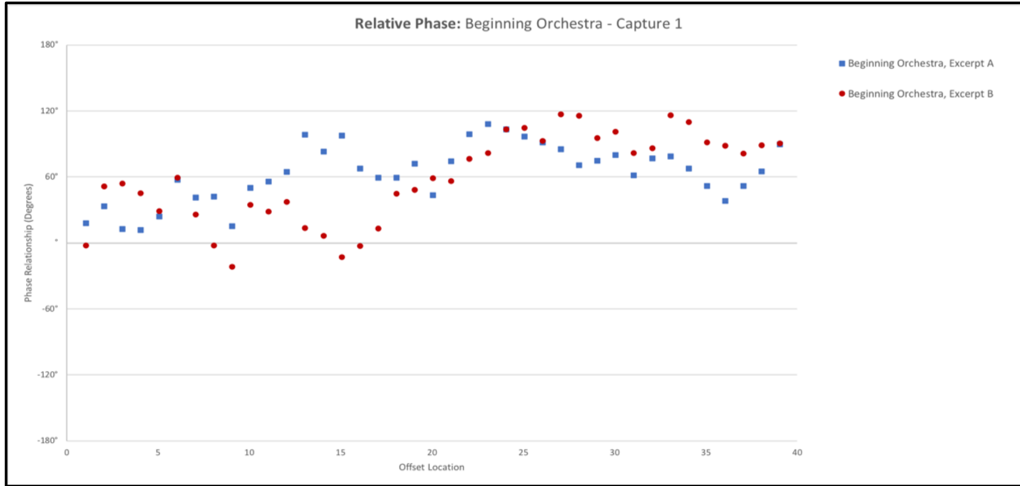
Offset Location
Beg. Orch Cap 1
Beg. Orch Cap 2
Beg. Orch Cap 3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-180°
Phase Relationship (Degrees)
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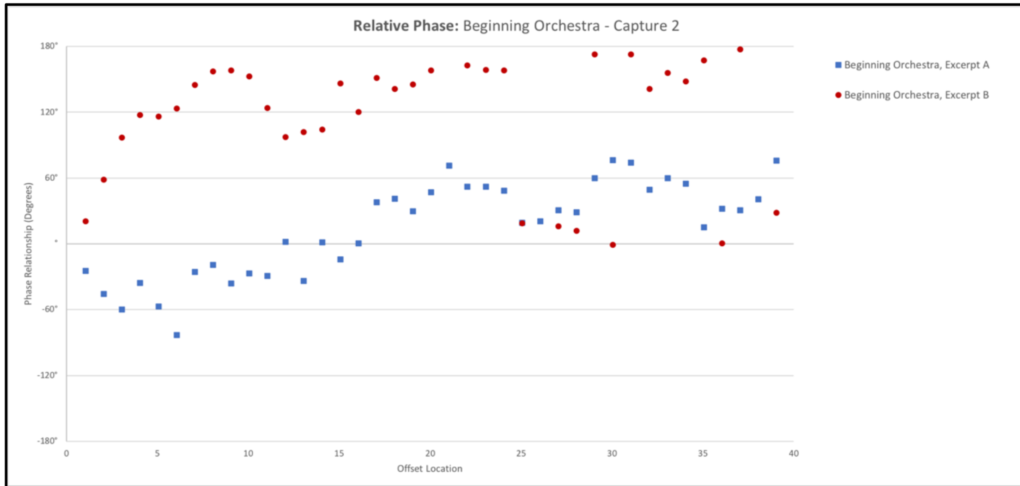
Offset Location
Beginning Orchestra, Excerpt A
Beginning Orchestra, Excerpt B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Phase Relationship (Degrees)
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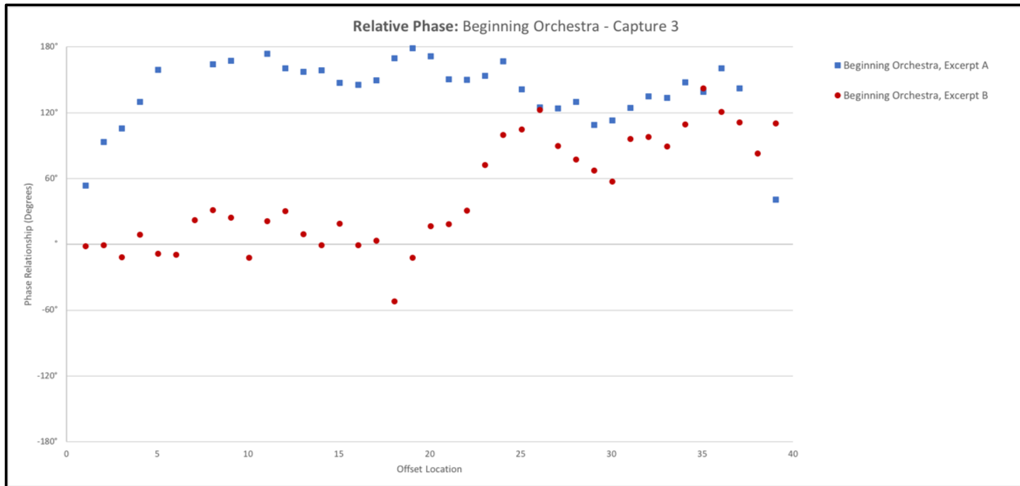
Offset Location
Beginning Orchestra, Excerpt A
Beginning Orchestra, Excerpt B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Phase Relationship (Degrees)
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25
30
35
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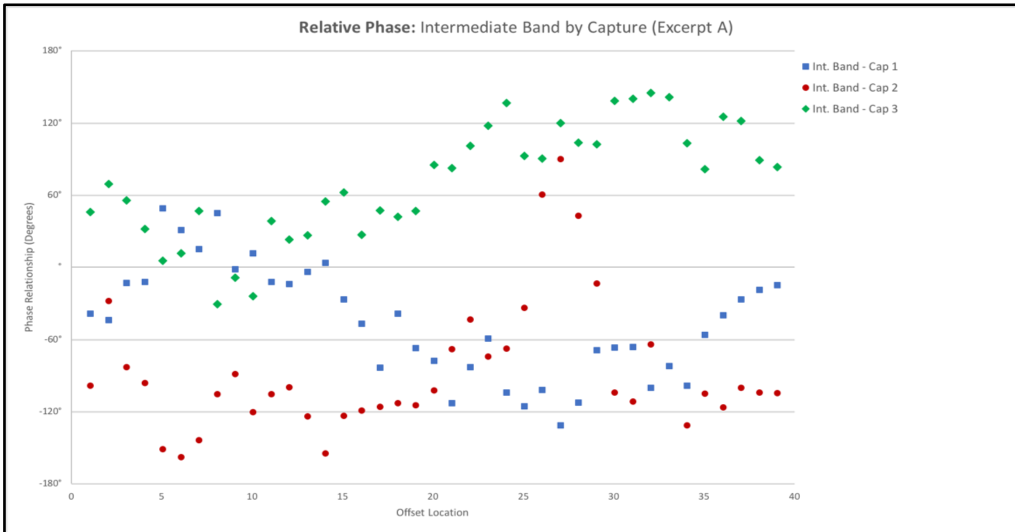
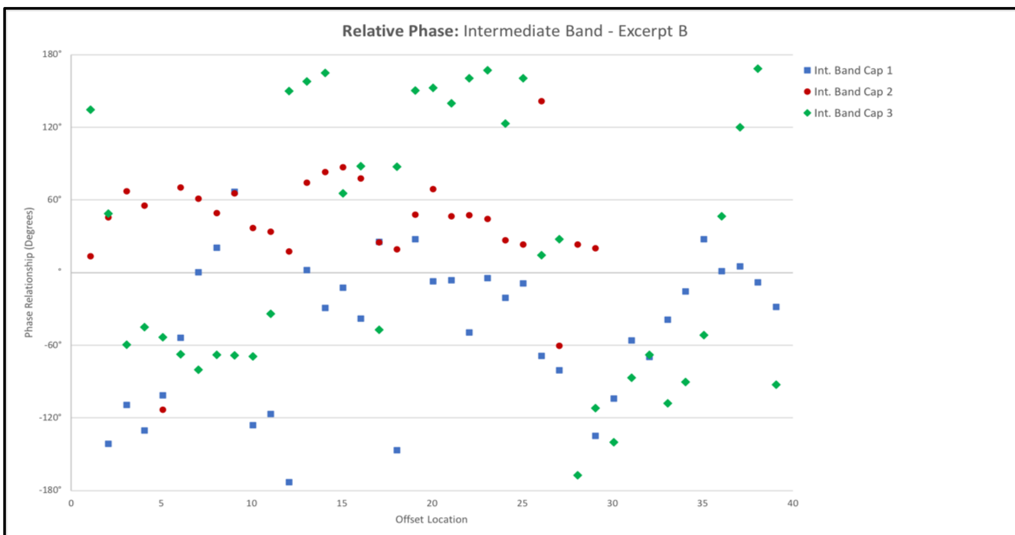
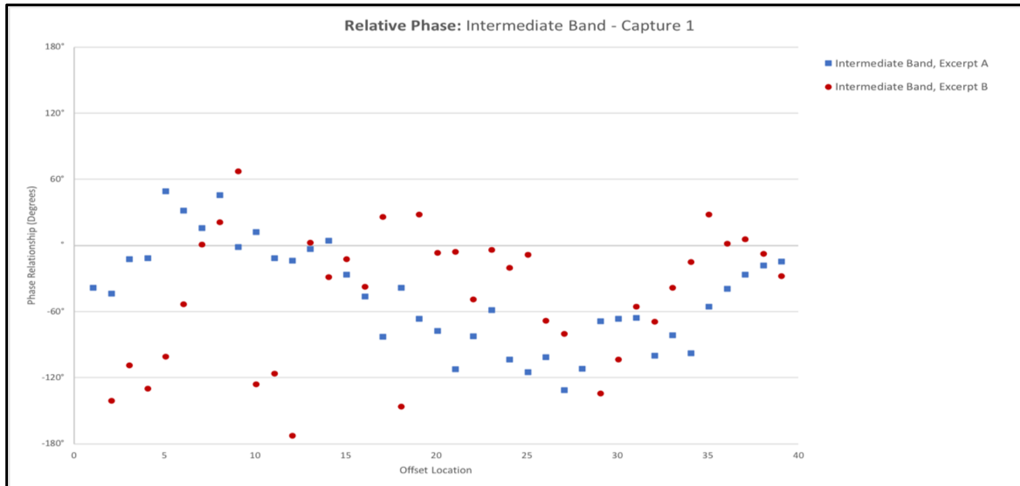
Offset Location
Beginning Orchestra, Excerpt A
Beginning Orchestra, Excerpt B

