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A COMPARISON OF CONDUCTING EFFECTIVENESS, INSTRUMENTALISTS PERFORMANCES, AND THE UNDERLYING BIOMECHANICS OF A CONDUCTOR WHILE PERFORMING EXAGGERATED AND UNDERSTATED VARIATIONS OF STACCATO AND LEGATO GESTURES

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Abstract

The purposes of this study were to compare the biomechanical characteristics, musicians' performances, and ratings of perceived conducting effectiveness of exaggerated and understated staccato and legato conducting gestures using motion capture data, clarinet and saxophone audio recordings, and a researcher created conducting effectiveness scale. Participants included one professional conductor, clarinet and saxophone players (n = 11), and university level large ensemble instrumentalists (n = 41) and vocalists (n = 34) from one large urban university in the Mid-South region of the United States. Results revealed that staccato gestures had higher vertical ranges of motion than horizontal, while legato gestures had higher horizontal ranges of motion than vertical. Peak acceleration measurements revealed that the largest cross gestural difference occurred between exaggerated legato and exaggerated staccato, where the exaggerated staccato gesture had a maximum vertical acceleration that was 28.8 times faster than the exaggerated legato condition. Results of a one-way within subjects ANOVA revealed an overall main effect for the average note lengths of the clarinet and saxophone recordings across the four conducting conditions $F(2.66, 26.57) = 29.15$, $p < .001$, $\eta_p^2 = .745$. Results of two separate mixed ANOVAs revealed main effects for effectiveness ratings in understated and exaggerated staccato conditions $F(1, 67) = 11.83$, $p = .001$, $\eta_p^2 = .15$ and understated and exaggerated legato conditions $F(1, 67) = 30.31$, $p < .001$, $\eta_p^2 = .31$ with participants rating overstated gestures more effective than understated gestures. Participants rated the exaggerated legato condition as the most effective gesture and the understated staccato condition as the least effective gesture.

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Chapter 1

Introduction

Conducting, at its most basic level, is a form of non-verbal communication: a transmission of musical intents by one person to other musicians through physical gestures that convey the conductor's interpretations of the composer's artistic conceptions as presented in the written score. Conductors utilize specific gestures to communicate directive, interpretive, and corrective instructions to the group of musicians who, either collectively or individually, interpret those gestures as directions for singing or playing their instruments (Huang et al., 2017; Running, 2012). Effective gestures are those that elicit a response from the ensemble (or specific musicians within an ensemble) that mirror the aural image that the conductor has interpreted through diligent score study and analysis (Ulrich, 2009).

Nonverbal communication is an important part of both teaching and conducting (Steele, 2010) and acquiring the necessary skills of effective conducting is an ongoing, lifelong pursuit (Van Weelden, 2002). Research into how effective and non-effective conducting influences perceptions of performance is a wide field of study that includes early investigations of the relationship between expressive gestures and performance quality (Grechensky, 1985; Laib, 1993; Sidoti, 1990), the effect of the conductor's body-type and gender on performance (Van Weelden, 2002), high school ensembles' and conductors' expressivity at concert festival (Price, 2006; Price & Chang, 2001; Price & Chang, 2005), horizontal conducting plane placement (Silvey & Fisher, 2015), high and low conducting expressivity videos over the same audio performance (Morison et al., 2009; Morrison & Selvey, 2014; Price & Mann, 2011;), high and low quality audio performances over the same conducting video (Silvey, 2011), and high school and middle school ensemble members' perceptions of conductor's and their own performance

expressivity (Silvey & Koerner, 2016). These studies, while vastly different in methods and scopes, illuminate the symbiotic connection between the conductor and their ensemble and demonstrate that effective conducting is a powerful tool for both reducing rehearsal verbiage (thereby increasing the efficiency and efficacy of rehearsals) and eliciting performances with higher levels of musicianship and expressivity. In addition, these non-verbal skills of conducting, meaning communicating the specific intent of the music through nonverbal gestures (Running, 2012), can be learned and acquired over time (Byo & Austin, 1994; Van Weelden, 2006) and therefore are a valid and important part of the curricula of music schools in higher education.

Conductors acquire the necessary gestural vocabulary through conducting courses offered in schools or departments of music, direct instruction from experts in the field of conducting through lessons and master-classes, and experiential opportunities with live ensembles. Teachers of conducting, while utilizing a variety of texts and philosophical frameworks (for example Green & Gibson, 2004; Hunsberger & Ernst, 1992; Rudolph, 1995), traditionally use qualitative and subjective descriptions and instructions when labeling gestures as appropriate or inappropriate. Consequently, standardization within conducting curricula across schools of music has been illusive (Hart, 2019) and the assimilation of physical gestures into non-verbal representations of the musical intent of composed music has had mixed results (Running, 2012). Even with the popular incorporation of a systematized movement theory into conducting curricula from either Laban's movement analysis and effort actions (Jordan, 2011), Dalcroze's Eurhythmics (Juntunen 2002), or the Alexander Technique (Alcantara, 1997), descriptions of conducting continue to be either subjective (as interpreted by the teacher) or reliant on the audible responses of an ensemble. However, specific, quantifiable descriptions of effective conducing gestures might be attainable through a cross-discipline approach utilizing

methodologies and technologies employed by the study of biomechanics in the field of sports science.

Biomechanics is the science involving the study of the mechanical physics of living organisms (Nelson, 1980). As a subdivision of biomechanics, kinematics investigates the magnitude, order, and timing of movements. Since conducting gestures utilize variations in size, sequencing, and speed of movement in an attempt to convey musical intent to an ensemble, an application of biomechanical kinematics to the field of conducting might provide valuable insight into the pedagogy and praxis of effective conducting gestures.

Researchers have had recent success in the application of biomechanical techniques and technology to the art of conducting. Studies involving conducting and biomechanics have investigated levels of perceived expression (Luck et al., 2010), synchronization between gestures and musicians' responses (Luck & Sloboda, 2007; Luck & Toiviainen, 2006), and whether conductors' gestures communicate specific, pre-determined intentions to their ensembles (Huang et al., 2017). While these and other fields of study are important contributions to the emerging body of knowledge, there is limited research that investigates the intricate relationship between the biomechanics of conductors' physical movements and the interpretation of physical gestures by musicians either through their playing and singing or their perceptions of its effectiveness. Specifically, there is an apparent gap between the biomechanics of conducting movements, how musicians perceive conducting gestures as effective or ineffective, and how musicians interpret those gestures into musical performances. While these fields have been investigated as individual questions, there is scant data that attempts to coalesce the biomechanics, perception, and performance of conducting gestures into a single investigation.

The purposes of this study are to describe the biomechanical characteristics of staccato and legato conducting gestures and compare musicians' performances and ratings of perceived conducting effectiveness across two variations of staccato and legato gestures with the kinematic descriptors of the conductors physical movements. The research questions that will guide this project are:

1. What are the biomechanical characteristics of the conducting gestures with two variants of staccato gestures and two variants of legato gestures?
2. Do college musicians' performances differ after viewing a conductor who demonstrated two variants of staccato gestures and two variants of legato gestrues?
3. Do college musicians' ratings of conducting effectiveness vary after viewing a conductor who demonstrated two variants of staccato gestures and two variants of legato gestures?

Definitions

For the purposes of this study, the following terms will be operationally defined as follows:

Audio wave visualizations: A visual representation of audio frequency over time produced by the recordings of the instrumentalists in question 2. Analyzed through custom software (MATLAB, Mathworks, Inc., Natick, MA, USA).

Beats per minute (BPM): A unit of measurement for the tempo of a piece of music. In this study, question 1 defines the tempo as 72 beats per minute, meaning that within the time of one elapsed minute, 72 equally spaced pulses would occur. At this tempo, each beat is .83 seconds long.

Conducting Effectiveness: A measurement on a Likert-type scale of participants' rating of their impression of how successfully the demonstrated gesture matches the given articulation in research question 3.

Conducting window: The average size of the area (in m^2) of each conducting condition, calculated by multiplying the x plane's range of motion by the z plane's range of motion for each conducting condition.

Duration of a note: A measurement of time in seconds from the onset of the pitch to its release, as measured through the audio wave visualization.

Exaggerated Gesture: A conductor's visual representation of, in this case, staccato and legato gestures that are larger and overstated in both size and intensity.

Field of view: With respect to the video recording made in question 1, the field of view describes the area of focus for the recording. The focus was exclusively on the trunk of the conductor's body, framed on the bottom by his waist and the top by the top of his head.

Gesture size: The measurement, in meters, of the traveling distance of the retro-reflective marker on the tip of the baton in both vertical and horizontal planes as captured through the 9 camera motion capture system in the human performance laboratory.

Legato: A gesture performed with the shortest silence between pitches. In conducting, this gesture is often demonstrated with smooth, connected movements with minimal points of stopping at the ictuses.

Maximum baton position: A measurement of the highest 3 dimensional coordinates of the retro-reflective marker placed on the tip of the conducting baton. In this study it is measured in both x and y planes for all four conducting conditions.

Maximum acceleration: A measurement of the highest rate of change of velocity over time of the tip of the conducting baton in both x and z planes for all four conducting conditions. Measured in meters per second squared (m/s^2).

Mean velocity: A measurement of the average directions and rates of speed (position over time) of the tip of the conducting baton in both x and z planes for all four conducting conditions. Measured in meters per second (m/s).

Minimum baton position: A measurement of the lowest 3 dimensional coordinates of the retro-reflective marker placed on the tip of the conducting baton. In this study it is measured in both x and y planes for all four conducing conditions.

Range of motion: Measured in meters (m) and calculated by subtracting the minimum baton position from the maximum baton position in each conducting plane and condition, it represents the average width and height of each conducting condition in question one.

Retro-reflective markers: Placed bilaterally on the body of the conductor's upper and lower extremity, trunk, and the tip of the baton, these markers are recorded using a 9-camera motion capture system (240 Hz., Qualisys, AB, Goteburg, Sweden) to measure individual segment motion during the four conducting trials in the human performance laboratory. The focus of this study was solely on the marker on the tip of the conductor's baton.

Staccato: An gesture performed with pitches of shortened duration that include perceptible silences between the pitches. In conducting, this gesture is often performed utilizing quick movements into and out of the ictus with perceptible points of stoppage after the rebound.

Understated gesture: A conductor's visual representation of, in this case, staccato and legato gestures that are small and subtle in both size and intensity.

X plane: The horizontal (left/right) dimension of measurements for position, velocity, and acceleration in question one.

Z plane: The vertical (up/down) dimension of measurements for position, velocity, and acceleration in question one.

Summary of Method

Because different samples were used to answer each of the three research questions, I will organize this section by describing the methodology of each research question in succession.

Research Question One

I will recruit one professional conductor who has extensive experience in teaching basic and advanced conducting at a large university in the mid-south region of the United States. This conductor specializes in wind band conducting, having worked as a conductor of college level ensembles for over ten years and as a guest clinician at numerous festivals and honors ensembles throughout the United States.

Frontal-view recordings of the conductor will be made using a Sony Handycam AX53 Camcorder (Model No. FDRAX53) in the musculoskeletal analysis laboratory on the university campus where the conductor is employed. The conductor will conduct four excerpts, each four measures long, to a consistent metronome pulse with the quarter note set to 72 beats per minute. Each excerpt will be a set of sixteen quarter notes conducted with the baton-hand only. For the first excerpt, the conductor will conduct each pulse with an exaggerated staccato gesture. The second excerpt will be conducted with an understated staccato gesture. The third excerpt will be conducted with an exaggerated legato gesture, and the final excerpt will be conducted with an understated gesture of legato.

In addition to the video recording, retro-reflective markers will be placed bilaterally on the participant's upper and lower extremity, trunk and the tip of the baton to measure individual segment motion during the four conducting exercises using a 9-camera motion capture system (240 Hz, Qualisys AB, Goteburg, Sweden).

Data from the retro-reflective marker on the tip of the baton will be analyzed in two planes: x (left and right), and z (up and down). Average position, velocity, and acceleration will be calculated for measures two and three for each of the four conducting conditions. Range of motion for each plane of the four conditions will be calculated by subtracting the minimum position from the maximum position, creating the total conducting area ("conducting window") for each condition. Mean velocities will be calculated to determine average rates of horizontal and vertical speed in each condition. Maximum accelerations will be calculated to determine the highest rate of change of velocity over time horizontally and vertically for each conducting condition.

Research Question Two

Undergraduate and graduate instrumentalists will be recruited to participate in the study. Participants will be clarinet players and saxophone players who have completed at least one semester of private study and large ensemble playing at a large university in the mid-south region of the United States. Data collection was originally planned to take place in a *Wenger Soundloc* Sound Isolating Practice Room within the school of music at the same university. However, do to the changing circumstances related to the global pandemic of COVID-19, the procedures will be converted to an online survey and will take place in the participants' homes.

After agreeing to informed consent letters (Appendix D) that will be attached to the recruitment email (Appendix B), participants will follow a link to the researcher created Playing Response to Conducting Videos survey. Following a demographic section, the participants will be given five minutes to prepare their instrument and body for playing utilizing their regular warm-up procedure.

Participants will then be instructed to prepare their external recording device to capture their audio response to the four conducting condition videos. Specific instructions and suggestions will also be given for labeling their recorded file, how far away to put the recording device, and hardware and software recording recommendations.

The four conducting conditions will be combined into one video and copied so that one video will show all four conditions twice. During the first set of four conducting videos, participants will be instructed to only watch all four videos, paying particular attention to the gesture styles that the conductor is demonstrating through his baton gesture. Participants then will begin recording their performance of the four videos, playing 16 single pitch quarter notes for each video. Clarinetists will perform each exercise on their written second-line G and alto saxophones will perform each exercise on their written fourth line D. Following the recording of the four conditions, participants will be instructed to save their file and uploaded it to a researcher-provided file request link that will save their recording to a secure cloud storage system.

The audio recordings will be analyzed by examining visualizations of the audio waves of the excerpts and measuring the durations the notes (from attack to release) utilizing custom software (MATLAB, Mathworks, Inc., Natick, MA, USA). Means for the duration and volume of the notes of each conducting condition from each participant will be calculated using the material from measures two and three (eight durations per excerpt). A one-way within subjects analysis of variance will be conducted to compare participants' note lengths across the four conducting conditions. Descriptive statistics will be used to make comparisons between average note lengths, the four conducting exercises, and the kinematic and biomechanical measurements taken from research question one.

Research Question Three

Students who are members of large ensembles at a large university in the mid-south region of the United States will be recruited to participate in the study. Participants will be enrolled in either band, orchestra or choir. Data collection was originally scheduled to take place during a scheduled rehearsal time in large ensemble practice spaces on the campus of the university. However, due to extenuating circumstances related to campus closures as a result of the global pandemic of COVID-19, the survey will be converted to an online survey and will be completed by participants in their own homes.

After agreeing to informed consent letters (Appendix E) that will be attached to the recruitment emails (Appendix C) sent by ensemble directors, participants will follow a link to the online survey that will begin with a demographic section to gather information for comparative analysis. The demographic section included the participants' sex, their current major, primary instrument, years of private study, years of participation in a conducted band, choir, or orchestra, an estimation of how many conductors they have performed under since their freshman year in college, and current classification.

In order to assess the participants' ratings of the effectiveness of the conductor's two variants of staccato and legato gestures, the participants will complete the researcher created Conducting Effectiveness Scale in which they will rate each randomized excerpt on how effective it is in demonstrating the desired gesture. After the participants watch each conducting condition video, they will be asked, "How effective was this demonstration of the (staccato/legato) gesture?" Participants will then respond to each question by selecting a number from 0 to 10, where 0 represents that the excerpt was perceived to be highly ineffective in

demonstrating the gesture and 10 represents that the excerpt was perceived to be highly effective in demonstrating either the staccato or legato gesture.

Two separate mixed analyses of variance will be conducted to determine if the ratings differ across the two staccato conducting exercises and two legato conducting exercises between ensemble membership, years of experience in a conducted ensemble, and the estimated number of conductors they have played under. Descriptive statistics will be used to make comparisons between the results of the mixed analysis of variance and the kinematic and biomechanical measurements taken from research question one.

Limitations

The results and conclusions of this study are specific to the location and sample that was utilized. As such, caution should be exercised in generalizing the conclusions and implications to contexts outside of the settings of this study.

Research question 3 includes participants who are members of large musical ensembles (band, choir, and orchestra) in a large university in the mid-south United States. Though the university from which this sample was taken includes participants from a variety of races, socio-economic statuses, rural and urban upbringings, and is located in a large, urban center, it may not be representative of other large universities in urban settings within the United States.

The sample size used for research question 2 is low which could also affect generalization. In addition, in an effort to minimize differences in embouchure formation and tone production, only participants who play single-reed instruments were included in the sample. Caution should be exercised when generalizing the results to musicians who produce sound in other ways (bowing, singing, brass mouthpieces, etc.)

Finally, in attempting to answer research question 1, a single participant was used and analyzed. While every effort was made to recruit a professional, high-level conductor, the participant only represents his own particular style, training, and execution of conducting gestures. As such, this conductor may not be representative of all styles, variations, and preferences of conducting. The wide varieties of conducting practices across genres (band, choir, orchestra, etc.), levels of experience, and philosophical and pedagogical beliefs must be considered when attempting to interpret and utilize the results and conclusions of this study.

Chapter 2

Review of Literature

Conducting is the communication of musical intent through physical gesture (Running, 2012). Conductors utilize score study to interpret the musical intentions of the composer and then, using a wide variety of physical gestures, employ specific body movements to communicate their musical intensions to musicians who interpret those gestures as directions for singing or playing their instruments (Huang et al., 2017). These gestures can be directive, interpretive, or corrective.

Directive gestures provide musicians with specific information on how to perform. These include intentional cues for when to begin playing and at what dynamic level the ensemble, sections, or individual musicians should perform. Interpretive gestures communicate the style of playing that the composer intended. Examples of interpretive gestures are smooth, detached, heavy, or light playing. Corrective gestures are responsive and communicate a desired change to the ensemble, section, or musician. These gestures include the conductor communicating to the musicians that they should play at a different dynamic level or utilizing an exaggerated or understated interpretive gesture to indicate a desired change in style. This gestural vocabulary is taught in conducting courses offered in schools of music utilizing a variety of methods (Green & Gibson, 2004; Hunsberger & Ernst, 1992; Rudolph, 1995), is honed and refined by the conductor through experience with an ensemble (Varvarigou & Durrant, 2011), and is the most prioritized objective by conducting teachers within their curricula (Hart, 2019). However, despite the importance of these directive, interpretive, and corrective gestures, investigations and teaching methods of conducting movement have traditionally been qualitatively or subjectively descriptive.

Conducting and Nonverbal Communication

Nonverbal communication is a key characteristic of effective teaching and ensemble directors regularly and intentionally implement these attributes through conducting (Steele, 2010). Acquiring the art and skills of effective nonverbal communication through conducting is a lifelong pursuit and research into what effective and non-effective conducting is and how it should be measured is wide in both its methodologies and philosophies (for example: Byo & Austin, 1994; Morrison et al., 2009; Price & Chang, 2005; Price & Mann, 2011; Silvey, 2011; Silvey & Fisher, 2015; Silvey & Koerner, 2016; Van Weelden, 2002;).

One aspect of effective conducting that has been a frequent subject of research is the relationship between expressive conducting and expressive ensemble performance. Early investigations indicated that higher levels or numbers of expressive gestures utilized by a conductor elicited better performance quality in secondary large ensembles (Grechensky, 1985; Laib, 1993; Sidoti, 1990). This however stands in contrast to a three-part study by Price (Price, 2006; Price & Chang, 2001; Price & Chang, 2005) where no relationship was found between conductor expressivity and ensemble expressivity in high school ensembles at concert festival. One explanation Price gives is that due to the high amount of time that is traditionally invested into preparing for a concert festival, performances at such events can often be mechanical for the ensemble and a source of anxiety for the conductor, leading to less expressive conducting (specifically less eye contact as the conductor looks at his or her score more frequently) and performance (Price 2006).

