

The Effect of Selective Attention on Error-Detection Abilities

Jeffrey Clayton Larkin

A dissertation  
submitted in partial fulfillment of the  
requirements for the degree of

Doctor of Musical Arts

University of Washington

2018

Reading Committee:  
Geoffrey Boers, Chair  
Giselle Wyers  
Christina Sunardi

Program Authorized in Offer Degree:  
School of Music

©Copyright 2018  
Jeffrey Clayton Larkin

University of Washington

**Abstract**

The Effect of Selective Attention on Error-Detection Abilities

Jeffrey Clayton Larkin

Chair of the Supervisory Committee:  
Geoffrey Boers  
Professor and Director of Choral Studies  
School of Music

This study evaluated the error-detection abilities of choral conductors while attending to variable quantities of simultaneously played vocal lines. The participants ( $n = 55$ ) were provided 16 8-measure musical excerpts and were instructed to detect rhythmic and melodic performance errors as performed within the audio excerpts. For each excerpt, errors of pitch and rhythm were inserted systematically within one, two, three, or four of the vocal lines. During playback, all four vocal lines were present; however, participants were asked to attend only to the directed lines.

It was hypothesized that a linear decrease in error-detection score would occur with the addition of two, three, and four attended vocal lines. Welch's Analysis of Variance (ANOVA) test indicated statistical significance of error-detection variability with increasing quantities of

attended vocal lines, Welch's  $F(3, 118.812) = 46.876, p < .001$ . Results indicated a non-linear decrease in error-detection score with the incorporation of additional attended vocal lines [one,  $M = 9.27$ ; two,  $M = 6.49$ ; three,  $M = 6.15$ ; four,  $M = 5.81$ , respectively).

Participants demonstrated an inability to accurately detect performance errors immediately upon attending to a second vocal line. These findings serve as a platform for which aural training must be modified to accommodate the detection of performance errors. Suggestions for an error-detection curriculum are provided to offset these deficiencies. Further research may be necessary to better understand and categorize the cognitive process of auralization during error-detection.

## TABLE OF CONTENTS

List of Figures .....	iv
List of Tables .....	v
Acknowledgements.....	vi
Dedication.....	vii
Chapter 1: Introduction	
Statement of the Problem.....	1
Need for the Study .....	4
Purpose of the Study .....	10
Description of the Study .....	11
Research Questions.....	12
Limitations .....	13
Delimitations.....	13
Assumptions.....	14
Organization of the Dissertation.....	14
Chapter 2: Review of Literature	
Score Study Methodology.....	15
Common Practice Methodologies.....	16
Effects of Differing Models .....	18
Aural Training Programs .....	20
Programmed Instruction.....	20
Error Detection Workbooks and Materials.....	22
Miscellaneous Aural Training Considerations.....	23
Error Detection Factors.....	26
Experience and Training.....	26
Parts, Texture, and Timbre.....	28
Effects of Conducting .....	29
Effects of Concurrent Piano Playing.....	29
Cognition: Processing.....	30
Auditory Filter Theories and Selective Attention.....	30
Perceptual Load Theory .....	33
Cognition: Perception .....	35
Auditory Scene Analysis and Streaming .....	35
Psychoacoustics .....	36
Pitch and Timbre Discrimination.....	38
Eye Movement Tracking.....	40
Chapter 3: Methodology	
Introduction.....	42
Context and Participants .....	42
Research Design and Materials.....	44

Visual Musical Excerpts .....	44
Error Insertion .....	45
Aural Musical Excerpts .....	46
Testing Video .....	47
Survey Instruments .....	47
Data Collection .....	49
Data Analysis .....	49
Chapter 4: Results	
Introduction .....	51
Demographic Information .....	52
Primary Questions .....	54
Question 1 .....	54
Question 2 .....	55
Question 3 .....	56
Question 4 .....	57
Question 5 .....	58
Question 6 .....	59
Question 7 .....	61
Conclusion .....	62
Chapter 5: Discussion	
Introduction .....	64
Research Questions .....	64
Discussion .....	65
Question 1 .....	65
Question 2 .....	66
Question 3 .....	67
Question 4 .....	68
Question 5 .....	70
Question 6 .....	70
Question 7 .....	71
Conclusion of Findings .....	72
Implications .....	73
Curriculum Development .....	74
Graduated Layering .....	74
Pitch and Rhythm Isolation .....	74
Pre-Determined Selective Attention .....	75
Error-Detection within Movement Training .....	75
Aural Visualization .....	76
Future Research .....	76
Conclusion .....	78
References .....	80
Appendix A: Glossary of Terms .....	97

Appendix B: Participant Consent Form .....	99
Appendix C: Experiment Materials .....	103
Appendix D: Answer Key for Performance Errors.....	123

## LIST OF FIGURES

Figure Number	Page
1. Processing Order of Choral Conductor as Influenced by Internal and External Stimulus ..6	
2. Filter Theory of Attention.....8	8
3. Filter Theory Attenuation .....8	8
4. Late-Stage Filtering Mode ..... 19	19
5. Mean Scores for Pitch and Rhythm Error-Detection.....56	56
6. Mean Error-Detection Score for Self-Assessment Score.....59	59
7. Undergraduate and Graduate Error-Detection Score.....60	60
8. Years of Experience and Error-Detection Score.....62	62
9. Error-Detection Graduated Layering Progression for Choral Music.....74	74

## LIST OF TABLES

Table Number	Page
1. Parameters for Musical Excerpt Creation .....	45
2. Scoring Guide for Performance Errors .....	50
3. Frequency of Participant College Degrees .....	53
4. Frequency of Participant Primary Ensemble Conducting Experience.....	54
5. Mean Error-Detection Score for Primary Ensemble Conducting Experience .....	68

## ACKNOWLEDGEMENTS

Thank you to every person who contributed to the completion of this dissertation and my doctoral work, whether musically, socially, academically, or emotionally. I am eternally grateful to the University of Washington School of Music and the UW Graduate Choral Cohort for embracing me as a musician and learner and allowing me to grow without prejudice. There had always been a part of me yearning for something more, musically and spiritually.

An unending thank you to Dr. Geoffrey Boers for guiding me along this journey. Despite the struggles faced, you unconditionally provided honesty, compassion, and empathy. Your lessons, spoken and silent, will continue to resonate with me in my music, philosophies, and relationships with others. Thank you to Dr. Giselle Wyers for her eternal enthusiasm, passion, and devotion to her students and the choral arts. I am astonished by everything I have learned from you as a conductor and academic. You are a model of professionalism and compassion; you have my utmost admiration. And to Dr. Steven Zielke for setting me upon this path many years ago. Without your mentorship and friendship, I would not be at this point today.

To my parents, siblings, and grandparents: thank you for always supporting my passion for music and learning these many years.

And to Ariana: thank you for standing by me all these years. Being apart has been unquestionably difficult, but your unending love and encouragement gave me the perseverance needed to live out this dream. Thank you for never giving up and always being my partner and best friend!

## **DEDICATION**

To Ariana, for all the endless support and love.

## CHAPTER I

### Introduction

#### Statement of the Problem

It has frequently been suggested that the ears are a conductor's greatest asset, and the ability to see the score through sound is paramount to their duty. "...the musician(s) must learn to 'hear with the eye, and see with the ear'" (Smith, 1934, p. 18). Someone outside the choral profession may conclude that the conductors' primary obligation is one of "arm-waving" and tempi control. However, a conductor's gestures are informed by perceptual reasoning—perceptions of what they see and hear in the ensemble and imagine as they study a score. Examples of conductor responsibilities include stylistic phrasing, dynamic indications, tempo variances, and pedagogical techniques. Unfortunately, the essential skill of error-detection is often neglected to be learned and is not intuitively taught within many of our current university teaching models. The consequences become significantly apparent within the perceptible quality of the ensemble.

The conductor, as the primary interpreter for an ensemble, is in charge of not only enhancing the qualities that the musicians bring, but also to correct errors as they occur. More so, it is necessary to be able to *audiate*,<sup>1</sup> that is, develop an aural template for which they can compare how the piece actually sounds against what they are hearing in the ensemble (Byo, 1997). The ability to isolate and segregate sounds amongst the whole is one of the most essential skills to acquire and master. As stated by Byo (1990):

---

<sup>1</sup> Term originally created and defined by Edwin Gordon (1978).

If a conductor's ears are to develop – that is, if a director is to hear beyond the massive, full ensemble sound of the band and orchestra – he or she must develop the ability to isolate specific sounds (instruments or sections) while ignoring others. (p. 45)

It has been found that colleges and universities which rely on traditional ear training models (i.e., aural dictation and sight-singing), are inadequately preparing their students to successfully detect musical errors while reading scores with varied staves and timbres (Brand & Burnsed, 1981; Doana, 1989; Gonzo, 1970; Sidnell, 1971). Sidnell (1967) identified the deficiency in error-detection training, stating that:

It is of paramount importance that future conductor-teachers of instrumental music performing groups be able to perceive, identify and correct student errors during the rehearsal period. Specifically, the teacher must have the ability to determine instantaneously that the aural stimulus agrees with the visual, and if not, what adjustments are necessary. (p. 1)

Pembroke and Riggins (1990) continued the discussion of inadequate training, suggesting that:

...error detection is the least practiced activity in aural-skills classes. Considering the frequency that students will use this skill (e.g., as conductors, classroom and studio instructors, adjudicators, etc.), it is reasonable to suggest that more time should be devoted to this vital skill! (p. 40)

Although beneficial, basic ear-training as taught in most institutions does not necessarily equate to equivalent error-detection training. Sheldon (1999) mentioned that,

Some have suggested that although it uses certain abilities that may have been cultivated through discrete and tangential activities (e.g., ear training, music theory, private instrumental instruction, ensemble participation), error detection may be a skill into

which other peripheral competencies may not be easily transferred or synthesized. (p. 390)

These skills are not identical and must be approached independently. And due to the lack of practice possibilities, ample opportunities must be presented to master the complex skill of error-detection (Stuart, 1979).

Although a large body of current aural and conducting training material includes insight upon *what* to listen for, few, if any, acknowledge the external influences upon our aural perceptibility. Significant research has been accomplished in the last 75 years with regards to cognition and processing abilities, however, such concepts are rarely implemented during aural and conducting training; explicitly speaking, *selective attention*<sup>3</sup> and *perceptual load*.<sup>4</sup> Each task presented to the conductor contains a quantifiable amount of information which requires processing. However, as with every technological device, a finite amount of processing capacity exists. Once this perceptual capacity reaches its maximum, the human brain embarks upon a slew of conscious and unconscious decisions to reduce the overall load. Unfortunately, these reductions often appear in the form of selectivity and *inattentional deafness*,<sup>5</sup> each of which may affect the conductor negatively. Lavie (1995) contended that “whether selective processing will occur is at the mercy of the perceptual load imposed by external events.” These conditions can often present detrimental effects upon the performance of an ensemble. Therefore, a deeper understanding of its practical effects and considerations for management must be made.

---

<sup>3</sup> Often grouped with filtering theories, *selective attention* is the prioritization of information processing due to conscious or unconscious selection.

<sup>4</sup> In the field of cognition, *perceptual load* is the perceptual capacity one has before cognitive filtering takes place.

<sup>5</sup> Term originally created and defined by Koreimann et al. (2014). It may be defined as the unintentional symptom of decreased aural acuity due to perceptual load.

## **Need for the Study**

Research in error-detection methods and cognitive processing, respectively, have provided a strong foundation of understanding. Additionally, an extensive breadth of aural perception and cognition have been explored. Despite the quantity of available research, many of the findings are void of practical applications which inform future teachings.

A significant body of texts and materials are currently available with regard to score study methodologies and aural training practices. Score study styles are nearly limitless and modifiable for individual preference, however, most sources focus upon: style, phrasing, melodic and harmonic structure, and pedagogical attributes. The intent of score study is to develop a complete aural image of the music and its technical requirements. Acquiring an aural template prior to the performance or rehearsal of a piece has proven to be a superior skill for error detection than without advanced study (Crowe, 1996). Although it is extremely difficult to justify the use of one methodology over another, previous research has strongly suggested that the hearing of an aural example prior to error-detection significantly enhances the listeners aural perception, as compared to silent study, sight-singing individual parts, and learning the score from the piano (Costanza, 1971; Gruno 1980; Hochkeppel, 1993; Hopkins, 1991; Ramsey, 1979). In general, these findings substantiate the necessity of internal audiation.

Beyond score study, active practice in error-detection is equally crucial. Numerous workbooks and computer-assisted training programs have been devised as a tool for teaching error-detection (Costanza, 1971; Deal, 1985; DeCarbo, 1982; Ramsey, 1979). Despite the effectiveness of these simulated training regimes, live podium experience has proven to be the superior method of instruction (DeCarbo, 1982; Doane, 1989). Regardless of these available tools, deficiencies still exist. Error-detection skills are frequently associated with basic aural-

training skills, thus trained similarly, despite strong suggestions that these skills be addressed separately from one another (Brand and Burnsed, 1981).

Research also exists regarding the difficulties and factors associated with error-detection, specifically, what influences an individual's response. A large number of factors associated with the identification of pitch and rhythm exist. For pitch alone, components of the spectral composition, sound pressure level (SPL), and duration are found to influence the listener's perception (Terhardt, 1988; Vurma, 2010). Rhythm perception is also affected by a set of variables, duration, sound envelope, and on-/off-set. The innumerable burdens placed upon the listener to accurately detect qualities and characteristics of sound is exponential.

If developing awareness of all of these subtle variables was not daunting enough, error-detection of pitch and rhythm becomes even more difficult with external variables. Previous research demonstrates that an increase of timbre and musical lines decreases error-detection abilities (Byo, 1993, 1997; Sheldon, 2004). Additionally, it was found that listeners were more adept at identifying rhythmic errors than of pitch (Byo & Sheldon, 2000), and identifying errors occurring within the outer-most voices (Huron, 1989). The kinesthetic act of conducting has been widely documented to impede the conductor's ability to successfully identify errors as they occur (Hayslett, 1991; Blocher, 1986; Forsythe & Woods, 1981; DeCarbo, 1982). Anecdotally, this phenomenon has resulted in the common practice among choral conductors to record rehearsals so that errors not heard in the moment can better be assessed after rehearsal.

The field of *psychoacoustics* is vast and spans across the realm of practicality and theory. Psychoacoustics is defined as the manner in which acoustics are cognitively processed (Howard, 1996). Due to spectral and synchronistic components of sound, the human brain has the possibility of re-categorizing and processing stimuli in a manner which makes the most sense.

Deutsch (2011, 2013) explains how auditory illusions and masking can occur. Additionally, *auditory scene analysis* and streaming play a vital role in our ability to segregate and combine multiple sound sources (Bregman, 1990). Although the effects of these are often unconscious and uncontrollable, it is important to acknowledge its possible influence upon our aural perception.

At any given moment, the conductor is presented with a sum of information for evaluating and reacting. Whether they are responding to an internal message, perceived sound/stimuli from the ensemble, or other external source, the flowchart of information processing is continuously revolving (see Figure 1).

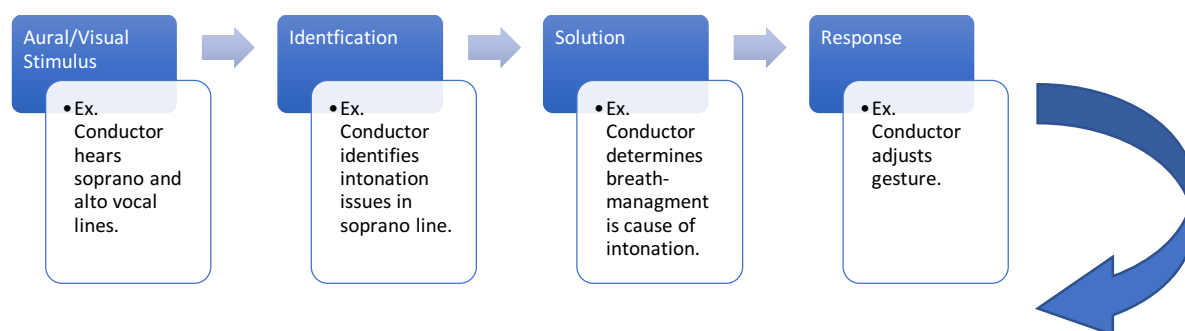


Figure 1. The progressive processing order of a choral conductor as influenced by internal and external stimulus.

The preceding discussion shows that the responsibilities of a conductor are not just musical; they also require immense cognitive processing. And yet, the human brain contains a finite amount of both processing space and capabilities; this is known as the *perceptual load*. Macdonald and Lavie (2011) define this as:

The concept of perceptual load corresponds to the amount of information involved in the perceptual processing of the task stimuli. This is operationally defined in terms of either the number of different task stimuli or the perceptual requirements of the task performed on the same stimuli (e.g., a simple feature detection task involves less perceptual load than a complex perceptual discrimination task). (p. 1780)

Once the perceptual load has reached its maximum, filtering occurs; this is known as *selective attention*. Commonly, this takes the form of auditory and visual filtering. It has been suggested in recent research that auditory and visual processing share *attentional capacity*;<sup>6</sup> this has been termed *cross-modal*. That being said, capacity in one modality may affect perceptual capabilities in another (Sinnott et al., 2006). Macdonald & Lavie confirmed this further:

These findings establish the phenomenon of inattentive deafness under visual load and extend the load theory of attention and cognitive control to address the cross-modal effect of visual attentional load on awareness of auditory information. They suggest that the elementary process of noticing the mere presence of a sound depends on an attentional capacity resource that is shared between the modalities of vision and hearing. (pp. 1785-1786)

With the effects of perceptual load being unavoidable, its influence upon the selection process is similarly unavoidable (Lavie, 1995).

There are three primary schools of thought concerning the cognitive process of selective attention. The first attempt to describe cognitive filtering was established by Broadbent (1958), who devised a *Filter Theory of Attention*. He suggested that irrelevant, or unattended stimulus, becomes filtered out during the initial selection process. The point of filtering is often considered

---

<sup>6</sup> *Attentional Capacity* is the combined perceptual processing limit of all sensory stimulus.

the “bottleneck” point (see Figure 2). In the role of conductor, such selectivity results in the aural exclusion of some vocal and instrumental parts in the overall texture.

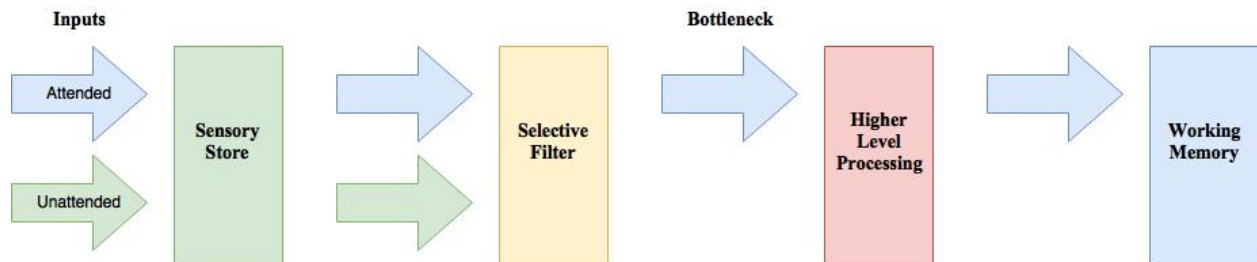


Figure 2. Broadbent’s (1958) *Filter Theory of Attention*. Unattended stimulus becomes filtered out during the initial selection process.

To address the issue of unattended stimuli being completely eliminated, Treisman (1960) devised a second approach, a *Filter Theory of Attenuation* --- a filtering model which attenuates unattended stimuli.<sup>7</sup> More directly, the brain attenuates the perceptibility of the undesired stimulus, as opposed to the initial rejection of information (i.e., early-stage filter). This results in the processing of all aural stimulus, although it is difficult to extract recognizable and meaningful content from the unattended sounds.

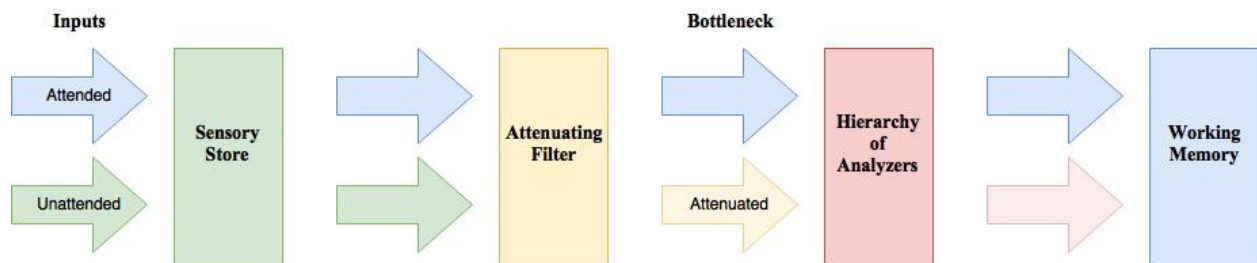


Figure 3. Treisman’s (1960) *Filter Theory of Attenuation*. Unattended stimulus becomes attenuated during late processing stage.

<sup>7</sup> Unattended stimuli are decreased, or *attenuated*, in perceptibility (e.g., turning the TV volume down).

Thirdly, Deutsch & Deutsch (1963) created a similar filter model as Broadbent, however, they identified the location of late-stage filtering. All information would be equally processed and would reach the bottleneck of attention during the entering of short-term memory (see Figure 4).

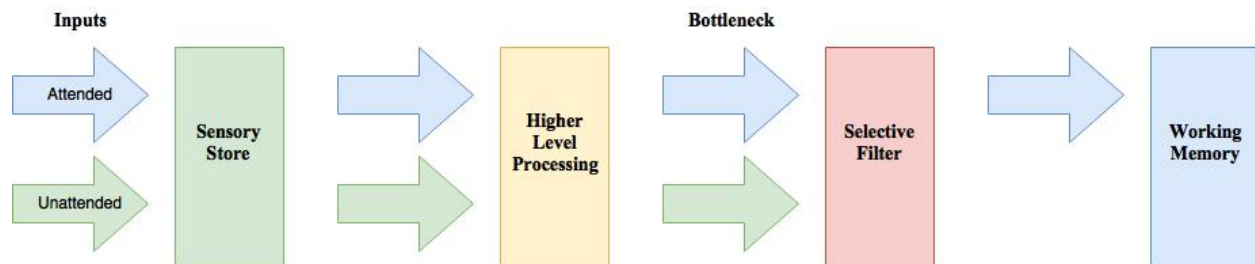


Figure 4. Deutsch and Deutsch's (1963) late-stage filtering model. Unattended stimulus becomes filtered, similar to Broadbent, however, at a later stage of processing.

Despite the debates of which model is most valid, researchers unitedly agree that perceptual selectivity occurs in one form or another.