Figure A.5.a-b. Intermediate Band Phase Relationships, Excerpt A & B
Figure A.6.a-c. Intermediate Band Phase Relationships, Capture 1-3
Figure A.7.a-b. Intermediate Orchestra Phase Relationships, Excerpt A & B
Figure A.8.a-c. Intermediate Orchestra Phase Relationships, Capture 1-3



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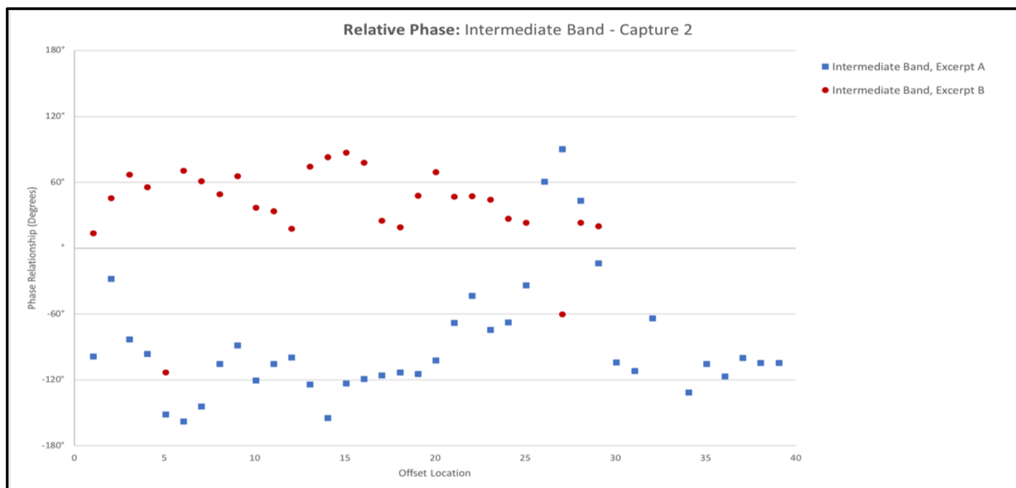
Intermediate Band, Excerpt A
Intermediate Band, Excerpt B
Phase Relationship (Degrees)
Offset Location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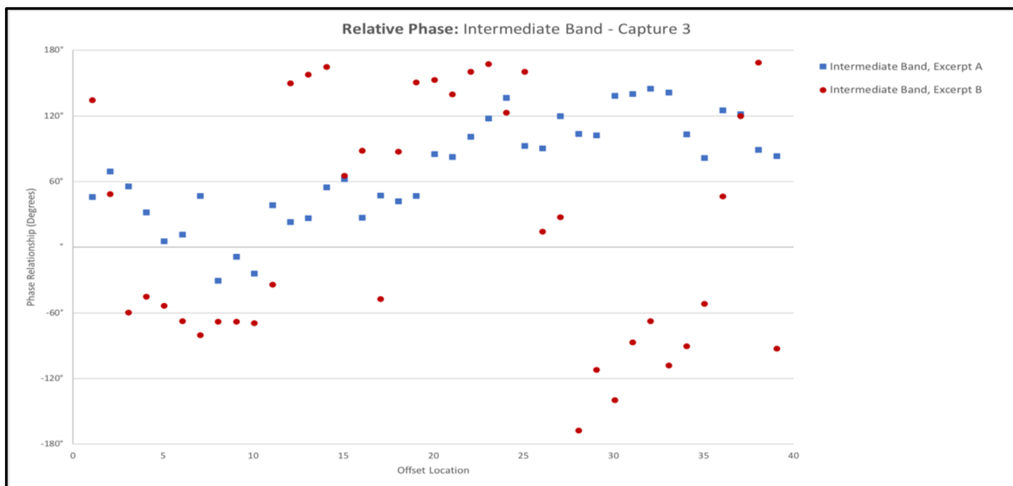
Intermediate Band, Excerpt B
Phase Relationship (Degrees)
Offset Location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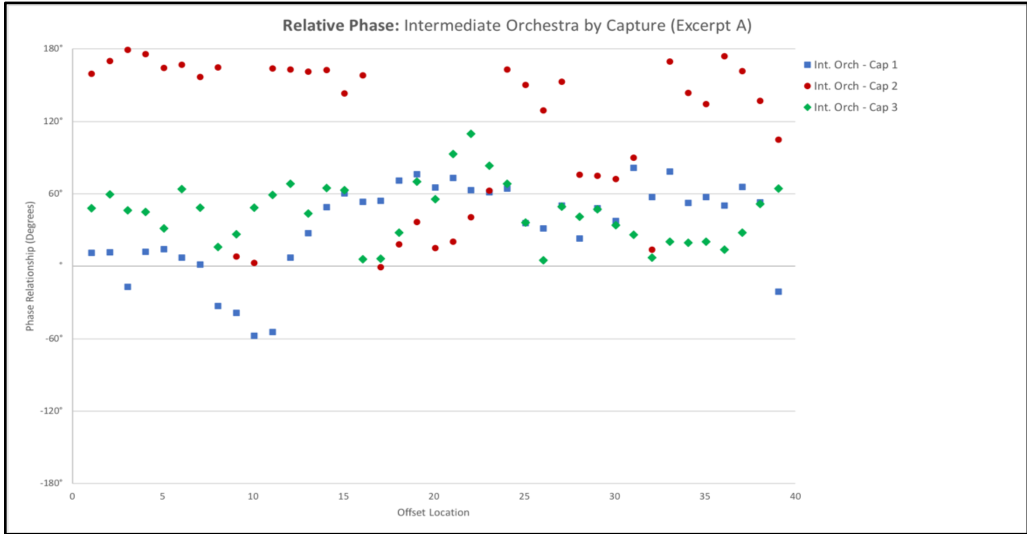