Investigations that evaluated ensemble expressivity of performances utilizing the same audio stimulus with conductors showing both high and low levels of expressivity consistently demonstrate that participants rate performances with conductors demonstrating expressive

gestures higher than performances with conductors demonstrating low levels of expressivity, despite listening to the same audio performance (Morison et al., 2009; Morrison & Selvey, 2014; Price & Mann, 2011;). Similarly, Silvey (2011) found that different audio performances (excellent and poor qualities) affected the expressivity ratings of identical conductor videos.

Sivey and Fisher (2015) investigated the effect that the horizontal conducting plane has on perceived expressivity. While they found that college level participants perceived the choir conductor to be more expressive in the middle plane and the band conductor to be more expressive in the lower plane, they found no significant differences in the ratings of the participants based on ensemble membership or voice/instrument part.

Students in middle and high school have shown preferences for being conducted expressively and can identify specific nonverbal behaviors that contribute to the perception of the level of expressivity shown by their ensemble director (Price & Winter, 1991; Silvey & Koerner, 2016; Whitaker, 2011). Conducting expressively, meaning communicating the specific intent of the music through nonverbal gestures (Running, 2012) as opposed to only keeping a steady pulse in the correct time pattern, appears to be linked to the performance of the musicians who are interpreting those gestures and is an integral part of the relationship between the music director and his or her ensemble.

While conducting expressively is an integral part of communicating the musical intentions of the composer to the ensemble, music directors use a variety of nonverbal techniques and cues to effect audible change in their musicians. Byo and Austin (1994) analyzed the nonverbal behaviors of six novice conductors and six accomplished university band conductors during a 15-minute rehearsal segment. They note that, while all of the expert conductors achieved high levels of musical and artistic success, “when compared to each other, they were as

dissimilar as they were similar in their nonverbal behavior" (p. 11). However, they did find significant differences in the categories of right arm/hand gestures and body movement between the experts and novices as groups, indicating that certain nonverbal traits and skills can be learned and taught over time and, therefore, deserve inclusion in the curricula of music schools in higher education.

Conducting Pedagogy and Curriculum

Courses in conducting play a pivotal roll within the curriculum of music schools in higher education. At their best, these course offerings serve as a synthesis of the knowledge and skills students have gained within other courses, including music theory, music history, and aural skills/ear training (Silvey, 2011). A basic understanding of the content within these music courses is essential to the successful completion of a conducting course since conducting combines the assimilation of physical gestures into a non-verbal representation of the musical intent of written and composed music (Running, 2012).

Additionally, the National Association of Schools of Music, the accrediting body for American higher education music programs, outlines specific requirements in conducting for all students majoring in music (NASM Handbook, 2016). The required competencies in conducting for music education majors are higher than those of performance majors. These include, among other things, that music education students should be competent as conductors, have opportunities in front of an ensemble to apply rehearsal techniques and procedures, and, even if students are training to be a teacher in a non-ensemble type classroom, be provided with music leadership skills to teach effectively in their area of specialization (Hart, 2019). Because conducting is a skill that requires synthesizing and applying skills learned from music theory, history, performance, and ear-training courses in addition to the novel information and physical

skills needed to be taught, conducting courses in schools of music are generally taught in two or three course sequences (Hart, 2019) and offered in the sophomore, junior, or senior year (Manfredo, 2007).

Research has shown that building confidence in initial conducting experiences is extremely important for students and directly impacts their success in future conducting situations (Fredrickson, Johnson, & Robinson, 1998). Because ensemble-based pedagogy is the most prevalent form of music education in America (Reimer, 2003), preparing music education students for these experiences in conducting courses within music teacher training programs is of the utmost importance. Providing a challenging and positive experience in the first basic conducting course may be the most important contributor to future success in the music classroom (Silvey & Major, 2014).

Despite the importance of conducting to the music curriculum in schools of music within institutions of higher education, a standardized curriculum for conducting within these schools does not currently exists. In fact, there is widespread disagreement on how to approach conducting courses by music faculty (Manfredo, 2007; Silvey & Major, 2014). This lack of consistency often results in teachers of conducting courses relying on materials and experiences they have had in their own past training instead of searching out a current and systematized method of delivering the content.

In addition, conducting courses within a school of music are frequently taught by more than one faculty member. Manfredo (2007) surveyed conducting teachers who taught in schools in the Midwest United States region (including Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, Pennsylvania, and Wisconsin) and found that there was no organized progression between the conducting course sequences. He suggested that this lack of coordination between conducting

courses and their instructors is due to the accepted practice of subjectively approaching conducting curriculum development. This finding proposes that conducting instructors are not heeding Romines' (2003) recommendation that the content of all conducting courses be known and designed through intentional collaboration by all faculty who are instructors of conducting.

Earlier studies have found that teachers of conducting courses primarily utilized a textbook as a primary source of instruction (Romines, 2003; Runnels, 1992). This is especially true when instructors were developing the physical skills and gestures of conducting in their students (Juslin & Persson, 2002). Recently, however, Hart (2019) found that only half of the over one hundred instructors of conducting he surveyed used a textbook as a primary instructional tool. Most (over 80%) utilized supplemental materials such as articles and specific chapters from a variety of books to build their semester's curriculum. Also of note, over half of the respondents incorporated a systematized movement theory into their class content. Laban Movement Analysis/Effort Actions (Jordan, 2011) was the most preferred method, followed by Dalcroze Eurhythmics, Alexander Technique, or some combination of the three. This progression away from the textbook being the primary source for educational content demonstrates an evolution of the curriculum and a desire from instructors to present a wider perspective of the knowledge and skills required to be a conductor.

Teachers of conducting live in the tension between transmitting the artistic and expressive gesture related skills and the proficiencies of pedagogy, effective teaching, and rehearsing (Manfredo, 2008). Often these skills are approached separately with the belief that you cannot address rehearsal, teaching, and pedagogical skills without first mastering basic expressive gestures. Current research, however, suggests that the physical skills of conducting and the pedagogy of rehearsal and performance should be seen as an integrated form of

knowledge and skill. Foster (2015), while looking for how conducting and music teaching intersect in practicing music educators, concluded that teaching and conducting are a specialized form of knowledge that are integrated into one construct when put into real-life scenarios. As such, the pedagogical aspects of conducting should be presented along with the physical gestures from the beginning, thereby mirroring the integration of teaching and conducting that occurs in practice.

Varvarigou and Durrant (2011) encouraged conducting teachers to consider the interplay of the complex knowledge and skills of conducting when designing and executing their curriculum. They advocated for clear objectives and learning targets within conducting courses that can be fulfilled by the students over time. They observed that these objectives can be categorized into three larger constructs that students need to master through their coursework.

According to Varvarigou and Durrant, the first attribute of an effective conductor was that he or she should possess philosophical and pedagogical awareness. Objectives that fall into this construct included understanding how instruments and the human voice function, knowing the instrumental and/or choral repertoire, and being aware of the social, psychological, and physical effects that participating in an ensemble has on an individual. Musical and technical skills described the second category of objectives included posture, gestural vocabulary, and aural and error detection skills. The final attribute of an effective conductor was that he or she should possess interpersonal and leadership skills. These objectives include encouragement and motivation, effective rehearsal pacing and planning, eye contact and other non-verbal communication methods, and enthusiasm/passion. While conceding that growth in leadership skills is a lifelong endeavor, Varvarigou and Durrant proposed that teachers of conducting courses offer support in confidence development and provide opportunities for students to not

only master musical and technical skills, but also leadership and interpersonal skills as well as pedagogical and philosophical knowledge.

While investigating the current status of conducting curricula, practices, and values, Hart (2019) found that conducting teachers value musical content knowledge and skills higher than general pedagogical and music pedagogical knowledge and skills. The knowledge and skills Hart associated with musical content included conducting patterns and gestures, score study/analysis, and expressive techniques. General pedagogical skills included managing the learning environment, understanding the characteristics of the learner, and responding to student needs. Finally, music pedagogical content knowledge and skills described the conductor's ability to combine pedagogy and musical knowledge together to present his or her musical ideas and intentions to musicians in meaningful ways that affect change. Included in this category were music assessment skills, ensemble rehearsal skills, specific knowledge of the instruments/voice, and music concept explanation and demonstration skills. Successful conducting curricula should have clear goals and objectives that present students opportunities not only to demonstrate learned gestural movements and other musical content knowledge and skills, but also to "think, feel, and act both like teachers and conductors, putting musical pedagogical content knowledge into practice" (Hart, 2019, 12).

As Romines (2003) and Manfredo (2007) suggested, the goals and objectives of conducting courses should be spiraled and sequenced over the entire conducting curriculum collaboratively so as to ensure that students can master the conducting objectives by the conclusion of their higher education experience. Each conducting course should incorporate objectives from each of the knowledge and skills constructs with a focus on providing authentic opportunities for students to not only learn musical and technical content knowledge and skills,

but also to practice the pedagogical, leadership, and music pedagogy skills they are acquiring. The practice of these previously mentioned content knowledge and skills requires the student to experiment with an ensemble (Varvarigou & Durrant, 2011). Hart (2019) suggested pairing the final conducting course with field placements congruently, so that pedagogical implications of conducting an ensemble can be discussed and transferred into practice in an authentic way.

Particular emphasis, especially in basic conducting courses, should be on building student conductors' confidence by setting clear objectives and learning targets that can be fulfilled within the first weeks of the semester. Building student confidence through the successful accomplishment of early learning targets could impact the future application of those skills when conducting students put them into practice with an ensemble (Fredrickson, Johnson, & Robinson, 1998).

While most teachers of conducting courses supplement their instruction with a variety of materials to demonstrate the wide array of opinions and techniques within the conducting community, textbooks continue to be an important aspect of the conducting curriculum (Hart, 2019; Romines, 2003; Runnels, 1992). Juslin and Persson (2002) highlight the usefulness of a textbook specifically in the pursuit of learning and developing the physical skills and gestures within conducting. The most popular textbooks for conducting courses (Manfredo, 2007) include *The Grammar of Conducting: A Comprehensive Guide to Baton Technique and Interpretation* (Rudolph, 1995), Green and Gibson's (2004) *The Modern Conductor*, and *The Art of Conducting* (Hunsberger & Ernst, 1992).

These texts are all quite similar in their design. All of them begin with a lengthy introduction of the physical gestures of conducting. These techniques are presented in sequential order of increasing difficulty. Green and Gibson (2004) and Hunsberger and Ernst (1992) begin

with posture with the former text providing simple movement exercises that are not bound by conducting gestures or patterns. Rudolph (1995) begins immediately by presenting basic techniques in patterns (part 1) followed by the applications of the basic techniques to concrete examples and interpretive gestures (part 2), the execution of gestures within a performance (part 3), and finally the interpretive and stylistic choices a conductor can and should not make (part 4).

All of the texts include (to varying degrees) sections on how to study scores and apply those skills to rehearsal and performance. Green and Gibson (2004) dedicate over a third of their book to discussing score study with applications made to band, orchestra, choral, opera, and concerto specific situations. Hunsberger and Ernst (1992) present score study within the first section of the book on basic techniques and principles while Rudolph (1995) focuses on the interpretation of the score and how the conductor should be dedicated to rehearsing and performing the repertoire as the composer intended it.

The Modern Conductor (Green & Gibson, 2004) is unique in that it provides applications to band, orchestra, and choir conductors. It also offers concrete pedagogical suggestions on rehearsal technique and public performance. *The Art of Conducting* (Hunsberger & Ernst, 1992) stands out with its useful anthology of musical excerpts for class performance and practice that correlate directly with each of the preceding 14 chapters. These provide an excellent application of the acquired skills in a musical context. While there are no specific music pedagogical strategies described, there are useful tools for conductors within the appendixes including sample syllabi, seating charts, and a concert preparation checklist. *The Grammar of Conducting* (Rudolf, 1995) is unique in its thorough approach and detailed descriptions of conducting gesture and performance. While applications of all of the gestures can be made to band and choral settings, it is primarily written from an orchestral perspective. All three of these textbooks possess their

own unique strengths and weaknesses and could be adapted to fit within a thoughtful conducting curriculum.

The use of assessment and feedback in conducting classes is strongly advocated for by researchers. Assessment in conducting classes should be student-focused and accompanied with specific feedback that highlights students' past growth and the areas in which they can improve. One of the most effective forms of feedback occurs when videotaping is combined with student reflection and teacher feedback (Runnels, 1992; Silvey & Major, 2014; Yarbrough et al., 1979). Providing opportunities for students to see their work and personally reflect on their experiences, preparation, and execution allows the feedback to be meaningful and might lead to higher retention rates. Silvey and Major (2014) found that weekly journal reflections were useful to students in successfully progressing through the course and Runnels (1992) reported that, even in the early 1990s, some conducting teachers were utilizing computers in their presentation of the conducting curricula.

Feedback that is student-focused, is made to specific individual students (as opposed to whole class feedback), and is more similar to a master class than a lecture provides opportunities for students to apply their knowledge and skills in a symbiotic environment where the teacher (and the conducting student's peers) can guide student progress toward the objectives being taught (Hart, 2019; Silvey & Major, 2014; Varvarigou & Durrant, 2011).

Courses in conducting are a crucial part of the curriculum in music schools in higher education. They are a synthesis of the knowledge and skills gained in other music courses (Silvey, 2011), provide opportunities for student leadership development (Hart, 2019; Manfredo, 2007), and prepare music education students and young conductors for their future rolls as ensemble leaders (Fredrickson et al., 1998; Silvey & Major, 2014). Despite its importance, a

standardized curriculum for conducting does not currently exist within schools of music. Many conducting teachers develop curriculum subjectively based on their own past experiences instead of investigating what current trends and pedagogical techniques might be available. One notable absence in most of the conducting textbooks and studies discussed above is the inclusion of the anatomic properties of conducting.

Since conducting involves physical movements that vary in size, sequencing, and timing, and biomechanics as a field continues to widen its scope of investigation and application, both fields of study might benefit from an integrative inquiry as to how conducting and biomechanics could better inform their respective pedagogies and praxis.

Biomechanics and Conducting

Biomechanics is the science involving the study of the mechanical physics of living organisms (Nelson, 1980). Biomechanical investigations examine both the internal forces produced from within the body and its muscles and external forces that act on the body. Kinematics is a subdivision of biomechanics and involves the magnitude, order, and timing of movements. Studies in biomechanics apply the principals of physics to biological systems in a wide variety of ways, highlighting the multidisciplinary nature of the science and its investigators (Hall, 2012).

Investigations of musical performances have shown that musicians' movements are associated with musical structures. Utilizing video and movement tracker analyses, Wanderley et al. (2005) observed that participating clarinetists' movements were directly connected with the musical qualities as presented in the score. Davidson (2012) used a single marker to track how clarinet and flute players moved while playing alone and as a duet. She found that, despite clear postural differences associated with playing the clarinet and flute, body movements and

engagement were similar and coincided with musical contours including rising and falling phrases being manifested in the bending of the knee, a crouched position while holding longer notes, and embodying rhythmic passaged with rocking or swaying. While musical performance certainly requires the application of physical movements to play music fluently, these skills must "coexist with expressive intentions manifested through bodily movements and facial expressions that permit the communication of musical intention (clarifying musical structure), or meaning" (Davidson, 2012, p. 623).

While investigating how sight and sound influence the perception of musical performance, Vines et al. (2006) presented musically trained participants visual only, aural only, and visual and aural performances by two clarinetists. Using a sliding potentiometer, participants gave continuous responses of perceived tension and phrasing when presented with the performances. Results indicated that visual stimuli augmented and reduced participants' experience of tension according to specific points in the musical score. Additionally, the visual presentations extended the participants' perception of phrasing and aided in the anticipation of changes in emotional content.

Using motion-capture technology, MacRitchie et al. (2013) analyzed the movements of nine pianists and concluded that the movements associated with compositional features contribute to the meaning of performed music. These universal and idiosyncratic motion shapes represented corporal manifestations of the performers' interpretive choices and coincided with melodic and harmonic relationships within the score. Their findings strengthen the connection between interpretation and the physical expressions of musical structures through performance.

Utilizing gestures and physical movements, conductors attempt to motivate and inspire expressive playing or singing from the ensemble they are directing. While this objective

involves a wide variety of necessary competencies (including leadership, pedagogical, philosophical, and interpersonal skills) (Hart, 2019), conducting gestures and posture are an integral skill in eliciting musical responses from an ensemble (Green & Gibson, 2004).

Mathers (2009) identified three gestural modes that conductors utilize in their non-verbal communication with their ensembles. Corrective modes, while important because they emphasize clarity and precision, tend to be overused by conductors who often only sparingly use declamatory and narrative modes. Utilizing the non-verbal communication categories of affect displays (muscle movements associated with displayed emotion), regulators (physical manifestations of regulating the back and forth nature of speaking and listening), and illustrators (movements that illustrate what is being said verbally) in a musical context can promote the enhancement of more expressive playing. This increase in the ensemble's musicality can be achieved by the conductor when a wider variety of declamatory and narrative modes are incorporated into his or her gestural vocabulary.

Utilizing spatial occlusion, Wöllner (2008) explored how different parts of the body communicate both expressive intentions and information. Participants watched randomized videos of conductors that were manipulated by showing only the face, only the arms, and a peripheral view of the entire body and were asked to rate various communicative items. While videos only presenting the face during performance were rated significantly higher in terms of expressivity, videos that showed only the arms communicated significantly more interpretive musical information to the observers.

Perceived expression in conducting has also been measured in biomechanical research using optical motion capture techniques. Luck et al. (2010) recorded two early-career professional conductors with a Qualisys Pro-Reflex system while they rehearsed Mozart's

Requiem Mass in D minor (K. 626) with an ensemble of forty musicians. Reflective markers were placed on the hands, wrists, elbows and shoulders of the conductors and tracked over six excerpts. The recordings were then converted into point-light videos using MATLAB and the MoCap Toolbox. Using a continuous response digital interface, participants rated each video's level of expression, valence (how pleasant they appeared), activity, and power. The investigators then extracted eleven movement features from each performance: four for the horizontal and vertical position of each hand, one for the distance between each hand, and six for the velocity, acceleration, and jerk of movements of each hand. While looking into the relationship between the continuous response digital interface data and the eleven movement features, Luck et al. concluded that higher perceived levels of expressive conducting could be conveyed to musicians using increased amplitude, greater variance, and higher speeds of movement.

Optical motion capture techniques were also used by Luck and Sloboda (2007) to measure musicians' synchronization with conducting patterns. After recording conductors' hands, arms, and shoulders, the investigators created point-light representations of simple conducting gestures and patterns. Participants viewed these life-size videos and were asked to tap in sync with the beat. The study revealed that students who had conducting experience showed higher levels of synchronization accuracy.

Synchronization has also been measured by comparing audio waves of musicians playing while being led by a conductor recorded with optical motion capture hardware and software simultaneously. Luck and Toiviainen (2006) analyzed audio data that were synchronized with the motion capture data of a single conductor. Four excerpts were extracted: two demonstrating high beat clarity and two demonstrating low beat clarity. The pulse of the ensemble, as measured through the spectral flux of the audio signal, was cross-correlated to the movement data and

results showed higher levels of synchronization when the conductor's hand had a greater upward velocity.