Finally, although peripheral to this study, *eye-movement tracking*<sup>8</sup> has shown influence upon performance and processing speed. The ability to view a printed score while processing an aural stimulus is imperative to successful error-detection. Current research has primarily studied the eye-movements during a sight-reading and playing process. Eye-movement often determines: (1) what visual information is made available for perceptual processing, (2) the sequence in which the information is made available, and (3) the duration that the information is made available (McConkie, 1983). It has been shown that successful music readers have significantly more eye-movement, and commonly view ahead of the point of performance (Goolsby, 1994;

---

<sup>8</sup> *Eye Movement Tracking* is the neurological, cognitive, and physiological study of eye movement.

Waters and Underwood, 1998; Karpinski, 2000). These movements result in a stronger structural understanding, thus providing a greater inferential ability. Sloboda (1985) suggested that,

The profiles for the skilled sight-reader indicate that one need not look at all of the visual information in order perform the notation. This may be evidence of inferring aspects of melody based on previous tonal/rhythmic sequences and diatonic organization that may be analogous to semantics of syntactics in language. (p. 165)

Goolsby (1994) added that,

While many researchers in language reading have proposed that an efficient reader can use knowledge of language to reduce the degree with which he must attend to the visual detail of the text (e.g., Goodman, 1976), one can assume that skilled music readers can successfully predict highly constrained notes or rhythms and not be required to attend to every detail of the melody. (p. 110)

The ability to infer and group together larger chunks of information (also known as *chunking*) is crucial, not only with regards to eye-movement, but within the entire perceptual and filtering process.

### **Purpose of the Study**

This document is intended to address numerous unanswered questions in earlier research and expand the current understanding of selective attention and perceptual load as it relates to music processing; specifically, the detection of performance errors. The primary purpose of this study was to investigate the effects, influences, and relationships the variable amount of attended stimuli have upon the listener's ability to successfully detect performance errors. The secondary purpose of this study was to investigate the relationships of different experiential training and its influence upon the primary objective.

With the exception of a limited list, previous perception studies have commonly been directed towards instrumental ensembles and non-music cognition studies. The current study was constructed to expand upon prior research and place it within the context of choral music. Additionally, this study attempted to remove common non-musical environmental variables (i.e., kinesthetic movement, visual distractors, etc.). Inequalities of score-study time have been limited to negate the variability of score-study methodology upon the overall results. Lastly, this study chose to use the term *selective attention* as the cognitive process of selectivity during the increase and decrease of aural and visual stimuli.

### **Description of the Study**

**The study consisted of testing error-detection abilities by manipulating the quantity of vocal lines the listener was to isolate, or selectively *attend*.<sup>9</sup>**

Participants consisted of adults who identified as being a future, current, or past choral conductor. The participants were presented with an independent variable, as they would be tested on an increasing number of vocal lines of which were to be attended (i.e., one, two, three, or four). Total error-detection score, as well as individual scores for each of the four possible variants of the independent variable, were the dependent variable in this study. Additional demographic and experiential information was obtained.

Participants were presented with 16 8-measure musical excerpts; each set in a four-part voicing (i.e., soprano, alto, tenor, and bass).<sup>10</sup> Each excerpt was randomly assigned to one of four possible variations: one-, two-, three-, or four attended vocal lines. During each, the prescribed vocal lines included performance errors of pitch and rhythm. Participants were provided limited

---

<sup>9</sup> For the purpose of this study, *attend* will refer to the directed attention of the participant.

<sup>10</sup> A traditional four-part choir consists of, arranged highest to lowest, sopranos, altos, tenors, and basses.

time for score study, followed by two performances of each excerpt. During which, participants were directed to attend to the prescribed vocal lines and identify performed errors. Data was collected, indicating the error-detection scores of each participant in the four variances.

Demographic and experiential data collected would be analyzed for possible relationships with the dependent variable.

### **Research Questions**

The primary research questions for this study were:

1. Is error-detection acuity affected by the quantity of selectively attended vocal lines?
2. Is error-detection acuity of pitch and rhythm, respectively, affected by the quantity of selectively attended vocal lines?
3. Does the quantity of selectively attended vocal lines affect the quantity of perceived *phantom errors*?<sup>11</sup>
4. Does *primary ensemble conducting experience*<sup>12</sup> affect error-detection acuity?
5. Is there a relationship between self-assessed “error-detection ability” and completed error-detection scores?
6. Does the type of college/university degree influence the conductor’s error-detection acuity? More so, does the variance in college/university degree provide corresponding data when examined against the quantity of selectively attended vocal lines?
7. Is there a relationship between years of conducting experience and error-detection acuity?

---

<sup>11</sup> *Phantom errors (or false-alarms)* are perceived performance errors which never occurred.

<sup>12</sup> For use within this study, *Primary Ensemble Conducting Experience* refers to the primary ensemble participants are used to working with (e.g., elementary choirs, middle school choir, church choir, etc.).

## **Limitations**

This study was constructed with a testing platform capable of being administered by the researcher or the participant, respectively. This decision allowed for a broader target population, however, also required careful control of additional variables. To ensure that all participants received a similar testing procedure, a video which described and administered the test was distributed to the participants, along with the official testing materials. However, due to the option of distance participation, an on-site investigator was unable to be present for some participants.

This study incorporated the use of 16 different musical excerpts, each constructed to be similar in difficulty. Some respondents, however, commented upon the variance of voice-leading and that they were unable to “predict” the direction of vocal resolutions. Despite the possible abnormalities in voice-leading, the researcher determined that due to the consistency of musical excerpts and all participants receiving identical materials, all error-detection scores were proportionally consistent; thus, the reliability of the study being uncompromised.

## **Delimitations**

This study examined the effects of variable selectively attended vocal lines upon error-detection acuity. During testing procedures, participants were only required to identify the error location; identification of the type of error was not necessary (i.e., pitch or rhythm). By examining the participants perceptual limits, identification of error location was sufficient.

Although the manner in which a participant viewed and methodically approached the score may have influenced their overall acuity, this study did not attempt to understand or identify the cognitive process of the participants before, during, or after the study.

## **Assumptions**

Participants were at least 18 years of age or older at the start of the study and identified as a past, current, or future choral conductor. Participants willingly volunteered their time without any form of monetary compensation or reward. Participants who completed the study did so honestly, and with the integrity of the study.

## **Organization of the Dissertation**

This chapter includes the introduction, statement of the problem, need for the study, research questions, definitions, limitations, delimitations, and assumptions. Chapter 2 reviews prior literature related to the skills of error-detection and perceptual cognition as it relates to the current study, including score study methodologies, aural training program and materials, factors associated with error detection, cognitive processing, cognitive perception, and eye movement tracking. Chapter 3 contains a description of the study design and procedure, context of participants, construction of visual and aural musical excerpts and materials, data collection, and data analysis procedures. Chapter 4 is an analysis of all quantitative data. Chapter 5 is a discussion of the findings, implications, and suggestions resulting from the findings, and recommendations for future research.

## **CHAPTER II**

### **Review of Literature**

The importance of error detection abilities have been significantly researched in the roles of conductor, director, and teacher. However, subject matter which equally affects aural perception (i.e., psychoacoustic, a variance of stimulus, cognitive processing) often becomes disassociated during error detection training. Studies and critical components to be examined within this chapter deal primarily with aspects relating to error-detection abilities and its training, as well as varying factors having a positive and negative effect upon the listener's ability to detect errors. Literature content areas to be reviewed will be: score study methodology, aural training programs and materials, factors directly associated with error detection abilities, cognitive processing, cognitive perception, and eye movement tracking. Although this chapter desires to bring light to different components and influential factors of error-detection and aural acuity, it is not within the scope of this research to specifically address many of the areas mentioned above.

#### **Score Study Methodology**

For most successful conductors, the initial score preparation includes a thorough analysis of melodic, harmonic, rhythmic, motivic, pedagogical, and other varying aspects pertinent to the particular piece. Although preference of study style ultimately depends upon the conductor, there have been common practices throughout the 20<sup>th</sup> and 21<sup>st</sup> centuries. An overview of methods most widely used, in addition to their perceived rationale and advantages, will be provided. It is important to note, however, that the goal of this review is not to prioritize a particular style of score analysis unless research exists which pertains directly to error-detection. More so, this review is placed merely to illustrate one aspect of error-detection.

**Common Practice Methodologies.** In Decker and Herford's iconic *Choral Symposium* (1988), Herford articulates his widely respected score study method. Herford's analysis views the musical ideas in relation to the overall piece, rather than individual sections.<sup>13</sup> Herford suggests the creation of a functional graph which identifies and labels varying musical aspects as a continuous spectrum. Elements included, but not limited to, are: bar numbers, phrase groupings text, keys and harmonic relationship, pitch relationship, instrumentation, and dynamics.

In practice, this method serves as a tool for score learning and memorization. The advantages of this method may better help conductors acquire a stronger sense of musical anticipation and audiation capabilities. This technique becomes extremely useful when first audiating the desired sound; this is the suggested first step in error detection.

Margaret Hillis, a student of Robert Shaw and founder of the Chicago Symphony Chorus, furthered Herford's technique. In a transcribed interview with Dennis Shrock (1991), she explained that her score study process offers further possibilities to internalize the workings of a musical score. Hillis' score study method incorporates various symbols or indicator marks, in addition to multiple colors which signify differing musical elements. Examples of this method include the use of shapes to indicate meter (e.g., square for 4/4, triangle for  $\frac{3}{4}$ ); squiggly and straight arrows for *accelerando* and *ritardando*<sup>14</sup>; and the use of lighter and darker colors for dynamic contrast. Similar to Herford, the intent of this methodology is to memorize the score through the process of study. Hillis stated, "Once a score has been totally marked – signifying your thorough study – it is basically memorized. You have your score in front of you, but you

---

<sup>13</sup> Although not stated, this manner of study may be associated with the cognitive function of *chunking*.

<sup>14</sup> *Accelerando* is the musical term for "speeding up." *Ritardando* is the musical term for "slowing down."

don't have to look at it." This recognition aids to further ideas of over-stimulation and processing. The more the conductor is processing, the further they will be unable to detect errors efficiently; by having the score memorized (i.e., the complete understanding of the musical sound and structure), they are capable of providing more attention to the success and errors of the performers. Further supporting the above discussion, like "arm-waving," the act of looking at a score adds a level of cognitive input, thus leading to a lower threshold of capacity. Similarly, this may further reduce the conductor's aural acuity.

Acknowledging the importance of both our inner and outer ear, Green and Malko (1975) addressed their beliefs concerning score study and the skill it imparts. Green suggested that there is a training of two types of hearing, "the objective hearing of audible sounds," and "the subjective, imagined, inner-ear process;" she additionally offers that training the imaginative process is often a significantly more difficult task. Even before score study, Green suggested that necessary skills must be obtained (e.g., imagining the ascending or descending of whole or half steps; singing all notes of a scale between outlining notes). She suggests that to strengthen the inner ear, the conductor should practice only singing the starting notes of each measure while audiating the passing tones in-between.

Malko also addressed the need for the conductor to understand the content and not just the overall sound. Such aspects include instrumentation, style, emotional qualities, phrasing, dynamics, articulation, structure, technical demands, and potential rehearsal problems. The impact of both Green's and Malko's approach is that conductors should be capable of analyzing the performance and comparing it to their mental image, rather than analyzing both the performance and score simultaneously. By knowing the inner workings of the score, the

conductor stands a greater chance for successful error-detection due to the significant study completed prior to conducting.

Lamb's (1988) *Choral Techniques* provides various guidelines regarding the aural training of the conductor's ear. Lamb considers the issue of aural training into two separate categories, either melodic or harmonic considerations. In addition to singing each part independently, he also suggests the self-prompting of questions regarding the melodic structure. Such questions may include phrase length and shaping, congruent and disjunct motion, intervals, and range/tessitura. Similar to melodic considerations, matters of harmonic concern are also presented: harmonic flow, modulation, consonance and dissonance, as well as other factors about the harmonic structure. Lamb suggests that these techniques may develop the aural sensitivity of the conductor during times of rehearsal and performance.

**Effects of Differing Models.** Crowe's (1996) research, *Effects of Score Study Style on Beginning Conductors' Error-Detection Abilities*, provides both a concise literature review, as well as an investigative study to examine the effects of score study on error-detection abilities. Specifically, Crowe brings attention to current observable trends and issues with successful error-detection. An overarching problem is the increase of difficulty when multi-part and multi-timbral music is presented, opposed to single melodic or timbral music. Crowe also states that current aural training instruction is often inadequate in many colleges and universities; conductors leave being under-equipped for successful error-detection.

To better understand the necessities a conductor requires while preparing a score, Crowe created a study to examine the error-detection abilities of undergraduate instrumental conductors. Conductors were to detect and isolate pitch and rhythmic errors within musical passages containing 6 to 8 measures and including 1 to 8 different parts using the following test groups:

no pre-study, study with the score alone, study with the score and a correct aural example, and score study at the keyboard. Results concluded that conductors who had studied with a score and an aural model were significantly more successful in identifying pitch and rhythmic errors. It was further acknowledged that the addition of multiple parts and timbre significantly decreased error-detection abilities.

Although results from this study provide insight into successful methods of teaching, it also provides an in-depth look at what skills conductors' lack—most germane to our discussion, audiation skills. The conductor's ability to audiate the music internally is crucial, not only to detect errors of pitch and rhythm, but also to begin detecting issues pertaining to tone and technique.

Hopkins (1991) examined the effect of varying score study methodologies on error-detection abilities of undergraduate choral conductors. Additionally, his study examined the skills of pianist conductors versus non-pianist conductors, and the extent to which conductors perceive nonexistent errors. Test groups were separated into the following categories: using a piano, using a recording, sight singing, and silent study. Results concluded, similarly to Crowe, that score-analysis with a correct aural model improved the ability to successfully detect errors. Furthermore, conductors were more apt to identify rhythmic errors than ones concerning pitch. Results also demonstrated that conductors who classified themselves as pianists also scored higher in their detection abilities. Lastly, over 90% of all conductors perceived some form of aural error which was nonexistent.

With regard to this study, Hopkins further identifies the strengths and weaknesses conductors face with aural modeling and audiation abilities. Even more telling, however, is the

evidence of conductors cognitively perceiving errors never committed; the issue of psychoacoustics plays a significant part in these results.

### **Aural Training Programs**

For most conductors, aural training occurs before the specialized training in their content area. Within a university setting, aural skills are taught within the first two years. More so, it is extremely rare that undergraduate preparation advances beyond these primary levels, and it is uncommon for graduate studies to include additional aural training. The fundamental purpose of aural training is to develop the perception and sensitivity to pitch and rhythm, as they relate to themselves and together. This form of training ultimately enables musicians to compare their aural and visual perceptions simultaneously (i.e., hearing sound while looking at a score) and vocalize written notation while visually reading a score. Beyond a student's primary development, more specific matters need to be learned, such as intonation<sup>15</sup> tolerance and acuity, pitch-related pedagogical issues, and focused listening (i.e., knowing *what* to listen for). Learning to use ones' own *inner ear* becomes crucial in being able to hear sounds internally.

This discussion will illustrate various tools and methods incorporated to develop fundamental error-detection abilities. Lastly, it is important to note that beginning aural training materials as used in entry-level courses will not be examined.

**Programmed Instruction.** To expand upon Ramsey's (1978) *Program in Error Detection* (PED), Deal (1985) developed a user interactive *Computer-Assisted Program in Error Detection* (CA-PED). The CA-PED intended to evaluate and compare its effectiveness as an error-detection training instrument. By integrating computer technology, the user was provided

---

<sup>15</sup> *Intonation* refers to the degree in which the pitch is accurate; affecting factors include fundamental pitch and harmonic series.

the opportunity for more advanced navigation of the programmed material and questions, as opposed to tape playback and physical writing materials.

Participants were subjected to the *Test in Error Detection* (TIED) (Ramsey, 1978) pre- and post-study. Following the initial TIED, participants were divided between the control (PED) and experimental (CA-PED) group; each group was provided 6-weeks to complete the presented material. Despite the diverse qualities between the original PED and CA-PED, results indicated that both methods of programmed instruction proved to be an effective method of improving error-detection abilities.

To contextual and provide realistic situations one may face as a conductor, Ramsey (1979) developed an effective program of error-detection training utilizing full-band literature. In addition to devising a method for the preparation of error-detection, Ramsey created an assessment to measure direct improvement of the subject. In the creation of the original *Program in Error Detection* test (PED) and *Test in Error Detection* (TIED), Ramsey codified a list of typical pitch and rhythm errors often made; such list was the basis of error insertion within the PED and TIED.

Subjects consisted of music students from 3 southern universities. Upon completion of the TIED pretest, participants were distributed amongst four groups: A, B, and C included differing lengths of the PED material, and D contained no PED material. Upon completion of the post-TIED, results indicated that those who used the PED material demonstrated significant growth in their error-detection abilities. More so, the data also suggested that the group provided with the most significant length of material made the greatest improvement. It may be assumed by the positive results of this study that Ramsey's PED test may be a useful tool for improving error-detection abilities at home and when class time may be limited.

**Error Detection Workbooks and Materials.** Serving primarily as a short workbook, Hondorp's (2015) *Choral Error Detection: Exercises for Developing Musicianship* was explicitly designed for the training of young choral conductors in the listening and identification of performance errors. By incorporating actual published music, Hondorp developed a sequence in which the learner begins with a solo melody and listens to the provided CD containing programmed errors. Exercises become increasingly difficult and dense as the author trains the student to become efficient and comfortable while reading the score vertically, in addition to linearly. Although this work does not contain new functional information, it is one contemporary model for the instruction of error detection for conductors.

Although not directly related to the detection of incorrect pitch and rhythm, the perception of tone quality may also affect the perception of pitch; hence the director must be able to diagnose vocal technique issues as they arise. In *the Choral Conductor's Aural Tutor: Training the Ear to Diagnose Vocal Problems*, Jordan (2006) includes an accompanying CD providing various demonstrations of common vocal issues that arise within the rehearsal. As a workbook, it provides an opportunity for conductors to begin identifying and making appropriate associations with healthy choral sounds, even prior to being in front of an ensemble.

Upon the realization of training deficiencies, Wright (2001) constructed an invaluable tool to train the aural abilities of choral conductors. Wright developed an extensive workbook which provides incremental progress in improving strong aural discriminatory skills. Unique to Wright's text is that it specifically utilizes choral music; many examples include excerpts from plainchant or other pieces from the choral canon. Similar to previous findings, this supports the idea that contextual practice and training provides stronger fundamental skills. Specific to this workbook, Wright directly focuses upon the development of multi-part hearing, vertical aural

discrimination, the formation of a mental-aural image of the score, and error-detection. Although not a promotion of these materials, it is believed that creating a contextually progressive training regime becomes beneficial in conductor's ability to detect errors successfully.

Spradling (2010) constructed a workbook and supplemental instrumental parts designed to hone the aural acuity of conductors through the live performance of various sized instrumental ensembles. This workbook provides an array of excerpts ranging from Grade 2 to Grade 6 difficulty;<sup>16</sup> this variance offers an invaluable tiered progression. Additionally, a full set of instrumental parts are provided, both correct and with inserted errors. These materials offer practical application within a broad array of classroom sizes and skill levels.

Following his text *Aural Skills Acquisition: The Development of Listening, Reading, and Performing Skills in College-Level Musicians* (Karpinski, 2000) which was developed as a compendium of current aural training research, Karpinski (2007) created a supplementary workbook allowing for the practice of components originally established in his earlier work. Implementing the theoretical approach to aural training as previously presented, Karpinski provides the user a graduated approach to aural training utilizing difficulty of content, in addition to difficulty of aural and visual perception.

**Miscellaneous Aural Training Considerations.** Sheldon's (1999) study illustrated the overall relationship of aural training and its effect on error-detection abilities; specifically, context-specific training regimes. Sheldon initially addressed the results of previous research suggesting that the most optimal method of instructing error-detection is through live podium

---

<sup>16</sup> Commonly used within symphonic bands and wind ensembles, a grading system of 1 to 6 is utilized when referring to repertoire difficulty level.

time. It is also mentioned that the degree of familiarity with a score has an impact on the overall perception abilities of the conductor; this reiterates the point for meaningful score preparation.

Sheldon provided the experimental group with an aural training regime which included singing children's songs using solfege syllables, in addition to tonal warm-ups reinforcing the given songs. All subjects were provided training and rehearsal time, practicing inner medial band repertoire by singing scales, triads, and similar patterns in the given key; fundamentals of various musical passages were also taught. Results indicated that those in the experimental group were more capable of detecting errors than those who were a part of the control group. It is thought that these forms of contextual training better allow the conductor to internalize the entire harmonic and melodic structure, thus creating a greater awareness of errors which do not align with the overall sound.

As a second layer in aural instruction after basic skills courses, students in conducting courses are encouraged to record and review video footage to better understand gesture from an outside perspective. Stuart (1979) examined the effect of video feedback on identifying errors versus strictly conducting without feedback. Results demonstrated that the participants who had spent time working with the post-visual materials scored higher in their abilities to detect errors. Although this study does not answer all the variables within, it does promote the need to become visually aware of the musicians and visual indicators of performance errors and technique. It is suggested that conductors should frequently record their rehearsals to examine mistakes within the ensemble, but to also identify possible errors within the gesture and how that may impact the performance of the ensemble.

Inspired from Forsythe and Wood's (1983) previous research, Hayslett (1996) continued examining the overall effect of movement training upon the aural acuity of conductors. Hayslett

found that those uncomfortable with kinesthetic movement were less successful with their aural detection abilities. Similar to previous studies, participants were assessed on aural perception questions while conducting, versus remaining static. An experimental group was assigned to several training sessions which included techniques from Rudolf von Laban's movement theory<sup>17</sup>, warmups based upon T'ai Chi studies, numerous physical independence exercises, and musical independence exercises. Results from the post-test revealed that those who received movement training scored significantly higher than of those who did not.

A possible theory may be that acuity improved as conductors became more aware and acclimated with their gesture. Another possible idea may be that some began cognitively chunking the conducting (i.e., an act of cognitively merging multiple gestural movements into one, opposed to managing multiple smaller movements); this would allow for more concentration on other areas. Although further research should be conducted, it is strongly suggested that movement training for conductors is a crucial skill for aural acuity.

The incorporation of eurhythmics<sup>18</sup> has long been in K-12 classrooms as a manner of teaching students musical fundamentals through a kinesthetic approach; Urista (2016) applies the same concept to musical and aural literacy within a collegiate aural skills classroom. Urista's belief is that learners should "experience before analysis;" this idea may also be referred to as "Do, then know."<sup>19</sup> This method is intended as a supplemental resource which has the ability to enhance the foundational training. As stated by Urista, a primary purpose of the text is to

---

<sup>17</sup> Rudolf van Laban (1879-1958) devised a systematic method for define body movements. Components of the system identified differences in movements by weight, time, space, and flow.