Phase Relationship (Degrees)
Offset Location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Phase Relationship (Degrees)
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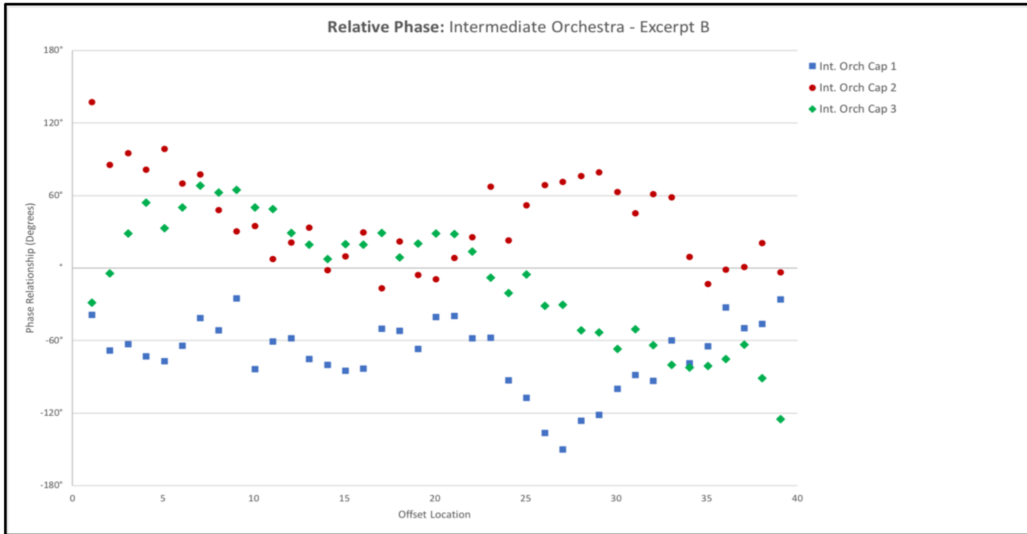
Int. Orch - Cap 2
Int. Orch - Cap 3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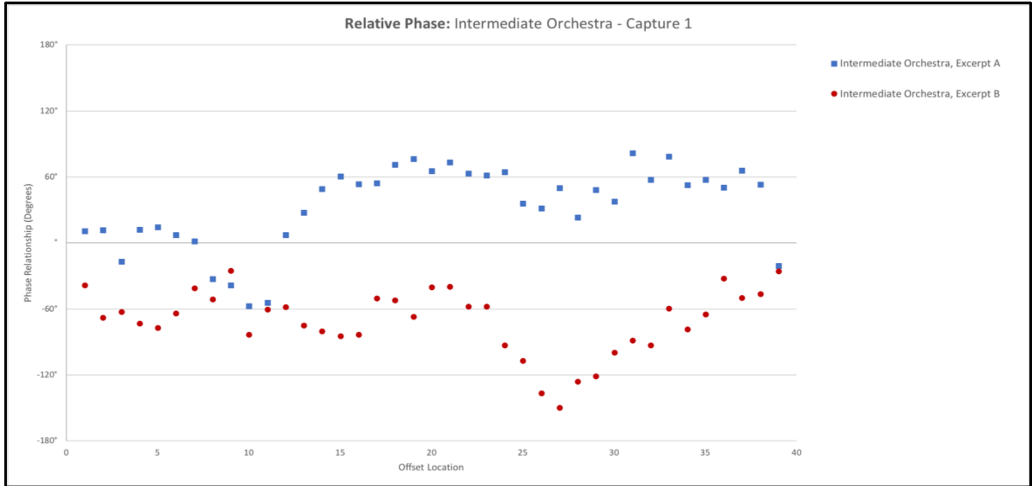
Int. Orch Cap 1
Int. Orch Cap 2
Int. Orch Cap 3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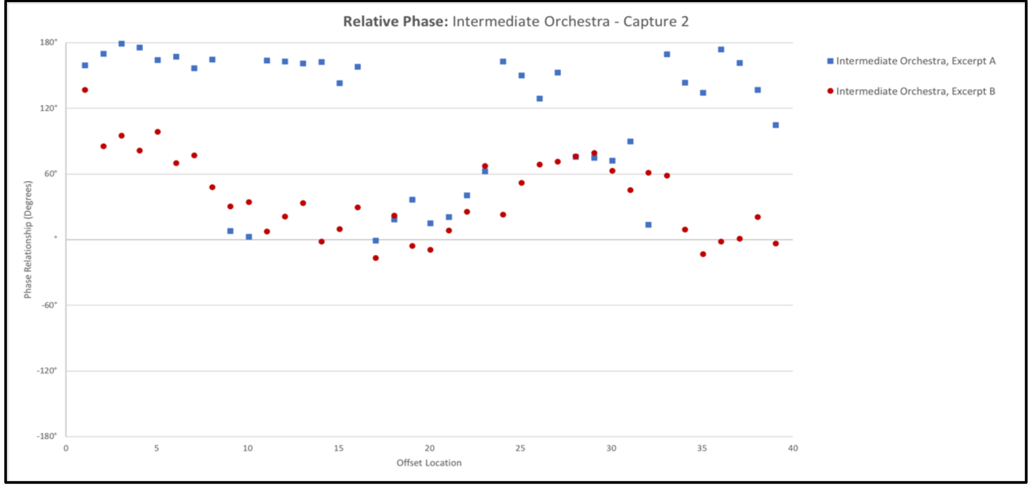
Intermediate Orchestra, Excerpt A
Intermediate Orchestra, Excerpt B
Phase Relationship (Degrees)
Offset Location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Phase Relationship (Degrees)
Offset Location