Motion capture techniques have recently been employed to measure how conductors' body movements communicate specific, pre-determined intentions and interpretations to their ensembles. Huang et al. (2017) met individually with six conductors who made a minimum of five specific annotations on their scores of the beginning of the first movement of *Eine Kleine Nachtmusic* by W. A. Mozart (K. 525). These annotations contained adjectives describing their gestures and an explanation of how the conductor expected the ensemble to respond. Each conductor then led a string quartet through three trials of the selected excerpt. The trials were recorded using a nine-camera Qualisys Pro-Reflex optical motion capture system. While the researchers used twenty-five markers, only the data from the tip of the baton marker was analyzed to identify prominent kinematic features.

Cross-correlations were used to investigate the relationships between the kinematic movements (including speed, acceleration, and jerk) and within-conductor and between-conductor trials. Huang et al. (2017) determined that within-conductor trials demonstrated significantly more similarities than between-conductor trials. However, when compared to the annotations made in their scores, conductors used similar gestures when delivering targeted musical structures and varied their movements after those moments. These findings suggest that, despite each conductor's unique gestural style, conductors' movement kinematics incorporate specific musical compositional structures and reflect the conductors' predetermined musical interpretational intentions.

Summary

Despite the recent contributions that have linked biomechanical techniques with the art of conducting, the majority of investigations of how conducting movement is analyzed in respect to compositional and expressive elements have been both subjective and qualitative. Frequently, conducting curricula and research studies rely on live or video-recorded observations that cannot accurately measure the forces produced within or externally on the body. Gestural vocabulary is learned by the conductor through detailed descriptions in textbooks (Green & Gibson, 2004; Hunsberger & Ernst, 1992; Rudolph, 1995), imitation and directives from teachers (Hart, 2019), and trial and error with an ensemble (Varvarigou & Durrant, 2011). These methods, by not incorporating biomechanical research, fail in quantifying what is specifically happening within the body while conducting, thereby missing the opportunity of being specific and direct in their instruction and feedback.

Another limitation to the current body of knowledge is the relationship between the interpretation of physical gestures by musicians through their playing or singing and the biomechanics of conductors' physical movements. In the same way that verbal communication is only effective if the listener internalizes and applies what is being said, effective non-verbal communication through gesture not only presents a musical idea, but, in order to be effective, must also communicate musical intent that is manifested in the musicians' playing. How the physical movements of conductors and the music that musicians produce as a result of those gestures influence each other is a guiding question within my investigation of the relationship between biomechanics and conducting. Congruently utilizing optical motion capture systems, 3-dimensional visual representation and analysis software, audio wave visualization analysis, and measures of musicians' perceived levels of conducting effectiveness will enhance our

understanding of how the physical movements of conductors, as demonstrated through their gestures, effectively communicate directive, interpretive, and corrective instructions to an ensemble who observe those movements and respond through their performed music.

Chapter 3

Method

In this chapter I will discuss the methodology used. Because different samples were used to answer different research questions, I will organize this chapter by describing each research question in succession. The methods used in this study were approved by the university institutional review board. The three research questions I will describe the methodology for are:

1. What are the biomechanical characteristics of the conducting gestures with two variants of staccato gestures and two variants of legato gestures?
2. Do college musicians' performances differ after viewing a conductor who demonstrated two variants of staccato gestures and two variants of legato gestures?
3. Do college musicians' ratings of conducting effectiveness vary after viewing a conductor who demonstrated two variants of staccato gestures and two variants of legato gestures?

Research Question One

Sample

I recruited one professional conductor who had extensive experience in teaching basic and advanced conducting at a large university in the mid-south region of the United States. This conductor specialized in wind band conducting, having worked as a conductor of college level ensembles for over ten years and as a guest clinician at numerous festivals and honors ensembles throughout the United States. In addition to undergraduate conducting courses, he also taught graduate courses in advanced conducting, rehearsal techniques, and score study. The conductor is a 43-year-old Asian-American male who holds two advanced degrees in conducting from a highly competitive school of music in the south-western region of the United States. He predominantly conducts with a baton held in his right hand.

Procedures

During the initial meeting, I described to the conductor that he would be asked to conduct four measures of quarter notes four times with his baton-hand only. For the first excerpt, I instructed him to conduct each pulse with an exaggerated staccato gesture. The second excerpt would be conducted with an understated gesture for staccato. An exaggerated gesture for legato would be used for the fourth excerpt and an understated gesture for legato would be used for the fourth and final excerpt. I selected staccato and legato gestures because they represent the extremes of playing in terms of the length and separation of the notes. Exaggerated and understated variants of these gestures were chosen for this research question to investigate the differences in biomechanical and kinematic characteristics between subtle and overstated movements by the conductor. I instructed the conductor to conduct all of the excerpts to a consistent metronome pulse with the quarter note set to 72 beats per minute. This tempo would allow the conductor enough time to demonstrate both understated and exaggerated gestures clearly and with precision.

During the meeting, I instructed the conductor to describe each of the gestures in terms of space/focus, weight, and time (Laban, 2011). At the conclusion of the meeting, the conductor successfully demonstrated each of the conducting exercises (exaggerated and understated staccato and legato) with the metronome and a videotaping session was scheduled for one week later.

Frontal-view recordings of the conductor were made using a Sony Handycam AX53 Camcorder (Model No. FDRAX53) in the musculoskeletal analysis laboratory on the university campus where the conductor was employed. There were no other people present in the lab besides the conductor, three laboratory technicians, two camera operators, and myself. The

conductor wore a long-sleeved compression shirt and held a white, 13-inch baton in his right hand. The field of view was focused exclusively on the trunk of the conductor's body, framed on the bottom by his waist and on the top by his forehead. I selected this frame and single arm conducting in an effort to capture the full movement of the conductor's gestures, and eliminate the influence of gestures of expression from the non-dominant hand.

The conductor conducted four excerpts, each four measures long, to a consistent metronome pulse with the quarter note set to 72 beats per minute. Each excerpt was a set of sixteen quarter notes conducted with the baton-hand only. For the first excerpt, the conductor conducted each pulse with an exaggerated staccato gesture. The second excerpt was conducted with an understated staccato gesture. The third excerpt was conducted with an exaggerated legato gesture and the final excerpt was conducted with an understated gesture of legato. Each style was recorded three times resulting in twelve total videos. These videos were imported into iMovie and converted to black and white. One trial of each style was chosen by the investigator resulting in four videos - one of each style. The four videos were deemed valid by a panel of three expert conductors who viewed the final videos and agreed that they demonstrated 2 distinct variants of each of the musical styles.

In addition to the video recording, retro-reflective markers were placed bilaterally on the participant's upper and lower extremity, trunk and the tip of the baton to measure individual segment motion during the four conducting exercises using a 9-camera motion capture system (240 Hz, Qualisys AB, Goteburg, Sweden). A pair of force platforms were also used to record ground reaction forces (GRFs; 1200 Hz, AMTI Inc., Watertown, MA, USA) during the four conducting exercises.

Data Analysis

A retro-reflective marker on the tip of the baton produced coordinates for the position of the baton in three planes: x (left and right), y (front and back), and z (up and down). For this study, only the x and z planes were analyzed. Using these coordinates, data for position, velocity (first derivative), and acceleration (second derivative) were calculated using Visual 3D (C-Motion, Bethesda, MD, USA).

Average position (maximum and minimum), velocity (minimum, maximum, and mean), and acceleration (minimum, maximum, and mean) were calculated for each of the four measures in all four conducting conditions. For this study, only averages from the second and third measures were included in the analysis. The first and last measures of each conducting condition demonstrated higher variability due to a larger preparatory beat before the first measure and a sudden stopping of the movement in the final beat of the last measure. The positions, velocities, and accelerations for measures 2 and 3 of each conducting condition were averaged to produce one value for each variable of interest.

Range of motion, measured in meters (m), was calculated to determine the average width and height of each conducting condition by subtracting the minimum baton position from the maximum position. Mean velocities, measured in meters per second (m/s), were calculated to determine the average rates of speed and direction horizontally and vertically for each conducting condition. Maximum accelerations, measured in meters per second squared (m/s^2), were calculated to determine the highest rate of change of velocity over time horizontally and vertically for each conducting condition.

Research Question Two

Sample

Undergraduate and graduate instrumental music majors ($N = 11$) were recruited to participate in the study. Participants were clarinet players ($n = 5$) and saxophone players ($n = 6$) who had completed at least one semester of private study and large ensemble playing at a large university located in the mid-south region of the United States. Single reed instrumentalists were chosen due to their consistency and clarity of articulation.

Participants were male ($n = 8$) and female ($n = 3$), undergraduate ($n = 7$) and graduate ($n = 4$) students representative of both music ($n = 8$) and non-music ($n = 3$) majors with a wide variety of experience in performing with large ensembles and under different conductors. See Table 1 for a description of this experience by participant.

Table 1

Frequency Report for Ensemble Years and Number of Conductors

Participant	Years in Band	Years in Choir	Years in Orchestra	Years in Jazz Band	Number of Conductors
1	6	0	0	0	2
2	7	1	1	0	9
3	1	0	0	0	4
4	12	5	8	0	21
5	12	0	3	0	2
6	12	0	3	11	10
7	6	0	0	5	6
8	11	0	0	4	5
9	5	0	0	5	5
10	7	5	0	8	6
11	4	10	0	20	15

Procedures

Initial data collections were planned to take place within in a *Wenger Soundloc* Sound isolating practice room with in the school of music on the campus of a large university in the mid-southern region of the United States. The practice room was selected in an effort to control for sound reflections (reverberations) when analyzing the specific length of notes and space between the notes being performed by the participants. This location would have allowed me to take more precise measurements of the durations and time between each of the notes. However, due to changing circumstances surrounding the global pandemic of the COVID-19, the data collection and instrument (Appendix F) were converted to an online survey delivery and data collection took place in the participants' homes.

Informed-consent letters (Appendix D) were attached to the recruitment letter (Appendix B) that was emailed to the participants. After agreeing to the informed consent letter, participants selected the link to the survey and completed a demographic survey that was used for comparative analysis. Included in this survey were questions pertaining to their sex, years of study, how many years they had taken private lessons, how many years they had participated in a large, conducted ensemble, their primary instrument, and their current classification.

Following the demographic section, students were given five minutes to prepare their instrument and body for playing through whatever warm-up procedure they routinely used. A video timer was embedded into the survey that automatically advanced to the next slide after 5 minutes had elapsed.

Participants were then instructed to prepare a recording device to record their playing while they watched the videos in the survey. Suggestions for recording their playing included utilizing a smartphone, portable audio recorder, tablet, or a second computer. Suggestions were

also given for which applications were available to record audio using a smartphone or tablet. Participants were told to label their file *LastName.FirstName.Instrument* and place the recording device 2-4 feet away from the bell of their instrument.

Following the warm-up and recording device set-up procedures, participants advanced to the performance portion of the measured experiment and were given the following instructions:

> You will now watch the set of four conducting videos twice. During the first viewing, only watch (do not play) all four videos, paying particular attention to the articulation that the conductor is demonstrating through his baton gesture. You will then start your recording on your device (phone, recorder, etc.). During the second viewing of the four videos, you will respond to each video by performing 16 single pitch quarter notes over each four measure exercise that demonstrate the articulation you observed. Clarinetists will perform each exercise on their second line G and alto saxophones will perform each exercise on their fourth line D (see image below). You will receive prompts throughout the video reminding you of each step. If your instrument and recording device are ready, please go to the next page.

The participants were also shown an image (Figure 1) that demonstrated the pitch and rhythm of the exercises.

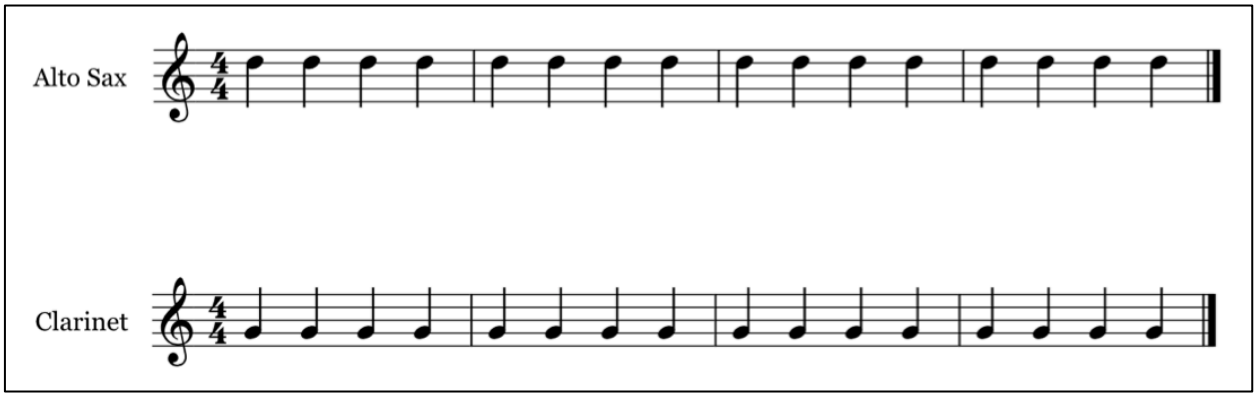

Figure 1. Image of Pitches and Rhythm for Clarinet and Saxophone Participants.

The participants watched a researcher-created video (Appendix H) that included the following prompts and instructions:

"Round 1: Watch the four conducting videos carefully."

"Pay attention to the articulation that the conductor is demonstrating in each video."

"Do *NOT* play along with these 4 videos – watch only."

"Round 2: During this round you will play 16 quarter-notes for each video."

"Clarinets will play on the second line 'G.'"

"Alto Saxophones will play on the fourth line 'D.'"

"Be sure to imitate the articulation that you see in each video on that pitch."

"You will record one audio file for all four videos."

"Press record on your recording device now."

"Prepare to play."

"Stop the recording on your recording device."

"Follow the directions for uploading your audio file on the next page of the survey."

"Thank You!"

Following the recording of the four conducting conditions, the participants were instructed to save the file (LastName.FirstName.Instrument) and upload it to a researcher-provided file request link that saved their file to a secure, password protected cloud storage system.

Data Analysis

The audio recordings were analyzed by examining visualizations of the audio waves of the excerpts and measuring the durations the notes (from attack to release) utilizing custom software (MATLAB, Mathworks, Inc., Natick, MA, USA). Note lengths were calculated by viewing a full-screen image of the audio waves, manually selecting the onset and offset positions of each note, and subtracting the onset time (in seconds) from the offset time (in seconds). Means for the duration of the notes of each conducting condition from each participant were calculated using the data from measures two and three (eight notes per condition). These central measures were selected to match the data analysis of research question one.

A one-way within subjects analysis of variance was conducted to compare participants' average note lengths across the four conducting conditions. Descriptive statistics were used to make comparisons between average note lengths, the four conducting exercises, and the kinematic and biomechanical measurements taken from research question one.

Research Question Three

Sample

Students (N = 75) who were members of large ensembles at a large university in the mid-south region of the United States were recruited to participate in the study. Participants were enrolled in either a band (n = 32), orchestra (n = 9), or choir (n = 34). Due to the low number of

orchestra participants, the band and orchestra participants were grouped together as instrumentalists (n = 41).

The sample that identified as instrumentalists was composed of the following instruments: bassoon (n = 2), cello (n = 2), clarinet (n = 6), double bass (n = 1), euphonium (n = 2), flute (n = 3), horn (n = 2), oboe (n = 1), percussion (n = 3), piano (n = 1), saxophone (n = 2), trombone (n = 3), trumpet (n = 5), tuba (n = 2), viola (n = 3), or violin (n = 3). Of the 34 vocalists, participants self-identified as sopranos (n = 12), altos, (n = 8), tenors (n = 6), baritones (n = 3), or basses (n = 5). The participants were male (n = 42) or female (n = 33) and were majoring in music business (n = 4), music composition (n = 3), music education (n = 26), music performance (n = 30), or a non-music field (n = 12).

Procedures

Initial data collection plans were to take place during scheduled rehearsal times in large rehearsal spaces on the campus of the university. This location was chosen as a convenience of having most large ensemble members present during a regularly scheduled rehearsal and to control for the size of projected videos. The initial method of collecting data was to have students use pencil on a paper copy of the demographics and Conducting Effectiveness Survey. However, due to changing circumstances surrounding the global pandemic of the COVID-19, the instrument (Appendix G) was converted to an online survey that participants completed remotely. Each ensemble director sent links to the survey to the participants in their groups. This included choir directors (n = 3), band directors (n = 2), and an orchestra director (n = 1).

Informed-consent letters (Appendix E) were attached to the recruitment email (Appendix C) that was sent to the participants by their directors. After agreeing to the informed consent letter, participants selected the link to the survey and completed a demographic survey to be used

for comparative analysis. Included in this survey were questions pertaining to the participants' sex, their current major, primary instrument, years of private study, years of participation in a conducted band, choir, or orchestra, an estimation of how many conductors they have performed under since their freshman year in college, and current classification. Following the demographic section, participants proceeded to the researcher-designed Conductor Effectiveness Survey (CES).

In order to assess the participants' ratings of the effectiveness of the conductor's two variants of staccato and legato gestures, the participants completed the researcher-designed CES in which they rated each conducting condition on how effective the conductor was in demonstrating the desired gesture. The four conducting condition videos (Appendix H) were randomized through the survey software but each participant was shown each condition one time. After each video, participants were asked, "How effective was this demonstration of the (staccato/legato) gesture?" Participants then responded to each question by selecting a number from 0 to 10 on a fixed, sliding scale selector, where 0 was labeled highly ineffective and 10 was labeled highly effective.

Instrumentation

The researcher-created CES was designed to measure participants' ratings of how effective the video-demonstrated conducting gestures were. Specifically, the instrument asked participants to rate how effective they perceived the demonstration of staccato and legato gestures were on a Likert-type scale from 0-10. A choice of 0 on the scale represented a perception of the participant that the demonstrated gesture was "highly ineffective." A choice of 10 on the scale represented a perception of the participant that the demonstrated gesture was "highly effective."

The CES was deemed valid by a panel of three expert conductors and music educators with an average of ten years of college ensemble conducting experience. Two of the experts identified as male and one expert identified as female. All three experts had at least one degree in wind conducting and all held doctorates in music. There was unanimous agreement between the experts when asked if both staccato and legato videos represented staccato and legato gestures. There was also unanimous agreement between the experts when asked if the two staccato and two legato examples were obviously different in size. When asked if the language of the instrument (specifically using the term "effective" in the participants' interpretation of the gestures) was appropriate, all three experts again agreed in the affirmative.

Minor suggestions in the language of the instrument were given. One expert suggested changing the word "demonstrate" when referring to the videos of the conducting to "feature." This correction was made in the final version of the CES by replacing the word "demonstrate" with "feature" twice in the directions preceding the instrument. Two experts questioned the need for including a question regarding participants' sex in the demographic portion of the instrument. One expert challenged the need for a binary definition of sex while the other expert suggested adding an option of "choose not to answer" or "other" in an effort to minimize the risk to identity. The question was retained in an effort to allow for further analysis of the descriptive data; however, the suggestion of adding two options, "other" and "choose not to answer," was applied to the final version of the instrument. The options under the question "what is your sex" were updated to "male," "female," "other," and "choose not to answer."

In a pilot study of undergraduate music education majors (n = 8), the researcher-designed CES showed a high degree of test-retest intra-class correlation reliability in all four conducting conditions. The average ICC measure with a 95% confidence interval in the understated staccato

condition was .92 and .81 in the exaggerated staccato condition. In the legato conditions, the average ICC measure with a 95% CI was .87 in the understated condition and .86 in the exaggerated condition.

Data Analysis

Two separate mixed analyses of variance were conducted to determine if the ratings differ across the two staccato conducting exercises and two legato conducting exercises between ensemble membership, years of experience in a conducted ensemble, and the estimated number of conductors they have played under. Descriptive statistics were used to make comparisons between the results of the mixed analysis of variance and the kinematic and biomechanical measurements taken from research question one.