<sup>18</sup> Also known as the *Dalcroze Method*, *Eurhythmics* is a music education methodology which highlights body-awareness and movement as its primary instruction tool.

<sup>19</sup> The pedagogical practice of "Do, then know" is integrated into the choral methodology at the University of Washington.

promote a deeper connection between the brain, which perceives and analyzes, and the body which is the performing medium (i.e., the overall neuromuscular system). Incorporated exercises often contain aspects in which the participant must multitask and process multiple stimuli (e.g., clap one rhythm, while the next clapped rhythm is demonstrated simultaneously). These exercises are highly applicable in training conductors to better detect possible errors. Although it would not classify as a method of itself, its purpose is valuable in providing conductors with direct cross-training in periods of multiple stimuli (i.e., aurally, visually, and kinesthetically).

DeCarbo (1981) investigated the effect of two separate error detection training regimes: (1) on-the-podium conducting format, and (2) pre-recording materials format. Although it had been identified previously that programmed instruction was a useful tool for error-detection training, DeCarbo inquired about the efficiencies of the two models. Both test groups received identical materials. Results indicated that those participating in the group provided with podium conducting experience scored significantly higher in the conducting error detection test. DeCarbo further added that although the content of the two separate programs was similar, the context and application of error-detection training may not always transfer into real-life situations.

### **Error Detection Factors**

It has been demonstrated that within the ability to detect musical errors, there exist internal and external factors which influence the listener's ability, negatively and positively.

**Experience and Training.** Although research has been completed to identify years of experience and its effect upon error-detection, results have demonstrated an insignificant relationship (e.g., Gonzo, 1971; Brand & Burnsed, 1981). It has been identified that experience with error-detection training has demonstrated an increase in error-detection acuity, however, generalized experience level has shown no effect upon error-detection acuity.

**Parts, Texture, and Timbre.** Huron (1989) examined the abilities and limitations of identifying the number of simultaneously sounded voices within a polyphonic texture. Huron discovered that as the number of concurrent voices increased, the ability to quantifiably detect the number of voices decreased. The point of confusion often was associated with the addition of a third and fourth voice; it was additionally noted that participants frequently underestimated the number of sounded voices. Explaining the limited abilities of the participants, Huron identifies the auditory scene analysis theory by Bergman, and Broadbent's' filter theory. Huron states:

Research in the perception of multiple concurrent speech streams has demonstrated a serious inability of subjects to attend to more than one voice at a time (Broadbent, 1958). When asked to attend to one of two concurrent speech streams, auditors may be unable to report even whether the language of the unattended stream was English. (pg. 378)

Byo (1997) studied the effect of multi-part and timbral music on error-detection abilities of undergraduate and graduate music students. Multi-part music may be defined as having more than one concurrent sounding line (i.e., soprano and bass), whereas multi-timbral is defined as has more than concurrent sounding instrumental timbres (i.e., violin and trumpet). Conductors were provided multiple examples, each including errors of pitch and rhythm; difficulties were varied. Results indicated that with an increase of texture and parts, the percentage of detection decreased. More so, it was found that that all subjects identified less than 50% of all errors. This number is startling, especially factoring in that no one was provided a pre-aural model. Graduate students, however, demonstrated a stronger ability of detection. Findings demonstrated a greater level of difficulty in identifying errors concerning pitch than of rhythm; undergraduate and graduate rhythmic detection scores were nearly identical.

Byo further suggested that additional development and training may be required to ignore specific aural stimuli to isolate a more targeted stimulus (i.e., pitch). This theory directly relates to ideas of overstimulation and overload of external stimuli. Therefore, there is need for a stronger foundational pedagogy in teaching conductors *isolated listening*, or the ability to focus the senses and processing on more specific targets, rather than generalities.

**Performance Anxiety.** Considered to be one of the most definitive texts in the field of *music performance anxiety* (MPA),<sup>20</sup> Kenny (2011) provides a detailed transcript of the neurological, cognitive, physiological, and emotional aspects of MPA. This text explicitly addresses the fundamental issues often associated with anxiety disorders and how matters relating to musical performance anxiety are similar and different. Additionally, Kenny provides various reasons why performers often experience these forms of anxiety. Although the role of the conductor is never mentioned in regard to symptoms of anxiety, it may be implied that many of the aspects discussed by Kenny may apply to the conductor. A common example of such may include conductors whom panic or become anxious during periods of feeling overwhelmed; symptoms may include a decrease in eye-sight, rapid heart-beat, and hyperventilation. The effect of such upon a conductor reduces their perceptual limit, thus reducing error-detection abilities.

As part of their overall view of neurological control and music, Altenmüller, Kesselring, Jürg, and Wiesendanger (2006) offers their final chapter within *Music, Motor Control, and the Brain* specifically to issues of MPA. Kesselring defines MPA as, “a state of arousal and anxiety occurring before or while a person is performing non-anonymously in front of an audience producing a valuable or evaluated task touching on his/her self-esteem.” This chapter rearticulates previous symptoms often associated with MPA, such as intestinal problems,

---

<sup>20</sup> *Music Performance Anxiety* is a condition of heightened anxiety during musical settings.

palpitations, irregular heartbeat, tremors, difficulty concentrating, difficulty with intonation, and unreliable memory. It is easy to assume that conductors experience forms of this anxiety disorder and are negatively affected by symptoms which may hinder overall aural acuity. Lastly, Altenmüller et al., provide suggestions for coping and alleviating MPA, including positive thoughts, visualization and distraction, muscle relaxation, deep breathing, proper nutrition, and exercise.

**Effects of Conducting.** *The Effects of Conducting on the Error Detection Ability of Undergraduate and Graduate Instrumental Conductors* designed by Forsythe and Woods (1983) provides significant insight into the challenges of “multi-tasking” facing conductors. This study was designed to examine whether the kinesthetic act of conducting would hinder the ability to successfully detect errors, in addition to testing for similarities and differences between undergraduate and graduate conductors. Results indicated that the kinesthetic movement did indeed negatively affect the conductor’s abilities to detect aural errors, however there appeared to be no statistically significance with relation to undergraduate and graduate conductors.

The outcome indicates that conductors are often inhibited in their processing abilities while conducting. More so, this signifies the need for further aural training during periods of endured multiple stimuli. Although results indicated no difference between the two different subject groups, it is posited that those with more experience in such situations often become more adequate of perceiving while conducting, thus being more successful at error detection

**Effects of Concurrent Piano Playing.** Napoles, Babb, Bowers, Hankle, and Zrust (2017) examined the effect of concurrent piano playing upon the error-detection abilities of preservice teachers. Participants were divided into two groups: (1) listening to an aural excerpt without additional accompaniment, and (2) listening to an aural excerpt while playing the prescribed

vocal line on the piano. During playback, participants were instructed to listen and identify errors present within the performed recordings; errors would only occur within the soprano and bass line. Results indicated that the playing of the piano during the identification process of errors had an adverse effect on their overall aural acuity. More so, it was found that participants were more capable of locating errors within a soprano line as compared to the bass line. The researchers suggested that identification of errors in a melodic line (i.e., soprano) commonly are more perceptible than errors of harmonic structure (i.e., bass).

### **Cognition: Processing**

Commonly referred to as an organic computer system, the human brain is capable of inputting and outputting massive amounts of information. However, as with all functioning systems in existence, a maximum load level exists; once reached, processing either reroutes or ceases entirely. Conductors are consistently processing multiple forms of stimuli, including the kinesthetic effects of movement and conducting, the aural perception of various sounds, and other external environmental stimuli (e.g., extraneous participant movement, classroom management needs). To identify the effects of varying amounts and forms of stimuli upon aural acuity (error-detection), previous research will examine: (1) the effect of physical movement on aural perception, in addition to the effect of movement training; (2) the effect of visual overload; and (3) the effect of aural overload. The perceived implications from these findings will provide a broader understanding of how conductors process, and how we may better prepare conductors to more efficiently organize and manage internal and external stimuli in a manner which promotes high aural acuity.

**Auditory Filter Theories & Selective Attention.** Intertwining the fields of auditory filters and selective attention, Hayslett (1991) examined the effect of directed attention upon

error-detection and peripheral hearing ability.<sup>21</sup> The secondary examination of Hayslett's study was to determine if the use of an aural model or "template" prior to selected musical excerpts improved ones' aural acuity. Participants were directed to maintain focus and attention to a prescribed part(s) and indicate performed errors; "focus reinforcers" were inserted into directed parts to ensure attention was directed toward the intended parts. Simultaneously, participants were advised to detect the deletion of musical lines in subsidiary parts. This procedure was completed in two forms: (1) with a correct aural template prior, and (2) no correct aural template prior. Results demonstrated that when aural attention was placed upon one musical line, aural acuity was diminished in concurrent lines. Additionally, trials which included a correct aural template prior proved to have an increased detection ability.

As a conductor, it is a crucial skill to be able to quickly and accurately reroute our attention while hearing multiple sounds (e.g., listening to multiple voice parts and identifying which require assistance, followed by immediate re-evaluation). Koch (2011) examined the ability of a listener to isolate and comprehend two separate audio messages and questions, while receiving visual prompts as to whom they should direct their attention. Koch points out that this is often classified as *selective hearing* by the lay-person. Results suggested that most participants required a short-to-significant amount of time to adjust their aural and cognitive attention upon a differing stimulus. These findings provide some insight into the ability/inability conductors encounters while evaluating multiple musical lines at the same period of time.

---

<sup>21</sup> The author used *directed attention* interchangeably with *selective attention*.

Creating an aural version of the “gorilla experiment”<sup>22</sup> by Simons and Chabris (1999), Koreimann (2014) devised a study which examined the participants aural perception while being assigned to a set task. Two separate groups (i.e., control and experiment) were asked to listen to *Also sprach Zarathustra* by Richard Strauss; the experimental group was asked to count the number of timpani strikes, whereas the control group was to listen without an assigned task. During the test, instances of an electric guitar solo were inserted as an unexpected event. Results demonstrated that those who were tasked with counting timpani strikes were often unable to recognize the occurrences of the unexpected event, whereas the control group demonstrated a stronger ability to identify the unique instance.

These findings are critical in how we approach conducting our ensembles and our pedagogical approach to teaching conducting. Due to this issue of inattentional deafness, it would often be possible to overlook aural discrepancies, mainly if the listener is already preassigned to listen for something else. As we train conductors, instruction must continue to develop their ability to process and analyze varying instruments and voices, while maintaining the perception of the overall sound.

Examining the effect unattended content has upon the processing of attending content, Davison and Banks (2003) constructed a study testing such by utilizing differing intervallic pairs. Devised as a set of two experiments, Experiment 1 asked participants to observe two 2-note fragments located in differing registers and timbres. Participants were subsequently asked the direction of one of the two moving lines while ignoring the other. Experiment 2 was constructed similarly, however, melodic fragments contained overlapping registers of pitch. Results from

---

<sup>22</sup> *Inattentional blindness* was demonstrated by having viewers count the number of passes within a basketball game while a participant in a gorilla suit walked amidst the game. Results indicated that most participants never noticed the gorilla suit.

experiment 1 indicated that participants were affected by intervallic movements of a second, whereas experiment 2 indicated that participants were affected by intervallic movements of a major second and perfect fifth. Davison and Banks suggested that although an unattended musical line may influence perception on an attended line, that the intervallic context may play a significant role within selective attention of musical counterpoint.

**Perceptual Load Theory.** Birthed from filter theories of Broadbent, Treisman, and Deutsch and Deutsch, Lavie (2005) suggested that regardless of where the filtering of stimuli occurs (i.e., early vs. late stage), there is a limited amount of processing capability. More so, Lavie argued that when the primary perceptual load is high, secondary perception (i.e., music, distractors) decreases due to limited processing capabilities; the converse of such is also true.

Macdonald and Lavie (2011) examined the effect of visual stimuli on aural acuity. Participants were presented with varying visual images containing cross-shapes which were made up of different colors and sizes; questions regarding the images were also presented simultaneously. During random points, an audio source of white noise was played. Results indicated that up to 79% of participants were unable to notice that an audio sound had been played. Additionally, it was observed that as the visual load increased (i.e., specificity and quantity of questions) their identification of the foreign sound decreased.

Both Macdonald and Lavie, and Koreimann's studies present us with interesting findings, but also disturbing realities. Current aural training classrooms are taught and presented under ideal situations, with most external stimulus being removed. However, it is clear from the previous two studies that to be aurally successful, one must be capable of managing the extraneous visual and aural stimuli that are also present. Examples of such within the tasks of a

conductor include classroom management, extraneous movement from within the room, extraneous sounds from within or outside (Macdonald and Lavie, 2011).

Acknowledging the array of literature presented in the area of visual perceptual load, Fairnie (2016) presented a study integrating an “auditory search task” which tested a variance of auditory load upon auditory perception. Participants took part in a set of two experiments, each dealing with attention and spatial location tasks. In Experiment 1, subjects were presented a binaural sound production including target sounds (e.g., a lion’s roar and dog bark), conditional stimulus (e.g., a driving car), and non-target sounds (e.g., chicken, cat). Participants were instructed to identify what target sound was played amongst the non-target sounds, in addition to indicating if the conditional stimulus was also present; the conditional stimulus was within 50% of trials. Experiment 2 followed similar procedures, however, expanded upon the variance of spatial proximity and location, and quantity of stimulus.

Similar to previous research, an increase in perceptual load resulted in a decrease of perception of a secondary auditory stimulus (i.e., a driving car). Conversely, participants demonstrated a 95% ability to detect the conditional stimulus when not provided with a primary auditory task (i.e., identifying the target sound). Fairnie identifies many real-world implications for these findings such as:

...when concentrating on a radio program while driving, one may fail to hear other important sounds such as an approaching ambulance. When eavesdropping on a conversation between two strangers on a train, you might fail to hear your station stop being announced. (p. 935)

Similarly, this poses multiple negative possibilities in aural perception in the musical realm (e.g., the inability to detect specific instrumentation within a large ensemble).

## **Cognition: Perception**

Issues of psychoacoustics are always at play when speaking of aural perception; however, they are often not labeled as such. Simply, psychoacoustics is defined as the way we individually process sound; examples of such include timbre, tone, temperament, volume, and intonation.

Within the context of choral conducting, this area of cognition plays a significant role, particularly regarding intonation and timbre. Each conductor unconsciously perceives sound with unique bias coming from specific experiences and backgrounds, which affects their overall aural perception. An example of such may include a conductor with primarily having experience with children's choirs, versus one whom has worked primarily with professional voices.

This sub-topic intends is to identify how issues of psychoacoustics impact the conductors error-detection abilities, either on a macro or micro level. Specifics will include: the effect of timbre on pitch perception; how volume influences our perception; tuning and temperament perceptions; and the issue of vocal formants and their effect upon perceivable pitch intonation.

**Auditory Scene Analysis and Streaming.** Established initially by Bregman (1990), the theory behind auditory scene analysis and auditory streaming addresses the manner in which the listener perceives and is capable of integrating and segregating multiple sound messages. As stated by Davison & Banks (2003), "The voices of a musical composition are in fact components of a single musical texture and may therefore be difficult to attend to separately because the interrelations between them would most likely affect processing of the unattended voice."

Additionally, Bregman (1990) and Deutsch (1999, 2011, 2013) identify the following *Gestalt* principles of grouping as influencing the perception of auditory streams: proximity, similarity, continuation and completion, organization, context, and perceptual field.

Testing the theories of auditory streaming as devised by Bregman, Gregory (1994) examined the effect timbre has upon auditory streaming. Participants listened to paired instruments each playing an individual, yet complementary scale. Such example includes: piano playing ascending C-Major scale and violin playing a descending C-Major scale. Timbre combinations were chosen at random and included the following instruments: horn, piano, flute, clarinet, trumpet, violin, and cello.

Gregory found that with an increase of timbre difference, increased the perceptual stream of the two musical lines; the converse is also true. Additionally, the relationship of timbre and scale continuity influenced the perception of segregate auditory streaming as well. These results are supported by the *segregation*<sup>23</sup> component of auditory streaming.

**Psychoacoustics.** *Acoustics and Psychoacoustics* by Howard and Angus (2006) serves as a compendium to all aspects regarding acoustics and the human perception of them; issues regarding music are also addressed. The primary interest of Howards' text is his explanation of the psychoacoustics of timbre. Interestingly, the author suggested that studies have demonstrated that listeners are unable to identify different musical instruments if the onset and offset phases have been removed.<sup>24</sup> Additionally, Howard addresses the issues of the harmonic and formant series. Due to the natural tendency of varying instruments having higher or lower formants than others, it may influence the listener to perceive tone and pitch differently (e.g., a trumpet may sound sharp and brittle, opposed to a trombone, due to the prevalence of higher partials).

---

<sup>23</sup> *Segregation* within auditory streaming is the ability to isolate selected sounds from the whole.

<sup>24</sup> *E.g.* Recordings of a note played on an open violin string and a trumpet are modified to remove their onset and offset phases in each case. Results indicated listeners having a difficulty identifying.

Although this text provides significant statistical and analytical analysis of acoustics, that is primarily out of the scope of this topic. It does, however, reinforce the theory of why conductors may perceive sound sources differently from one another.

Geringer (2015) developed a study to determine if listeners perceived the same type and quality of intonation based upon the specific instrument; more simply, does the sound of the instrument affect how we perceive intonation? Subjects consisted of 150 graduate and undergraduate music majors; within the group, 50 each studied voice, wind instruments, and string instruments. During the study, a solo trumpet, violin, and soprano voice each performed *Ave Maria* by J.S. Bach as a solo. Amongst each performance were three assigned moments of pitch deviation, flattening or sharpening, in increments of 10, 20, or 30 cents. Results indicated that listeners perceived the flattening of a trumpet further out of tune than as compared to the violin and voice. Conversely, the trumpet and violin were perceived as more out of tune while sharpening than was the soprano voice. Lastly, it was also observed that differences in pitch discrimination differed amongst the listeners depending upon their applied area of study.

This particular study reiterates the following ideas: our previous experiences and skills may determine how we hear particular timbres; specific timbres may be prone to acute perception; and more importantly, some timbres more easily may fall under the radar regarding critical discrimination. An example of such theory is: if the conductor is a tenor, they may be overly sensitive to errors occurring within the tenor line, however the alto lines may tend to be under-perceived. Although this factor may be reduced due to proper score preparation, it is in the researcher's opinion that over time, our ears develop an individual default, or bias.

There has been historically a steady increase in the desire for overall volume when it comes to music and film, specifically louder (Devine, 2013). This can be frequently observed in

the overall dynamic contrast of popular music – sound is heavily compressed to eliminate low-volume passages. Haack (1975) studied the aural acuity of various musical details and how they related to overall volume. Upon testing the various perception of the subjects, the results indicated the following: tonal characteristics (i.e., issues relating to tone and timbre) are more easily perceived under low volumes, whereas louder volumes supported the perception of dynamic contrast (i.e., issues relating to volume).

The results may be viewed in a multitude of ways. Firstly, the concept of “louder” and “softer” is on a continuum, meaning that one conductor may perceive volume differently than another. Secondly, the change in volume may not create a better overall listening environment for detailed listening, however, it may influence the implied focus of the listener. Similar to error-detection, this may suggest that the conductor should train and practice listening under different conditions. Lastly, further research should be applied to the following question: If volume affects our discriminatory abilities, do conductors in the “softer-volume” arts (e.g., choral music) have a stronger advantage in hearing minute detail as opposed to those in “louder-volume” arts (e.g., symphonic band and orchestra)?

**Pitch and Timbre Discrimination.** While choral conductors are often trained to detect errors of pitch based on the fundamental frequency, they often overlook the effect resonance has upon the perception of intonation. Ternström (1993) investigated the overall tolerance of sound by a unison choir, factoring in issues of fundamental pitch and the lowest formant frequencies. This study examined the maximum deviated tolerance and preferred unison sound created; this test was also performed on multiple vowels (i.e., ae, a, u). Results showed that listeners preferred a 0-5 cent deviation and would tolerate a 10-15 cent deviation with regards to fundamental pitch. Additionally, they would tolerate a formant smear of up to 12%, with a preference of 2-6%.

Listeners expressed most tolerances of pitch scatter and vowel smear while listening to the [u] vowel.

Although this study does not provide a direct solution to any of the problems mentioned above, it is assumed that our overall opinions of *choral blend*<sup>25</sup> may differ amongst conductors; more specifically, the pedagogy involved to achieve choral blend. This further relates to the overall perception of the harmonic series. Despite the fact that all singers are singing the same fundamental frequency, if formants are not appropriately engaged or aligned, the overall sound may be perceived as flat or sharp. This suggests the need for additional pedagogical and rehearsal training in vowel tract resonance, such as techniques devised by Berton Coffin (1976).<sup>26</sup>

Vurmas (2011) examined the influence varied timbres have upon the assessment of pitch, particularly in relation to one another. Subjects listened to two pitches played in sequence and determine whether the following pitch was higher or lower; instrument variables were trumpet, viola, and voice. Results indicated that timbre did indeed influence subjective intonation quality. Individually, instruments that were brighter in (e.g., trumpet and tenor voice) were perceived as higher pitched than of the viola, despite the fundamental pitch ( $F_0$ ) being similar.

Psychoacoustic factors of timbre influence issues of error-detection, both in the manner of the inability to perceive errors, and by the perception of non-existent errors. One such example where this may come into light is during the conducting of combined choral and orchestral works; a choral conductor's unfamiliarity with orchestral timbres may negatively

---

<sup>25</sup> *Choral blend* is the collective sound of a choral ensemble which aligns with the conductor's aural preference.

<sup>26</sup> Berton Coffin was a 20<sup>th</sup> century vocal pedagogue who contributed to the research and practice of vocal resonance by the maximization of vocal formants.

influence their perception of pitch amongst the larger ensemble. Although it is fundamentally more challenging, this may suggest that continued aural training, not just in fundamental pitches, but also in harmonic overtones must be practiced in developing a more accurate aural acuity.

**Eye Movement Tracking.** It has been well documented that proficient sight-readers: (a) look ahead of the point of performance, (b) have faster eye movement, and (c) have shorter fixations. Arthur, Khun, and Blom (2016) investigated the effect of how visually altered and disrupted scores would affect the eye movement of music readers. The researchers composed specific musical excerpts to sight-read to obtain baseline data. Following, Arthur et al., re-noted the musical score by removing bar lines, altering note spacing, and inserting unpredictable beaming directions.

Researchers found that expert musicians performed more efficiently in both situations, as compared to non-experts; this is similar to previous research. However, it was observed that the length of fixation for expert readers increased significantly. Arthur et al. suggested that "...the disruption of visual expectation was sufficient to cause a lengthening of saccade programming in the experts – an indication of interference with the ‘chunking’ process.” More specifically, the ability of expert readers to group notational symbols into larger chunks of information for processing was interrupted due to the false expectation of what was to be observed visually.