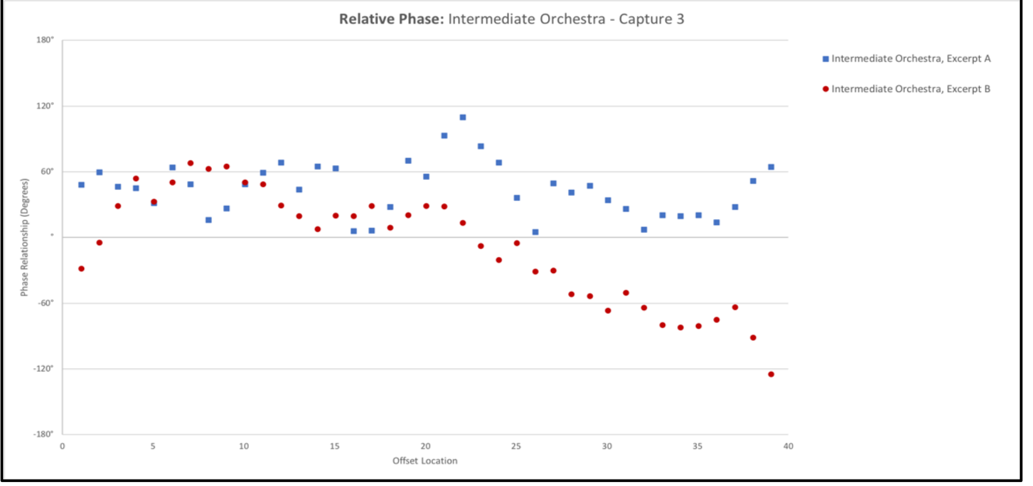
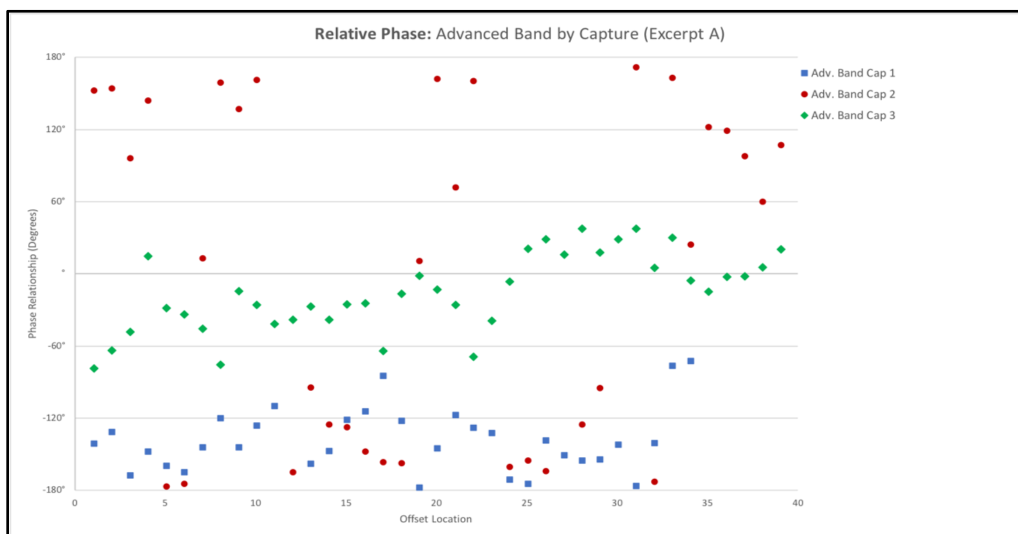
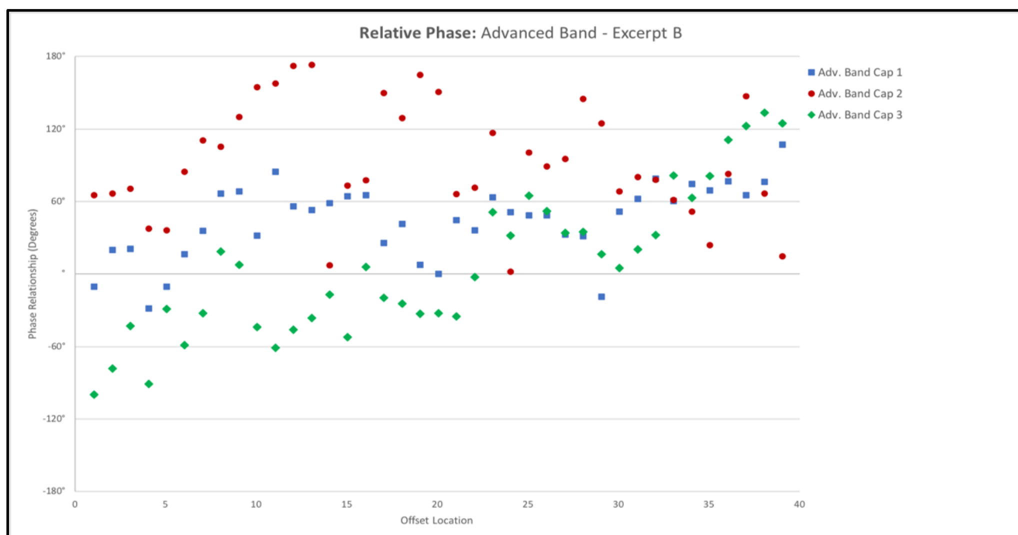
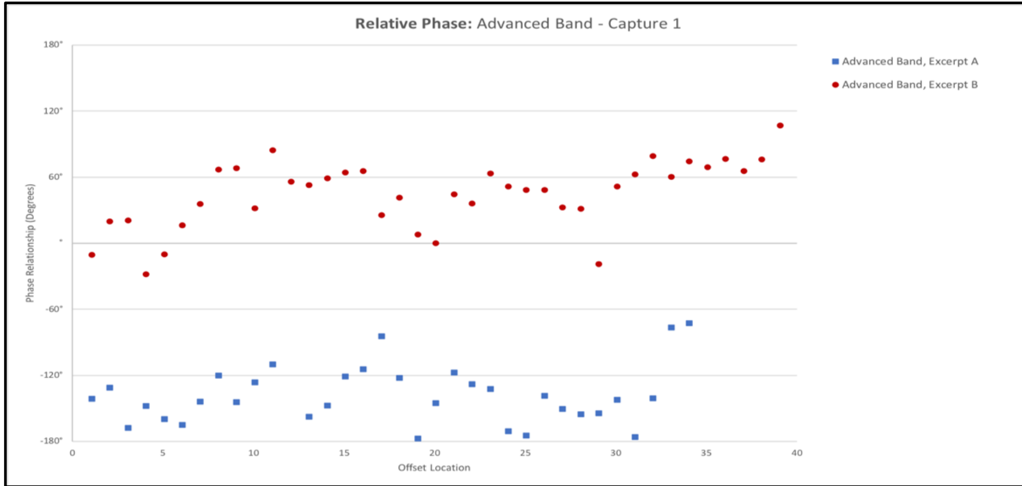
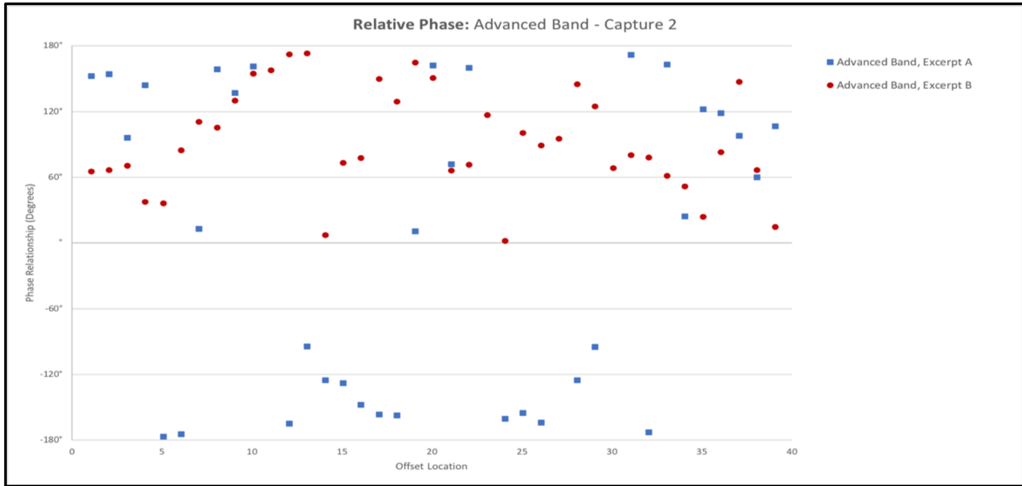

Relative Phase: Intermediate Orchestra - Capture 3
Intermediate Orchestra, Excerpt A
Intermediate Orchestra, Excerpt B
Phase Relationship (Degrees)
Offset Location

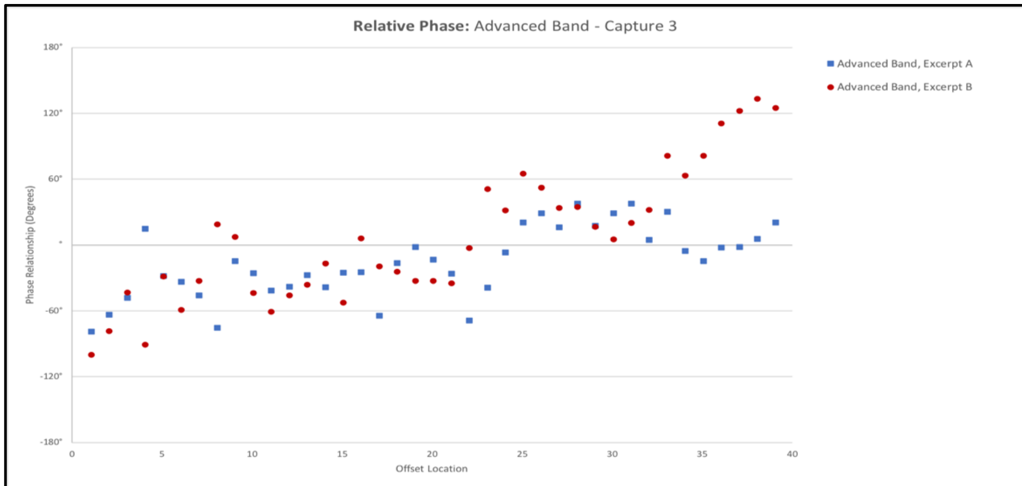
Figure A.9.a-b. Advanced Band Phase Relationships, Excerpt A & B
Figure A.10.a-c. Advanced Band Phase Relationships, Capture 1-3
Figure A.11,a-b. Advanced Orchestra Phase Relationships, Excerpt A & B
Figure A.12.a-c. Advanced Orchestra Phase Relationships, Capture 1-3