Chapter 4

Results

Research Question One

Research question one examined the biomechanical characteristics of two variants of staccato gestures and two variants of legato gestures. Specifically, the variables of interest were the range of motion, mean velocity, and maximum/peak acceleration of the tip of the baton in two planes: x (horizontal) and z (vertical). Table 2 presents the descriptive statistics of these variables for each of the four conducting conditions (understated and exaggerated legato and staccato).

Table 2

Range of Motion, Mean Velocity, and Maximum Acceleration of the Tip of the Baton for Staccato and Legato Conducting Conditions in Horizontal (x) and Vertical (z) Planes

Conducting Condition	Range of Motion (m)		*M* Velocity (m/s)		Maximum Acceleration (m/s^2)	
	x	z	x	z	x	z
Legato						
Understated	0.23	0.14	0.001	-0.002	23.32	12.47
Exaggerated	0.63	0.36	-0.014	-0.009	32.94	18.31
Staccato						
Understated	0.05	0.07	-0.002	-0.003	21.29	46.91
Exaggerated	0.41	0.46	0.003	-0.00004	82.50	473.12

Understated conditions in both staccato and legato had smaller vertical and horizontal ranges of motion than their exaggerated counterparts. Across gestures, the understated legato condition's horizontal range of motion was 4.5 times higher and the vertical range of motion was 2.1 times higher than the understated staccato condition's range of motion, indicating that the conducting pattern of the understated legato condition was wider and higher than the understated

staccato condition's pattern. The exaggerated legato condition had a higher horizontal range of motion but a lower vertical range of motion than the exaggerated staccato condition, indicating that the conducting pattern of the exaggerated legato condition was wider and shorter than the exaggerated staccato condition's pattern. Figure 2 shows the size of the each conducting pattern ("conducting window") by plotting the ranges of motion in the x and z planes of each condition.

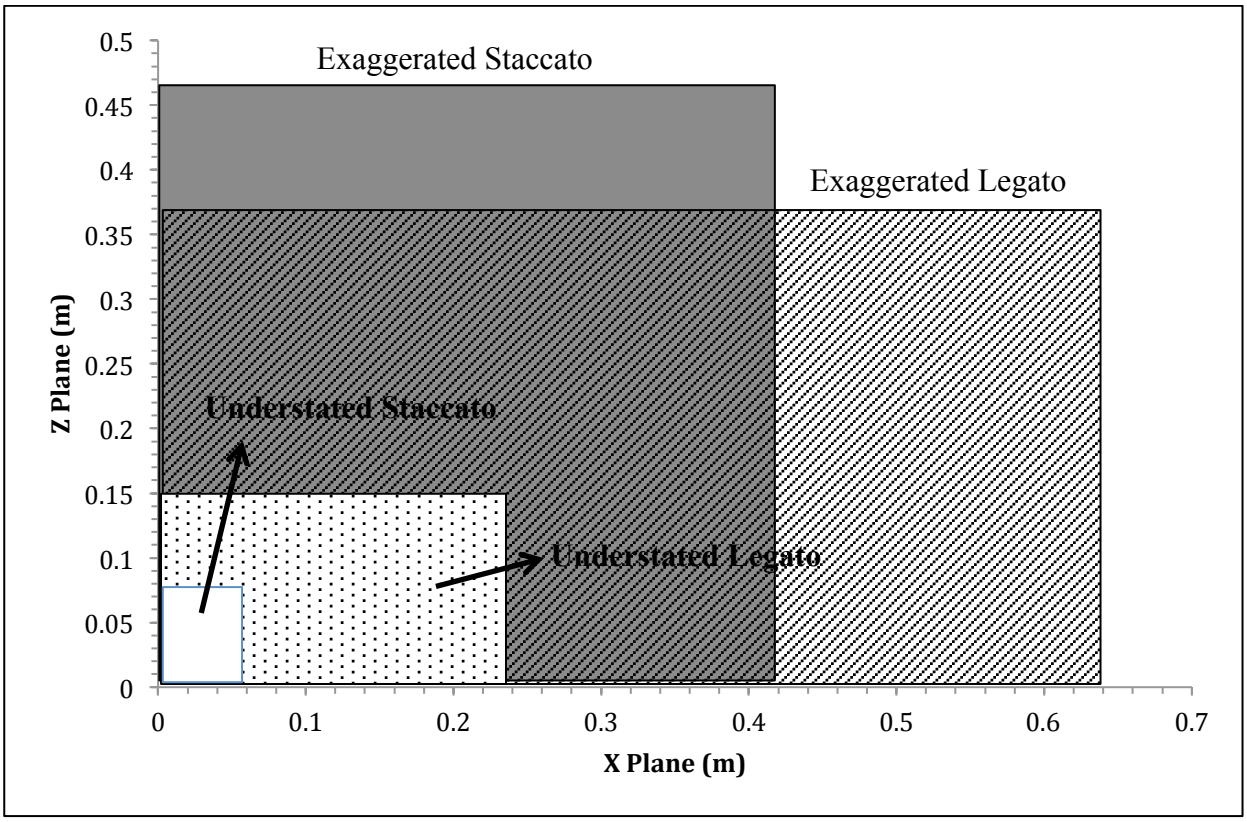

Figure 2. "Conducting Window" Sizes from Conducting Ranges of Motion (Z Plane and X Plane) for Exaggerated and Understated Staccato and Legato Conducting Conditions.

Both legato conditions had higher horizontal (x) ranges of motion than vertical (z) ranges of motion. The understated legato condition had a horizontal range of motion that was 1.62 times longer than its vertical range of motion. The exaggerated legato condition had a horizontal

range of motion that was 1.76 times longer than its vertical range of motion. By contrast, both staccato conditions had higher vertical (z) ranges of motion than horizontal (x) ranges of motion. The understated staccato condition had a vertical range of motion that was 1.33 times higher than its horizontal range and the exaggerated staccato condition had a vertical range of motion that was 1.13 time higher than its horizontal range. This indicates that legato gestures tend to be wider than their staccato counterparts.

Further comparisons of the conducting conditions revealed that the exaggerated legato condition's range of motion was 22.37cm wider and 10.4 cm shorter than the exaggerated staccato conduction. The understated legato condition was both taller and wider than the understated staccato condition (z plane = 7.24 cm, x plane = 17.55 cm).

As an example of how horizontal and vertical position work together, Figure 3 shows how the marker on the tip of the baton recorded 1 measure (4 beats) of horizontal movement (W1::X) and vertical movement (W1::Z) in the exaggerated staccato condition. The movement in the z plane displays large, sudden changes while the x plane movement is gradual until the time between beats 3 and 4 (indicated by the 4^{th} and 5^{th} tick-marks).

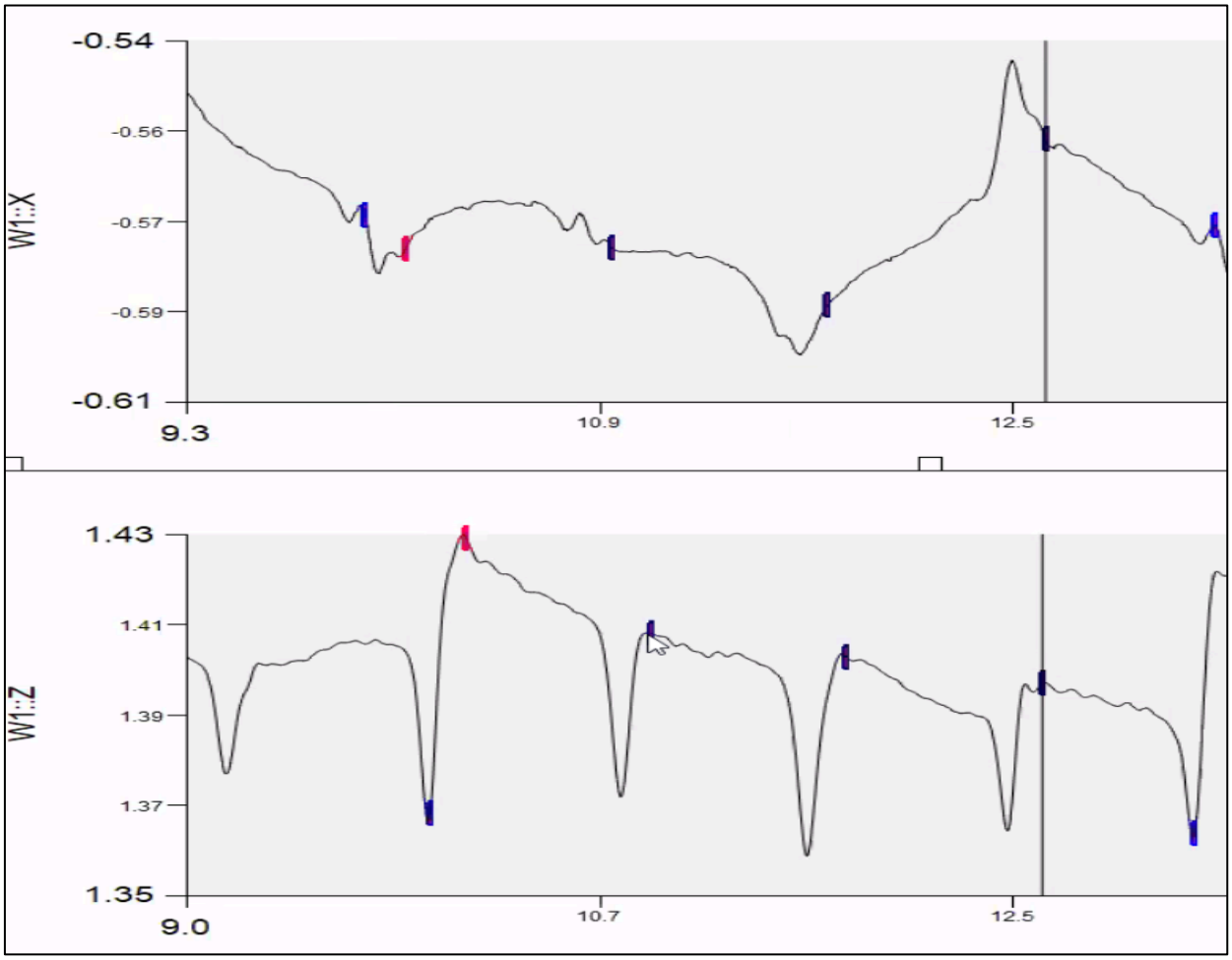

Figure 3. XY Position Measurements in the Exaggerated Staccato Condition Across Four Beats.

Changes in velocity also become clearer when compared with position. Figure 4 shows how the velocity in the z plane (W1_VEL::Z) spikes during ictus and then remains stagnant as the motion slows in the exaggerated staccato condition. By contrast, Figure 5 shows less static velocity and position, representing the continuous and smooth vertical movement in the understated legato condition.

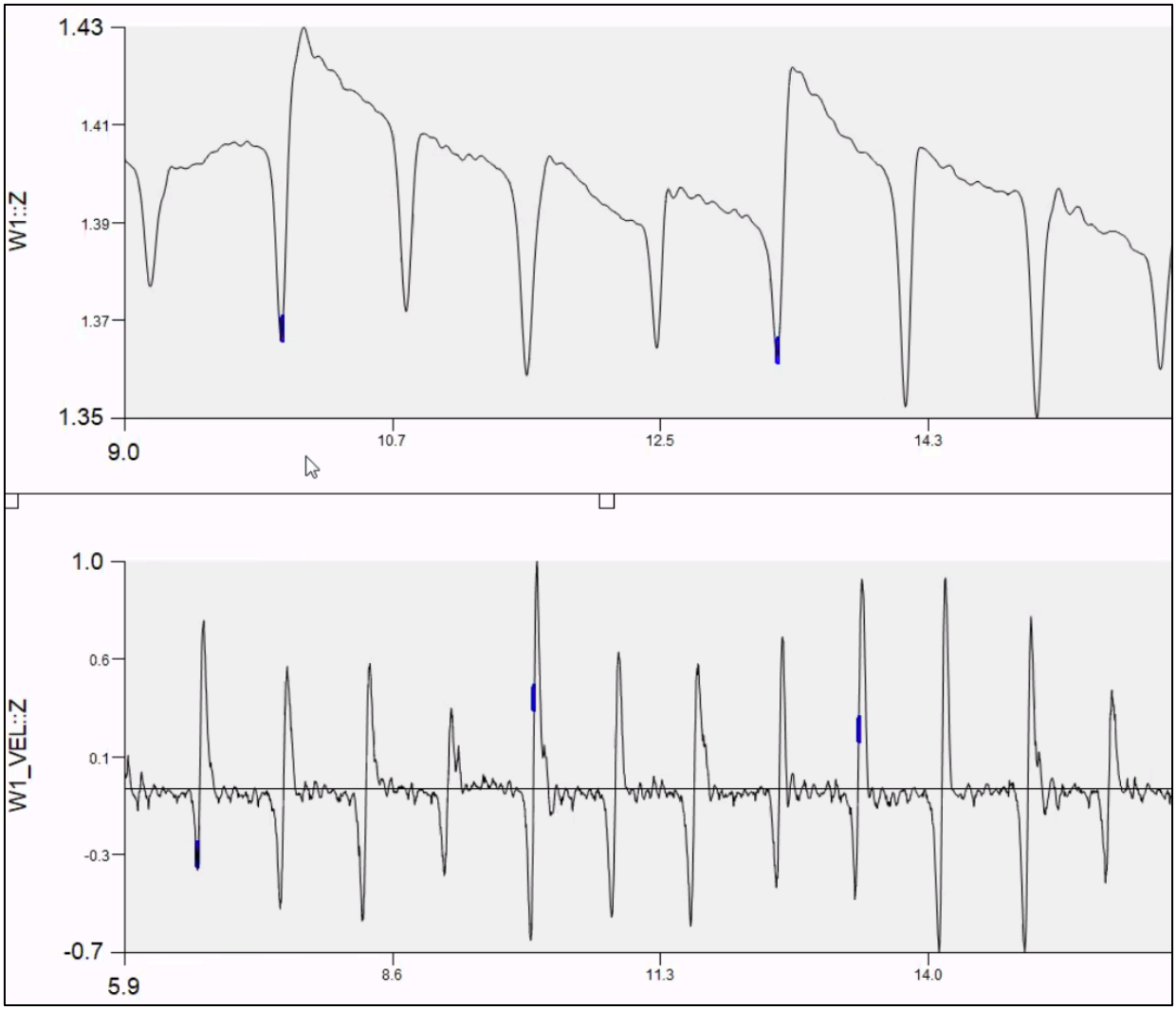

Figure 4. Z Position and Z Velocity Over Time (s) in the Exaggerated Staccato Condition.

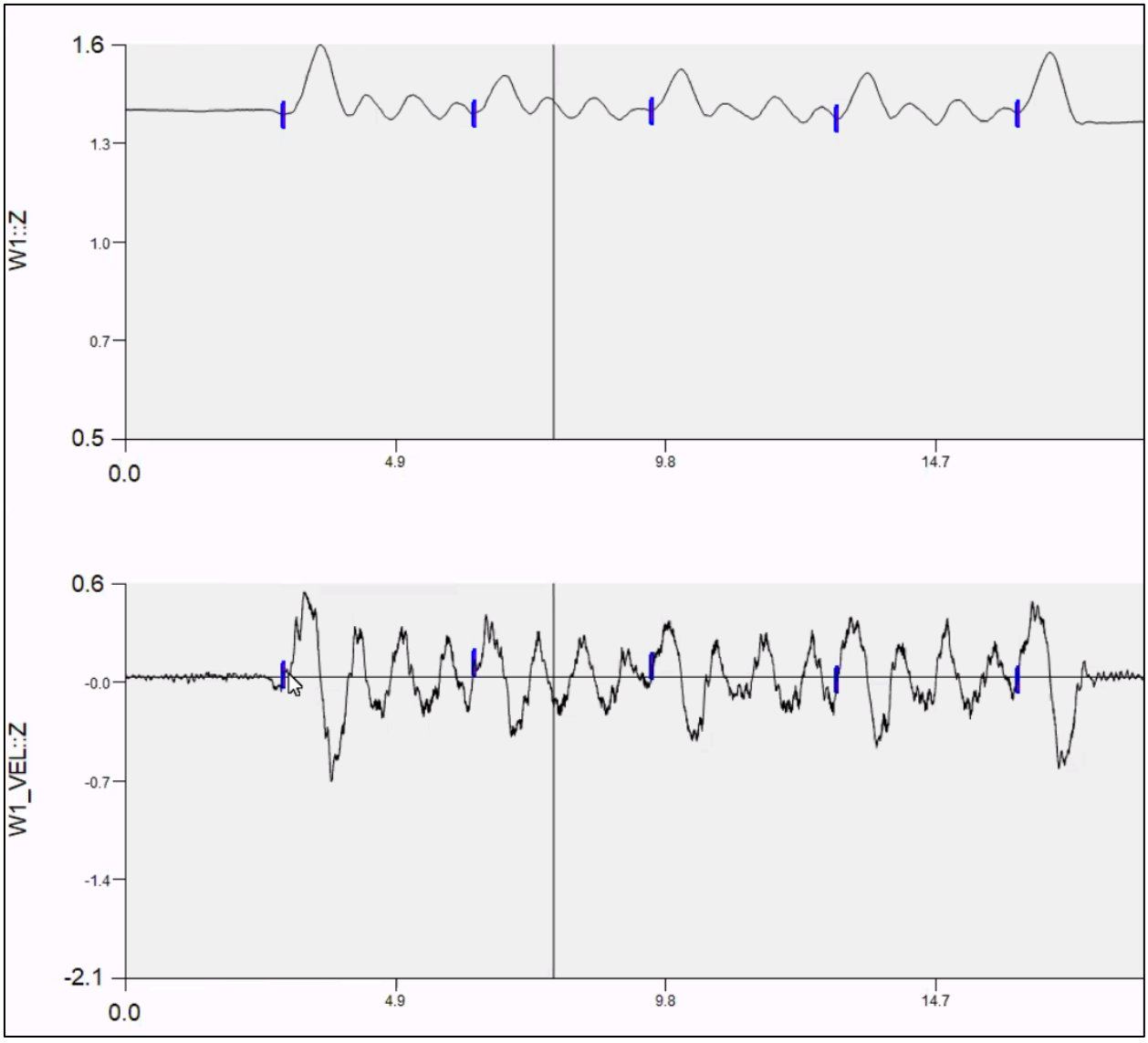

Figure 5. Z Position and Z Velocity Over Time (s) in the Understated Legato Condition.

Maximum accelerations were also calculated and were higher in both x and z planes in exaggerated conditions than understated conditions. Across gestures, the understated legato condition had a slightly higher horizontal peak acceleration than the understated staccato condition. However, its vertical peak acceleration was 3.8 times slower than the understated staccato condition. The exaggerated staccato condition's peak acceleration was 2.5 times higher

in the horizontal plane and 25.8 times higher in the vertical plane than the exaggerated legato condition.

Research Question Two

Research question two examined the reactions (performances) of clarinet and saxophone players to the four conducting conditions as demonstrated by the expert conductor in research question one. Means were calculated for each participant's performance of each conducting condition by averaging the note lengths from measures two and three (eight notes in total) of each recording. The mean note length (in seconds) of each conducting condition was calculated by taking the mean of all of the participants' average note length in that condition. Figures 6, 7, 8, and 9 show the onset measurements (represented by a red circle) and the offset measurements (represented by the intersection of the crosshairs) of the first beat of measure two of Participant 10's understated staccato, understated legato, exaggerated staccato, and exaggerated legato recordings, respectively.