Goolsby (1994) investigated the eye movements of music readers, by observing the music reading ability of the participants, the notational complexity, and variable encounters with the music.

Results indicated that more skilled music readers demonstrate significantly more eye movement. More specifically, Goolsby found that experienced readers often demonstrate eye movement which looks ahead of the point of performance. Goolsby stated that “The skilled

music readers may use a strategy in which fixations are directed well ahead of the performance to perceive where the melody is “headed,” and then back to the point of performance.” Lastly, it was observed that the visual complexity and density of the notation played less of an effect upon fixation, however notational spacing universally influenced the amount of eye movement of readers. Results from Goolsby’s study may suggest an influence upon the current study; those whom read ahead may be better suited to anticipate the musical direction of each excerpt.

As demonstrated throughout this chapter, many components and influential factors of error-detection and aural acuity exist, however it is not within the scope of this research to directly implement them within the current study. Such factors may be addressed by further research. Despite the vast array of available research, a lack of specificity and context exist, thus creating a particular need for the current study. There is an absence of awareness with regards to non-musical factors and their implications upon aural acuity, with regards to choral music. This research hopes to contribute to the existing literature and pedagogical practices by providing awareness and empirical proof that other considerations must be made with regards to aural training.

## CHAPTER III

### Methodology

#### Introduction

The first two chapters provide the foundation of this study by illustrating the necessity and significance of this current research. As indicated in the previous literature, aural training programs focus primarily on the musical understanding of the score. Studies in the areas of filter theory, perceptual load capacity, and the like, show that the human brain is incapable of completely processing the entirety of information and stimuli presented. Therefore, consciously and unconsciously, cognition plays a significant role in the filtering, rejecting, and attenuation of various inputs deemed irrelevant for processing.

Building upon previous research, this study will examine the influence of selective attention, cognitive filtering, and perceptual load upon the ability to correctly detect performed aural errors. Additionally, a great deal of research in cognition has taken place outside of the context of musical performance. This study was constructed to simulate similar visual and aural components in the most common choral setting, that is, a 4-part vocal setting for soprano, alto, tenor, and bass, as opposed to differing instrumental combinations and timbres. Although certain aspects of a realistic error-detection opportunity were excluded (see Delimitations), this study was aimed at explicitly isolating variables to identify the numerable influence of attended vocal lines on the error-detection acuity of participants.

#### Context and Participants

The *Effect of Selective Attention on Error-Detection* study was submitted to the Human Subjects Division for Institutional Review Board (IRB) at the University of Washington on April 21, 2017; acceptance was granted on April 24, 2017. Upon approval of the IRB, participants

were recruited via email, personal contact, and social media (e.g., Facebook); snowball and convenience sampling were employed. Specifically, an electronic interest form was created and dispersed via email and social media on large organization pages. Those who were interested in participating in the entirety of the study would submit the interest form with further contact information. The researcher also promoted and encouraged the sharing of electronic recruitment materials to other possible participants.

The population targeted for this study were musicians identifying as either being a past, current, or future choral conductor.<sup>27</sup> The desired sample of participants were to include those working with a varied set of ensembles and experiences (e.g., elementary school choir, college choir, church choir).

Participants consisted of those who had completed the entirety of the 45-minute study. Eligibility was further screened to meet the following criterion: (1) 18 years or older, (2) identified as past, current, or future choral conductor, (3) identified as having absolute pitch<sup>28</sup>, or not, and (4) identified as having some form of hearing limitation, or not. Those who answered in the negative on questions 1 or 2, and the affirmative on questions 3 or 4 were allowed to complete the study, however, their data was deemed ineligible and excluded from the results due to conflicting variability.

From the 96 who indicated initial interest, 58 individuals initiated the start of the study. Among the 58, one was unable to complete the study due to time constraints, and two were later deemed ineligible due to eligibility questions; their data were excluded from the completed

---

<sup>27</sup> Participants enrolled in an undergraduate conducting degree program may be defined as a *future* conductor; more simply, or a conductor with little or no experience.

<sup>28</sup> *Absolute (perfect) pitch* is the ability to vocalize or aurally identify a specific pitch without any previous reference tone.

analysis. Of the 55 eligible participants, 30 were administered the study in-person with the researcher present, and 25 were provided the testing materials electronically or via United States Postal Service. Those who were mailed materials were provided with a pre-addressed and stamped envelope for return of the completed documents.

Participants within this study did so under the assurance of anonymity and willingness to volunteer without pressure. Additionally, all identifying information was kept in confidence as set in accordance with the Institutional Review Board at the University of Washington. Participants received no compensation for completed participation.

### **Research Design and Materials**

In acknowledgment of the strengths and weaknesses of previous research, it was determined that a quantitative approach would be the most efficient way of assessing error-detection abilities. The design of the study required all participants to attend to and identify aurally performed errors that differentiated from accurate visual scores in four separate possibilities: (1) attending to one assigned vocal line, (2) attending to two assigned vocal lines, (3) attending to three assigned vocal lines, and (4) attending to all four vocal lines. During each variance, all four vocal lines were sounded, however only the assigned lines would contain performance errors. All materials for the study were created by the researcher, incorporating practices from previous research, and expanded upon as further described.

**Visual Musical Excerpts.** The researcher used an online sight-reading material generator<sup>29</sup> as the foundation for creating the visual musical excerpts. Due to the programmability of musical variables in the passages, this service was deemed effective in eliminating large variances in part writing conditions. In total, 16 musical excerpts were created:

---

<sup>29</sup> [www.sightreadingfactory.com](http://www.sightreadingfactory.com)

8 sharp keys (i.e., 4 in A Major and 4 in B Major) and 8 flat keys (i.e., 4 in B-flat Major and 4 in D-flat major). All keys were created with major tonality to avoid differences between major and minor detection acuity. Additionally, excerpts were divided among flat and sharp keys to provide an equivalent amount of visual differentiation and maturation. All music excerpts were notated and formatted in *Sibelius*<sup>TM</sup>.

Musical excerpts followed similar guidelines to ensure rhythmic and intervallic equivalency.<sup>30</sup> All excerpts followed the following parameters as seen in Table 1.

*Table 1*

*Parameters for Musical Excerpt Creation*

<b>Musical Component</b>	<b>Parameter</b>
Tonality	Major
Measures	8-measures
Meter	Common Time (4/4)
Pitch Duration	Quarter, Half, Whole, Eighth, Dotted Half, and Dotted Quarter [ties allowed]
Rest Duration	Quarter, Half, Dotted Quarter
Intervals	Unison, Major 2 <sup>nd</sup> , Major 3 <sup>rd</sup> , Perfect 4 <sup>th</sup> , and Perfect 5 <sup>th</sup>

**Error Insertion.** To detect participant’s aural acuity, musical errors were inserted within the aural performances. Incorporating principles dictated by Ramsey (1979) and the researcher’s design, the included errors followed a set of guidelines consisting of errors most commonly

<sup>30</sup> Although traditional voice leading rules were considered, some excerpts may have demonstrated examples of voice leading which may not be intuitive or predictable.

observed among musicians. Errors were equally distributed between pitch and rhythm to test the acuity of them separately. Randomization was applied to the location and form of error; the researcher was allowed freedom to dictate the implementation of the error in an effort to contextual the error more appropriately. Errors were equally divided among the variance of the independent variable. Each excerpt contained three errors, regardless the quantity of attended voices (e.g., attend to the soprano Line: 3 errors; attend to the soprano and bass Line: 3 errors total). The insertion of errors followed the given parameters:

1. Augmentation and Diminution of Rhythmic Value
2. Diatonic lowering, raising, or stasis of a pitch (no chromaticism)

More so, to avoid aural confusion and discrepancy, alterations excluded from error insertion were:

1. No voice crossing during moments of error insertion
2. No errors in measure 1 to allow for tonal and rhythmic adjustment
3. No errors greater than 1.5 beats to avoid location discrepancy

**Aural Musical Excerpts.** All excerpts were notated in *Sibelius* and rendered down into separate WAV files. To avoid timbral influence upon data (Byo, 1993, 1997), all voices parts were played back utilizing a piano timbre with a MIDI<sup>31</sup> virtual instrument. Additionally, excerpts were recorded at an average-listening volume, void of dynamic variance. Lastly, the speed of playback was recording at 80 beats per minute.

---

<sup>31</sup> *Musical Instrument Digital Interface*

**Testing Video.** To maintain consistency and timing of the test administration, a pre-recorded video was constructed, the purpose of which was to guide and administer the study to all participants. The video included a description and purpose of the given study. Additionally, prompts were included to pause during the completion of the Informed Consent form. Following such, instructions on how to complete the study were dictated, as well as visual examples of what participants were to expect. Once verbal instructions were provided, the official study commenced. All aural and visual components of the testing video were created and recorded by the researcher. Verbal instructions were recorded through a MacBook Pro into *Audacity*. All musical excerpts and visual/aural instructions were imported into iMovie. The completed video was rendered to a MOV file for distribution, in addition to uploading onto YouTube for distant participants.

### **Survey Instruments**

Data collection was accomplished by creating a materials packet for each participant, in which they could notate their answers. Due to convenience sampling, test administration was split between in-person administration and remote testing. During examples of distant administration, participants were supplied the physical testing materials either electronically via email, or postal mail. The testing video was provided to participants via DVD or YouTube link.

The initial four questions of the study assessed the eligibility of the participant for data inclusion. Additionally, the researcher deemed it significant to collect additional information which could be analyzed and compared to previous research for similarities and possible differences. Such questions included age, gender, highest degree obtained, and primary conducting experience. Lastly, all participants were asked to self-assess their error-detection abilities on a Likert scale from 1 (*low*) to 10 (*high*). Following the initial questions, participants

were provided verbal instructions, via the testing video, on how to complete the study. After which, they were instructed to continue the video without pauses and rewinding.

All musical examples were organized via random selection of tonality and independent variable to avoid visual and aural maturation. Before each excerpt, participants were provided an aural and visual prompt of when the example process would begin. After the prompt of each question, tonicization was presented to establish tonality.<sup>32</sup> Following tonicization, participants were provided 30 seconds to study the whole score, as well as any vocal line(s) that were indicated to include errors; writing upon the music was permitted. Upon completion of the 30-second study period, the musical passage sounded, preceded by a one measure click track to establish tempo. After the initial playback, five seconds of silence was provided followed by an additional repetition of the click track and musical excerpt; all examples were performed twice. A pause of ten seconds before each following question was inserted to allow for completion. During the hearing of each example, participants were asked to indicate errors which occurred on the aural playback. Participants were instructed to be as specific as possible with regard to voice part, measure, and beat where the error occurred. Upon completion of the 16 musical questions, participants were thanked for their participation and offered space to provide comments and questions regarding the study.

Participants who completed the in-person administration of the study returned their testing materials directly to the researcher. Those who completed the study via distance were permitted to scan and email their documents or send via postal mail.

---

<sup>32</sup> *Tonicization* within this study provided a harmonic reference point. All excerpts used a traditional [ I IV V I ] as its harmonic progression.

## Data Collection

The research study officially began May 15, 2017. A participant interest survey was disbursed electronically via email and social media; the questionnaire was used to ascertain individuals interested in full participation. Each interested candidate received an immediate follow-up email with attachments and links to the testing materials if they indicated off-site participation, or available times if they indicated on-site participation. From the 55 eligible participants, 30 completed the study on-site and 25 off-site. Those who stated interest in off-site participation received one reminder email two weeks following receipt of the materials if they had yet to complete the study.

## Data Analysis

Data was collected via returned study materials. Before the data input, all submissions required scoring against a corrected template. Each question was examined for four factors: pitch, rhythm, *misses*,<sup>33</sup> and phantom errors. Questions contained three errors dealing with pitch and rhythm. Due to preselection and random placement of errors, some examples included zero of a particular error (e.g., 3 pitch errors and 0 rhythm errors); however, an equivalent amount of each were present within the cumulative study. Each error was equivalent to *1-point*, and the point allocation for each error was broken down as indicated in Table 2.

---

<sup>33</sup> In error-detection tasks, a *miss* is considered an error which was unidentified.

Table 2

*Scoring Guide for Performance Errors*

	<b>Allocation</b>	<b>Points</b>
Voicing		
	Correct Voice	.5-point
	Correct Beat, but incorrect voice	.25-point
Beat		
	Correct Beat	.5-point
	Off by 1 beat	.25-point
Total		__ out of 1-point

Upon scoring completion, data was inputted into Microsoft Excel for organization. Participants who did not meet eligibility requirements or did not complete the study were excluded from the data input stage. Once placed into data sets, scores were summed and averaged for variables that required an overall comparison and analysis. Following, the researcher imported all data sets into *Statistical Package for the Social Sciences* (SPSS) for additional analysis. It was determined by the researcher to use one-way multivariate analysis of variance (MANOVA), one-way analysis of variance (ANOVA), two-way analysis of variance (ANOVA) and Pearson correlation to analyze quantitative questions.

## CHAPTER IV

### Results

#### Introduction

As mentioned, a significant role of the conductor is to be able to detect errors and remedy them quickly and efficiently. Although choral sources commonly cite the skill of error-detection as crucial, few sources address the specific training of the craft. More problematically, error-detection is widely, and inaccurately, grouped into the overall aural training curriculum. Additionally, previous research is significantly lacking in the understanding of how selective attention, filtering, and perceptual load influences the conductors' ability to detect errors as they occur. This chapter will subsequently examine the effect of varied listening tasks and loads has upon error-detection acuity. The collected data will provide an empirical understanding of the effects mentioned above and will contribute to implications for training practices and suggestions for future research.

The design of this study subjected participants to detect musical errors under four separate and increasingly difficult conditions: (1) listening for errors in one vocal line, (2) listening for errors in two vocal lines, (3) listening for errors in three vocal lines, and (4) listening for errors in all four vocal lines. While performance errors occurred only within attended lines; all four vocal lines played throughout each condition. Results were then organized to address the following primary questions:

1. Is error-detection acuity affected by the quantity of selectively attended vocal lines?
2. Is error detection acuity of pitch and rhythm, respectively, affected by the quantity of selectively attended vocal lines?

3. Does the quantity of selectively attended vocal lines affect the quantity of perceived phantom errors?
4. Does primary ensemble conducting experience affect error-detection acuity?
5. Is there a relationship between the self-assessed “error-detection ability” and completed error-detection scores?
6. Does the type of college/university degree influence error-detection acuity? More so, does the variance in college/university degree provide corresponding data when examined against the quantity of selectively attended vocal lines?
7. Is there a relationship between years of experience and error-detection acuity?

To best provide a foundational understanding of the data, necessary demographic information will be provided, followed by an analysis of each primary question. For all possibilities, confidence intervals (CI) were set at 95%. During the process of statistical analysis, collected participant data was collated into one large data set.

### **Demographic Information**

Potential participants were recruited via email and social media materials. Those expressing interest completed the ‘Study Volunteer Interest Form,’ which provided the researcher with contact information to provide study materials. There was a total of 96 interested responses; 58 respondents initiated the start of the study. The study required participants to answer preliminary questions to determine participation eligibility within the study; additionally, completion was a requirement for inclusion. From the 58 participants, two were ineligible due to criteria failure and one was unable to complete the study due to time constraints; their data sets were excluded from the finished analysis. A total of 55 participants were eligible for the study and data inclusion.

Of the 55 participants, 45% were female ( $n = 25$ ), and 55% were male ( $n = 30$ ). The age of participants ranged from 21 to 63 years ( $M = 33.6$ ,  $SD = 9.37$ ). Of the 55 participants, 30.9% had obtained an undergraduate degree ( $n = 17$ ), and 69.1% had completed a graduate degree ( $n = 38$ ). The frequencies of the various degrees obtained are indicated in Table 3.

Table 3

*Frequency of Participant College Degrees*

Highest Obtained Degree	Frequency
Bachelor of Art	6
Bachelor of Science	4
Bachelor of Music	4
Bachelor of Music Education	2
Master of Music	28
Master of Music Education	1
Master of Arts	2
Master of Arts in Teaching	6
Doctorate of Musical Arts	2

Additionally, 12 participants indicated that they were currently enrolled in a graduate degree program: Master of Music ( $n = 2$ ), Master of Arts in Teaching ( $n = 1$ ), and Doctorate in Musical Arts ( $n = 9$ ). The mean years of experience were 12.5 ( $SD = 8.66$ ).

The frequencies of primary ensemble conducting experience are diverse, as seen in Table 4.

Table 4

*Frequency of Participant Primary Ensemble Conducting Experience*

Primary Ensemble Experience	Frequency
Elementary School	5
Middle School	8
High School	9
College/University	9
Community	10
Church	12
Semi-Professional	2
Professional	0

Participant *Error-Detection Self-Assessment* ranged from 6 to 10 ( $M = 7.91$ ,  $SD = 0.97$ ). The researcher determined that the collection of participant background information would allow for further analysis of how certain aspects may influence the dependent variable.

### Primary Questions

**Question 1.** In determining the influence of selectively attended vocal lines upon error-detection acuity, ANOVA procedures were utilized for analysis across the different variants of the independent variable (i.e., quantity of selectively attended parts). There were no known outliers and the data demonstrated normal distribution for individual groups, as determined by boxplot inspection. Tests for Homogeneity of variances were violated, as determined by Levene's Test of Homogeneity of Variance ( $p = .009$ ). Error-Detection scores were shown to be statistically significantly different between the variance of selectively attended vocal lines,

Welch's  $F(3, 118.812) = 46.876, p < .001$ . Error-detection scores decreased from one selectively attended vocal line ( $M = 9.27, SD = 1.75$ ), to two ( $M = 6.49, SD = 2.24$ ), three ( $M = 6.15, SD = 1.43$ ), and four ( $M = 5.81, SD = 1.64$ ) selectively attended vocal lines, in that order. A Games-Howell post hoc test indicated that the mean decreased from one to two selectively attended vocal lines (2.78, 95% CI [1.78, 3.78],  $p < .001$ ), one to three (3.12, 95% CI [2.32, 3.91],  $p < .001$ ), and one to four (3.46, 95% CI [2.62, 4.30],  $p < .001$ ) selectively attended vocal lines were statistically significant.

**Question 2.** Testing for individual effects upon pitch and rhythm acuity, respectively, required the use of MANOVA testing procedures. Preliminary assumption analysis indicated that data was not normally distributed, as assessed by Shapiro-Wilk test ( $p < .05$ ); there were acceptable and retained univariate outliers and no multivariate outliers as determined via boxplot; there were moderate linear relationships, as assessed by scatterplot; no multicollinearity ( $r = -.357, p < .001$ ); and there was homogeneity of variance-covariance matrices, as assessed by Box's M test ( $p = .036$ ). In respect of the one voice, two voice, three voice, and four voice conditions of the Independent Variable, participants scored higher in the detection of rhythmic errors ( $M = 4.58, SD = .92$ ;  $M = 3.44, SD = 1.04$ ;  $M = 4.01, SD = .95$ ;  $M = 3.34, SD = .98$ , respectively) than their pitch detection scores ( $M = 4.64, SD = 1.28$ ;  $M = 3.05, SD = 1.57$ ;  $M = 2.14, SD = .93$ ;  $M = 2.48, SD = 1.25$ , respectively). Multiple follow-up univariate ANOVAs indicated that there was a statistically significant difference between the number of vocal parts on the combined dependent variables,  $F(6, 430) = 25.664, p < .001$ ; Wilks'  $\Lambda = .542$ ; partial  $\eta^2 = .264$ . Additionally, there was a statistically significant difference in pitch detection scores of participants listening to varied attended vocal lines,  $F(3, 216) = 41.170, p < .001$ ; partial  $\eta^2 = .364$ . Tukey post-hoc tests showed participants demonstrated statistically significantly lower

mean scores for pitch, as compared to rhythm detection scores from one to four vocal lines (pitch:  $M = 4.64, p < .001$ ;  $M = 2.48, p < .001$ ; rhythm:  $M = 4.58, p < .001$ ;  $M = 3.34, p < .001$ ).

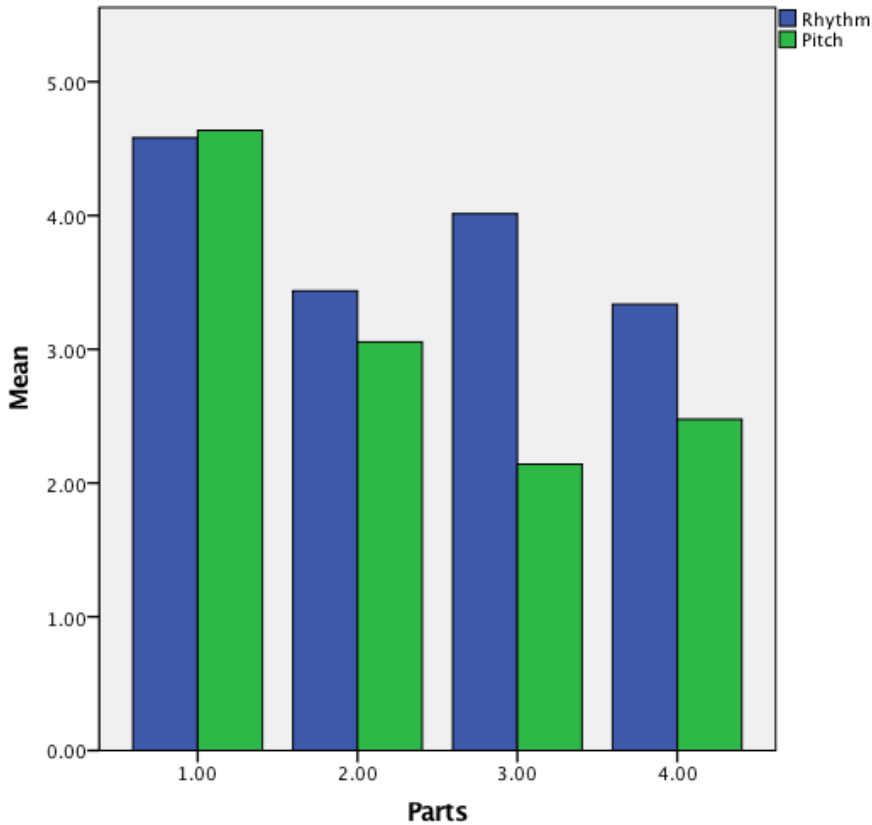


Figure 5. Mean scores for pitch and rhythm, respectively, on one, two, three, and four attended vocal lines.