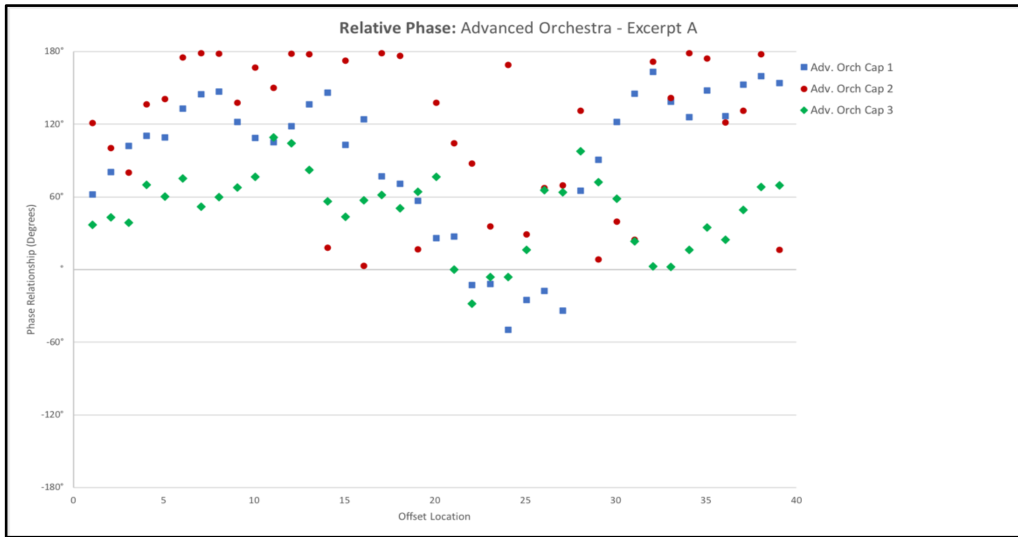


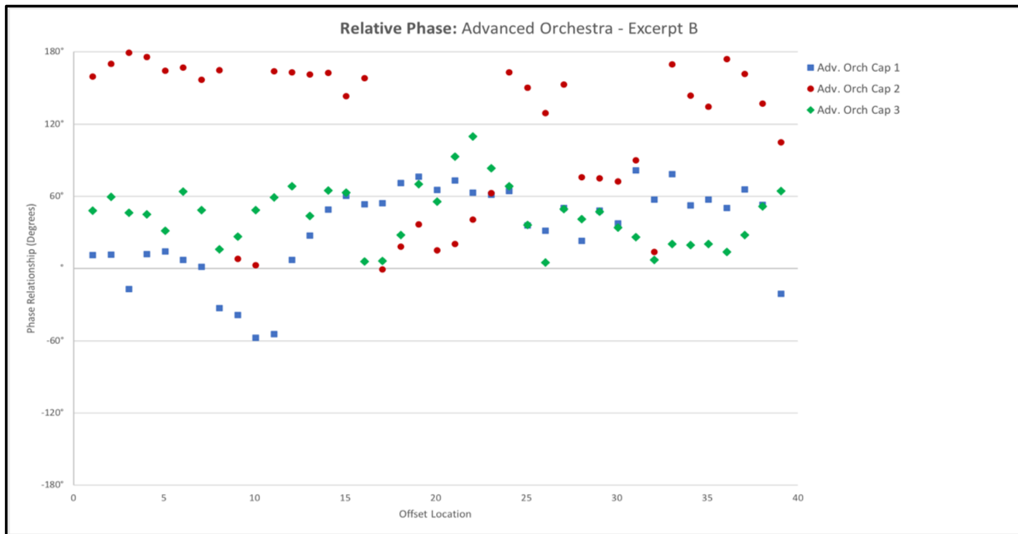


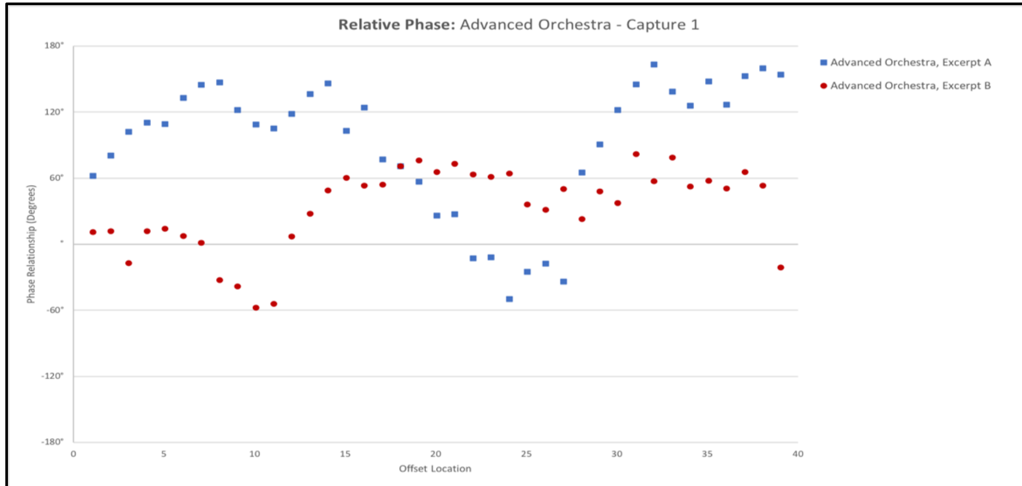

Relative Phase: Advanced Band - Capture 1
Advanced Band, Excerpt A
Advanced Band, Excerpt B
Phase Relationship (Degrees)
Offset Location

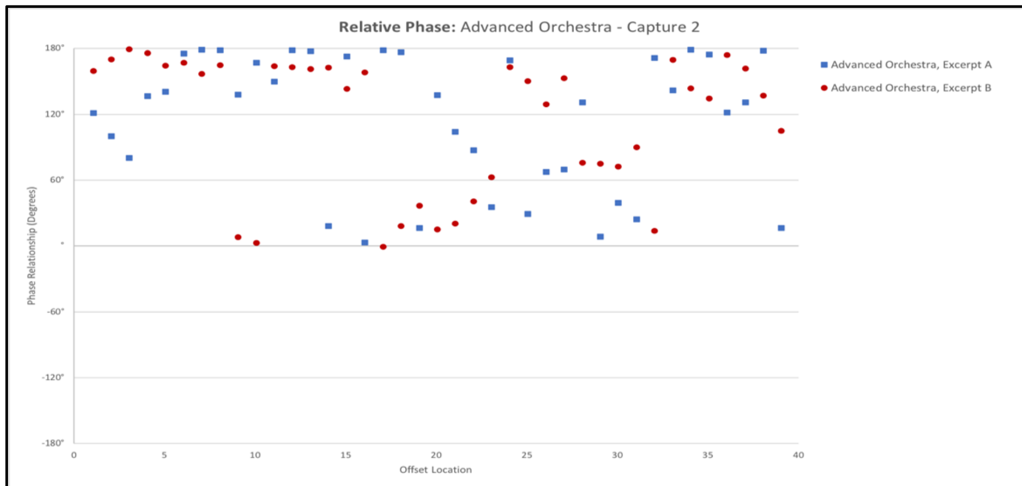

Relative Phase: Advanced Band - Capture 2
Advanced Band, Excerpt A
Advanced Band, Excerpt B
Phase Relationship (Degrees)
Offset Location


Relative Phase: Advanced Band - Capture 3
Advanced Band, Excerpt A
Advanced Band, Excerpt B
Phase Relationship (Degrees)
Offset Location


Relative Phase: Advanced Orchestra - Excerpt A
180°
120°
60°
-60°
-120°
-180°
Phase Relationship (Degrees)
0
5
10
15
20
25
30
35
40
Offset Location
Adv. Orch Cap 1
Adv. Orch Cap 2
Adv. Orch Cap 3


Relative Phase: Advanced Orchestra - Excerpt B
180°
120°
60°
-60°
-120°
-180°
Phase Relationship (Degrees)
0
5
10
15
20
25
30
35
40
Offset Location
Adv. Orch Cap 1
Adv. Orch Cap 2
Adv. Orch Cap 3