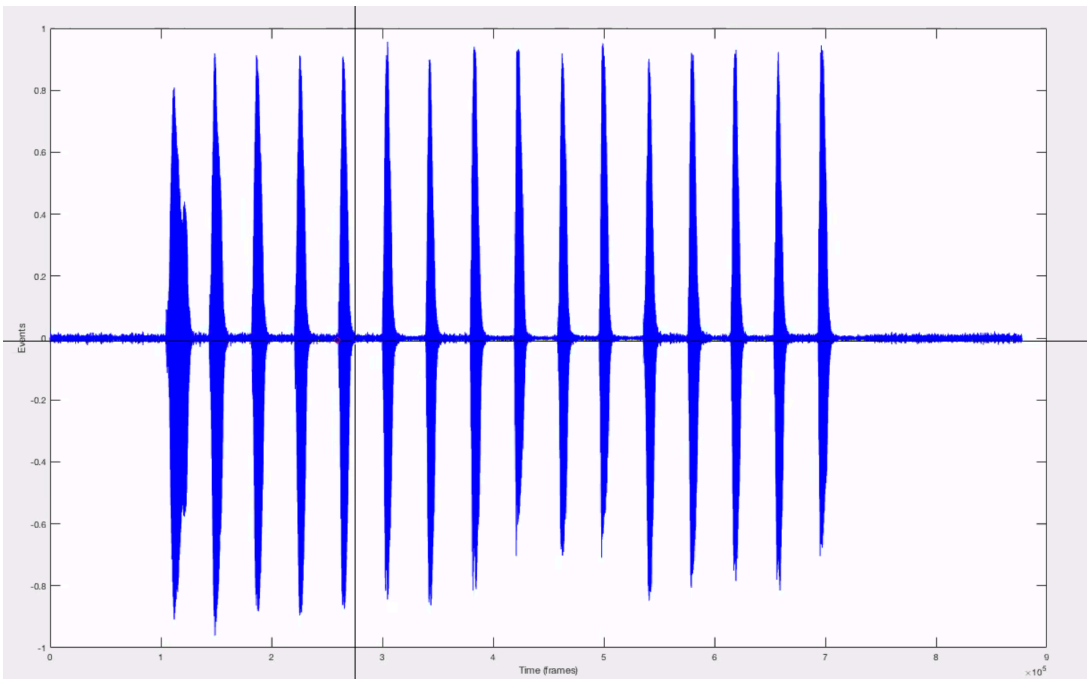

Figure 6. Onset and Offset Measurements of a Participant's Understated Staccato Recording.

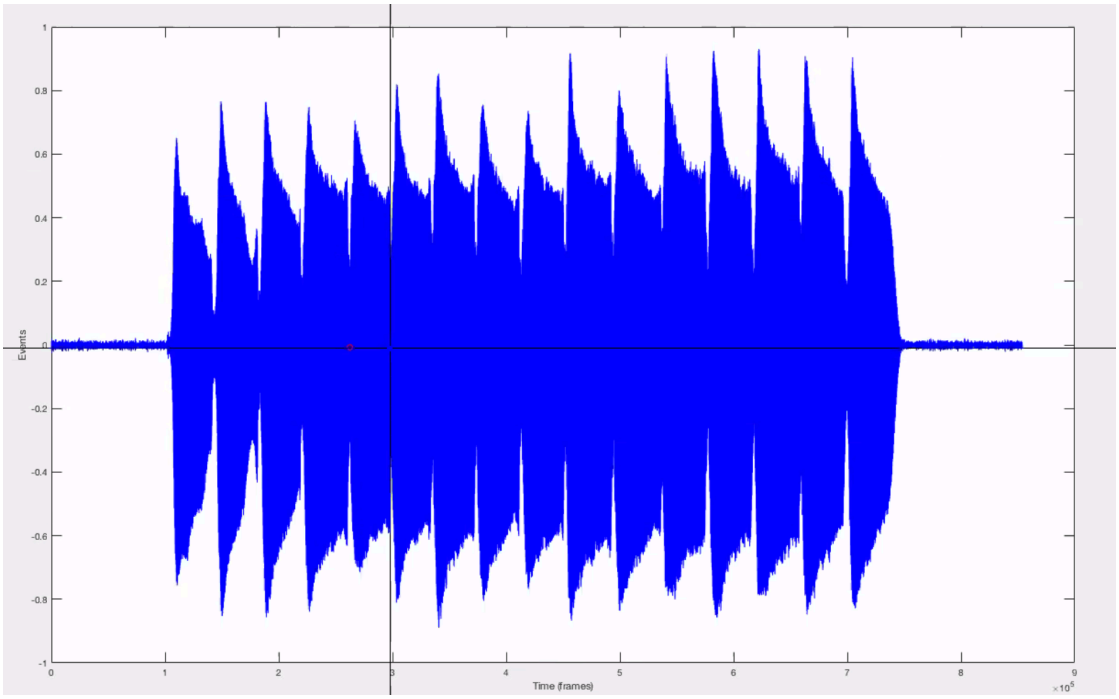

Figure 7. Onset and Offset Measurements of a Participant's Understated Legato Recording.

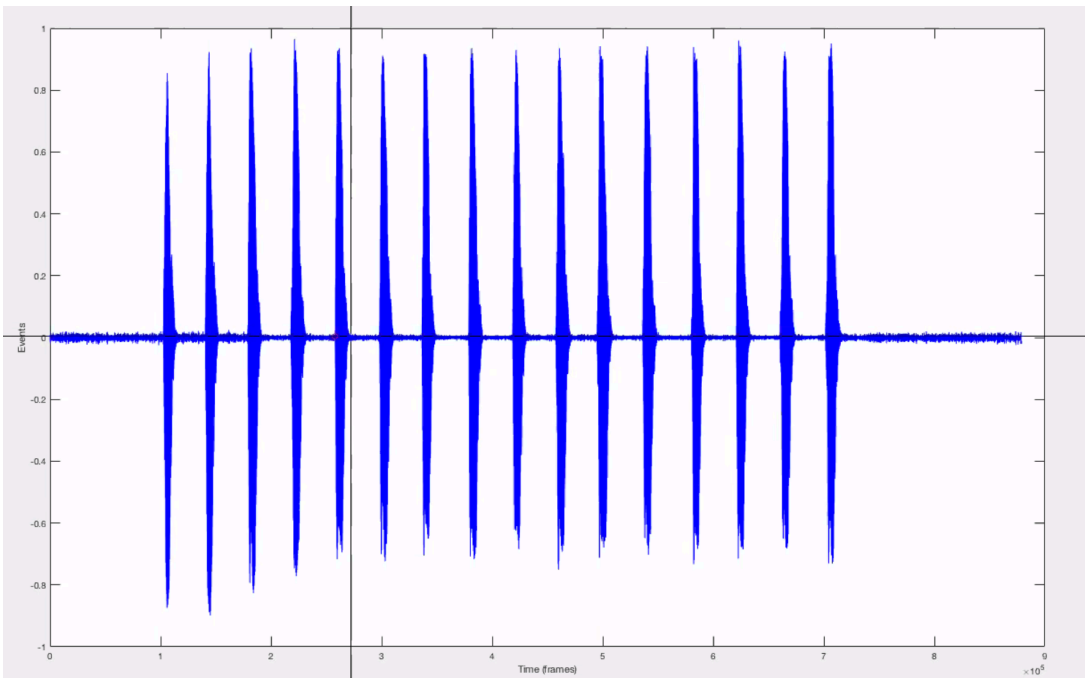

Figure 8. Onset and Offset Measurements of a Participant's Exaggerated Staccato Recording.

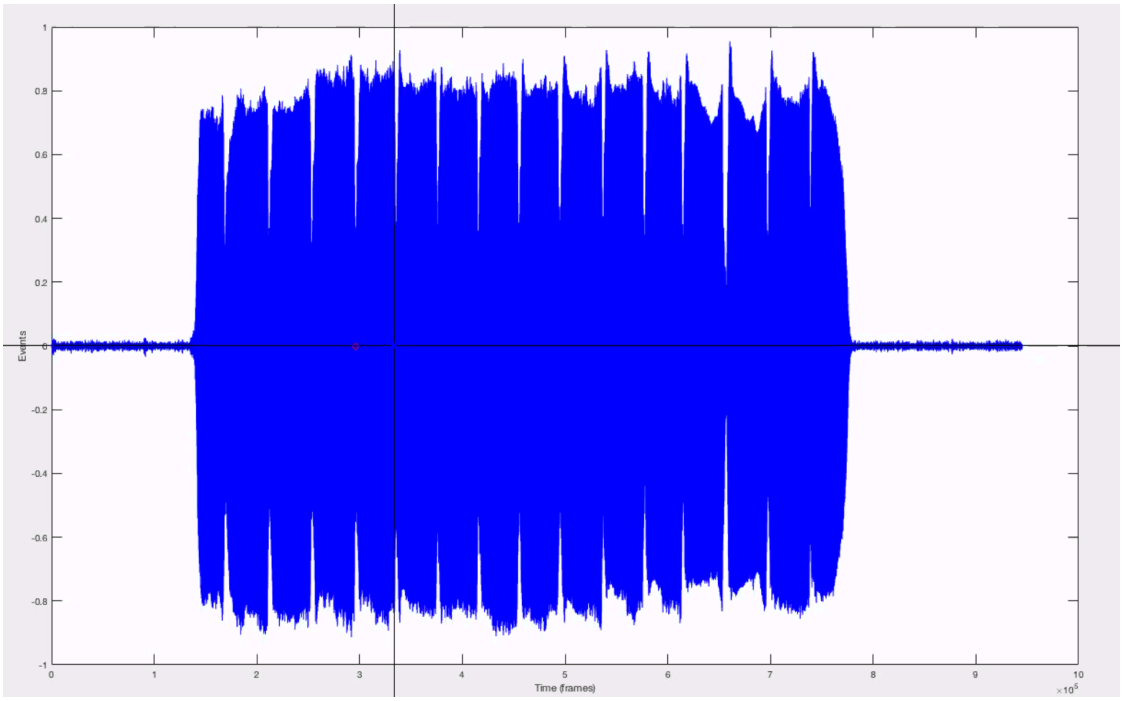

Figure 9. Onset and Offset Measurements of a Participant's Exaggerated Legato Recording.

Table 3 presents the descriptive statistics of the average note lengths for each of the four conducting conditions (understated and exaggerated staccato and legato). As a reference, one beat of music at 72 beats per minute is .833 seconds long.

Table 3

Descriptive Statistics of Average Note Lengths (s) in Four Conducting Conditions

Condition	*M*	*SD*	Minimum	Maximum	Skewness	Kurtosis
Understated Staccato	.44	.14	.25	.75	1.06	1.92
Exaggerated Staccato	.40	.12	.23	.59	.048	-1.48
Understated Legato	.68	.12	.38	.76	-1.94	2.77
Exaggerated Legato	.75	.02	.70	.78	-1.30	1.28

The exaggerated legato condition had a longer mean note length than the understated legato mean note length, indicating that the larger beat pattern of the conductor produced longer notes. The exaggerated staccato condition had a slightly lower mean note length than the exaggerated staccato condition, indicating that the larger, more intense beat pattern produced slightly shorter notes. Understated staccato, exaggerated staccato, and understated legato all had standard deviations between .12 and .14 and ranges of .50, .36, and .38 seconds respectively. By contrast, the exaggerated legato condition had a standard deviation of .02 and a range of .08 seconds, indicating that this condition had the most consistency of performance by the participants among the four conducting conditions.

In order to compare the average note lengths across the four conducting conditions (exaggerated and understated staccato, exaggerated and understated legato), a one-way within subjects ANOVA was performed. Due to the violation of sphericity, the Greenhouse-Geisser

correction was used. The result from the one-way ANOVA revealed an overall main effect, $F(2.66, 26.57) = 29.15$, $p < .001$, $\eta_p^2 = .745$. Comparison of conditions using a Bonferroni correction found significant differences between understated legato and understated staccato (mean difference = .24, $p = .01$, 95% CI [.07-.41]), understated legato and exaggerated staccato (mean difference = .27, $p = .001$, 95% CI [.11-.43]), exaggerated legato and understated staccato (mean difference = .32, $p < .001$, 95% CI [.18-.45]), and exaggerated legato and exaggerated staccato (mean difference = .35, $p < .001$, 95% CI [.22-.48]). No significant differences were found between exaggerated and understated staccato or exaggerated and understated legato.

Research Question Three

Research question three examined the ratings of conducting effectiveness of college musicians who were members of large ensembles. Table 4 presents the descriptive statistics for each of the four conducting conditions (understated and exaggerated staccato and legato). The overall mean score was higher for exaggerated legato than understated legato. Similarly, exaggerated staccato had a higher overall mean score than understated staccato. Range scores were either from 0-10 (understated staccato and exaggerated legato) or 1-10 (exaggerated staccato and understated legato).

In terms of skewness and kurtosis, both understated conducting conditions were slightly negatively skewed while the exaggerated staccato condition was moderately negatively skewed. Kurtosis data for both staccato videos and the understated legato video were negative and above -1.0. The skewness and kurtosis data for the exaggerated legato condition are different when compared to the other three conducting conditions. The data are highly negatively skewed and the kurtosis demonstrates a leptokurtic distribution, indicating that there is a cluster of consistently higher rated scores in the exaggerated legato condition.

Table 4

Descriptive Statistics of University Musicians' Ratings of Conducting Effectiveness

Condition	*M*	*SD*	Range	Skewness	Kurtosis
Understated Staccato	5.36	2.59	0-10	-.18	-.69
Exaggerated Staccato	6.87	2.51	1-10	-.69	-.60
Understated Legato	6.07	2.52	1-10	-.36	-.84
Exaggerated Legato	8.17	2.10	0-10	-1.79	3.98

In order to compare the four conducting conditions, two mixed analyses of variance were performed to analyze the impact of the independent variables on the ratings of the four videos. The variables of interest were ensemble type (instrumental or choral), the estimated number of conductors each participant had performed under since their freshman year in college (Group A = 1-6 conductors; Group B = 7 or more conductors), and the estimated total number of years each participant had performed in a conducted ensemble since their freshman year in high school (Group A = 1-8 years; Group B = 9 or more years). These groupings were determined through an analysis of the data and finding midpoints for both the independent variables of number of conductors and number of ensemble years. A summary of the descriptive statistics for these groups and the four conducting conditions can be found in Tables 5 and 6.

Table 5

Descriptive Statistics for Staccato Conditions by Independent Variable Groups

Independent Variable Groups	Staccato			
	Understated		Exaggerated	
	M	*SD*	*M*	*SD*
Ensemble Type:				
Choral (*n* = 34)	5.06	2.39	6.56	2.51
Instrumental (*n* = 41)	5.61	2.75	7.12	2.49
Number of Conductors:				
1-6 Conductors (*n* = 31)	4.90	2.79	7.16	2.42
7 or more Conductors (*n* = 44)	5.68	2.42	6.66	2.57
Number of Conducted Ensembles:				
1-8 years in an Ensemble (*n* = 38)	4.58	2.43	7.11	2.32
9 or more years in an Ensemble (*n* = 37)	6.16	2.52	6.62	2.69

Table 6

Descriptive Statistics for Legato Conditions by Independent Variable Groups

Independent Variable Groups	Legato			
	Understated		Exaggerated	
	M	*SD*	*M*	*SD*
Ensemble Type:				
Choral (*n* = 34)	5.74	2.40	8.15	1.89
Instrumental (*n* = 41)	6.34	2.61	8.20	2.27
Number of Conductors:				
1-6 Conductors (*n* = 31)	6.71	2.53	8.29	1.81
7 or more Conductors (*n* = 44)	5.61	2.44	8.09	2.29
Number of Conducted Ensembles:				
1-8 years in an Ensemble (*n* = 38)	6.00	2.59	7.92	2.05
9 or more years in an Ensemble (*n* = 37)	6.14	2.57	8.43	2.14

Two separate mixed ANOVAs were performed with the within subject variables being the conditions of exaggerated and understated staccato for the first analysis and exaggerated and understated legato for the second analysis. The between subject variables for both mixed

ANOVAS were ensemble type, estimated number of conductors group, and estimated number of years in a conducted ensemble group.

Conductor effectiveness ratings for each of the two staccato conducting videos (understated and exaggerated) were compared to determine the effects of ensemble membership, estimated number of conductors group, and estimated number of years in a conducted ensemble group on the conductor effectiveness ratings. Before conducting the four-way mixed ANOVA, a separate repeated-measures ANOVA was used to check for an order effect. No presentation order effect was found for the two staccato conditions, $F(1, 73) = .33$, $p = .57$.

A main effect was found between the understated ($M = 5.36$, $SD = 2.59$) and exaggerated ($M = 6.87$, $SD = 2.51$) staccato gestures, $F(1, 67) = 11.83$, $p = .001$, $\eta_p^2 = .15$, with participants preferring exaggerated staccato over understated staccato. No main effects were found for ensemble membership, number of conductors, or number of years of ensemble participation. A statistically significant interaction was found for the staccato condition by the ensemble experience group, $F(1, 67) = 5.50$, $p = .02$, indicating that participants with one to eight years of experience in an ensemble had much less preference for the understated staccato condition than the exaggerated staccato condition, while those with nine or more years of experience in an ensemble remained reasonably constant in their rating of both staccato conditions (see Figure 10).

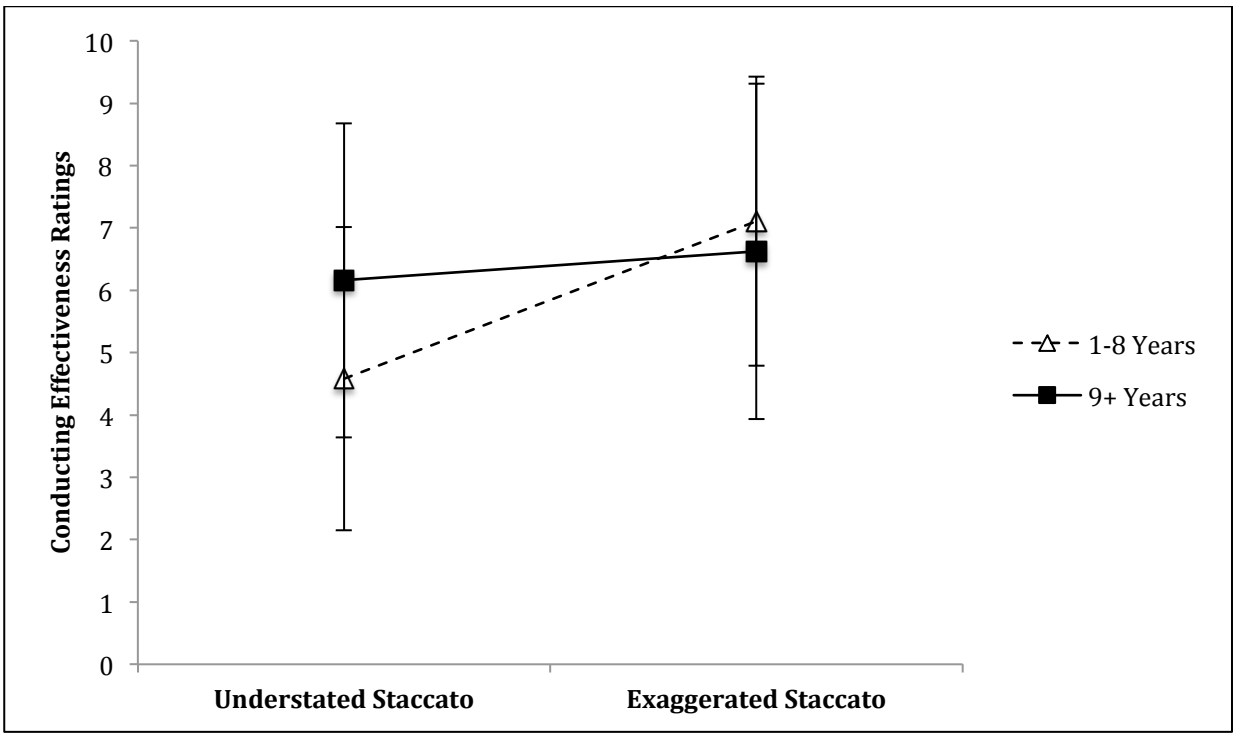

Figure 10. Interaction of the Staccato Condition by Ensemble Experience Group.