**Question 3.** To determine the effect of selectively attended vocal lines upon the number of perceived phantom errors, ANOVA procedures were established. Participants responded to phantom errors while attending to one, two, three, and four selectively attended vocal lines. Inspections of outliers within a boxplot determined three outliers under the one-vocal line and three outliers during the four-vocal line conditions. All outliers were determined to be genuine, therefore included in the analysis. Data was determined to be not normally distributed for each group, as assessed by Shapiro-Wilk's test ( $p < .05$ ). The assumption of homogeneity of variances was violated, as assessed by the Levene's test for equality of variances ( $p = .011$ ), therefore the

robust Welch's test was used. The number of perceived phantom errors was statistically significantly different for the different number of attended vocal lines,  $F(3, 116.363) = 49.402, p < .001$ . The number of phantom errors identified during the listening of selectively attended vocal lines increased from one vocal line ( $M = .89, SD = .98$ ), to two ( $M = 3.82, SD = 1.50$ ), decreased to three ( $M = 1.76, SD = 1.41$ ), and increased to four ( $M = 2.27, SD = 1.99$ ) selectively attended vocal lines. Games-Howell post hoc analysis identified an increase of phantom error detection from one to two voices (2.93, 95% CI [2.29, 3.56],  $p < .001$ ), and a decrease from two to three (2.05, 95% CI [2.78, 1.33],  $p < .001$ ) statistically significant. However, an increase from three to four voices (.51, 95% CI [.35, 1.37],  $p = .415$ ) was deemed statistically insignificant.

**Question 4.** In determining if the primary ensemble conducting experience affected error-detection acuity, ANOVA procedures were used. From the eight possibilities participants could choose from, a representation from seven categories was present. An inspection of outliers via boxplot indicated two data outliers: Semi-Professional ( $n = 2$ ) and Professional ( $n = 0$ ). These outliers were removed from the overall analysis due to their insufficient sample size. With the exception of *Middle School* ( $p = .002$ ), data was normally distributed for each group, as assessed by the Shapiro-Wilk's test ( $p > .05$ ). The assumption of homogeneity of variances was violated, as determined by Levene's test for equality of variances ( $p = .038$ ), there the robust Welch's test was used. The primary ensemble experience was considered statistically significant for error-detection scores,  $F(6, 10.232) = 3.227, p = .048$ . The error-detection scores for each group are listed in ascending order, as seen in Table 5.

Table 5

Mean Error-Detection Score for Primary Ensemble Conducting Experience

Primary Ensemble Experience	X	SD
Church	23.6	4.16
Elementary School	24.4	4.85
Community	27.1	4.41
Middle School	28.4	3.36
College/University	30.8	8.31
High School	32.1	4.09

*Note:* The *Semi-Professional* and *Professional* groups were omitted due to insignificant sample sizes.

Games-Howell post hoc analysis identified an increase of mean score from church choir to high school (8.41, 95% CI [14.4, 2.39],  $p = .003$ ) to be statistically significant.

**Question 5.** In determining possible relationships between self-assessed scores and error-detection scores, Pearson correlation procedures were used. Preliminary analysis indicated a linear relationship and the error detection score variable to be normally distributed ( $p = .175$ ) as determined by Shapiro-Wilk’s testing; self-assessments were deemed not normally distributed ( $p < .05$ ). One outlier was present for the error-detection score, as inspected via boxplot, however, data was determined to be genuine and kept for analysis. Mean scores increased for each level of self-rated as indicated in Figure 6.

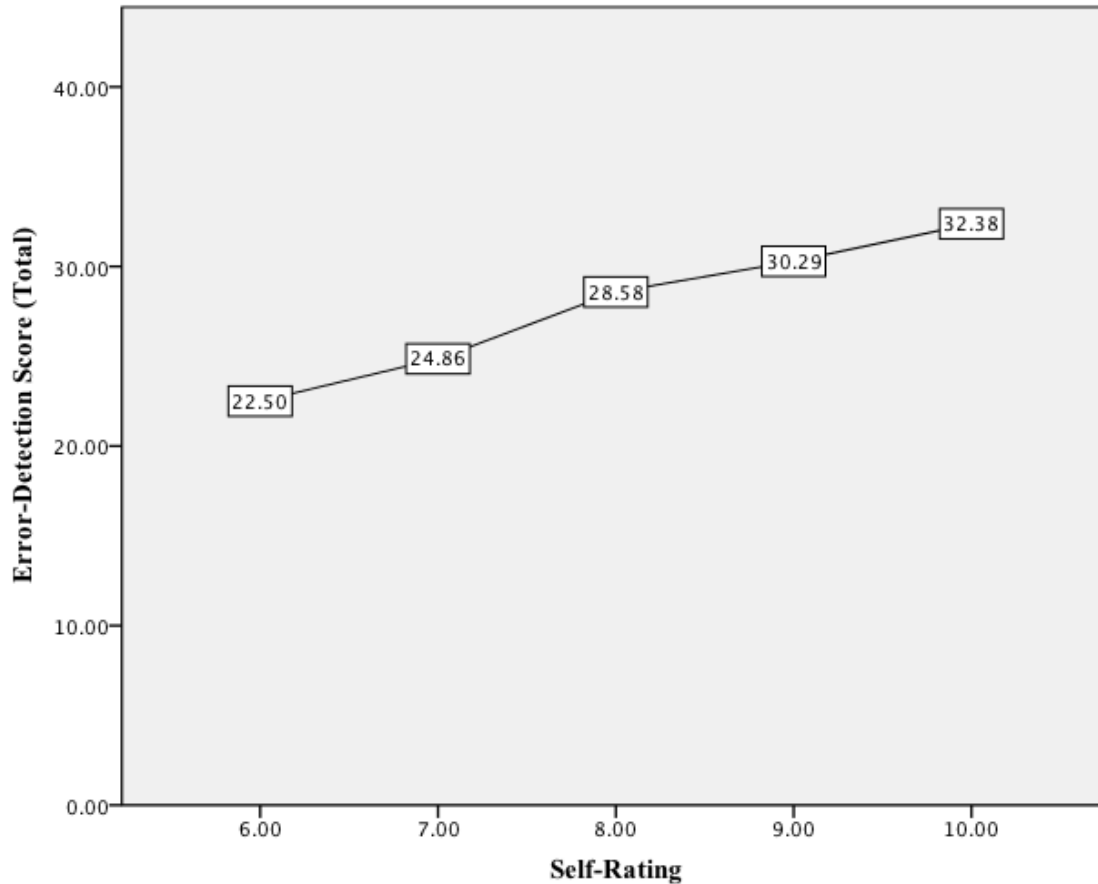


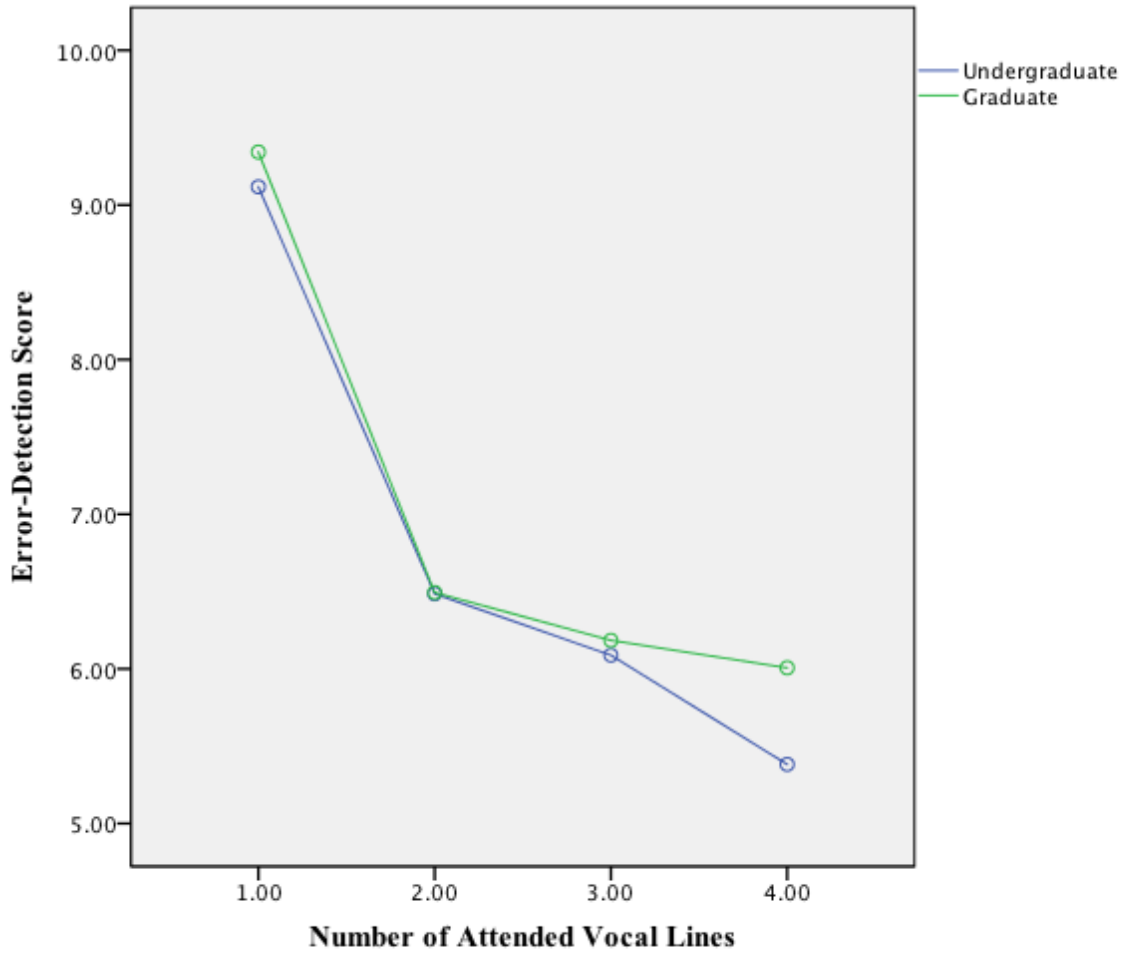
Figure 6. Mean error-detection scores for self-assessment score.

There was a moderate positive correlation between self-rated scores and error detection scores,  $r(53) = .448, p = .001$ , with self-ratings explaining 20% of the variation in error-detection scores.

**Question 6.** In determining the influence of higher education upon error-detection scores and their differences with a variation of attended vocal parts, two-way ANOVA procedures were used. Within the preliminary questions, participants were asked to indicate the highest degree obtained. For the sake of analysis, all degrees were reclassified as either undergraduate ( $n = 16$ ) or graduate ( $n = 39$ ). Residual analysis was performed to test the assumptions of the two-way ANOVA. Boxplot inspection assessed outliers; outliers were identified, however, were considered genuine and kept for analysis. With the exception of graduate one- and two-voice

combinations ( $p = .039$ ;  $p = .002$ ), residuals were normally distributed ( $p > .05$ ). Additionally, homogeneity of variances was determined ( $p = .084$ ).

Individual means scores for undergraduate and graduate students under different voice conditions are located in Figure 7.



Note: Error-Detection Scores is the marginal mean for each independent variant.

Figure 7. Undergraduate and Graduate error-detection scores for one, two, three, and four attended vocal lines.

Although there are differences in marginal mean scores, the interaction effect between educational degree and number of parts on error-detection scores was not statistically significant,  $F(3, 212) = .270$ ,  $p = .847$ , partial  $\eta^2 = .004$ . Due to statistical insignificance, an analysis of the

main effect for education level was initiated, which indicated that the main effect was statistically significant,  $F(1, 212) = 4.242, p = .041$ , partial  $\eta^2 = .020$ . All pairwise comparisons were run with 95% confidence intervals and p-values were Bonferroni-adjusted. The unweighted marginal means for 'Error Detection Scores' for undergraduate and graduate degrees were 6.55 (SE = .222) and 7.09 (SE = .142), respectively. A graduate level education was associated with a statistically significant higher mean error-detection score than that of undergraduate degrees (.542, 95% CI [.023, 1.062],  $p = .041$ ).

**Question 7.** In determining relationships between years of experience and error-detection scores, Pearson correlation procedures were used. Preliminary analysis indicated a weak linear relationship and outliers were assessed via boxplot inspection. The existence of outliers was present; however, data was determined to be genuine, and thus kept. Data within *Years of Experience* was considered not normally distributed, as assessed by Shapiro-Wilk's test ( $p < .05$ ). The mean years of experience were 12.5 (SD = 8.7).

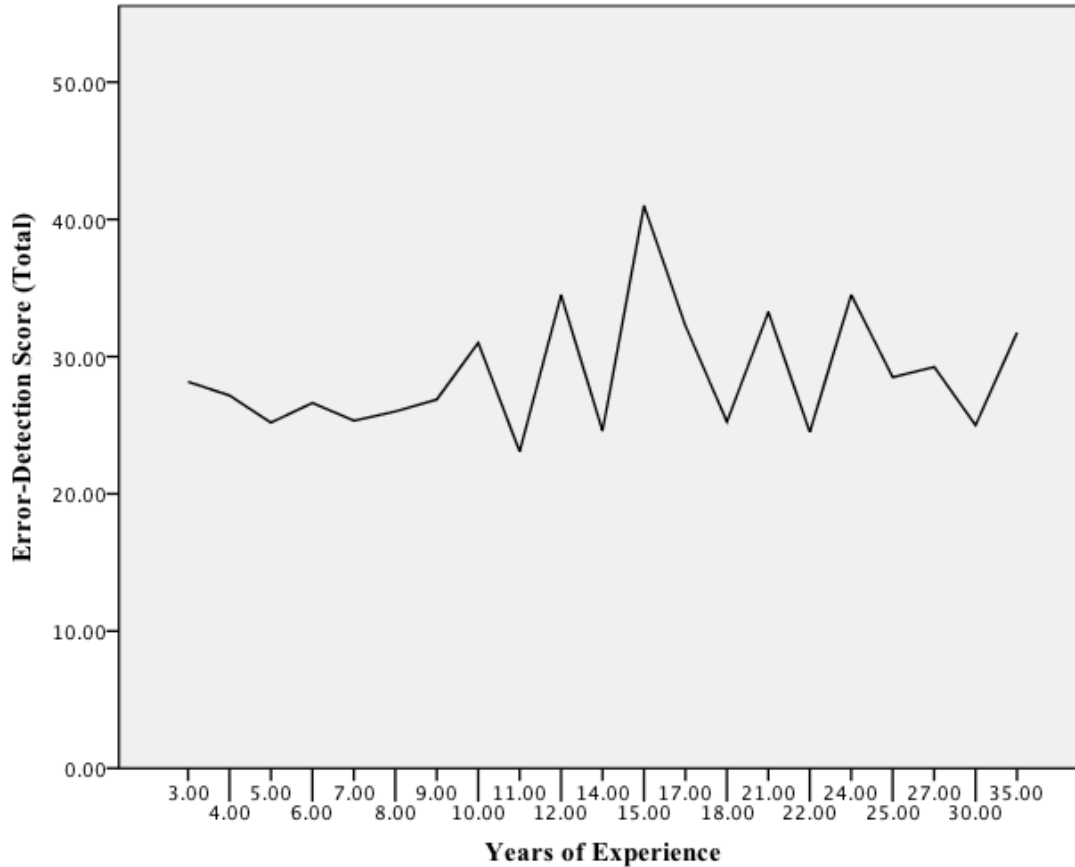


Figure 8. The relationship between years of experience and error-detection scores.

As shown in Figure 8, correlation between years of experience and error-detection scores were considered statistically insignificant,  $r(53) = .141, p = .303$ .

### Conclusion

The analysis of data within this chapter sheds light upon areas which need additional attention and study as well as supports previous research. The result of this data was to illustrate the effect increasing quantities of selectively attended vocal parts has upon error-detection abilities, much like what is experienced within a live rehearsal and performance. Additionally, this data has provided a look at various aspects of previous educational experiences and their relationship to the primary task; results both are independent and are validated by previous research. In addition to this discussion, continued discussion of how selective attention and

perceptual load plays a role in error-detection acuity will be discussed in Chapter 5, with suggestions for effective training devices to improve aural acuity.

## **CHAPTER V**

### **Discussion**

#### **Introduction**

By examining how increasing stimuli, among other factors, affect aural acuity, this study aimed to discover how error-detection acuity was affected by the quantity of selectively attended vocal lines. Additionally, this study assessed varying demographics to identify relationships individually and within one another. This chapter is organized by discussing the quantitative findings of the primary research questions, providing implications of the study, ideas for future training devices, and suggestions for future research. The overarching intent will be to discuss the perceptual response a conductor may have during rehearsals and performances.

This study was established to provide a deeper understanding of how selective attention and perceptual load interact and influence the ability to detect performance errors. Therefore, this study was devised in a manner to be inclusive, thus providing as much statistically significant data as feasibly possible. Although a wide range of ages, genders, and experiences participated in this study, some results may need additional research with larger sample sizes to statistically and practically answer the proposed questions.

#### **Research Questions**

This discussion will address the results of the following research questions:

1. Is error detection acuity affected by the quantity of selectively attended vocal lines?
2. Is error detection acuity of pitch and rhythm, respectively, affected by the quantity of selectively attended vocal lines?
3. Does the quantity of selectively attended vocal lines affect the quantity of perceived 'phantom errors?'

4. Does primary ensemble conducting experience affect error-detection acuity?
5. Is there a relationship between the self-assessed “error-detection ability” and completed error-detection scores?
6. Does the type of college/university degree influence error-detection acuity? More so, does the variance in college/university degree provide corresponding data when examining against the quantity of selectively attended vocal lines?
7. Is there a relationship between years of experience and error-detection acuity?

## **Discussion**

**Question 1.** The primary inquiry of this study was to identify a correlational relationship between the quantity of selectively attended vocal lines and error-detection acuity. The data indicated that when a listener is asked to attend to an increase of vocal lines, their error-detection score declined; of most interest was the rate of score decrease. The score decreases between the one ( $M = 9.27$ ) and two ( $M = 6.49$ ) vocal line variables were almost 3 points, whereas from two ( $M = 6.49$ ) to three ( $M = 6.15$ ), and three ( $M = 6.15$ ) to four ( $M = 5.81$ ) were less than 1 point, respectively. The significance of this drop in score from one-voice to two-voices suggest an immediate inability to accurately perceive multiple stimuli. The insignificant difference in scores among the other variations may indicate that the dispersion of perceptual load was not linear. Filtering models explain that rather than distributing processing power equally, selectivity may occur to ensure maximum utilization. A linear distribution would suggest that with every additional vocal line, processing power would be divided equally, resulting in a graduated decrease in perceptual capacity. Conversely, selectivity may prioritize specific lines higher than others, thus preventing perceptual overload. Without additional inquires and equipment, it is difficult to determine the prioritization and perceptual practice each participant engaged in,

however, one additional effect possibly observed due to selective attention may have been *inattentional deafness*<sup>35</sup>. Similar to Koreiman's (2014) findings, this may explain as to why some errors were perceived, while others were *missed*.<sup>36</sup> In the event of an overload, perceptual abilities would be minimized. And although musical excerpts were created as equivalent as possible, the context-specific error placement and voice leading may have unexpectedly inhibited the perceptual equality amongst the examples. Although this may have consequently skewed the data, all participants received identical material, thus it is believed not to deter from the overall statistically significant findings. Lastly, multiple participants reported aural and mental fatigue as the study commenced.<sup>37</sup> Effects of fatigue may have feasibly skewed results in the latter portion of the study, due to decreased cognitive focus and aural sensitivity. However, musical excerpts were assigned in non-sequential order to negate the statistical effects of fatigue.

**Question 2.** It was deemed imperative to understand how the perception of pitch and rhythm, respectively, are affected by the quantity of selectively attended vocal lines. Similar to previous research, the results indicated a stronger ability to detect errors of rhythm, than of pitch (see Figure 5); this proved statistically true among all variations of the independent variable. More specifically, a significantly more substantial mean decrease between one and four attended vocal lines occurs during pitch detection compared to rhythm detection. Multiple reasons may explain the inequivalent decline between pitch and rhythm detection. Previous research has illustrated the perceptual preference of rhythmic inaccuracies over tonal ones (Byo, 1997; Huron, 1989). Additionally, the variance, training, and prioritization of score study styles may play into

---

<sup>35</sup> *Inattentional deafness* is defined as a loss of aural acuity due to perceptual load.

<sup>36</sup> A *miss* is a performance error *not* identified by the participant.

<sup>37</sup> Open-ended participant responses were reported in the *Questions/Comments* section of the study materials.

effect, particularly during periods of limited study time and the lack of an aural model. An assumption can be made that during moments of high perceptual load, participants may, consciously and unconsciously, develop a perceptual bias as to what to selectively listen to. Additionally, errors of pitch may be difficult to perceive, particularly when the misplaced note is performed without dissonance; this commonly occurs when the *intended* pitch is replaced with one in the harmonization (e.g., singing an *E*, instead of a *C* within a C-Major chord).

**Question 3.** Due to various distractors and contextual make-up, it is not uncommon for the perception of *phantom errors* or *false alarms*<sup>38</sup> to occur. Results indicated that the quantity of attended vocal lines influenced the perception of phantom errors. Although complete linearity was not achieved,<sup>39</sup> the quantity of detected phantom errors increased congruently with the quantity of attended vocal lines. The general increased perception of phantom errors may be explained due to poor contextual processing during the increase of *perceptual load*.<sup>40</sup> And although the two-voice condition (e.g., soprano and bass) did not follow the path of linearity, it may still be explained. In the understanding of perceptual load, it is understood that there is an opposing relationship between load and distractors (e.g., low perceptual load, high distractor influence; high perceptual load, low distractor influence). More so, it was suggested that with regards to perceptual capacity, it must be fully saturated under all conditions with a variable ratio between load and distractors. Due to the possibility of the two-voice condition creating a lesser perceptual load than that of the three- and four-voice conditions, distractors may prove to be more influential within the two-voice condition.

---

<sup>38</sup> *Phantom errors* or *false-alarms* are errors perceived by the listener which did not occur.

<sup>39</sup> The *two-voice* condition demonstrated a non-linear spike of phantom error detection.

<sup>40</sup> *Perpetual load* is the overall capacity of perceived stimuli.

Furthermore, the increase of phantom errors proved non-exponential within the three- and four-voice condition. Although one may expect a significantly greater quantity of phantom errors within the latter, it may be explained by perceptual overload and inattentive deafness upon the third stimulus. If the listener became overwhelmed with a combination of aural and visual stimuli, and unable to successfully filter, then cognitive processing would immediately decrease, thus resulting in a *low* detection of phantom errors, and an increased quantity of *misses* (i.e., the quantity of errors not perceived).<sup>41</sup> And although the one-voice condition had the fewest detections of phantom errors, perceptual attention may be more efficiently selective of distractors and their influence. This theory would follow similar theories of Question 1 -- there is a significant decrease in perceptual abilities immediately following the second stimulus. Lastly, although no follow-up communication between the researcher and participants occurred, an increase in phantom error detection may be anecdotally explained by *participant obligation*. I speculate that during excerpts which participants were unable to detect errors, they may have felt obligated to indicate some form of perceived error. Further research is necessary to explore the social obligations participants may outline for themselves with regards to error-detection abilities.