Relative Phase: Advanced Orchestra - Capture 1
Advanced Orchestra, Excerpt A
Advanced Orchestra, Excerpt B
Phase Relationship (Degrees)
Offset Location


Relative Phase: Advanced Orchestra - Capture 2
Advanced Orchestra, Excerpt A
Advanced Orchestra, Excerpt B
Phase Relationship (Degrees)
Offset Location

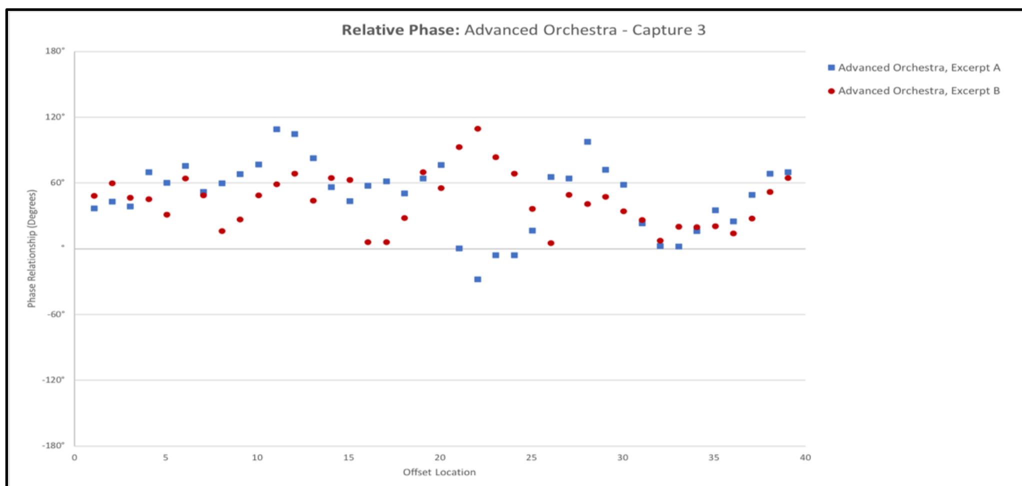
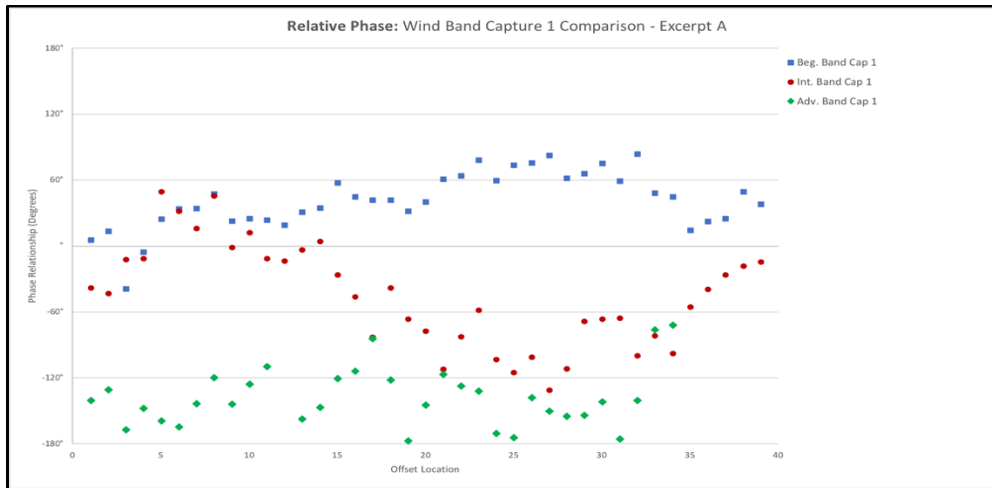
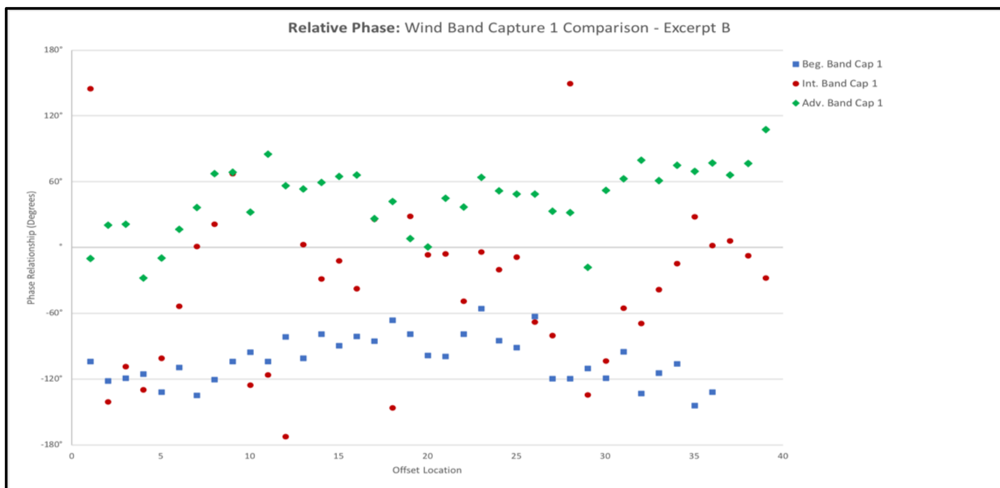
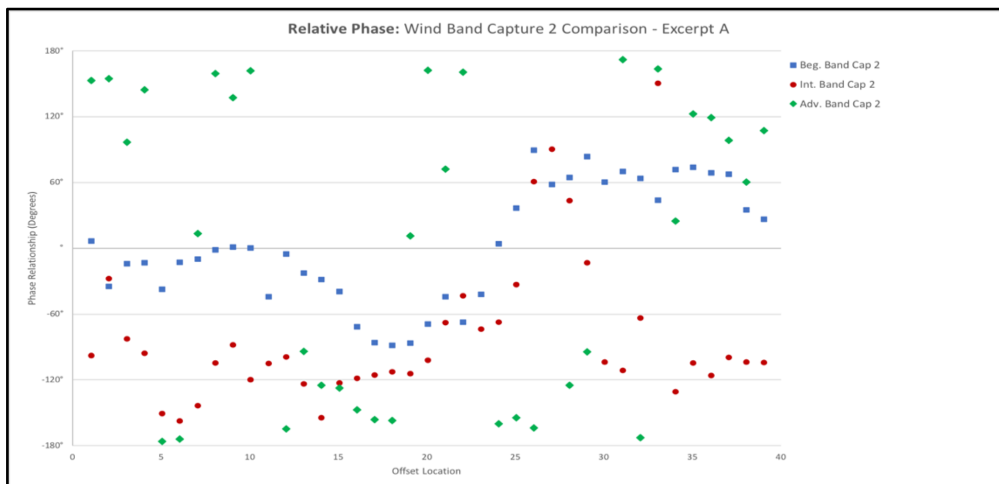
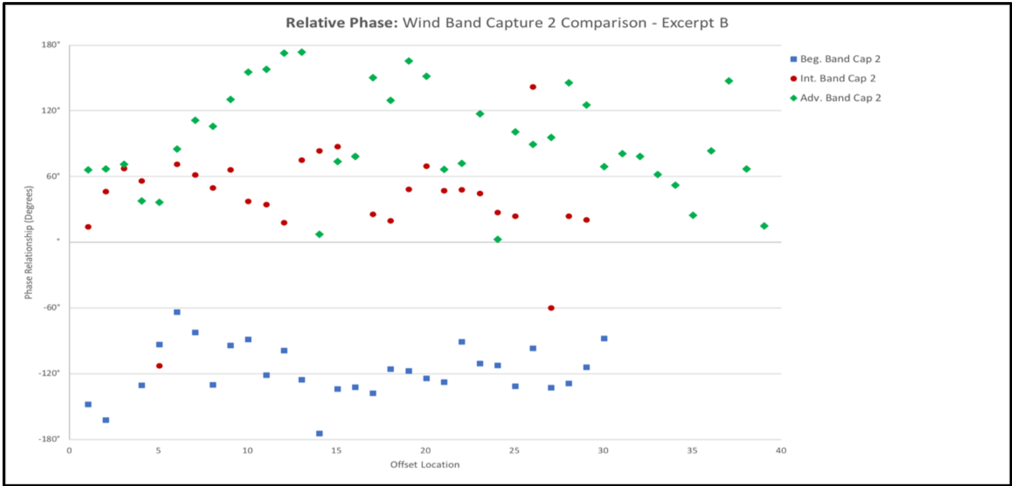