Conductor effectiveness ratings for each of the two legato conducting videos (understated and exaggerated) were also compared to determine the effects of ensemble membership, estimated number of conductors group, and estimated number of years in a conducted ensemble group on the conductor effectiveness ratings. Before conducting the four-way mixed ANOVA, a separate repeated-measures ANOVA was used to check for an order effect. No presentation order effect was found for legato, $F(1, 73) = 3.70$, $p = .06$.

A main effect was found between understated ($M = 6.07$, $SD = 2.52$) and exaggerated ($M = 8.17$, $SD = 2.10$) legato gestures, $F(1, 67) = 30.31$, $p < .001$, $\eta_p^2 = .31$, with participants preferring exaggerated legato over understated legato. No main effects were found for ensemble membership, number of conductors, or number of years of ensemble participation.

A statistically significant interaction was found between the number of conductors and ensemble type in the exaggerated legato condition with instrumentalists with one to six conductors rating the condition higher than vocalists and vocalists with 7 or more conductors rating higher than instrumentalists, $F(1,67) = 4.63$, $p = .04$, $\eta_p^2 = .07$. This interaction in Figure 11 shows that while instrumentalists' ratings of the exaggerated legato condition decreased as their exposure to more conductors increased, vocalists' ratings increased as they were exposed to higher numbers of conductors.

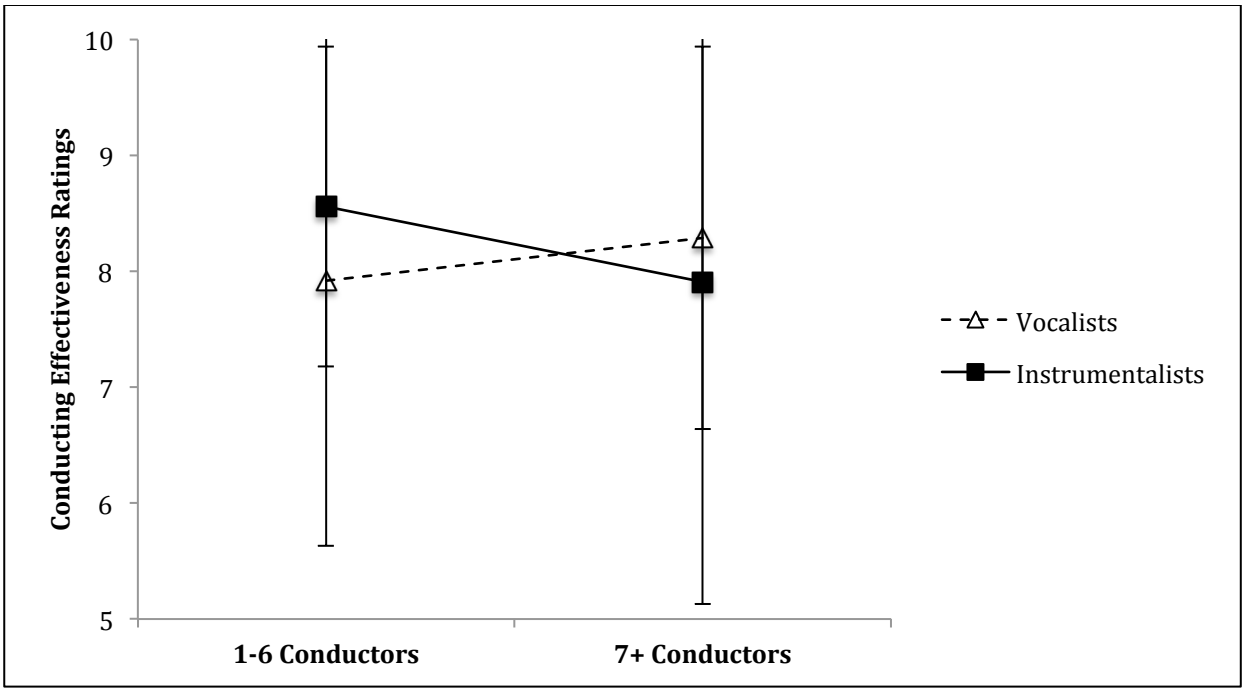

Figure 11. Interaction of the Number of Conductors Groups by Ensemble Type in the Exaggerated Legato Condition.

Statistically significant interactions were also found between the ensemble years groups and ensemble membership type, $F(1, 67) = 6.49$, $p = .01$, in both the exaggerated and understated legato conditions. Figures 12 and 13 show that in both understated and exaggerated legato

conditions, instrumentalists' ratings increased and vocalists' ratings decreased when comparing the lower ensemble experience group with the higher ensemble experience group. Instrumentalists who had more ensemble experience rated both legato conditions higher than their less experienced counterparts while more experienced vocalists rated both legato conditions lower than those vocalists with less experience.

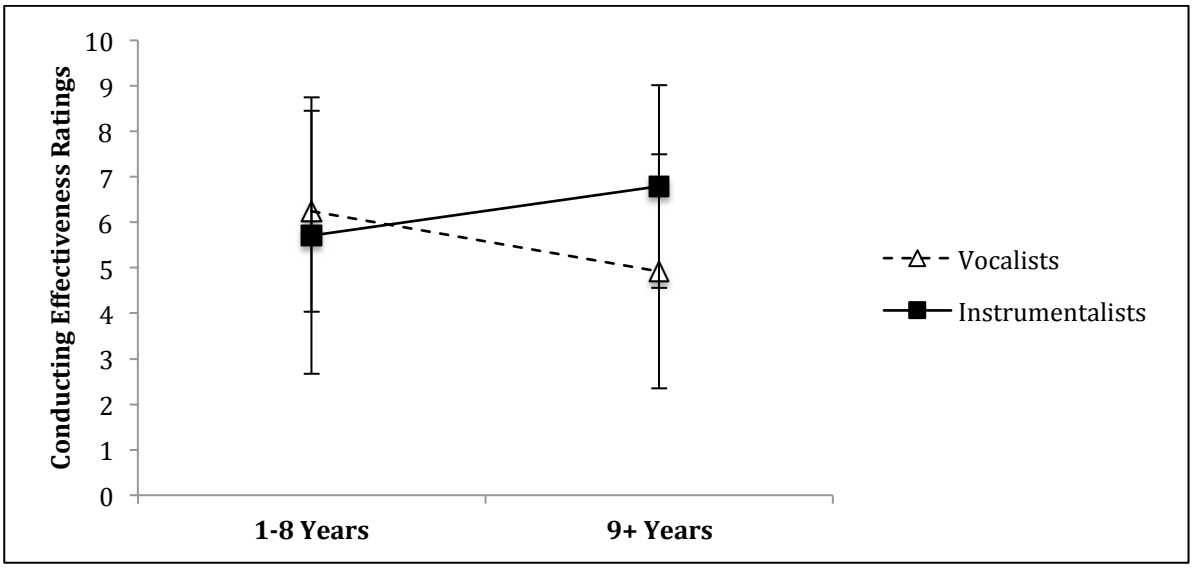

Figure 12. Interaction of the Ensemble Years Groups by Ensemble Type in the Understated Legato Condition.

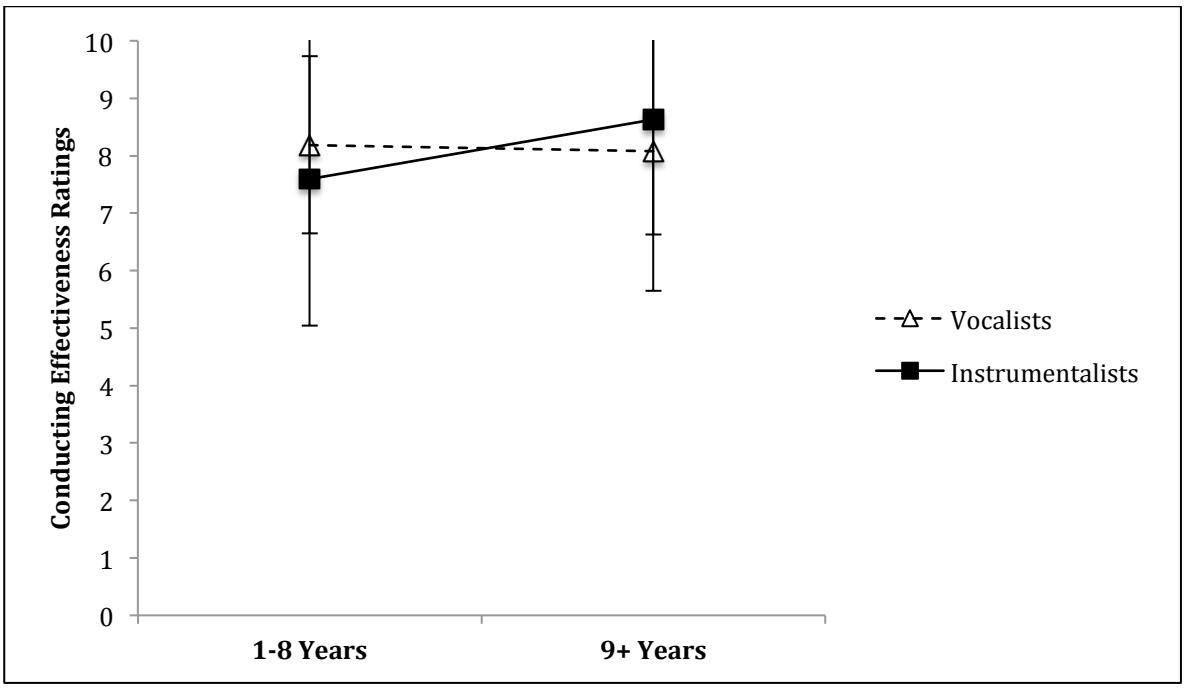

Figure 13. Interaction of the Ensemble Years Groups by Ensemble Type in the Exaggerated Legato Condition.

Statistically significant interactions were also found between the conductor exposure groups and ensemble membership type, $F(1, 67) = 4.65$, $p = .04$, in both the exaggerated and understated legato conditions. Figure 14 shows that while instrumentalists' ratings of the exaggerated legato condition decreased from the low conductor exposure group to the high conductor exposure group, vocalists' ratings increased when the lower conductor exposure group was compared to the higher conductor exposure group. This interaction also demonstrates that in the group that has been exposed to seven or more conductors, both groups preferred the exaggerated legato condition with the vocalists showing a slightly higher rate of change than the instrumentalists.

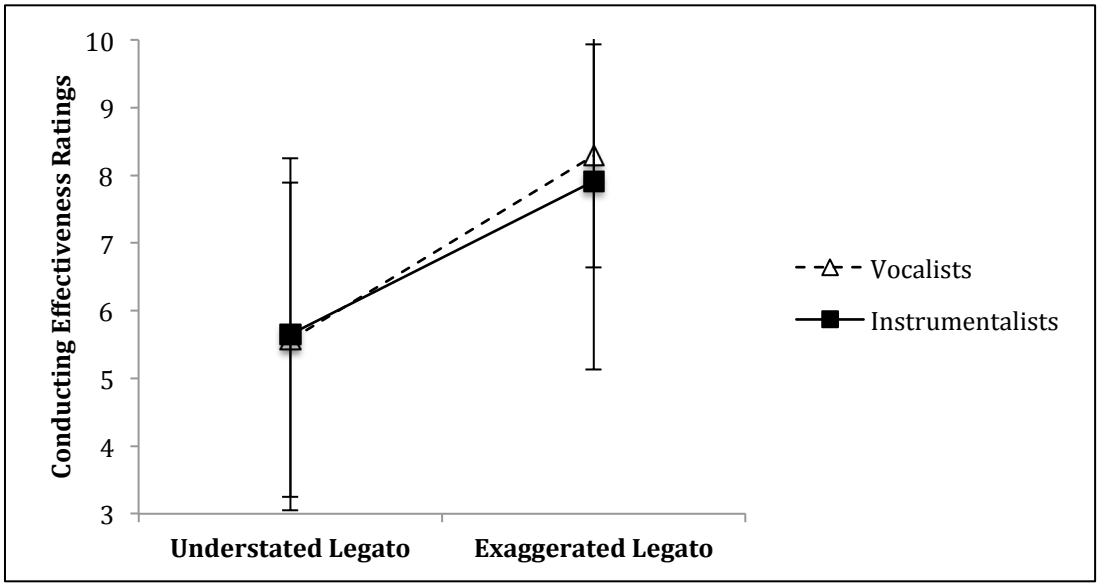

Figure 14. Interaction of the Legato Condition by Ensemble Type in the Seven or More Conductors Group.

Chapter 5

Discussion

The purposes of this study were to describe the biomechanical characteristics of staccato and legato conducting gestures and compare musicians' performances and ratings of perceived conducting effectiveness of conducting gestures across two variations of staccato and legato gestures with the kinematic descriptors of the gestures. The research questions that guided this project were:

1. What are the biomechanical characteristics of the conducting gestures with two variants of staccato gestures and two variants of legato gestures?
2. Do college musicians' performances differ after viewing a conductor who demonstrated two variants of staccato gestures and two variants of legato gestures?
3. Do college musicians' ratings of conducing effectiveness vary after viewing a conductor who demonstrated two variants of staccato gestures and two variants of legato gestures?

Summary of Results

Because different samples were used for each question, I will organize the summary of results by research question before addressing the synthesis of results from all three questions.

Research Question One

Research question number one's broad focus was on describing and comparing the biomechanical characteristics of two variations of four conducting gestures: understated staccato, exaggerated staccato, understated legato, and exaggerated legato. In an effort to narrow the scope of the investigation, I decided to focus specifically on the data gathered from one retro-reflective marker attached to the tip of the baton. This marker was chosen as the focus of attention because it is the furthest extension of the conducting arm and is in consort with current motion capture

research in conducting (Huang et al., 2017). The data of interest gathered through the baton tip marker included the position, velocity, and acceleration in horizontal (x) and vertical (z) planes over four measures of four quarter notes in the four conducting conditions. The central two measures of each conducting condition were extracted and analyzed due to their low variability. Averages for position, mean velocity, and maximum acceleration of measures two and three were calculated for each conducting condition in both x and z planes. Finally, range of motion was calculated for each conducting condition and plane by subtracting the minimum position from the maximum position.

Range of motion represents the average width and height of the conducting gestures in measures two and three of each conducting condition (see Table 2). Both understated conditions were narrower and shorter than their exaggerated counterparts with understated staccato having the smallest conducting window (area of the gesture). The legato gestures had higher horizontal ranges of motion than vertical ranges of motion, meaning they were wider than they were tall. By contrast, the staccato gestures had higher vertical ranges of motion than horizontal ranges of motion, meaning they were taller than they were wide (see Figure 2).

Exaggerated legato was the widest conducting condition and exaggerated staccato was the tallest conducting condition. Understated staccato was both the narrowest and shortest conducting condition.

Maximum acceleration represents the highest rate of change of the velocity over time. The lowest maximum rate of horizontal change was measured in the understated staccato condition while the highest maximum rate of horizontal change was measured in the exaggerated staccato condition. The lowest maximum rate of vertical change was measured in the understated legato condition while the highest maximum rate of vertical change was measured in

the exaggerated staccato conducting condition. Understated conditions had lower peak accelerations in both planes than their exaggerated counterparts. When comparing across gestures, the largest difference in maximum acceleration was measured between exaggerated staccato and exaggerated legato, where the exaggerated staccato gesture had a maximum acceleration in the vertical plane (z) that was 25.8 times faster than the exaggerated legato condition.

Research Question Two

Research question two investigated the recorded reactions (or performances) of clarinet and saxophone players to the videos created by the expert conductor in research question one. Specifically, this question examined the average note lengths of the participant's audio recordings to see how they differ by conducting condition (understated and exaggerated staccato and understated and exaggerated legato).

Analysis of the total note length means revealed statistically significant differences between the two staccato conditions and the two legato conditions, indicating that the performers perceived and performed different average note lengths between the two different gestures types. While no statistically significant differences were shown between exaggerated and understated variations of either staccato or legato, descriptive statistics indicate that the exaggerated gesture led to slightly shorter notes in the staccato conditions and longer notes in the legato conditions. Standard deviations and ranges also indicate that the exaggerated legato condition had the lowest variance of the four conditions, meaning the participants played their note lengths most consistently in that condition.

While not a direct focus of measurement for this study, visual examinations of the waves also indicate that exaggerated conditions had higher amplitudes than understated conditions (see

Figures 6, 7, 8, and 9 as an example from participant 10). This might indicate that the exaggeration or understatements of gestures are more related to volume than they are to note length.

These visual inspections also revealed more of a decay in the understated legato condition than in the exaggerated legato condition which might indicate that exaggerated gestures in legato result in greater connection of the sound while exaggerated staccato gestures have less impact on the length of the notes.

Research Question Three

Research question three investigated the perceptions of the four conducting condition recordings by university large ensemble members. Specifically, this question investigated if ensemble members' ratings would differ on the four conducting conditions based on ensemble type (band or choir), years of experience in a large ensemble since their freshman year in high school (1-8 years or 9 or more years), or their experience with different conductors since their freshman year in college (1-6 conductors, 7 or more conductors).

Significant differences were found in both staccato and legato conditions with participants preferring exaggerated demonstrations of the conducting conditions over understated conditions. Within the staccato condition, while participants with 9 or more years of experience remained reasonably constant in their ratings of both staccato conditions, participants with less experience had far greater preference for the exaggerated staccato condition than the understated condition. Within the legato conditions, two differences where found between instrumentalists and vocalists. Instrumentalists' ratings of the exaggerated legato condition decreased as they had exposure to more conductors while the vocalists' ratings increased (Figure 11). Conversely,

instrumentalists' ratings of both legato conditions increased as they gained more ensemble playing experience while vocalists' ratings decreased (Figures 12 and 13).

Descriptively, while all conducting conditions were rated moderately effective or above, participants rated the understated staccato condition as least effective and the exaggerated legato condition as most effective with skewness and kurtosis data showing a large cluster of participants rating the exaggerated legato condition highly. Generally speaking, participants rated the legato conditions higher than the staccato conditions within all but two groups (see Tables 5 and 6).

Synthesis of Influences of the Three Research Questions

This project was designed to answer three research questions regarding the biomechanics of conducting, musicians' response to video conducting stimuli, and musicians' ratings of conducting effectiveness. Through design, however, these three questions were not vaguely related to each other, but were purposefully linked through design, methodology, and analysis in an effort to provide a more holistic synthesis of how musical intent is communicated through physical gesture (Running, 2012). In that vein, the following is a combination of the influences of the results of the primary research questions.

The exaggerated legato condition was both rated as being the most effective in communicating its desired gesture and was performed by the instrumentalists with the lowest amount of variance when compared to the other conducting conditions. When looking at the results of the biomechanical measurements, the exaggerated legato condition had the highest conducting gesture area (x plane times z plane) and was the widest conducting condition. One possible explanation of the low variability and higher effectiveness rating is that when the conducting pattern is widened, beat placement becomes clearer. Specific to a pattern in 4/4 time,

the placement of the baton tip on beat one in the center of the pattern, beat two to the conductor's left, the longest horizontal travel to beat three on the right, and finally beat four back to the left might be made more clearly if the horizontal plane is elongated. This clearly defined pattern might be seen as reassuring to musicians who are looking for confirmation of their rhythm counting and performing, thereby being seen as more effective and being performed more consistently. Because expressive and specific gestures by conductors are both perceived as being preferential (Morison et al, 2009; Morrison & Selvey, 2014; Price and Mann, 2011) and influential on ensembles (Grechensky, 1985; Laib, 1993; Sidoti, 1990), despite some contrary findings (Price, 2006; Price & Chang, 2005), attention to clarity and the horizontal space required to show it might benefit from an expansion of the x (horizontal) conducting plane.