**Question 4.** Arising from anecdotal observation, the guiding curiosity behind this question was: Does working primarily with an ensemble of a particular skill-level or age develop a perceptual tolerance, or bias? It has been previously documented that there is a difference in intonation perception by those with different levels of experience. Question 4 was devised to determine if primary ensemble conducting experience affected the acuity of error-detection.

---

<sup>41</sup> Total number of misses: *One voice* ( $M = 2.73$ ); *Two voice* ( $M = 5.33$ ); *Three voice* ( $M = 5.56$ ); *Four voice* ( $M = 5.96$ )

Results indicated that ensemble conducting experience did influence error-detection abilities, however, the data did not concisely point to an increase or decrease in accuracy.<sup>42</sup> At initial glance, there was an increase of scores through the progression of the educational system; this suggests a graduated theory of tolerance. Interestingly, however, was that the *high school* group demonstrated the highest mean score. It would be expected to observe those classified as *college* to demonstrate a higher mean score; however, this may be explained by those who indicated they were a current doctoral student. Students completing doctoral course work often come directly from working within a secondary school environment (i.e., middle and high school); they may identify *college* as their primary experience, despite minimal time with a collegiate ensemble. Therefore, any score differences between the two may be insignificant and skewed due to errors in reporting. The *church* category received the lowest mean score. Although there is little evidence to demonstrate a causal relationship between church ensemble experience and error-detection ability, a correlation does exist. A possibility of explanation may be linked to the training church choir conductors may or may not have, or the level of repertoire previously exposed to. Depending upon the location, denomination, and financial status of the church, there may be a substantial possibility that the choir director at said church may have been placed in such role due to: (a) previous experience singing in the ensemble or (b) volunteering due to budgetary reasons. It is difficult to be certain and additional research may be required to fully understand, but with a large percentage of participants being church musicians and receiving the lowest mean score, it is determined to be statistically significant and deserves further research. Lastly, to provide substantial evidence of tiered aural acuity due to different primary ensemble

---

<sup>42</sup> *Semi-Professional* and *Professional* subgroups were removed from data analysis due to insufficient sample size.

conducting experiences, a larger study should be conducted, having a larger and more equivalent sample population amongst all categories.

**Question 5.** Commonly, musicians are often asked to self-assess various aspects of their capabilities, however, it is unclear as to whether these assessments are reliable.<sup>43</sup> This question identified if participants *were* a reliable evaluator of their individual error-detection abilities prior to assessment. Using a Pearson correlation model, it was determined that error-detection scores were aligned with their preliminary self-assessments; *low* self-assessments earned *lower* error-detection scores, and *high* self-assessments received a *higher* error-detection scores. This revelation indicates that individuals are often aware of their error-detection capabilities. Whether they are truthful in a public forum is up for debate, however, they are intuitively correct about their abilities. However, due to a Likert scale response carrying an ambiguous quality without the use of indicator rubrics, and the prevalence for respondents to provide a score which is neither too low or high, it may be difficult to substantiate these claims in a more extensive framework. One aspect of this question which was not addressed was the variability of previous experience. This study was devised in a four-voice setting, where as some participants may work solely with one-, two-, and three-voice ensembles in which they often feel successful. In some cases, participants may rate higher or lower without acknowledgment of the increased contextual difficulty.

**Question 6.** It would be assumed that with the advancement of a higher education degree, there would also be an equivalent increase of aural acuity, associated with the additional collegiate training. After grouping the degree responses into either undergraduate or graduate, degree level was compared against error-detection scores. It was found that there was no

---

<sup>43</sup> Reliability is questioned due to bias and lack of self-awareness/acknowledgment.

relationship between degree level and their score for each variable, however, it was found that a graduate-level education was associated with a higher error-detection score than that of an undergraduate level education. Although statistical significance was seen, there is room to question the actuality of the outcome due to the 0.54-point difference between undergraduate and graduate. It is to be noted that within most graduate studies in music, students rarely receive additional aural and dictation training. According to previously cited research, participants with differing levels of experience demonstrated similar error-detection abilities. Due to conflicting reports, an increased sample size would be recommended to test for a more significant population effect. These findings may support previous research and reiterate the imperative deficiency in aural training regimes -- error-detection training is inadequate throughout all degree-levels of education.

**Question 7.** Similar to the previous question, the influence of experience was a point of interest on error-detection abilities; in this case, years of experience. Using similar Pearson correlation procedures, no relationship was established between years of experience and error-detection abilities; this supports previous research. These findings may assume that error-detection skills are not ones that are necessarily obtained through years of generic experience. Taking into consideration that with an increase of experience may provide a more mature and efficient form of process handling, it alone is not adequate to effectively detect performance errors. It may be possible that experience may provide different results if set within a live setting, as opposed to a pre-recorded model; this may be explained by maturation of experience, and the handling of non-musical stimuli. Nevertheless, the most significant take away from this is that regardless of experience, error-detection skills of all individuals require significantly more attention and training.

## Conclusion of Findings

Based on this study, the following conclusions can be drawn:

1. When listeners are asked to attend to an increasing number of stimuli, their ability to correctly detect performance errors decreases. More so, upon the immediate addition of a second part, perception noticeably declines.
2. There is stronger perceptual ability to detect errors of rhythm, as opposed to those of pitch. Additionally, there is a significant drop-off in pitch detection, as opposed to rhythm detection, during three- and four-voice variances. This suggests possible conscious and unconscious preference of rhythmic selectivity and attention.
3. The detection of phantom errors within all vocal variants was observed. Furthermore, there is linearity between the quantity of phantom errors and quantity of attended vocal lines.
4. Primary ensemble conducting experience may influence the ability to perceive performance errors, although additional research is required to determine the increase or decrease, and degree of influence.
5. There is a positive linear relationship between participants' error-detection self-assessment scores and their error-detection score, suggesting that individuals are already aware of their error-detection skill level.
6. A graduate-level degree in music was associated with a higher error-detection score, however further studies may be necessary due to the minimal difference between mean scores.
7. The number of years of experience does not predict an individual's error-detection ability.

## **Implications**

Results of this study reiterate a considerable deficiency of error-detection ability and training which spans across all degrees, ensembles, experiences, and ages. Forsythe and Woods (1983) further identified the faults of our current conducting training and aural skills building model:

Moreover, the traditional curriculum reflects a somewhat fragmented approach to the various dimensions involved, thus a sequential, cumulative approximation of synthesis may not occur. Furthermore, it seems possible that attention to one aspect of conducting, at some phase in the process, may even adversely affect development of another, particularly if the attention is exclusory. For example, if the teacher of a conducting class places emphasis upon clear, expressive, visually pleasing conducting, with little or no attention to listening skills, perhaps this focus will even diminish students' abilities to listen and detect errors. (p. 12)

It is evident through previous research that many considerations have been made with regard to the process of score study and aural training, however error-detection abilities are not directly improved by collegiate aural training courses. Firstly, the process of error-detection involves significantly more processing of bi-directional information. Secondly, the aural model which must be created before aural comparison is not sufficient enough. Thirdly, due to controllable and uncontrollable conditions, selective attention may not always correctly prioritize content to be filtered.

## Curriculum Development

In light of these findings, a curriculum must be constructed to offset the current deficiencies in our current educational model. Suggestions for implementation are included below.

**Graduated Layering.** As observed, conductors exhibit an inability of accurate error-detection immediately upon attending to a second vocal part; it is illogical to expect an increase in accuracy with the addition of a third and fourth line. Therefore, it is suggested that students of error-detection training be presented with a graduated implementation of timbre and musical lines (i.e., gradual increase in the quantity of musical lines and different timbres). An example for progression within a choral model may be seen in Figure 9.

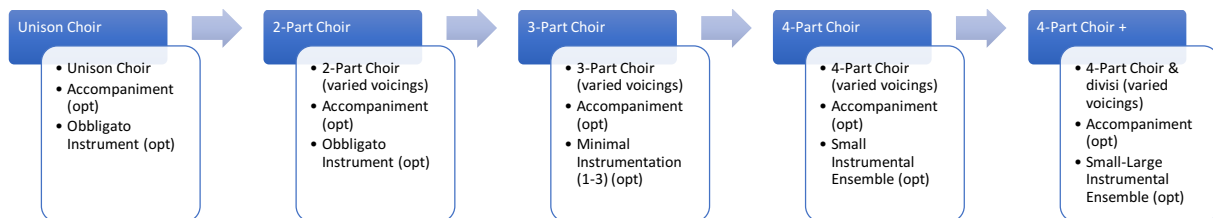


Figure 9. Error-detection graduated layering progression for choral music

**Pitch and Rhythm Isolation.** Due to biases and preferences in our score study and listening choices, the listener may not always prioritize rhythm and pitch equally. Curricula should provide training which isolates the two independently (e.g., rhythm error training; pitch error training). In addition to pitch and rhythm, intonation, tone, balance, and texture among others are part of the multitude of independent components the conductor must assess for errors during the rehearsal/performance situation. However, trying to assess everything at once will

quickly lead to perceptual overload and may cause *inattentional deafness*, therefore it is imperative for the conductor to become self-aware and thoughtful with processing resources.

**Pre-Determined Selective Attention.** Expanding upon the above discussion, there is a finite amount of processing that can occur at any given time. Once the maximum has been reached, various stimulus, in part or whole, may be unconsciously filtered out. Typically the human brain is efficient during this filtering stage, however other times it may lead to the undesirable filtering of critical information. A strong conductor knows the strengths of their ensembles and of themselves, therefore it is wise to suggest a preliminary selection of what to consciously attend to. More so, it has been observed by the researcher that conductors, often inexperienced, will frequently direct their attention to the musical score either in independent parts or as a homogenous unit. This ‘either/or’ approach commonly creates issues of inattentional deafness due to overstimulation or incomplete aural data due to insufficient specificity. Therefore, training in *what* and *how* to expand and isolate one’s field of listening may aid in preliminary selective attention, as well as training the ability to effectively chunk information for processing. Within the proposed curriculum, this may include guided listening excerpts which strengthens the conductor’s ability to alternate directed attention between micro and macro predefined parameters.

**Error-Detection within Movement Training.** It has been well documented the negative effect movement has upon aural acuity; additionally, the improvement movement training has upon aural acuity. Hayslett (1996) stated:

The knowledge that one's aural perception may be influenced by physical movement has the potential to radically affect not only the way in which we rehearse our ensembles, but the methods we currently use to teach conducting. If we can assume from previous

research that limitations in our processing can be minimized by increasing processing efficiency through practice and experience (Stallings, 1982; Marteniuk, 1976), then the application of a systematic approach to teaching expressive movement from Rudolf von Laban's movement theory should result in increased aural acuity. (p. 16)

Given that this study was set in isolated conditions, if participants would have been asked to assess errors while conducting, scores may have resulted lower than already recorded. The act of conducting from a score requires a variable amount of processing power to: determine speed, articulation, and dynamics. It would seem unreasonable to suggest that there is a preferred form of conducting training, however rarely does error-detection training occur during conducting training. In fact, training in the detection of errors, whether musical or pedagogical, often happen in a separate course. Therefore, it is suggested that error-detection and movement training be implemented within undergraduate and graduate conducting courses.

**Aural Visualization.** Through eye-tracking research, it has been shown that the best readers often have the quickest eye movements. It is documented that quality music readers often look ahead the point of performance. This tool is vital, as it provides an assumable path for auralization. Waters and Underwood (1998) suggested the following as a means of improvement: (a) become more knowledgeable about musical structures and more efficient at recognizing them rapidly, and (b) develop the skill of scanning music as rapidly as possible. While these techniques are not always effective in errors which are homogenous in context, it may allow for the chunking of musical aspects and detection of errors that may be non-contextual.

### **Future Research**

Although providing multiple answers to the issues of error-detection, the study has also illuminated additional questions for future research, either due to the current studies design or

data outcomes. Despite the significance of positive data, much can be improved upon to reach more definitive conclusions.

Firstly, although this study has demonstrated that individuals are affected by the increase in attended stimuli, it does not identify *how* the effect occurs. An example of such may include the ratio of conscious and unconscious selectively attended choices made during perceptual load. In understanding more fully the interaction between the two, additional quantitative and qualitative research must be completed to examine the processing structure of an individual. It goes without saying that there is a multitude of variables which will influence the various outcomes including score study abilities, aural proficiency, musical and environmental context, among others. Despite the large variance in possibilities, findings of this study leave the effectiveness of current practices in the spotlight. A considerably stronger effort of understanding is required to grasp a better understanding if the 'effectiveness' is equivalent to the abilities it provides.

Secondly, as a conductor, we are less frequently asked to identify performance errors of an ensemble without previous score analysis; typically, score study and aural models are established prior. Current research has indicated that students using an aural model as a form of score study often are more aurally adept at identifying errors. To better understand the effects of selectivity and perceptual limits, additional research must commence identifying a congruency or differentiation of having a previously established aural model. Hayslett incorporated the use of aural templates as a variable within his work; a similar approach would be suggested. Use of such aural model would aid in the understanding of how chunking, short-term memory, and selectivity interact with one another during periods of error identification.

Lastly, few studies have ventured into the realm of error-detection concerning pedagogical and musical practices (i.e., tone quality, intonation, dynamic variance). Unquestionably, many objections may occur during pedagogical error-detection, as these aspects of music are highly subjective. Jordan has previously written materials which allow the user to identify performed vocal issues, however, the identification is based strongly on his personal pedagogical teachings. Being capable of detecting defects in vocal production is a requirement of successful conducting. More so, within the context of rehearsals and performances, issues of anxiety, perceptual load, and psychoacoustic perceptions frequently inhibit the listeners' ability for success. Future research in the development of pedagogical aural training devices is imperative, so that conductors may have the opportunity to practice these essential aural skills prior to the extreme demands set in a live situation.

## **Conclusion**

Without question, a conductor's aural capabilities determine the actions they are to make, whether it be musically or pedagogically. Aural training, as practiced within the majority of all undergraduate and graduate music curricula, is a necessary and foundational curriculum. This traditional method, however, has been demonstrated to contain significant deficiencies. As exemplified by this study, error-detection abilities are demonstratively weak across the board. Current error-detection training is commonly intertwined with generalized dictation and sight-singing practices, however, a the training of one does not provide equivalent training in the other. Unfortunately, the conductor's ability to process multiple forms of information often may be overestimated. While incorporating previous research, this study sheds light on the challenges that exist to attend to and process a variable amount of simultaneously voiced musical lines. These findings are startling and demonstrate a needed effort for training error-detection abilities

under various circumstances in our educational system. To overcome these deficiencies, we must address and revamp current aural training curricula to accommodate these neglected shortcomings. In the training of conductors, we must go further and teach listeners not only *what* to listen for, but *how* to listen.

## References

- Adolphe, Bruce. *The Mind's Ear: Exercises for Improving the Musical Imagination for Performers, Composers, and Listeners*. Second edition. New York: Oxford University Press, 2013.
- Albert S. Bregman. *Auditory Scene Analysis: The Perceptual Organization of Sound*. Cambridge, Mass.: MIT Press, 1990.
- Arthur, P., Sieu Khuu, and Diana Blom. "Music Sight-Reading Expertise, Visually Disrupted Score and Eye Movements." *Journal of Eye Movement Research* 9, no. 7 (2016): 1–12.
- Backer, Kristina. "Effects of Attention on Change Deafness." ProQuest Dissertations Publishing, 2010. <http://search.proquest.com/docview/869287948/>.
- Bailey, Wayne. *Aural Skills for Conductors*. Mountain View, Calif.: Mayfield PubCo, 1992.
- Benward, Bruce, and J. Timothy Kolosick. *Ear Training: A Technique for Listening*. 5th ed. Dubuque, Iowa: Brown and Benchmark, 1996.
- Bernstein, Joshua G. W., and Andrew J. Oxenham. "The Relationship between Frequency Selectivity and Pitch Discrimination: Effects of Stimulus Level." *The Journal of the Acoustical Society of America* 120, no. 6 (2006): 3916–28.
- Bigand, E., and B. Poulin - Charronnat. "Are We 'Experienced Listeners'? A Review of the Musical Capacities That Do Not Depend on Formal Musical Training." *Cognition* 100, no. 1 (2006): 100–130. <https://doi.org/10.1016/j.cognition.2005.11.007>.
- Brand, Manny, and Vernon Burnsed. "Music Abilities and Experiences as Predictors of Error-Detection Skill." *Journal of Research in Music Education* 29, no. 2 (1981): 91–96.
- Bregman, A.S. *Auditory Scene Analysis*. Cambridge, MA: Bradford/MIT Press, 1990.

- Broadbent, D.E. "Listening Between and During Practiced Auditory Distractions." *British Journal of Psychology* 47 (1956): 51–60.
- . *Perception and Communication*. London: Pergamon Press, 1985.
- . "The Role of Auditory Localization in Attention and Memory Span." *Journal of Experimental Psychology* 47, no. 3 (1954): 191–96.
- Butler, David. *The Musician's Guide to Perception and Cognition*. New York: Schirmer Books; Maxwell Macmillan Canada ; Maxwell Macmillan International, 1992.
- Byo, James L. "The Effects of Texture and Number of Parts on the Ability of Music Majors to Detect Performance Errors." *Journal of Research in Music Education* 45, no. 1 (1998): 51–66.
- . "The Influence of Textural and Timbral Factors on the Ability of Music Majors to Detect Performance Errors." *Journal of Research in Music Education* 41 (1993): 156–67.
- Byo, J. (1990). Teach Your Instrumental Students to Listen. *Music Educators Journal*, 77(4), 43–46.
- Cherry, E.C. "Some Experiments on the Recognition of Speech, with One and with Two Ears." *Journal of Acoustic Society of America* 25 (1953): 975–79.
- Costanza, A. Peter. "Programmed Instruction in Score Reading Skills." *Journal of Research in Music Education* 19 (1971): 453–59.
- Crowder, Robert G. "Auditory Memory." Oxford University Press, 1993.
- Crowe, Don R. "Effects of Score Study Style on Beginning Conductors' Error-Detection Abilities." *Journal of Research in Music Education* 44, no. 2 (1996): 160–171.

- Dalton, Polly, and Nick Fraenkel. "Gorillas We Have Missed: Sustained Inattentive Deafness for Dynamic Events." *Cognition* 124, no. 3 (2012): 367–372.  
<https://doi.org/10.1016/j.cognition.2012.05.012>.
- David M. (David Martin) Howard. *Acoustics and Psychoacoustics*. Music Technology Series. Oxford: Focal, 1996.
- Davison, Lynn, and William Banks. "Selective Attention in Two-Part Counterpoint." *Music Perception* 21, no. 1 (2003): 3–20. <https://doi.org/10.1525/mp.2003.21.1.3>.
- Deal, J.J. "Computer-Assisted Instruction in Pitch and Rhythm Error Detection." *Journal of Research in Music Education* 33 (1985): 159–66.
- Decarbo, Nicholas. "The Effect of Years of Teaching Experience and Major Performance Instrument on Error Detection Scores of Instrumental Music Teachers." *Contributions to Music Education*, no. 11 (1984): 28–32.
- . "The Effects of Conducting Experience and Programmed Materials on Error Detection Scores of College Conducting Students." ProQuest Dissertations Publishing, 1981.  
<http://search.proquest.com/docview/303173130/>.
- . "The Effects of Conducting Experience and Programmed Materials on Error-Detection Scores of College Conducting Students." *Journal of Research in Music Education* 30 (1982): 187–200.
- Deutsch, D. "Grouping Mechanisms in Music." In *The Psychology of Music*, 2nd ed., 299–348. San Diego: Academic Press, 1999.
- . *The Psychology of Music*. New York: Academic Press, 1982.
- . "Two-Channel Listening to Musical Scales." *Journal of Acoustic Society of America* 57 (1975): 1156–60.

Deutsch, Diana. "Musical Illusions, Absolute Pitch, and Other Enigmas of Sound Perception."

*The Journal of the Acoustical Society of America* 129, no. 4 (2011): 2430–2430.

<https://doi.org/10.1121/1.3587948>.

———. "The Psychology of Hearing." *Sound & Video Contractor* 16, no. 10 (1998): 34.

———, ed. *The Psychology of Music*. 3rd ed. Waltham, MA: Academic Press, 2013.

Deutsch, J.A., and D. Deutsch. "Attention: Some Theoretical Considerations." *Psychological*

*Review* 70 (1963): 80–90.

Devine, K. (2013). Imperfect Sound Forever: Loudness Wars, Listening Formations and the

History of Sound Reproduction. *Popular Music*, 32(2), 159-176.

Dittrich, Kerstin, and Christoph Stahl. "Selective Impairment of Auditory Selective Attention

under Concurrent Cognitive Load." *Journal of Experimental Psychology: Human*

*Perception and Performance* 38, no. 3 (2013): 618–627. <https://doi.org/10.1037/a0024978>.

Doane, C. "The Development and Testing of a Program for the Development of Conductor Aural

Error Detection Skills." *College Band Directors National Association Journal* 6 (1988): 11–

14.

Driver, J. "A Selective Review of Selective Attention Research from the Past Century." *British*

*Journal of Psychology* 92 (2001): 53–78.

Duncan, J. "The Locus of Interference in the Perception of Simultaneous Stimuli." *Psychological*

*Review* 87 (1980): 272–300.

Egan, James, and Harold Hake. "On the Masking Pattern of a Simple Auditory Stimulus." *The*

*Journal of the Acoustical Society of America* 22, no. 5 (1950): 622–30.

- Fairnie, Jake, Brian C. J. Moore, and Anna Remington. "Missing a Trick: Auditory Load Modulates Conscious Awareness in Audition." *Journal of Experimental Psychology: Human Perception and Performance*, 2016. <https://doi.org/10.1037/xhp0000204>.
- Fauls, Brenda. "A Choral Conductor's Reference Guide to Acoustic Choral Music Measurement: 1885 to 2007." ProQuest Dissertations Publishing, 2008. <http://search.proquest.com/docview/304658296/>.
- Forsythe, Jere L., and Jon R. Woods. "The Effects of Conducting on the Error Detection Ability of Undergraduate and Graduate Instrumental Conductors." *Contributions to Music Education*, no. 10 (1983): 27–32.
- Geringer, John M., Rebecca B. Macleod, and Justine K. Sasanfar. "In Tune or out of Tune: Are Different Instruments and Voice Heard Differently?" *Journal of Research in Music Education* 63, no. 1 (2015): 89–101. <https://doi.org/10.1177/0022429415572025>.
- Gillespie, Jeffrey. "Difficulty Factors in the Perception of Melody by Skilled Listeners." ProQuest Dissertations Publishing, 1996. <http://search.proquest.com/docview/304302473/>.
- Gonzo, C.L. "An Analysis of Factors Related to Choral Teachers' Ability to Detect Pitch Errors While Reading the Score." *Journal of Research in Music Education* 19 (1971): 259–71.
- Goodman, K.S. "Behind the Eye: What Happens in Reading?" In *Theoretical Models and Processes of Reading*. Newark: DE: International Reading Association, 1976.
- Goolsby, Thomas W. "Eye Movement in Music Reading: Effects of Reading Ability, Notational Complexity, and Encounters." *Music Perception: An Interdisciplinary Journal* 12, no. 1 (1994): 77–96. <https://doi.org/10.2307/40285756>.
- . "Profiles of Processing: Eye Movements during Sightreading." *Music Perception: An Interdisciplinary Journal* 12, no. 1 (1994): 97–123. <https://doi.org/10.2307/40285757>.