Relative Phase: Advanced Orchestra - Capture 3
Advanced Orchestra, Excerpt A
Advanced Orchestra, Excerpt B
Phase Relationship (Degrees)
Offset Location

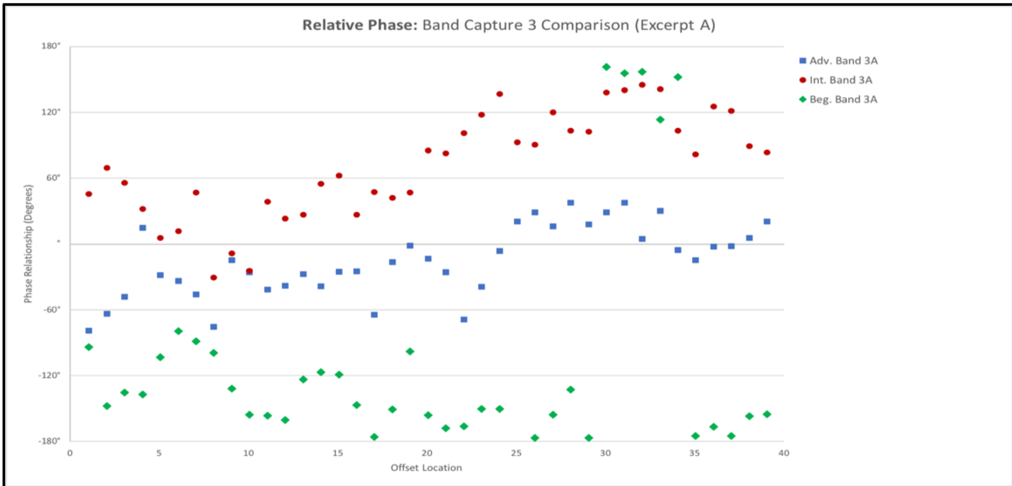
Figure A.13.a-f. Wind Band Comparison, Capture 1-3 & Excerpt A & B
Figure A.14.a-f. Orchestra Comparison, Capture 1-3 & Excerpt A & B

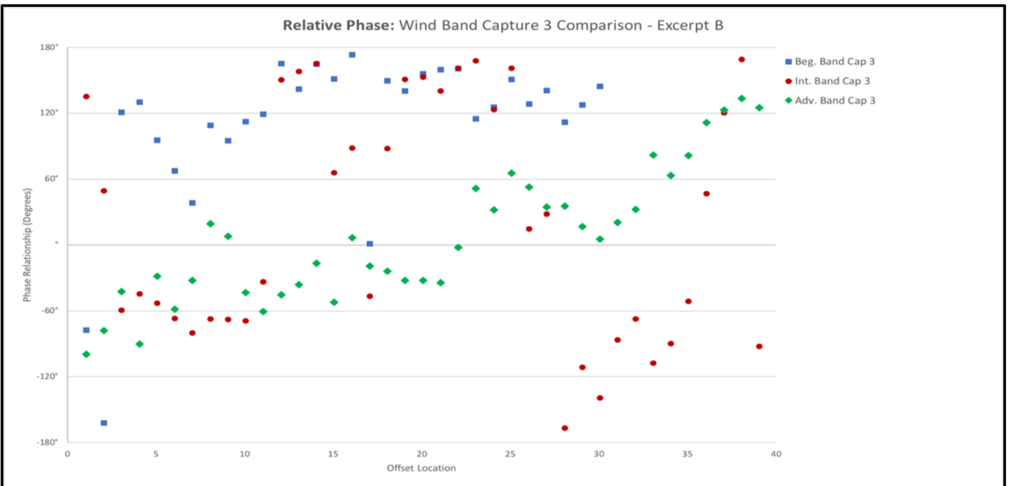


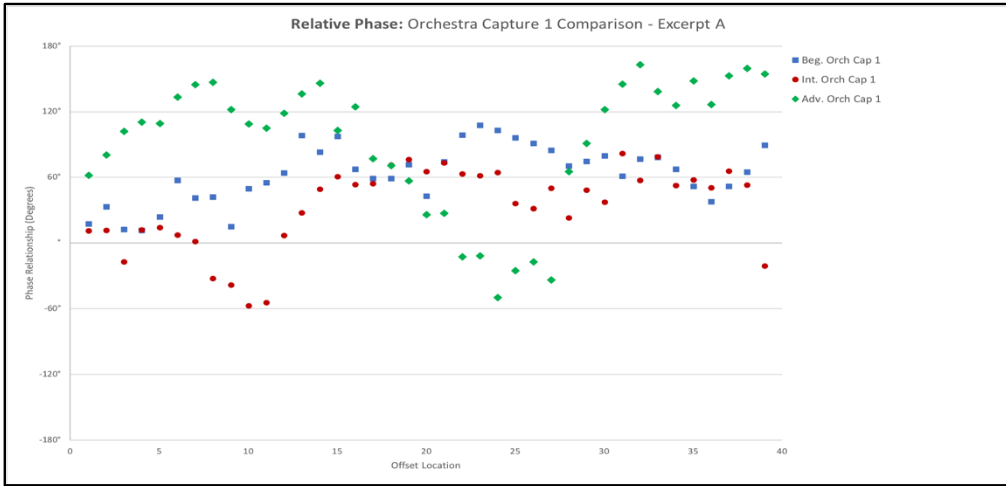


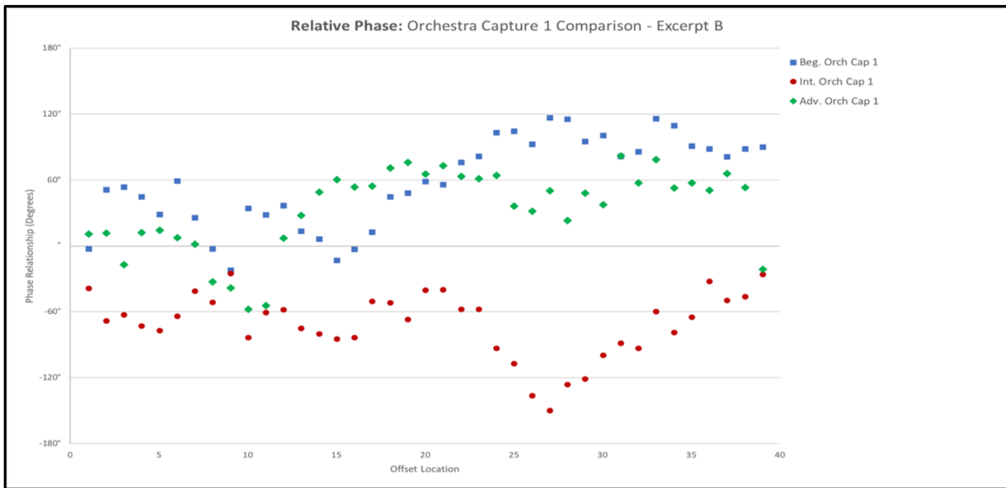


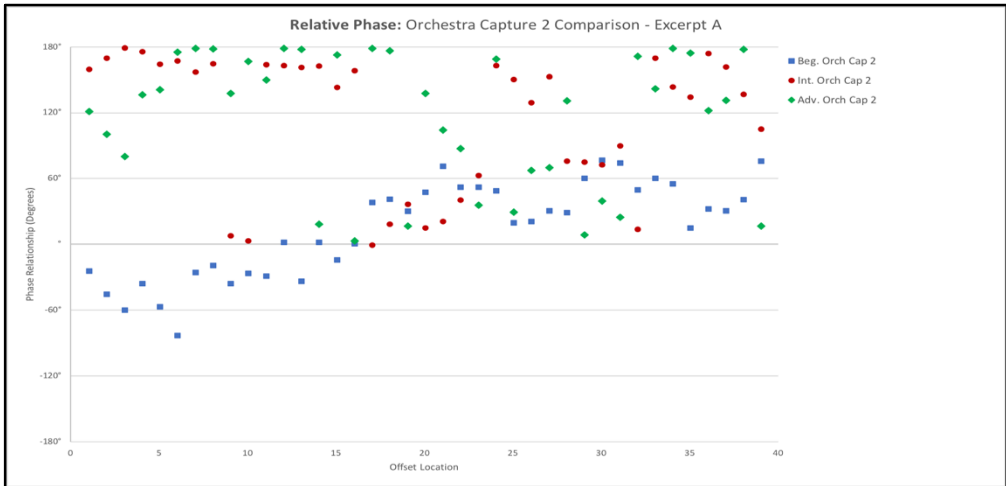

Relative Phase: Wind Band Capture 2 Comparison - Excerpt B
Phase Relationship (Degrees)
Offset Location
Beg. Band Cap 2
Int. Band Cap 2
Adv. Band Cap 2