A second observation when considering the synthesis of this research is how the significant preference of the exaggerated gestures relates to the performance and biomechanical characteristics of the conducting conditions. Participants rated both the exaggerated staccato and legato conditions significantly higher than the understated conditions. This is in line with Luck et al. (2010) who found that higher perceived levels of expressive and specific conducting were conveyed to musicians when the conductor employed increased amplitude and higher rates of speed into their movements. Interestingly, while the changes in note length by the single reed participants were appropriately affected (exaggerated staccato gesture was an average of 40 ms shorter than understated and exaggerated legato was an average of 70 ms longer than understated), consistency of the exaggerated legato condition increased greatly by employing greater conducting range, speed, and maximum acceleration while the variance in the exaggerated staccato condition remained relatively constant. When conductors utilize directive or interpretive gestures (Mathers, 2009) with an ensemble, conductors might benefit from an

increased or exaggerated beat pattern. However, while corrective exaggerated legato gestures might be able to concisely affect change and increase precision, exaggerated staccato gestures may not have the same effect. The results of this study are clear that the height of the gesture and surprisingly high measurement of maximum vertical acceleration in the exaggerated staccato condition produced less average change in note length and far less consistency within the participants than the exaggerated legato pattern. This is in contrast to Luck and Toivianinen (2006) who found higher levels of synchronization in an ensemble when the conductor utilized greater upward velocity. These contrasting results might be attributed to the differences between ensemble playing and the individual nature of the data collection in this study. When musicians perform as an ensemble they utilize not only the conductor for group synchronization, but also aural cues from the musicians around them. This study eliminated that variable and had musicians record their responses to the conducting stimuli individually.

While the effectiveness of conducting certainly has multiple variables (Morrison & Selvey, 2014; Price, 2006; Silvey, 2011; Silvey & Fisher, 2015; Van Weelden, 2002), the interpretive and musical information that is transmitted and communicated non-verbally through the gestures of the arms continues to be of great significance (Green & Gibson, 2004; Huang et al., 2017; Wöllner, 2008) and therefor deserve consideration for future research.

Future Research

The results of this study demonstrate the high level of efficacy, precision, and practicality that can be attained when research into music performance, conducting, preference, and effectiveness are combined with the methodology, technology, and science of biomechanics. As researchers and conductors continue to search for ways to improve the use of body movements to communicate musical intensions to musicians who then interpret those gestures as instructions

for performance (Huang et al., 2017), it will be highly useful to employ the multidisciplinary (Hall, 2012) study of biomechanics and its implications on future research, performance, and pedagogy.

One possible area of future research involves the analysis of data from other parts of the conductor's body. While this study did collect data from multiple retro-reflective markers on the conductor, only the data from the tip of the baton was analyzed and reported in this investigation. Immediate research might consider investigating the joints of the arm that lead up to the tip of the baton, beginning with the shoulder, through the elbow and wrist, and up to the index finger to examine how the arm creates the movement of the tip of the baton. This future investigation might include the order of movements and the positions, velocities, and accelerations of these points in all three planes.

Another area of future research that applies do data collection could involve incorporating other technologies already in use by the field of biomechanics. Force platform data (which was recorded in this study, but not analyzed) would be highly useful in determining if or how the weight of the body shifts while conducting. Non-invasive surface electromyography could be used to determine the magnitude and firing order of the muscles involved in conducting. The use of these technologies, along with the motion capture data, could be maximized through their portability into live-ensemble settings where "real-life" data could be collected in real time, both in rehearsal and performance.

From a design standpoint, future research might consider expanding the number of conductors and participants who record their responses to visual cues. This study was limited by the small sample sizes in question one (one conductor who represented his own sex, race, training, and experience) and question two. Comparing the biomechanical and musical

differences of band, orchestra, and choir conductors, conductors of different body types, or conductors of varying experience levels, could provide useful data to practitioners and pedagogues alike. Expanding the question two respondent pool to all instruments within a band, orchestra, or choir could provide useful data on how musicians who perform on different voice parts or on different instruments respond to conductors' nonverbal cues.

Future research might also consider analyzing not only average note length, but also the amplitude, consistency of onset and offset when compared to a steady beat, and the slope of the audio wave visualizations. While not included in the data analysis of this study, visual observations of the waveform indicated that exaggeration of the gestures affected not just the average note length, but also how loud and with how much decay it was played. Investigations into these analyses could give the body of knowledge a more complete understanding of what it actually means to exaggerate a gesture and how exactly that exaggeration affects the musicians who are interpreting it.

Finally, the data collected in this study could be extrapolated over time to give an indication of the effect of conducting on the body over the careers of conductors and educators. The physical nature of conducting (and music making in general) might be prone to similar repetitive use injuries that have been heavily studied in sports sciences. By taking a similar approach to investigating the toll that performing music has on the body, perhaps more effective treatments and, more importantly, preventative measures could be explored. Targeted flexibility and strength training protocols could be devised in an effort to provide longer and healthier opportunities for students, performers, and educators to make music for a lifetime.

Limitations of Study

It is important to note that the results and implications of this study are specific to the location and samples that were employed. As such, caution should be exercised in generalizing the conclusions to contexts outside the settings of this study.

Research question one did not control for the face of the conductor. Plans were in place to record videos and collect data with a screen hiding the conductor's face. However, due to the global pandemic of COVID-19, a truncated timeline was employed and videos controlling for this variable could not be captured. As such, this study did not control for participants' potential bias towards the sex or race of the conductor. In addition, since the conductor was an ensemble director at the university where this study took place, this study could not control for prior relationships between the conductor and members of his ensemble who participated in this study through research questions two or three.

Another limitation due to the COVID-19 pandemic was the method of collecting data. Data collection was planned to take place on the campus of a large urban university in controlled environments. However, due to circumstances, the method was adjusted to a digital format where participants individually took part in questions two and three. This impacted the quality of the audio recordings of question two (which made offset and onset detection more difficult to determine due to uncontrolled reverberations) and the lack of control over how participants viewed the conducting videos of questions two in three. Students viewing the gestures on smaller devices might not have been able to detect some of the nuances that were demonstrated in the conducting videos, which might have influenced their results.

Sample size is also a limitation of this study. The one conductor that served as the participant for question one represents his own particular style, training, and execution of

gestures. As such, this conductor may not be representative of all styles, pedagogies, or conducting practices across genres (band, choir, orchestra, etc.), levels of experience, or philosophical beliefs about conducting. In addition, the sample size of question two is small which could also affect generalization. Single-reed instruments were selected in an effort to control for differences in embouchure formation and tone production. As such, caution should be exercised when generalizing the results of this study to musicians who produce sound in other ways.

Implications

Implications of the results and conclusions of this study could be of great benefit to musicians, educators, and conductors. Just as people can verbally communicate more effectively when they have a deeper understanding of each other's background, musicians who better understand how a conductor is attempting to communicate nonverbally may be able to better replicate the musical directions being given. By understanding what the size of the horizontal or vertical plane and changes in speed, velocity, and acceleration are communicating, musicians might be able to more effectively mirror what they see in their playing.

Educators and teachers of conducting may also benefit from the results of this study. By better understanding how the body moves and how those movements impact the responses in an ensemble, conducting pedagogues can begin to provide the specific and practical feedback that has been shown to influence the greatest amounts of change in behavior (Fredrickson et al.; 1998, Hart, 2019; Silvey & Major, 2014). The results of this study demonstrate that greater attention to widening the horizontal plane might help in evoking more precise performances. Conducting teachers might also consider emphasizing beat placement in the horizontal plane throughout all demonstrated gestures early in a conducting student's class sequence. This study

also implies that while greater vertical acceleration in staccato conducting may have an effect on the volume of the responses, it has little effect on the consistency or performance of the note length in the staccato gesture.

Another implication for conducting teachers is when, in the conducting course sequences, they begin teaching the staccato gesture. Frequently, conducting courses begin by emphasizing fluidity and minimal stopping of the pattern; a simple flick at the ictus before moving to the next beat. As such, staccato gestures begin to be applied after the fluid patterns have been acquired and get less practice and attention. The results of this study indicate that in order to be perceived as more effective than the understated legato condition, the conductor had to implement much greater acceleration to communicate the gesture. This skill takes time to develop and conducting teachers might consider ways to incorporate both fluid and stop patterns earlier in the course sequences.

Finally, conductors of ensembles might also benefit from the results and implications of this study. Utilizing wider horizontal conducting planes might aid in producing more consistent note lengths from the ensemble. The results of this study indicate specifically that if single reed instruments are struggling to play with even note lengths, conductors might consider widening their gesture. Placing beats clearly in the horizontal plane can confirm to musicians that they are placing their rhythms in the context of the time signature. This confirmation might provide musicians ease of mind, allowing them to more clearly focus on the interpretive gestures and musicality of the piece.

Conductors should also be conscious of the type of gestures they are providing to an ensemble. The results of this study show that there was little difference in note length in the performance of the staccato conditions, despite the high maximum vertical acceleration in the

exaggerated conducting condition. However, the understated staccato was perceived by ensemble members to be the least effective conducting gesture. If a conductor is utilizing directive or interpretive gestures in a staccato condition, varying the size and intensity of the pattern may have an effect on the volume and onset of the response, but it may not be necessary to substantially affect the precision or performance of the note length.

In total, when I consider the results and implications of this study, I am reminded that there is no perfect gesture; no "one and only way" to evoke a sound from an ensemble. Just as members of choirs, bands, and orchestras make countless decisions, most of them instinctively, to perform with nuance and musicality, so to do conductors experiment and respond in the moment to communicate with an inviting and infectious passion. In the end, these scientific investigations into conducting and biomechanics serve to strengthen that unexplainably symbiotic relationship between the ensemble and the person who has the privilege to stand in front of them and humbly be a part of the music being created – the conductor.

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Appendix A

IRB Approval Letter

Institutional Review Board
Division of Research and Innovation
Office of Research Compliance
University of Memphis
315 Admin Bldg
Memphis, TN 38152-3370

January 10, 2020

PI Name: Jonathan Schallert
Co-Investigators: Douglas Powell
Advisor and/or Co-PI: Ryan Fisher
Submission Type: Initial
Title: A comparison of conducting effectiveness, instrumentalists' performances, and the underlying biomechanics of a conductor while performing exaggerated and understated variations of staccato and legato gestures
IRB ID **:** #PRO-FY2019-598

Expedited Approval: December 23, 2019

The University of Memphis Institutional Review Board, FWA00006815, has reviewed your submission in accordance with all applicable statuses and regulations as well as ethical principles.

Approval of this project is given with the following obligations:

1. When the project is finished a completion submission is required
2. Any changes to the approved protocol requires board approval prior to implementation
3. When necessary submit an incident/adverse events for board review
4. Human subjects training is required every 2 years and is to be kept current at citiprogram.org.

For additional questions or concerns please contact us at irb@memphis.edu or 901.6783.2705

Thank you,
James P. Whelan, Ph.D.
Institutional Review Board Chair
The University of Memphis.

Appendix B

Recruitment Letters for Question Two

Good Afternoon [Studio Professor Name],

As part of my dissertation investigating the biomechanics of conducting, I am wanting to gather data on students' playing responses of a conductor demonstrating two variations of staccato and legato gestures. Would you be willing send the following email out to the members of your private studio? **I am hoping to have the email sent out TODAY - Wednesday, April 1st and have students reply to the survey link by April 10th**. Please copy me on the email you send to your studio members so that I can have a record of when the survey was disseminated. Below you will find the text for the body of the email that includes the link to the survey, the link to the Drop Box for uploading the audio, and the attached consent form that should be attached to your email. Thank you very much and feel free to reach out with any questions or concerns you may have.

Best,

Jonathan Schallert

Dear University of Memphis Clarinet or Saxophone Player,

I would like to invite you to participate in a research study as a part of my dissertation that investigates your played responses to conducting gestures. You are being invited to take part in this study because you are a current member of clarinet or saxophone studio at the University of Memphis.

For this study, you will complete a 20-minute survey and recording that asks you perform your interpretation of the articulations demonstrated by four conducting videos. Each video contains four measures of quarter notes that you will perform on a consistent, single pitch. You will record your playing with a smart phone or other audio recorder and then upload your audio file to a private folder.

Prior to the survey you will be asked to fill out a demographic information section. While we will ask for your name (to link your survey to your uploaded audio file), all information will be kept strictly confidential. No information will be able to identify you specifically in the analysis, results, or publication phases of this research. .

I sincerely hope that you would consider participating in this project as I work to finish my dissertation! If you would like more information, please contact Jonathan Schallert at (256) 679-1301 or jschllrt@memphis.edu or his dissertation advisor, Dr. Ryan Fisher at (901) 678-3196 or rfisher3@memphis.edu.

If you would like to participate in this research study, please click the link below and follow the directions within the survey:

Playing Response Survey

Once you have completed the survey and recording, save your audio file by labeling it: LastName.FirstName.Instrument (*ex: Schallert.Jonathan.Saxophone*). Then you can upload your file to this link:

Audio File Responses to Conducting Videos

This survey will only be active from Wednesday, April 1st – Friday, April 10th. I sincerely appreciate your efforts to help me complete this dissertation process in a timely manner despite the difficult circumstances we find ourselves in now.

By clicking the above link and beginning the survey, you are agreeing to provide anonymous data to the researcher. Please read the attached Informed Consent Form for information regarding this study.

Thank you in advance for your time and consideration and I sincerely wish you all the best as you finish out the semester!

Sincerely,

Jonathan Schallert
PhD Candidate, Music Education
The University of Memphis

Follow-up Email:

Dear UofM Clarinet and Saxophone Players,

Thank you so much to those who have begun or finished their surveys and audio file uploads! I am sincerely grateful for your help in completing this research for my dissertation.

Those of you who have not completed the survey, would you be willing to help before the survey closes **this Saturday, April 11th**? If so, here is the link to the survey:

Playing Response Survey

And here is the link to upload your audio recording (labeled: LastName.FirstName.Instrument (*ex: Schallert.Jonathan.Saxophone*)) once you've completed the survey:

Audio File Responses to Conducting Videos

Please remember that in order to be included in the study, **you must complete both the survey and upload your recording**. Your name will only be used to match your survey with your recording and will remain strictly confidential. No personal information linked to you will be used for analysis, results, or publication of this research.

Thank you again for your consideration and if you have any questions or difficulties, please do not hesitate to reach out at jschllrt@memphis.edu.

Sincerely,

Jonathan Schallert
PhD Candidate, Music Education
The University of Memphis

Greetings Again, UofM Clarinet and Saxophone Players,

Thank you again to those who have completed the survey and file upload – the time you spent filling out the survey, recording, and uploading are SO appreciated; especially during these stressful and anxious times. Thank you for helping me make significant progress on this dissertation journey despite the circumstances!

We could really use more participants, so if you haven't completed the survey and recording, would you please consider doing so? It should take no more than 20 minutes of your time and would be a tremendous help to me and the progress we are making in understanding how conducting and the interpretation of conducting gestures work together.

In an effort to accommodate your schedules, I've extended the deadline to Monday, April 13th. That gives you the weekend to complete the project, if you chose to participate.

Here again is the link to the survey. Start here and simply follow the directions in the survey at your own pace:

Playing Response Survey

Then, upload your recording (labeled: LastName.FirstName.Instrument (*ex: Schallert.Jonathan.Saxophone*)) to this link:

Audio File Responses to Conducting Videos

Please remember that in order to be included in the study, **you must complete both the survey and upload your recording**. Your name will only be used to match your survey with your recording and will remain strictly confidential. No

personal information linked to you will be used for analysis, results, or publication of this research.

Thank you again for your consideration, time, and help despite the circumstances. If you have any questions or difficulties, please do not hesitate to reach out at jschllrt@memphis.edu.

Sincerely,

Jonathan Schallert
PhD Candidate, Music Education
The University of Memphis

Appendix C

Recruitment Letters for Question Three

Good Afternoon [Ensemble Director Name],

As part of my dissertation investigating the biomechanics of conducting, I am wanting to gather data on members of large ensembles' perceived level of effectiveness of a conductor demonstrating two variations of staccato and legato gestures. Would you be willing send the following email out to the members of your ensemble(s)? **I am hoping to have the email sent out TODAY - Friday, March 27th and have students reply to the survey link by April 3rd**. Please copy me on the email you send to your ensemble members so that I can have a record of when the survey was disseminated. Below you will find the text for the body of the email that includes the link to the survey. Thank you very much and feel free to reach out with any questions or concerns you may have.

Best,

Jonathan Schallert

Dear University of Memphis Ensemble Member,

I would like to invite you to participate in a research study as a part of my dissertation that investigates your perceived level of effectiveness of conducting gestures. You are being invited to take part in this study because you are a current member of a large ensemble at the University of Memphis.

For this study, you will complete a 10-minute online survey that asks you to rate the effectiveness of four conducting videos; two demonstrating staccato gestures and two demonstrating legato gestures. After watching each video, you will indicate your perceived level of effectiveness on a scale from 0 to 10. Prior to the survey you will be asked to fill out a demographic information section. All information will be kept strictly confidential. No information will be able to identify you specifically.

I sincerely hope that you would consider participating in this project! If you would like more information, please contact Jonathan Schallert at (256) 679-1301 or jschllrt@memphis.edu or his dissertation advisor, Dr. Ryan Fisher at (901) 678-3196 or rfisher3@memphis.edu.

If you would like to participate in this research study, please click the link below and follow the directions within the survey:

Conducting Effectiveness Survey

This survey will only be active from Friday, March 27th – Friday, April 3rd. I appreciate your efforts to help me complete this dissertation process in a timely manner despite the difficult circumstances we find ourselves in now. Also, if you are

a member of multiple large ensembles at the University of Memphis and you receive this email twice, please only respond one time.

By clicking the above link and beginning the survey, you are agreeing to provide anonymous data to the researcher. Please read the attached Informed Consent Form for information regarding this study.

Thank you in advance for your time and consideration and I sincerely wish you all the best as you finish out the semester!

Sincerely,

Jonathan Schallert
PhD Candidate, Music Education
The University of Memphis

Appendix D

Informed Consent for Question Two

THE UNIVERSITY OF MEMPHIS.
Dreamers. Thinkers. Doers.

Institutional Review Board

315 Administration Bldg.
Memphis, TN 38152-3370
Office: 901.678.2705
Fax: 901.678.2199

Consent for Research Participation

Title	**A comparison of conducting effectiveness, instrumentalists' performances, and the underlying biomechanics of a conductor while performing exaggerated and understated variations of staccato and legato gestures**
Researcher(s)	Jonathan Schallert, University of Memphis Dr. Ryan Fisher, University of Memphis Dr. Douglas Powell, University of Memphis
Researchers Contact Information	(256)679-1301, jschllrt@gmail.com

You are being asked to participate in a research study. The box below highlights key information for you to consider when deciding if you want to participate. More detailed information is provided below the box. Please ask the researcher(s) any questions about the study before you make your decision. If you volunteer, you will be one of approximately 20 participants to partake in this phase of the research project.

Key Information for You to Consider

Voluntary Consent: You are being asked to volunteer for a research study. It is up to you whether you choose to participate or not. There will be no penalty or loss of benefit to which you are otherwise entitled if you choose not to participate or discontinue participation.

Purpose: The purpose of this research is to better understand how musicians' ratings of conducting effectiveness, musicians' responses through performance to a conductor, and the underlying biomechanics of conducting are related. We hope that this information will impact both how we teach conducting and how we evaluate the effectiveness of its instruction.