- Goolsby, Thomas Watson. *The Parameters of Eye Movement in Vocal Music Reading*.  
University of Illinois at Urbana-Champaign, 1987.
- Gordon, Edwin. *Learning Sequences in Music: Skill, Content, and Patterns*. 1989 ed. Chicago,  
IL]: GIA Publications, 1988.
- Gordon, Edwin. *Pattern Sequence and Learning in Music*. Chicago, IL: GIA Publications, 1978.
- Green, Elizabeth. *The Conductor and His Score*. Englewood Cliffs, N.J.: Prentice-Hall, 1975.
- Gregory, Andrew. "Timbre and Auditory Streaming." *Music Perception: An Interdisciplinary  
Journal* 12, no. 2 (1994): 161–74.
- Grey, John, and J.W. Gordon. "Perceptual Effects of Spectral Modifications on Musical  
Timbres." *Journal of the Acoustical Society of America* 63, no. 5 (1978): 1493–1500.
- Gromko, Joyce Eastlund. "Perceptual Differences between Expert and Novice Music Listeners:  
A Multidimensional Scaling Analysis." *Psychology of Music* 21, no. 1 (1993): 34–47.  
<https://doi.org/10.1177/030573569302100103>.
- Gruters, Kurtis. "Non-Auditory Influences on the Auditory Periphery." ProQuest Dissertations  
Publishing, 2016.
- Haack, Paul A. "The Influence of Loudness on the Discrimination of Musical Sound Factors."  
*Journal of Research in Music Education* 23, no. 1 (1975): 67–77.
- Harold A. Decker, and Julius Herford. *Choral Conducting; a Symposium*. New York: Appleton-  
Century-Crofts, 1973.
- Hayslett, Dennis. "The Effect of Directed Focus on the Peripheral Hearing of Undergraduate  
Instrumental Music Majors." ProQuest Dissertations Publishing, 1991.  
<http://search.proquest.com/docview/303932008/>.

- . “The Effect of Movement-Based Training upon the Aural Acuity of Conductors.” *Contributions to Music Education* 23 (1996): 7–18.
- Hayslett, D.J. “The Effect of Directed Focus on the Peripheral Hearing of Undergraduate Instrumental Majors.” New Orleans, 1992.
- . “The Effect of Maintaining Conducting Patterns upon the Aural Acuity of Conductors.” presented at the Ohio Music Educators Associate annual convention, Cleveland, OH, February 1991.
- Hillis, Margaret, and Dennis Shrock. “An Interview with Margaret Hillis: On Score Study.” *The Choral Journal* 31, no. 7 (1991): 7–12.
- Hondorp, Paul. *Choral Error Detection: Exercises for Developing Musicianship*. Carl Fischer LLC, 2015.
- Hopkins, Jesse. “The Effect of Four Approaches to Score Study on Student Conductors’ Ability to Detect Errors in the Performance of Choral Music.” ProQuest Dissertations Publishing, 1991. <http://search.proquest.com/docview/303918692/>.
- Huron, David. “Voice Denumerability in Polyphonic Music of Homogeneous Timbres.” *Music Perception: An Interdisciplinary Journal* 6, no. 4 (1989): 361–382. <https://doi.org/10.2307/40285438>.
- Jones, Mari Riess, Richard R. Fay, and Arthur N. Popper. *Music Perception*. Springer Handbook of Auditory Research ; v. 36. New York: Springer, 2010.
- Jordan, James Mark. *Evoking Sound: The Choral Warm-up : Method, Procedures, Planning, and Core Vocal Exercises*. Chicago: GIA Publications, 2005.
- . *The Choral Conductor’s Aural Tutor: Training the Ear to Diagnose Vocal Problems*. Chicago: GIA Publications, 2006.

- Kahneman, Daniel. *Attention and Effort*. Prentice-Hall Series in Experimental Psychology. Englewood Cliffs, N.J.: Prentice-Hall, 1973.
- Karns, Christina M., Elif Isbell, Ryan J. Giuliano, and Helen J. Neville. "Auditory Attention in Childhood and Adolescence: An Event-Related Potential Study of Spatial Selective Attention to One of Two Simultaneous Stories." *Developmental Cognitive Neuroscience* 13 (2015): 53–67. <https://doi.org/10.1016/j.dcn.2015.03.001>.
- Karpinski, Gary. *Aural Skills Acquisition: The Development of Listening, Reading, and Performing Skills in College-Level Musicians*. New York: Oxford University Press, 2000.
- . *Manual for Ear Training and Sight Singing*. New York: Norton, 2007.
- Kenny, Dianna. *The Psychology of Music Performance Anxiety*. Oxford: Oxford University Press, 2011.
- Kersh, B. "The Classroom Simulator: An Audio-Visual Environment for Practice Teaching." *Audiovisual Instruction* 6 (1961): 447–48.
- Kesselring, Jurg. "Music Performance Anxiety." In *Music, Motor Control and the Brain*. Oxford: Oxford University Press, 2006.
- Kirlin, P.B., and P.E. Utgoff. "Voice: Learning to Segregate Voices in Explicit and Implicit Polyphony." London, UK, 2005.
- Koch, Iring, Vera Lawo, Janina Fels, and Michael Vorlander. "Switching in the Cocktail Party: Exploring Intentional Control of Auditory Selective Attention." *Journal of Experimental Psychology: Human Perception and Performance* 37, no. 4 (2011): 1140–1147. <https://doi.org/10.1037/a0022189>.
- Kock, W.E. "Binaural Localization and Masking." *Journal of Acoustic Society of America* 22 (1950): 801–4.

- Koelsch, Stefan. *Brain and Music*. 1st ed. Chichester, West Sussex ; Hoboken, NJ: Wiley-Blackwell, 2012.
- Koreimann, Sabrina, Bartosz Gula, and Oliver Vitouch. "Inattentional Deafness in Music." *Psychological Research* 78 (2014): 304–12.
- . "Inattentional Deafness in Music." *Psychological Research* 78, no. 3 (2014): 304.
- Kraft, Leo. *A New Approach to Ear Training*. 2nd ed. New York: W.W. Norton, 1999.
- Kraus, Nina, and Bharath Chandrasekaran. "Music Training for the Development of Auditory Skills." *Nature Reviews. Neuroscience* 11, no. 8 (2010): 599–605.  
<https://doi.org/10.1038/nrn2882>.
- La Reau, Marcia. "An Auralization-Based Curriculum as a Methodology for Advanced Aural Skills Training for Wind Band Conductors." ProQuest Dissertations Publishing, 1989.  
<http://search.proquest.com/docview/303829329/>.
- Lamb, Gordon. *Choral Techniques*. 3rd ed. Dubuque, Iowa: Wm. C. Brown Publishers, 1988.
- Larson, Richard C. "Relationships between Melodic Error Detection, Melodic Dictation, and Melodic Sight-singing." *Journal of Research in Music Education* 25, no. 4 (1977): 264–271.
- Lavie, Nilli. "Distracted and Confused?: Selective Attention under Load." *Trends in Cognitive Sciences* 9, no. 2 (2005): 75–82. <https://doi.org/10.1016/j.tics.2004.12.004>.
- . "Perceptual Load as a Necessary Condition for Selective Attention." *Journal of Experimental Psychology: Human Perception and Performance* 21, no. 3 (1995): 451–468.  
<https://doi.org/10.1037/0096-1523.21.3.451>.
- Lavie, Nilli, Aleksandra Hirst, Jan W. De Fockert, and Essi Viding. "Load Theory of Selective Attention and Cognitive Control." *Journal of Experimental Psychology: General* 133, no. 3 (2004): 339–354.

- Lavie, Nilli, and Yehoshua Tsal. "Perceptual Load as a Major Determinant of the Locus of Selection in Visual Attention." *Perception & Psychophysics* 56, no. 2 (1994): 183–197. <https://doi.org/10.3758/BF03213897>.
- Lim, Sung-Joo, Malte Wöstmann, and Jonas Obleser. "Selective Attention to Auditory Memory Neurally Enhances Perceptual Precision." *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience* 35, no. 49 (2015): 16094–104. <https://doi.org/10.1523/JNEUROSCI.2674-15.2015>.
- Macdonald, James, and Nilli Lavie. "Visual Perceptual Load Induces Inattentive Deafness." *Attention, Perception, & Psychophysics* 73, no. 6 (2011): 1780–1789. <https://doi.org/10.3758/s13414-011-0144-4>.
- Mack, A., and I. Rock. *Inattentive Blindness*. Cambridge: MIT Press, 1998.
- Malone, P.R. "Development and Evaluation of an Approach to Increasing Pitch Error Detection Skills in Choral Music Education Students." Florida State University, 1985.
- McConkie, G. "Eye Movement and Perception during Reading." In *Eye Movements in Reading: Perceptual and Language Processes*. New York: Academic Press, 1983.
- Memmert, D. "The Effects of Eye Movements, Age, and Expertise on Inattentive Blindness." *Consciousness and Cognition* 15 (2006): 620–27.
- Micheyl, Christophe, Joshua G. W. Bernstein, and Andrew J. Oxenham. "Detection and F0 Discrimination of Harmonic Complex Tones in the Presence of Competing Tones or Noise." *The Journal of the Acoustical Society of America* 120, no. 3 (2006): 1493–1505.
- Micheyl, Christophe, Karine Delhommeau, Xavier Perrot, and Andrew J. Oxenham. "Influence of Musical and Psychoacoustical Training on Pitch Discrimination." *Hearing Research* 219, no. 1 (2006): 36–47. <https://doi.org/10.1016/j.heares.2006.05.004>.

- Miller, G.A. "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information." *Psychological Review* 63 (1956): 81–97.
- Miller, J. "Divided Attention: Evidence for Coactivation with Redundant Signals." *Cognitive Psychology* 14 (1982): 247–79.
- Mount, T. "Pitch and Rhythm Error Identification and Its Relevance in the Use of Choral Sectional Rehearsals." University of Southern California, 1982.
- Murphy, Sandra, Charles Spence, and Polly Dalton. "Auditory Perceptual Load: A Review." *Hearing Research*, 2017. <https://doi.org/10.1016/j.heares.2017.02.005>.
- Napoles, Jessica, Sandra L. Babb, Judy Bowers, Steven Hankle, and Adam Zrust. "The Effect of Piano Playing on Preservice Teachers' Ability to Detect Errors in a Choral Score." *Journal of Music Teacher Education* 26, no. 2 (2017): 39–49. <https://doi.org/10.1177/1057083716639724>.
- Neill, W.T., and R.L. Westberry. "Selective Attention and the Suppression of Cognitive Noise." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 13 (1987): 327–34.
- Norman, Donald. "Toward a Theory of Memory and Attention." *Psychological Review* 76, no. 6 (1968): 522–36.
- Park, S., M.S. Kim, and M.M. Chun. "Concurrent Working Memory Load Can Facilitate Selective Attention: Evidence for Specialized Load." *Journal of Experimental Psychology: Human Perception and Performance* 33 (2007): 1062–75.
- Pembroke, Randall G., and H. Lee Riggins. "'Send Help!': Aural Skills Instruction in the U.S. Colleges and Universities." *Journal of Music Theory Pedagogy* 4 (1990): 231–41.
- Penttinen, Marjaana, Erkki Huovinen, and Anna-Kaisa Ylitalo. "Reading Ahead: Adult Music Students' Eye Movements in Temporally Controlled Performances of a Children's Song."

*International Journal of Music Education* 33, no. 1 (2015): 36–50.

<https://doi.org/10.1177/0255761413515813>.

Phillips, Joel. *The Musician's Guide to Aural Skills*. 2nd ed. New York: WWNorton & Co, 2011.

Pratt, George. *Aural Awareness: Principles and Practice*. Milton Keynes ; Philadelphia: Open University Press, 1990.

Ramsey, D.S. “Programmed Instruction Using Band Literature to Teach Pitch and Rhythm Error Detection to Music Education Students.” *Journal of Research in Music Education* 27 (1979): 149–62.

Rasch, R. A. “Perception of Simultaneous Notes Such as in Polyphonic Music.” *Acustica* 40, no. 1 (1978): 21–33.

———. “The Perception of Simultaneous Notes such as in Polyphonic Music.” *Acustica* 40 (1978): 22–33.

———. “Timing and Synchronization in Ensemble Performance.” In *Generative Processes in Music: The Psychology of Performance, Improvisation, and Composition*. Oxford: Oxford University Press, 1988.

Roederer, Juan. *The Physics and Psychophysics of Music: An Introduction*. New York: Springer-Verlag, 1995.

Rogers, George L., and Rosemary C. Watkins. “The Relationship Between Prior Musical Training and Aural Discrimination Skills of Elementary Education Majors.” *Contributions to Music Education*, no. 13 (1986): 48–55.

Rolf Bader, editor. *Sound - Perception - Performance*. Current Research in Systematic Musicology ; v. 1. Cham ; New York: Springer, 2013.

- Russo, F.A., and W.F. Thompson. "An Interval Size Illusion: The Influence of Timbre on the Perceived Size of Melodic Intervals." *Perception & Psychophysics* 67, no. 4 (2005): 559–68.
- Schlauch, Robert S. "Selective Attention and Auditory Filters." *The Journal of the Acoustical Society of America* 134, no. 5 (2013): 4163–4163. <https://doi.org/10.1121/1.4831258>.
- Schumann, Robert. "Musikalische Haus- Und Lebensregeln." In *Im Eigenen Wort*, Ed. Willi Reich. Zurich: Manesse Verlag, 1848.
- Selvey, Jeremiah. "Visual and Aural Modes of Perception in Choral Performance Evaluations." ProQuest Dissertations Publishing, 2014. <http://search.proquest.com/docview/1652865748/>.
- Sheldon, D.A. "Effects of Multiple Listenings on Error-Detection Acuity in Multivoice, Multitimbral Musical Examples." *Journal of Research in Music Education* 52 (1971): 102–15.
- Sheldon, Deborah A. "Effects of Contextual Sight-Singing and Aural Skills Training on Error-Detection Abilities." *Journal of Research in Music Education* 46, no. 3 (1999): 384–95.
- Sidnell, R.G. "The Development of Self-Instructional Drill Material to Facilitate Growth of Score Reading Skills of Student Conductors." *Council for Research in Music Education Bulletin* 10 (1967): 1–6.
- Silvey, Brian A., D. Gregory Springer, and Stephen C. Eubanks. "An Examination of University Conducting Faculty Members' Score Study Attitudes and Practices." *Journal of Music Teacher Education* 26, no. 1 (2016): 82–95. <https://doi.org/10.1177/1057083715616442>.
- Simons, Daniel, and Christopher Chabris. "Gorillas in Our Midst: Sustained Inattentional Blindness for Dynamic Events." *Perception* 28, no. 9 (1999).

- Sinnett, S., A. Costa, and S. Soto-Faraco. "Manipulating Inattentional Blindness within and across Sensory Modalities." *The Quarterly Journal of Experimental Psychology* 59 (2006): 1425–42.
- Sloboda, J.A. "Experimental Studies of Music Reading: A Review." *Music Perception* 2 (1984): 222–36.
- . *The Musical Mind: The Cognitive Psychology of Music*. Oxford: Oxford University Press, 1985.
- Smith, Donald Jay. *An Investigation of the Effects of Varying Temporal Settings on Eye Movements While Sight-Reading Trumpet Music and While Reading Language Aloud*. Pennsylvania State University, 1988.
- Smith, M. (1934). Solfège: An Essential in Musicianship. *Music Educators Journal*, 20(5), 16-20.
- Snyder, Joel, and Melissa Gregg. "Memory for Sound, with an Ear toward Hearing in Complex Auditory Scenes." *Attention, Perception, & Psychophysics* 73, no. 7 (2011): 1993–2007. <https://doi.org/10.3758/s13414-011-0189-4>.
- Spradling, Robert. *Error Detection: Exercises for the Instrumental Conductor*. New York: Carl Fischer, 2010.
- Stambaugh, Laura A. "Differences in Error Detection Skills by Band and Choral Preservice Teachers." *Journal of Music Teacher Education* 25, no. 2 (2016): 25–36. <https://doi.org/10.1177/1057083714558421>.
- Steven M. Larson. *A Comparison of Saccadic Eye Movements by Keyboard Musicians When Reading Music versus Text*. Pacific University, 1989.
- Stevens, S. "The Relation of Pitch to Intensity." *The Journal of the Acoustical Society of America* 6, no. 3 (1935): 150–54.

- Stuart, Melanie. "The Use of Videotape Recordings to Increase Teacher Trainees' Error Detection Skills." *Journal of Research in Music Education* 27, no. 1 (1979): 14–19.
- Tan, Siu-Lan, Peter Pfordresher, and Rom Harre. *Psychology of Music: From Sound to Significance*. New York: Psychology Press, 2010.
- Terhardt, E. "Intonation of Tone Scales: Psycho-Acoustic Considerations." *Archives of Acoustics* 13 (1988): 147–56.
- Ternström, Sten. "Perceptual Evaluations of Voice Scatter in Unison Choir Sounds." *Journal of Voice* 7, no. 2 (1993): 129–135. [https://doi.org/10.1016/S0892-1997\(05\)80342-X](https://doi.org/10.1016/S0892-1997(05)80342-X).
- Theeuwes, J, A.F. Kramer, and A.V. Belopolsky. "Attentional Set Interacts with Perceptual Load in Visual Search." *Psychonomic Bulletin & Review* 11 (2004): 697–702.
- Treisman, A.M. "Contextual Cues in Selective Listening." *Quarterly Journal of Experimental Psychology* 12, no. 4 (1960): 242–48.
- . "Strategies and Models of Selective Attention." *Psychological Review* 76, no. 3 (1969): 282–99.
- . "The Effect of Irrelevant Material on the Efficiency of Selective Listening." *The American Journal of Psychology* 77, no. 4 (1964): 533–46.
- Treisman, A.M., and A. Davies. "Divided Attention to Ear and Eye." In *Attention and Performance IV*, 101–17. New York: Academic Press, 1973.
- Treisman, A.M., and G. Geffen. "Selective Attention: Perception and Response?" *Quarterly Journal of Experimental Psychology* 19 (1967): 1–18.
- Treisman, A.M., and J.G. Riley. "Is Selective Attention Selective Perception or Selective Response? A Further Test." *Journal of Experimental Psychology* 79, no. 1 (1969): 27–34.

- Urista, Diana. *The Moving Body in the Aural Skills Classroom: A Eurhythmics Based Approach*.  
New York, NY: Oxford University Press, 2016.
- Vurma, Allan, Marju Raju, and Annika Kuuda. “Does Timbre Affect Pitch?: Estimations by Musicians and Non-Musicians.” *Psychology of Music* 39, no. 3 (2011): 291–306.  
<https://doi.org/10.1177/0305735610373602>.
- . “Timbre-Induced Pitch Deviations in the Perception of Musicians and Nonmusicians,”  
12.
- Waggoner, Dori. “Effects of Listening Conditions, Error Types, and Ensemble Textures on Error Detection Skills.” *Journal of Research in Music Education* 59, no. 1 (2011): 56–71.
- Wang, DeLiang, and Guy J. Brown. *Computational Auditory Scene Analysis: Principles, Algorithms, and Applications*. Hoboken, N.J. : Chichester: Wiley interscience ; John Wiley distributor, 2006. <http://ieeexplore.ieee.org/xpl/bkabstractplus.jsp?bkn=5769523>.
- Warrier, C.M, and R.J. Zatorre. “Influence of Tonal Context and Timbral Variation on Perception of Pitch.” *Perception & Psychophysics* 64, no. 2 (2002): 198–207.
- Waters, Andrew J., and Geoffrey Underwood. “Eye Movements in a Simple Music Reading Task: A Study of Expert and Novice Musicians.” *Psychology of Music* 26, no. 1 (1998): 46–60. <https://doi.org/10.1177/0305735698261005>.
- Wood, N.L., and N. Cowan. “The Cocktail Party Revisited: Attention and Memory in the Classic Selective Listening Procedure of Cherry.” *Journal of Experimental Psychology: General* 124 (1995): 243–62.
- Wright, William. “A Study of the Choral Conductor’s Ear -Training Process, and the Development of an Ear -Training Workbook for Choral Conductors.” ProQuest Dissertations Publishing, 2001. <http://search.proquest.com/docview/251682824/>.

Yigit-Elliott, Serap, John Palmer, and Cathleen M. Moore. "Distinguishing Blocking from Attenuation in Visual Selective Attention." *Psychological Science* 22, no. 6 (2011): 771–80. <https://doi.org/10.1177/0956797611407927>.

Appendix A  
Glossary of Terms

## Glossary of Terms

**Audiation:** As coined by Gordon (1978), audiation (audiate) is the ability of developing an internal aural template.

**Auditory Stream Analysis:** Originating from Bregman (1990), auditory stream analysis is the manner in which the auditory system organizes sound into comprehensible elements.

**Aural Acuity:** Aural acuity is the overall auditory perception ability and strength.

**Chunking:** As identified by Miller (1956), *chunking* is the cognitive process of binding together smaller pieces of information into an understandable whole.

**Error-Detection:** *Error-detection* is defined as the overall ability to detect performance errors of pitch, rhythm, or technique.

**Inattentional Deafness:** Defined by Koreimann et al. (2014), *inattentional deafness* is the inability to perceive some, or all auditory stimulus; this is often caused by perceptual overload or attention selectivity.

**Miss:** In error-detection tasks, a *miss* is considered an error which was unidentified.

**Perceptual Load:** In the field of cognition, *perceptual load* is the perceptual capacity one has before cognitive filtering takes place.

**Phantom Error (also known as *False-Alarm*):** *Phantom errors (or false-alarms)* are perceived performance errors which never occurred.

**Psychoacoustics:** *Psychoacoustics* is a field of cognition which explores how the human brain processes sound.

**Selective Attention:** Often grouped with filtering theories, *selective attention* is the prioritization of information processing due to conscious or unconscious selection.