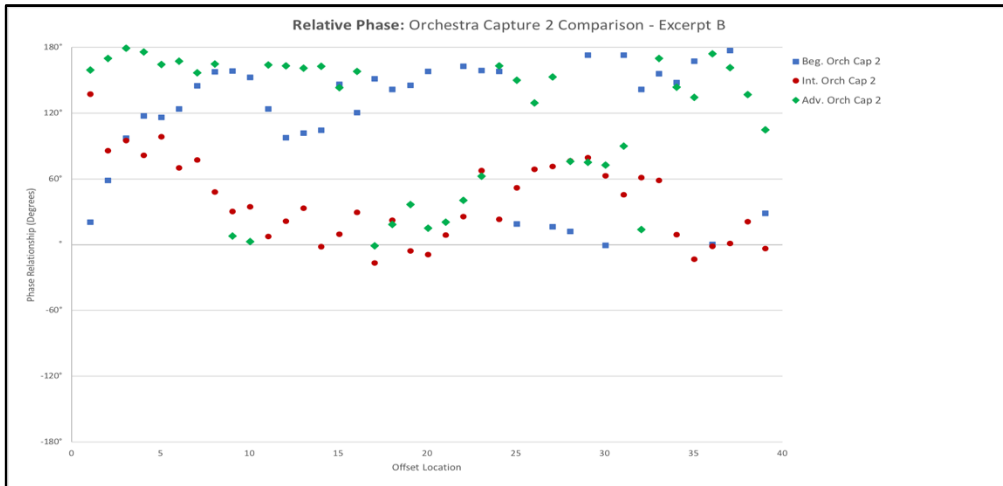

Relative Phase: Band Capture 3 Comparison (Excerpt A)
Phase Relationship (Degrees)
Offset Location
Adv. Band 3A
Int. Band 3A
Beg. Band 3A

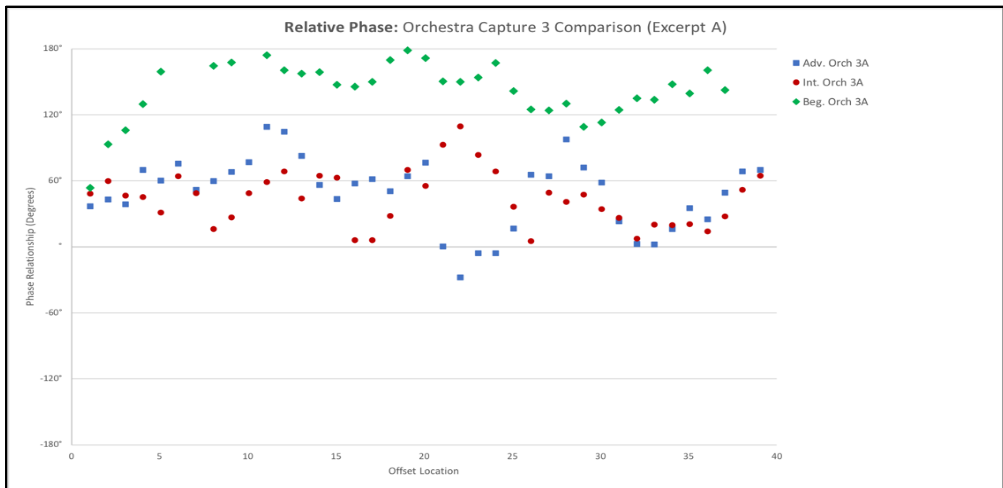

Relative Phase: Wind Band Capture 3 Comparison - Excerpt B
Phase Relationship (Degrees)
Offset Location
Beg. Band Cap 3
Int. Band Cap 3
Adv. Band Cap 3

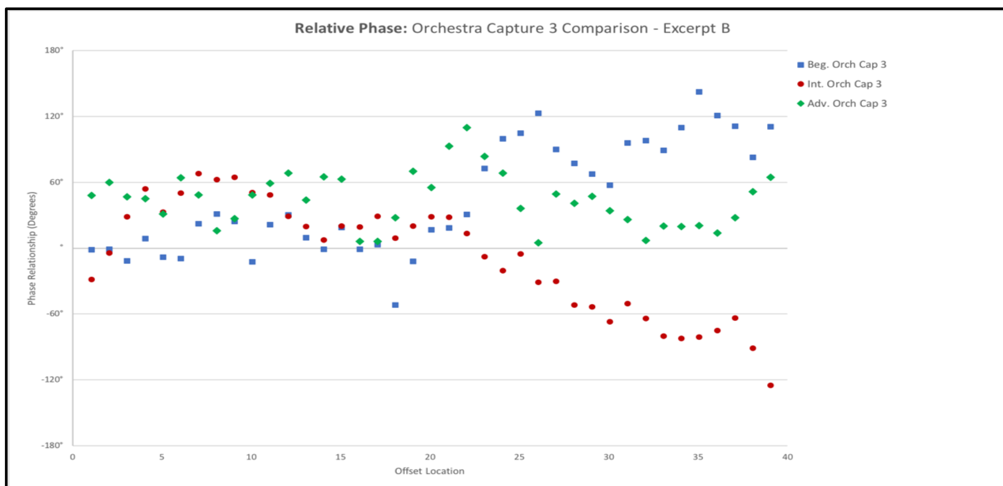

Relative Phase: Orchestra Capture 1 Comparison - Excerpt A
180°
120°
60°
-60°
-120°
-180°
Phase Relationship (Degrees)
0
5
10
15
20
25
30
35
40
Offset Location
Beg. Orch Cap 1
Int. Orch Cap 1
Adv. Orch Cap 1


Relative Phase: Orchestra Capture 1 Comparison - Excerpt B
180°
120°
60°
-60°
-120°
-180°
Phase Relationship (Degrees)
0
5
10
15
20
25
30
35
40
Offset Location
Beg. Orch Cap 1
Int. Orch Cap 1
Adv. Orch Cap 1


Relative Phase: Orchestra Capture 2 Comparison - Excerpt A
180°
120°
60°
-60°
-120°
-180°
Phase Relationship (Degrees)
0
5
10
15
20
25
30
35
40
Offset Location
Beg. Orch Cap 2
Int. Orch Cap 2
Adv. Orch Cap 2


Relative Phase: Orchestra Capture 2 Comparison - Excerpt B
Beg. Orch Cap 2
Int. Orch Cap 2
Adv. Orch Cap 2
Phase Relationship (Degrees)
Offset Location


Relative Phase: Orchestra Capture 3 Comparison (Excerpt A)
Adv. Orch 3A
Int. Orch 3A
Beg. Orch 3A
Phase Relationship (Degrees)
Offset Location


Relative Phase: Orchestra Capture 3 Comparison - Excerpt B
Beg. Orch Cap 3
Int. Orch Cap 3
Adv. Orch Cap 3
Phase Relationship (Degrees)
Offset Location

Appendix F. Experimental Interface, Paper Three

Conductor Evaluation: Excerpt *x*

Linked YouTube content

SAMPLE

Please evaluate...

... the performance of the ensemble:

○	○	○	○	○
1	2	3	4	5
Poor				*Excellent*

... the performance of the conductor:

○	○	○	○	○
1	2	3	4	5
Poor				*Excellent*

... the performance overall:

○	○	○	○	○
1	2	3	4	5
Poor				*Excellent*

Briefly describe your impression of the relationship between the conductor and ensemble:
(100 characters maximum)

Response window (*100 characters*)

One response page per evaluated excerpt.