Duration: It is expected that your participation will last approximately 30 minutes.

Procedures and Activities: After providing anonymous demographic information, you will be asked to watch four videos of a conductor demonstrating two variations of staccato and legato gestures. After watching for the first time, you will watch the four exercises again, this time performing the articulation you observe on a single pitch of sixteen quarter notes over a four measure exercise. Clarinets will perform the exercises on your written G and alto saxophones

Institutional Review Board

315 Administration Bldg.
Memphis, TN 38152-3370
Office: 901.678.2705
Fax: 901.678.2199

will perform their exercises on their written D.

Risk: As a participant in this study, the things you will be doing have no more risk of harm than what you would experience in everyday life. There are no direct benefits to being a participant in this study. However, the researcher hopes to utilize the knowledge gained through this research to further our understanding of conducting pedagogy and musicians' health.

Alternatives: Participation is voluntary, and the only alternative is to not participate.

WHY ARE YOU BEING INVITED TO TAKE PART IN THIS RESEARCH?

You are being invited to take part in a research study about conducting effectiveness. You are being invited to take part in this research study because you are a current student at a college or university that meets the criteria for this study. If you take part in this study, you will be one of approximately 20 participants to partake in this phase of the research project.

WHO IS DOING THE STUDY?

The person in charge of this study is Jonathan Schallert, a PhD candidate at the University of Memphis' Music Department. He is being advised and assisted in this research by Dr. Ryan Fisher, Associate Dean of the University of Memphis' College of Communication and Fine Arts, and Dr. Douglas Powell, Assistant Professor at the University of Memphis' School of Health Studies.

WHAT IS THE PURPOSE OF THIS STUDY?

By doing this study, we hope to learn whether or not there is a connection between how musicians rate the effectiveness of a conductor, how musicians respond through performance to a conductor, and the underlying biomechanics of conducting. We hope that this new information will impact how we teach conducting and how we measure the effectiveness of that instruction and pedagogy.

WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST?

This study will take place in a *Wenger Soundloc* Sound Isolating Practice Room on the second floor of the School of Music at the University of Memphis. You will complete this study by performing four exercises on your instrument. The exercises will be recorded using a TASCAM DR-44WL audio recorder. The protocol will take approximately 30 minutes to complete and is comprised of an anonymous demographic section followed by the two viewings of the four video exercises.

WHAT WILL YOU BE ASKED TO DO?

As a part of this research, you will participate in a demographic survey. Following the survey, you will watch four conducting videos. Two videos will demonstrate two variations of staccato gestures and two will demonstrate two variations of legato gestures. The first time you watch the videos, you will be asked to only observe, paying particular attention to what articulation the conductor is demonstrating. After the first viewing, you will watch the four exercises again, this time performing the articulation you observe on a single pitch of sixteen quarter notes over a four measure exercise. Clarinets will perform the exercises on your written G and alto saxophones will perform their exercises on their written D.

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life.

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WILL YOU BENEFIT FROM TAKING PART IN THIS STUDY?

There is no guarantee that you will get any benefit from taking part in this study. Your willingness to take part, however, may, in the future, help society as a whole better understand this research topic.

DO YOU HAVE TO TAKE PART IN THE STUDY?

If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you choose not to volunteer. You can stop at any time during the study and still keep the benefits and rights you had before volunteering.

IF YOU DON'T WANT TO TAKE PART IN THE STUDY, ARE THERE OTHER CHOICES?

If you do not want to be in the study, there are no other choices except not to take part in the study.

WHAT WILL IT COST YOU TO PARTICIPATE?

There are no costs associated with taking part in the study.

WILL YOU RECEIVE ANY REWARDS FOR TAKING PART IN THIS STUDY?

You will not receive any rewards or payment for taking part in the study.

WHO WILL SEE THE INFORMATION THAT YOU GIVE?

We will make every effort to keep private all research records that identify you to the extent allowed by law.

Your information will be combined with information from other students taking part in the study. When we write about the study to share it with other researchers, we will write about the combined information we have gathered. You will not be personally identified in these written materials. We may publish the results of this study; however, we will keep your name and other identifying information private.

This study is anonymous. That means that no one, not even members of the research team, will know that the information you gave came from you.

We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is. The survey containing your anonymous information will be stored in a locked cabinet, in a locked closet in the researcher's office. Following the study, all identifying information will be destroyed.

We will keep private all research records that identify you to the extent allowed by law. However, there are some circumstances in which we may have to show your information to other people. For example, the law may require us to show your information to a court. Also, we may be required to show information which identifies you to people who need to be sure we have done the research correctly; these would be people from such organizations as the University of Memphis, or other higher education institution.

CAN YOUR TAKING PART IN THE STUDY END EARLY?

If you decide to take part in the study you still have the right to decide at any time that you no longer want to continue. You will not be treated differently if you decide to stop taking part in the study.

The individuals conducting the study may need to withdraw you from the study. This may occur if you are not able to follow the directions they give you, if they find that your being in the study is more risk than benefit to you, or if the agency funding the study decides to stop the study early for a variety of scientific reasons.

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WHAT IF YOU HAVE QUESTIONS, SUGGESTIONS, CONCERNS, OR COMPLAINTS?

Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind. If you have questions, suggestions, concerns, or complaints about the study, you can contact the investigator, Mr. Jonathan Schallert at jschllrt@memphis.edu or 256.679.1301 or his academic advisor, Dr. Ryan Fisher at rfisher3@memphis.edu or 901.678.2350 . If you have any questions about your rights as a volunteer in this research, contact the Institutional Review Board staff at the University of Memphis at 901-678-2705. We will give you a signed copy of this consent form to take with you.

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STATEMENT OF CONSENT

I have had the opportunity to consider the information in this document. I have asked any questions needed for me to decide about my participation. I understand that I can ask additional questions through the study.

By signing below, I volunteer to participate in this research. I understand that I am not waiving any legal rights. I have been given a copy of this consent document. I understand that if my ability to consent for myself changes, my legal representative or I may be asked to consent again prior to my continued participation

As described above, you will be audio recorded while performing the activities described above. Audio recorded will be used for determining the average length of notes performed for each exercise. Initial the space below if you consent to the use of audio recorded as described.

____ I agree to the use of audio recording

Name of Adult Participant	Signature of Adult Participant	Date

Researcher Signature (To be completed at the time of Informed Consent)

I have explained the research to the participant and answered all of his/her questions. I believe that he/she understand the information described in this consent and freely consent to participate**.**

Name of Research Team Member	Signature of Research Team Member	Date

Appendix E

Informed Consent for Question Three

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Consent for Research Participation

Title	**A comparison of conducting effectiveness, instrumentalists' performances, and the underlying biomechanics of a conductor while performing exaggerated and understated variations of staccato and legato gestures**
Researcher(s)	Jonathan Schallert, University of Memphis Dr. Ryan Fisher, University of Memphis Dr. Douglas Powell, University of Memphis
Researchers Contact Information	(256)679-1301, jschllrt@gmail.com

You are being asked to participate in a research study. The box below highlights key information for you to consider when deciding if you want to participate. More detailed information is provided below the box. Please ask the researcher(s) any questions about the study before you make your decision. If you volunteer, you will be one of about 100 participants to partake in this phase of the research project.

Key Information for You to Consider

Voluntary Consent: You are being asked to volunteer for a research study. It is up to you whether you choose to participate or not. There will be no penalty or loss of benefit to which you are otherwise entitled if you choose not to participate or discontinue participation.

Purpose: The purpose of this research is to better understand how musicians' ratings of conducting effectiveness, musicians' responses through performance to a conductor, and the underlying biomechanics of conducting are related. We hope that this information will impact both how we teach conducting and how we evaluate the effectiveness of its instruction.

Duration: It is expected that your participation will last approximately 15 minutes.

Procedures and Activities: After providing anonymous demographic information, you will be asked to rate the effectiveness of four conducting videos; two demonstrating staccato gestures and two demonstrating legato gestures. You will rate how effective you perceive the demonstration of the conducting style to be by circling a number on a scale from 0 to 10.

Risk: As a participant in this study, the things you will be doing have no more risk of harm than

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what you would experience in everyday life. There are no direct benefits to being a participant in this study. However, the researcher hopes to utilize the knowledge gained through this research to further our understanding of conducting pedagogy and musicians' health.

Alternatives: Participation is voluntary, and the only alternative is to not participate.

WHY ARE YOU BEING INVITED TO TAKE PART IN THIS RESEARCH?

You are being invited to take part in a research study about conducting effectiveness. You are being invited to take part in this research study because you are a current student at a college or university that meets the criteria for this study. If you take part in this study, you will be one of about 100 participants to partake in this phase of the research project.

WHO IS DOING THE STUDY?

The person in charge of this study is Jonathan Schallert, a PhD candidate at the University of Memphis' Music Department. He is being advised and assisted in this research by Dr. Ryan Fisher, Associate Dean of the University of Memphis' College of Communication and Fine Arts, and Dr. Douglas Powell, Assistant Professor at the University of Memphis' School of Health Studies.

WHAT IS THE PURPOSE OF THIS STUDY?

By doing this study, we hope to learn whether or not there is a connection between how musicians rate the effectiveness of a conductor, how musicians respond through performance to a conductor, and the underlying biomechanics of conducting. We hope that this new information will impact how we teach conducting and how we measure the effectiveness of that instruction and pedagogy.

WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST?

This study will take place in your rehearsal space during a regularly scheduled rehearsal time. You will complete the survey on paper with a pen or pencil. The survey will take approximately 15 minutes to complete and is comprised of an anonymous demographic section followed by the conducting effectiveness survey.

WHAT WILL YOU BE ASKED TO DO?

As a part of this research, you will participate in a demographic survey. Following the survey, you will watch four conducting videos. Two videos will demonstrate two variations of staccato gestures and two will demonstrate two variations of legato gestures. After each video, you will be asked to rate how effective you perceive the demonstration of the conducting style to be by circling one number on a scale from 0 to 10, where 0 represents "highly ineffective" and 10 represents "highly effective."

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life.

WILL YOU BENEFIT FROM TAKING PART IN THIS STUDY?

There is no guarantee that you will get any benefit from taking part in this study. Your willingness to take part, however, may, in the future, help society as a whole better understand this research topic.

DO YOU HAVE TO TAKE PART IN THE STUDY?

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If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you choose not to volunteer. You can stop at any time during the study and still keep the benefits and rights you had before volunteering.

IF YOU DON'T WANT TO TAKE PART IN THE STUDY, ARE THERE OTHER CHOICES?

If you do not want to be in the study, there are no other choices except not to take part in the study.

WHAT WILL IT COST YOU TO PARTICIPATE?

There are no costs associated with taking part in the study.

WILL YOU RECEIVE ANY REWARDS FOR TAKING PART IN THIS STUDY?

You will not receive any rewards or payment for taking part in the study.

WHO WILL SEE THE INFORMATION THAT YOU GIVE?

We will make every effort to keep private all research records that identify you to the extent allowed by law.

Your information will be combined with information from other students taking part in the study. When we write about the study to share it with other researchers, we will write about the combined information we have gathered. You will not be personally identified in these written materials. We may publish the results of this study; however, we will keep your name and other identifying information private.

This study is anonymous. That means that no one, not even members of the research team, will know that the information you gave came from you.

We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is. The survey containing your anonymous information will be stored in a locked cabinet, in a locked closet in the researcher's office. Following the study, all identifying information will be destroyed.

We will keep private all research records that identify you to the extent allowed by law. However, there are some circumstances in which we may have to show your information to other people. For example, the law may require us to show your information to a court. Also, we may be required to show information which identifies you to people who need to be sure we have done the research correctly; these would be people from such organizations as the University of Memphis, or other higher education institution.

CAN YOUR TAKING PART IN THE STUDY END EARLY?

If you decide to take part in the study you still have the right to decide at any time that you no longer want to continue. You will not be treated differently if you decide to stop taking part in the study.

The individuals conducting the study may need to withdraw you from the study. This may occur if you are not able to follow the directions they give you, if they find that your being in the study is more risk than benefit to you, or if the agency funding the study decides to stop the study early for a variety of scientific reasons.

WHAT IF YOU HAVE QUESTIONS, SUGGESTIONS, CONCERNS, OR COMPLAINTS?

Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind. If you have questions, suggestions, concerns, or complaints about the study, you can contact the investigator, Mr. Jonathan Schallert at jschllrt@memphis.edu or 256.679.1301 or his academic advisor, Dr. Ryan Fisher at rfisher3@memphis.edu or 901.678.2350 . If you have any questions about your rights as a volunteer in this research, contact the Institutional Review Board staff at the University of Memphis at 901-678-2705. We will give you a signed copy of this consent form to take with you.

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STATEMENT OF CONSENT

I have had the opportunity to consider the information in this document. I have asked any questions needed for me to decide about my participation. I understand that I can ask additional questions through the study.

By signing below, I volunteer to participate in this research. I understand that I am not waiving any legal rights. I have been given a copy of this consent document. I understand that if my ability to consent for myself changes, my legal representative or I may be asked to consent again prior to my continued participation

Name of Adult Participant	Signature of Adult Participant	Date

Researcher Signature (To be completed at the time of Informed Consent)

I have explained the research to the participant and answered all of his/her questions. I believe that he/she understand the information described in this consent and freely consent to participate.

Name of Research Team Member	Signature of Research Team Member	Date

Appendix F

Performance Survey for Question Two

Performance Survey

Thank you for taking the time to complete this survey that is designed to measure your performance of demonstrated staccato and legato conducting styles. You are being invited to take part in this research study because you are a clarinet or saxophone player that meets the criteria for this study. If you take part in this study, you will be one of about 20 students to do so.

After providing anonymous demographic information, you will first be asked to watch four conducting excerpts, paying particular attention to the articulation that the conductor is demonstrating through his baton gestures. After watching the four excerpts, you will be asked to perform the articulation you observed on a single pitch of sixteen quarter notes over the four measure exercise. Clarinetists will perform the exercises on their written G and alto saxophones will perform the exercise on their written D. Every effort to keep research records private will be made to the full extent of the law and the things you will be doing have no more risk of harm than what you would experience in everyday life.

This survey is completely anonymous and your honest responses are greatly appreciated. By continuing to the next section of the survey, you are consenting to provide anonymous information to the research team. The survey should take approximately 15 minutes to complete. Thank you for your time and participation!

The following questions will be used for anonymous demographic purposes. Please complete the items by responding to each prompt to the best of your knowledge.

Are you 18 years old or older *(circle one)* Yes No

What is your sex? *(circle one)* Female Male Other Chose not to answer

Circle your current classification: *(circle one)* Freshman Sophomore Junior Senior

Masters Student Doctoral Student Artist Diploma Student

Write in your current declared major and/or concentration *(ex: music – music education)*:

_____

Write in your instrument or choral voice part in this ensemble:

_____

Circle the conducted ensembles that you have participated in and write how many years you have participated with them since your **freshman year in high school**:

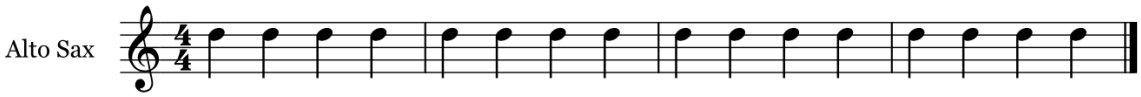
Ensemble	Number of Years Participated
Choir	_____
Band	_____
Orchestra	_____

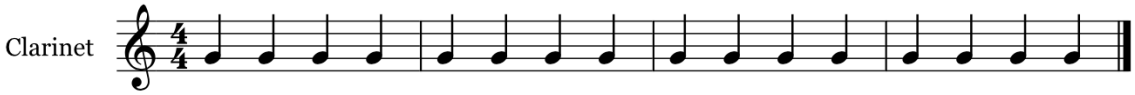
In your best estimation, how many conductors have you performed under since your **freshman year in college**?

_____

Directions:

You will see a set of four videos twice during this survey. Two videos will demonstrate two variations of staccato gestures and two will demonstrate two variations of legato gestures. During the first viewing, only watch (do not play) all four videos, paying particular attention to the articulation that the conductor is demonstrating through his baton gesture. During the second viewing of the four videos, you will respond to each video by performing 16 single pitch quarter notes over a four measure exercise that demonstrate the articulation you observed. Clarinetists will perform their exercises on their written G and alto saxophones will perform their exercises on their written D. See below for examples of the four measures.





Appendix G

Conducting Effectiveness Survey for Question Three

Conducting Effectiveness Survey

Thank you for taking the time to complete this survey that is designed to measure your judgment of the effectiveness of demonstrated staccato and legato conducting styles. You are being invited to take part in this research study because you are a current member of a conducted university ensemble that meets the criteria for this study. If you take part in this study, you will be one of about 150 students to do so.

After providing anonymous demographic information, you will be asked to rate the effectiveness of four videos; two demonstrating staccato gestures and two demonstrating legato gestures. Every effort to keep research records private will be made to the full extent of the law and the things you will be doing have no more risk of harm than what you would experience in everyday life.

This survey is completely anonymous and your honest responses are greatly appreciated. By continuing to the next section of the survey, you are consenting to provide anonymous information to the research team. The survey should take approximately 10 minutes to complete. Thank you for your time and participation!

The following questions will be used for anonymous demographic purposes. Please complete the items by responding to each prompt to the best of your knowledge.

Are you 18 years old or older *(circle one)* Yes No

What is your sex? *(circle one)* Female Male

Circle your current classification: *(circle one)* Freshman Sophomore Junior Senior

Masters Student Doctoral Student Artist Diploma Student

Write in your current declared major and/or concentration *(ex: music – music education)*:

_____

Write in your instrument or choral voice part in this ensemble:

_____

Circle the conducted ensembles that you have participated in and write how many years you have participated with them since your **freshman year in high school**:

Ensemble	Number of Years Participated
Choir	_____
Band	_____
Orchestra	_____

In your best estimation, how many conductors have you performed under since your **freshman year in college**?

_____

Directions:

You will see four videos during this survey. Two videos will feature two variations of staccato gestures and two will feature two variations of legato gestures. After each video, please rate how effective you perceived the demonstration of the conducting style to be by selecting one number on a scale from 0 to 10, where 0 represents "highly ineffective" and 10 represents "highly effective." Be sure to **circle one, and only one** number for each exercise. If you need to erase, please erase completely.

Video 1
How effective is this demonstration of a staccato gesture?

0 1 2 3 4 5 6 7 8 9 10

"Highly Ineffective" "Highly Effective"

Video 2
How effective is this demonstration of a legato gesture?

0 1 2 3 4 5 6 7 8 9 10

"Not Effective" "Effective"

Video 3
How effective is this demonstration of a staccato gesture?

0 1 2 3 4 5 6 7 8 9 10

"Not Effective" "Effective"

Video 4
How effective is this demonstration of a legato gesture?

0 1 2 3 4 5 6 7 8 9 10

"Not Effective" "Effective"

Appendix H

Links to Audio and Videos

Question Two Conducting Video with Directions

https://youtu.be/PUGp_0PGAj0

Playing Response Example to Question Two

The following is an example of the audio recording submitted for question two. This response is by participant number 10, a saxophone player. The order of the conducting conditions being performed is understated staccato, exaggerated legato, exaggerated staccato, and understated legato.

https://www.dropbox.com/s/wj859gslr967xrf/Participant_10_.Saxophone.m4a?dl=0

Question Three Conducting Exercises

Exaggerated Staccato

https://youtu.be/ESKoFr71ReA

Understated Staccato

https://youtu.be/fqjOFJEcIUQ

Exaggerated Legato

https://youtu.be/YsRxQ1hipKc

Understated Legato

https://youtu.be/-cFDrJzl3jk