Appendix B  
Participant Consent Form

# Selective Attention on Error-Detection Abilities Study

University of Washington

*Questions? Contact Jeffrey Larkin (larkinje@uw.edu)*



**The Selective Attention on Error-Detection Abilities Study** is a part of the dissertation by doctoral candidate Jeffrey Larkin (larkinje@uw.edu) at the University of Washington. The researcher seeks to understand how selective attention affects the aural perception of conductors in the form of error-detection. Results from this research may provide practical implications of musicians in the way of score study, aural training, and aural perception.

Participants will be locating musical errors that occur within digitally sampled performances. Participation in the study will take participants 35-40 minutes, and completion is required to be included within the final research analysis.

## **Participant Requirements:**

1. You must be at least 18 years old.
2. You must have at training with musical notation.
3. You must identify as a previous, current, or future choral conductor.

## **Researcher**

*Principal Investigator & Contact Person for Questions or Concerns*

Jeffrey Larkin, Doctoral Candidate, School of Music

Contact Information: larkinje@uw.edu

*Faculty Advisor*

Geoffrey Boers, Director of Choral Studies, School of Music

## **Researchers' Statement**

We are asking you to participate in a research study. The purpose of this consent page is to give you the information you will need to help you decide whether or not to be in the study. Please read the page carefully. You may ask questions about the purpose of the research, what we would ask you to do, your rights as a volunteer, and anything else about the research or this consent that is not clear. When we have answered all your questions, you can decide if you want to be in the study or not. This process is called "informed consent."

## **Purpose of the Study**

The purpose of this study is to examine the interaction between selective attention during an aural stimulus and its effect upon aural perception. For the purpose of this study, the following terms and concepts are defined as the following:

- Selective Attention - *Cognitive focus, including visual and/or aural stimulus*
- Aural Stimulus - *Digital sampling of a multi-voice performance (ex. Bach chorale played within Sibelius or Finale)*
- Aural Perception - *The overall ability to detect music errors*

More specifically, participants will be detecting various musical errors within a musical score while being directed to maintain primary attention to a particular musical line.

## **Study Procedures**

Once participants have confirmed 'Informed Consent,' proper set-up, and set aside 25-30 minutes for the study, they will then be directed through a series of background questions. Questions may include education level, experience level, location, and musical identity. None of the responses will be participant identifiable.

Participants will then listen to 16 audio examples of digitally sampled performances. Below is the procedure for each participant.

1. Participants will read through the informed consent.
2. Upon completion of the consent, participants will be instructed in the process and format of the study.
3. Participants will be played 16 aural excerpts, with visual music scores.
4. For each example, participants will be directed to visually examine specific vocal lines from a musical score, during which an auditory example will be played simultaneously.
5. During playback, participants will be asked to compare visual and auditory excerpts, and indicate musical errors.
6. Upon completion of the study, participant responses will be referenced with the error-key.

## **Confidentiality of Research Information**

No specifically identifiable will be recorded or collected as part of this study. All responses will include generic data which not be identifiable post-study.

## **Other Information**

Participation is voluntary. Participants may refuse to answer optional questions and/or withdraw from this study at any time. Refusing to participate or withdrawing from this study will involve no penalty or loss of benefits to which the subject is otherwise entitled. Initial consent will be confirmed by signing the consent. Any questions, concerns, complaints, or reports of research-relate injury can be directed to Jeffrey Larkin ([larkinje@uw.edu](mailto:larkinje@uw.edu)).

### Subjects Consent

This study has been explained to me. I volunteer to take part in this research. I have had a chance to ask questions. If I have questions later about the research, or if I have been harmed by participating in this study, I can contact one of the researchers listed on the first page of this consent form. If I have questions about my rights as a research subject, I can call the Human Subjects Division at (206) 543-0098 or call collect at (206) 221-5940.

---

Printed name of subject  
subject

Signature of

Date

If you are interested in receiving the results from this study, please indicate: Yes [ ] No [ ]

Email Address: \_\_\_\_\_

Appendix C  
Experiment Materials

# Selective Attention on Error-Detection Abilities Study

University of Washington

Questions? Contact Jeffrey Larkin ([larkinje@uw.edu](mailto:larkinje@uw.edu))



The **Selective Attention on Error-Detection Abilities Study** will take approximately 35-40 minutes. The priority of this study is to investigate the affect selective attention has upon aural acuity in the form of error-detection. Further instructions will be provided following the initial questionnaire.

- |  |         |        |
|--|---------|--------|
| 1. I have training with musical notation.                      | YES [ ] | NO [ ] |
| 2. I identify as a past, current, or future choral conductor.  | YES [ ] | NO [ ] |
| 3. I identify as having <i>absolute pitch</i> (perfect pitch). | YES [ ] | NO [ ] |
| 4. I identify as having some form of hearing limitation.       | YES [ ] | NO [ ] |

---

Age: \_\_\_\_\_

Gender: \_\_\_\_\_

Highest Degree Obtained: \_\_\_\_\_

If a student, list the degree you are pursuing AND your year in school. \_\_\_\_\_

Years of Experience as a Choral Conductor and/or Choral Musician: \_\_\_\_\_

---

**Primary Experience** (*Select One which best represents the ensemble you primarily work with*)

Professional [ ]   Semi-Professional [ ]   College/University [ ]   High School [ ]

Middle School [ ]   Elementary School [ ]   Community Choir [ ]   Church Choir [ ]

---

Please assess your error-detection abilities from 1(*low*) to 10(*high*).

1 2 3 4 5 6 7 8 9 10

# Selective Attention on Error-Detection Abilities Study

University of Washington

Questions? Contact Jeffrey Larkin ([larkinje@uw.edu](mailto:larkinje@uw.edu))

## INSTRUCTIONS

You are about to listen to a total of 16 different audio excerpts. For each audio example, you will be directed to aurally and visual focus your attention to a selected vocal line(s). During the example, performance errors will occur ONLY within the selected vocal line(s). For this study, possible errors will include and be defined as:

- **Incorrect Pitch:** Pitches performed differently than as notated.
- **Incorrect Rhythm:** Rhythms performed differently than as notated.

When the detection of errors occurs, you are asked to circle the error location, being specific to:

- **Vocal Line(s)**
- **Measure(s)**
- **Beat(s)**

The image shows a musical score for a 4-measure excerpt in 4/4 time, key of B-flat major. The score consists of four staves: three vocal staves and one piano accompaniment staff. The first two vocal staves are marked 'f' (forte) and the last two are marked 'p' (piano). A circled note in the second measure of the second vocal staff indicates an error location.

Please Note: You will NOT be asked to identify the type of error. Additionally, no errors will occur in Measure 1 of any example.

Prior to the performance of each example, you will be provided a tonicization of the key (I, IV, V, I), and 30 seconds to study the notated score.

At the start of the performance, you will be given a 1 measure metronome track to establish tempo. Once the performance starts you are free to indicate errors as they occur or after the performance. The example will be played 2 times, with a 5 second pause in-between performances.

There will be a 10 second pause in-between examples.

IF YOU HAVE ANY QUESTIONS, PLEASE ASK THE ADMINISTRATOR AT THIS POINT

**EXAMPLE 1**

*Please direct your attention to the **SOPRANO** part.*

**♩ = 80**

The musical score consists of four staves: Soprano, Alto, Tenor, and Bass. The key signature is D major (two sharps) and the time signature is 4/4. The tempo is marked as ♩ = 80. The Soprano part is the primary focus, with measures 2 through 8 numbered above the staff. The Alto part features a melodic line with some rests. The Tenor part provides a harmonic accompaniment with a mix of eighth and quarter notes. The Bass part provides a steady accompaniment with a mix of quarter and eighth notes.

**EXAMPLE 2**

*Please direct your attention to the **SOPRANO & ALTO** part.*

**♩ = 80**

The musical score is written in 4/4 time with a key signature of two flats (B-flat and E-flat). The tempo is marked as 80 bpm. The score consists of four staves: Soprano, Alto, Tenor, and Bass. The Soprano part is the primary focus, with measure numbers 2 through 8 indicated above the staff. The Alto part provides a counter-melody, while the Tenor and Bass parts provide harmonic support. The Soprano part begins with a quarter rest in measure 1, followed by a quarter note in measure 2, and continues with a series of quarter and eighth notes through measure 8. The Alto part starts with a quarter note in measure 1 and continues with a similar rhythmic pattern. The Tenor part begins with a quarter note in measure 1 and features a half note in measure 2. The Bass part starts with a quarter note in measure 1 and continues with a steady eighth-note pattern.

**EXAMPLE 3**

*Please direct your attention to the ALTO part.*

**♩ = 80**

Soprano

Alto

Tenor

Bass

**EXAMPLE 4**

Please direct your attention to the **SOPRANO, ALTO, TENOR, & BASS** part.

**♩ = 80**

The musical score consists of four staves: Soprano, Alto, Tenor, and Bass. The key signature is two sharps (F# and C#) and the time signature is 4/4. The tempo is marked as quarter note = 80. The Soprano part has measures 2 through 8 numbered above. The Alto, Tenor, and Bass parts are written in their respective staves.

**EXAMPLE 5**

*Please direct your attention to the **TENOR & BASS** part.*

**♩ = 80**

The musical score consists of four staves: Soprano, Alto, Tenor, and Bass. The key signature is three sharps (F#, C#, G#) and the time signature is 4/4. The tempo is marked as quarter note = 80. The Soprano part has measures 2 through 8 numbered above. The Tenor and Bass parts are also present.

**EXAMPLE 6**

*Please direct your attention to the **SOPRANO, TENOR, & BASS** part.*

**♩ = 80**

The musical score consists of four staves: Soprano, Alto, Tenor, and Bass. The key signature is three flats (B-flat, E-flat, A-flat) and the time signature is 4/4. The tempo is marked as quarter note = 80. The Soprano part has measures 2 through 8 numbered above. The Alto, Tenor, and Bass parts are written in their respective staves.

**EXAMPLE 7**

*Please direct your attention to the **TENOR** part.*

**♩ = 80**

The musical score is written for four voices: Soprano, Alto, Tenor, and Bass. The key signature is one flat (B-flat) and the time signature is 4/4. The tempo is marked as ♩ = 80. The Soprano part begins with a circled '2' above the first measure, followed by circled '3', '4', '5', '6', '7', and '8' above subsequent measures. The Tenor part has a circled '8' below the first measure. The Alto and Bass parts follow the same melodic contour as the other voices. The score concludes with a double bar line.

**EXAMPLE 8**

Please direct your attention to the **SOPRANO, ALTO, TENOR, & BASS** part.

**♩ = 80**

The musical score is written for four voices: Soprano, Alto, Tenor, and Bass. It is in 4/4 time and has a tempo of 80 beats per minute. The key signature has two flats (B-flat and E-flat). The Soprano part begins with a half note G4, followed by quarter notes A4, B4, and C5. The Alto part begins with a half note G3, followed by quarter notes A3, B3, and C4. The Tenor part begins with a half note G3, followed by quarter notes A3, B3, and C4. The Bass part begins with a half note G2, followed by quarter notes A2, B2, and C3. The Soprano part has numbers 2, 3, 4, 5, 6, 7, and 8 above the notes. The Alto, Tenor, and Bass parts have corresponding rhythmic accompaniment.

**EXAMPLE 9**

*Please direct your attention to the ALTO, TENOR, & BASS part.*

**♩ = 80**

Soprano

Alto

Tenor

Bass

**EXAMPLE 10**

Please direct your attention to the **SOPRANO, ALTO, TENOR, & BASS** part.

**♩ = 80**

The musical score consists of four staves: Soprano, Alto, Tenor, and Bass. The key signature is three sharps (F#, C#, G#) and the time signature is 4/4. The tempo is marked as quarter note = 80. The Soprano part has measures 2 through 8 numbered above. The Alto, Tenor, and Bass parts are written in their respective staves.

**EXAMPLE 11**

*Please direct your attention to the ALTO & TENOR part.*

**♩ = 80**

The musical score consists of four staves: Soprano, Alto, Tenor, and Bass. The key signature is three flats (B-flat, E-flat, A-flat) and the time signature is 4/4. The tempo is marked as quarter note = 80. The Soprano part has notes numbered 2 through 8. The Alto and Tenor parts are the focus of the instruction.

Soprano

Alto

Tenor

Bass

**EXAMPLE 12**

*Please direct your attention to the **SOPRANO & BASS** part.*

**♩ = 80**

Soprano

Alto

Tenor

Bass

**EXAMPLE 13**

*Please direct your attention to the **BASS** part.*

**♩ = 80**

The musical score consists of four staves: Soprano, Alto, Tenor, and Bass. The key signature is B-flat major (two flats) and the time signature is 4/4. The tempo is marked as quarter note = 80. The Soprano part has lyrics 2-8 above it. The Bass part is the focus of the instruction.

Soprano: 2 3 4 5 6 7 8

Alto

Tenor

Bass

**EXAMPLE 14**

Please direct your attention to the **SOPRANO, ALTO, & TENOR** part.

**♩ = 80**

The musical score consists of four staves: Soprano, Alto, Tenor, and Bass. The key signature is one flat (Bb) and the time signature is 4/4. The tempo is marked as quarter note = 80. The Soprano part has measures 2 through 8 numbered above. The Alto, Tenor, and Bass parts are written in their respective staves.

**EXAMPLE 15**

Please direct your attention to the **SOPRANO, ALTO, TENOR, & BASS** part.

**♩ = 80**

The image shows a musical score for four voices: Soprano, Alto, Tenor, and Bass. The score is written in 4/4 time with a key signature of three flats (B-flat, E-flat, A-flat). The tempo is marked as ♩ = 80. The Soprano part has measures numbered 2 through 8. The Alto, Tenor, and Bass parts are written in their respective staves, with the Tenor staff having an 8va marking below the first measure. The music consists of a series of notes and rests across eight measures.

**EXAMPLE 16**

*Please direct your attention to the **SOPRANO, ALTO, & BASS** part.*

**♩ = 80**

Soprano

Alto

Tenor

Bass

# Selective Attention on Error-Detection Abilities Study

University of Washington

*Questions? Contact Jeffrey Larkin ([larkinje@uw.edu](mailto:larkinje@uw.edu))*



Thank you for your participation in this study. Your responses aid in the overall analysis of the collected data.

If you have any comments and/or suggestions for this study, please include them below:

If you have further questions, please contact Jeffrey Larkin ([larkinje@uw.edu](mailto:larkinje@uw.edu))

## Appendix D

### Answer Key for Performance Errors

PLEASE RETURN STUDY TO THE TEST ADMINISTRATOR

1

**EXAMPLE 1**

Please direct your attention to the **SOPRANO** part.

Musical score for Example 1, Soprano part. The score is in 4/4 time with a key signature of two sharps (F# and C#). It consists of two systems of four staves each (Soprano, Alto, Tenor, Bass). The first system is numbered 2 through 8. The second system is labeled "PERFORMANCE ERRORS" and shows the same music with yellow highlights on the Soprano staff at measures 3, 6, and 7.

1

**EXAMPLE 2**

Please direct your attention to the **SOPRANO & ALTO** part.

Musical score for Example 2, Soprano and Alto parts. The score is in 4/4 time with a key signature of two flats (Bb and Eb). It consists of two systems of four staves each (Soprano, Alto, Tenor, Bass). The first system is numbered 2 through 8. The second system is labeled "PERFORMANCE ERRORS" and shows the same music with yellow highlights on the Soprano staff at measures 5, 6, and 7, and on the Alto staff at measures 6 and 7.

**EXAMPLE 3**

Please direct your attention to the **ALTO** part.

Musical score for Example 3, measures 2-8. The score is in 4/4 time with a key signature of three sharps (F#, C#, G#). The parts are Soprano, Alto, Tenor, and Bass. The Alto part is highlighted as the focus of the instruction.

**PERFORMANCE ERRORS**

Musical score for Example 3, measures 2-8, showing performance errors. The Alto part has yellow highlights under the notes in measures 4 and 5, indicating errors in the original performance.

**EXAMPLE 4**

Please direct your attention to the **SOPRANO, ALTO, TENOR, & BASS** part.

Musical score for Example 4, measures 2-8. The score is in 4/4 time with a key signature of three sharps (F#, C#, G#). The parts are Soprano, Alto, Tenor, and Bass.

**PERFORMANCE ERRORS**

Musical score for Example 4, measures 2-8, showing performance errors. The Soprano, Alto, and Bass parts have yellow highlights under the notes in measures 5 and 6, indicating errors in the original performance.

**EXAMPLE 5**

Please direct your attention to the **TENOR & BASS** part.

Musical score for Example 5, Soprano, Alto, Tenor, and Bass parts. The score is in 4/4 time with a key signature of three sharps (F#, C#, G#). The Soprano part has measures 2-8 numbered above. The Tenor and Bass parts have yellow highlights in the 'PERFORMANCE ERRORS' section: Tenor measure 6 (G#4), Bass measure 5 (F#3), and Bass measure 8 (G#2).

**EXAMPLE 6**

Please direct your attention to the **SOPRANO, TENOR, & BASS** part.

Musical score for Example 6, Soprano, Alto, Tenor, and Bass parts. The score is in 4/4 time with a key signature of three flats (Bb, Eb, Ab). The Soprano part has measures 2-8 numbered above. The Soprano, Tenor, and Bass parts have yellow highlights in the 'PERFORMANCE ERRORS' section: Soprano measure 5 (Ab4), Tenor measure 4 (Ab3), and Bass measure 6 (Ab2).

**EXAMPLE 7**

Please direct your attention to the **TENOR** part.

Musical score for Example 7, Soprano, Alto, Tenor, and Bass parts. The score is in 4/4 time with a key signature of two flats. It consists of two systems. The first system shows the original notation with measures 2-8 numbered above the Soprano staff. The second system, labeled "PERFORMANCE ERRORS", shows the same notation with yellow highlights on the Tenor staff in measures 6, 7, and 8, indicating specific performance issues.

**EXAMPLE 8**

Please direct your attention to the **SOPRANO, ALTO, TENOR, & BASS** part.

Musical score for Example 8, Soprano, Alto, Tenor, and Bass parts. The score is in 4/4 time with a key signature of two flats. It consists of two systems. The first system shows the original notation with measures 2-8 numbered above the Soprano staff. The second system, labeled "PERFORMANCE ERRORS", shows the same notation with yellow highlights on the Soprano, Alto, and Tenor staves in measures 6, 7, and 8, indicating performance issues across all parts.

**EXAMPLE 9**

Please direct your attention to the *ALTO, TENOR, & BASS* part.

Musical score for Example 9, featuring Soprano, Alto, Tenor, and Bass parts. The score is in 4/4 time with a key signature of three sharps (F#, C#, G#). The Soprano part is marked with measures 2 through 8. The Alto, Tenor, and Bass parts are also marked with measures 2 through 8. A box labeled "PERFORMANCE ERRORS" is placed above the second system of music. In this second system, yellow highlights are placed on specific notes in the Alto, Tenor, and Bass parts to indicate errors: a quarter note in the Alto part (measure 4), a quarter note in the Tenor part (measure 4), and a quarter note in the Bass part (measure 4).

**EXAMPLE 10**

Please direct your attention to the *SOPRANO, ALTO, TENOR, & BASS* part.

Musical score for Example 10, featuring Soprano, Alto, Tenor, and Bass parts. The score is in 4/4 time with a key signature of three sharps (F#, C#, G#). The Soprano part is marked with measures 2 through 8. The Alto, Tenor, and Bass parts are also marked with measures 2 through 8. A box labeled "PERFORMANCE ERRORS" is placed above the second system of music. In this second system, yellow highlights are placed on specific notes in the Soprano, Alto, and Tenor parts to indicate errors: a quarter note in the Soprano part (measure 8), a quarter note in the Alto part (measure 5), and a quarter note in the Tenor part (measure 5).

**EXAMPLE 11**

Please direct your attention to the **ALTO & TENOR** part.

Musical score for Example 11, Soprano, Alto, Tenor, and Bass parts. The score is in 4/4 time with a key signature of three flats (B-flat, E-flat, A-flat). The Soprano part has measures 2-8 with a red dot under the second measure. The Alto part has yellow highlights under measures 3 and 8. The Tenor part has a yellow highlight under measure 7. The Bass part is consistent throughout. A box labeled "PERFORMANCE ERRORS" is placed above the second system of staves.

**EXAMPLE 12**

Please direct your attention to the **SOPRANO & BASS** part.

Musical score for Example 12, Soprano, Alto, Tenor, and Bass parts. The score is in 4/4 time with a key signature of three sharps (F-sharp, C-sharp, G-sharp). The Soprano part has measures 2-8 with a yellow highlight under measure 7. The Alto part is consistent throughout. The Tenor part is consistent throughout. The Bass part has a yellow highlight under measure 4. A box labeled "PERFORMANCE ERRORS" is placed above the second system of staves.

**EXAMPLE 13**

Please direct your attention to the **BASS** part.

Musical score for Example 13, featuring Soprano, Alto, Tenor, and Bass parts. The score is in 4/4 time with a key signature of three flats. The Soprano part is numbered 2 through 8. Below the main score is a section labeled "PERFORMANCE ERRORS" which repeats the same musical notation. In this section, several notes in the Bass part are highlighted in yellow to indicate errors: the first note of the 5th measure, the first note of the 6th measure, and the last note of the 8th measure.

**EXAMPLE 14**

Please direct your attention to the **SOPRANO, ALTO, & TENOR** part.

Musical score for Example 14, featuring Soprano, Alto, Tenor, and Bass parts. The score is in 4/4 time with a key signature of three flats. The Soprano part is numbered 2 through 8. Below the main score is a section labeled "PERFORMANCE ERRORS" which repeats the same musical notation. In this section, several notes in the Soprano, Alto, and Tenor parts are highlighted in yellow to indicate errors: the 5th measure of the Soprano part, the 5th measure of the Alto part, and the 8th measure of the Tenor part.

**EXAMPLE 15**

Please direct your attention to the *SOPRANO, ALTO, TENOR, & BASS* part.

Example 15 is a musical score for Soprano, Alto, Tenor, and Bass parts. The score is in 4/4 time and features a key signature of three flats (B-flat, E-flat, A-flat). The Soprano part has measures 2 through 8 numbered above. The Alto, Tenor, and Bass parts follow. A section labeled "PERFORMANCE ERRORS" is shown below the original score, with yellow highlights on specific notes in the Tenor and Bass parts.

**EXAMPLE 16**

Please direct your attention to the *SOPRANO, ALTO, & BASS* part.

Example 16 is a musical score for Soprano, Alto, Tenor, and Bass parts. The score is in 4/4 time and features a key signature of three sharps (F-sharp, C-sharp, G-sharp). The Soprano part has measures 2 through 8 numbered above. The Alto, Tenor, and Bass parts follow. A section labeled "PERFORMANCE ERRORS" is shown below the original score, with yellow highlights on specific notes in the Tenor and Bass parts.