2010

The effect of directed attention score study procedures on music majors' error detection in three-part instrumental music

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THE EFFECT OF DIRECTED ATTENTION SCORE STUDY PROCEDURES ON MUSIC MAJORS' ERROR DETECTION IN THREE-PART INSTRUMENTAL MUSIC

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
In partial requirements for the degree of
Doctor of Philosophy

in

The College of Music and Dramatic Arts

by
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B.M., Grove City College, 1998
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December 2010

ACKNOWLEDGEMENTS

The completion of this process is due to the support, generosity, faith, and efforts of many people. Thanking them through written word seems inadequate, but as with all of the tasks along this journey, I will do my best.

First and foremost, I must extend my most sincere appreciation and gratitude to my uncle, Glenn R. Jones, whose generosity and faith in my abilities far exceed the bounds of comprehension. Your generosity has provided me the incredible opportunities. I could not have accomplished this without you.

It is impossible to thank all of the friends that have helped me during this process, but I need to acknowledge those friends and colleagues who have walked this journey with me and given unwavering support, especially Elizabeth Menard, Katie-Beth Traxler, Pam Taylor, Alan Clark, Nan Baker Richerson, Rebecca Bellelo, Neil Nelson, Sara McCall, and Kathryn Strickland. Your patience and support through this process has been invaluable and much appreciated. Becoming life-long friends with all of you is one of the best by-products of this journey.

Thank you to all of the willing participants and professors not only here at LSU, but also at Bowling Green State University, and Florida Gulf Coast University who graciously gave of their time and energies to help me complete this project, with special thanks to Elizabeth Menard and Melinda Doyle for all your help in the process.

I wish to express my sincere gratitude to the members of my committee. Thank you to James Garand for graciously agreeing to participate in this process. Thank you to Pamela Pike for serving on my committee and lending additional perspectives on my

research. I am very privileged to have had Robert Mathews as my minor professor. His insight, commentary, and helpful nature were essential in the completion of this project.

My time here at LSU has been the greatest professional opportunity and I am forever changed as a result of my experiences here. This is due in large part to the training, guidance, and support that I received from Jane Cassidy and Jim Byo. I do not know how to express the magnitude of the influence you have had on my life. I am a better writer, scholar, teacher, musician, and person because of your efforts. My time here learning from you both has truly been one of the greatest privileges of my professional and personal life.

None of this would have been possible without the profound love and support of my family, especially my parents who supported my decision to pursue this degree and move thousands of miles away to do it. They have shared in every triumph, struggle, and tear that has led to this conclusion. If everyone were as well loved as I have been, the world would be a better place. Thank you for your steadfast love and confidence in my abilities.

Finally, I dedicate this work to every student I have been privileged to teach and those yet to come.

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ABSTRACT

The purpose of this study was to determine the effects of directing participant (N = 60) attention to one voice in three-part homophonic and polyphonic instrumental music on music majors' detection of pitch and rhythm errors. Directed attention participants studied one voice prior to studying the entire score through either visual or aural methods. Visual group participants (n = 20) studied the voice of directed attention (VDA), which was color highlighted, in silence. Aural group participants (n = 20) studied the VDA in a three-phase treatment: sight-singing the VDA, using a piano and their own singing to correct any errors they perceived in their sight-singing performance, and singing the VDA again. Free group participants (n = 20) studied the entire score for the duration of their score study period and choose any strategy to learn the music. Following score study, participants listened three times to the recorded marred performance of the excerpt and detected pitch and rhythm errors inserted into the studied excerpt. Four errors (2 pitch and 2 rhythm) were inserted into the six excerpts used in this study for 24 total errors.

Neither treatment group (aural, visual, or free) nor texture (homophonic/ polyphonic) had a significant main effect on participants' error detection accuracy. Error type (rhythm over pitch), error focus (focused over non-focused), and error location (top over middle and bottom voices) had significant main effects on error detection accuracy, illustrating the influence of musical context on error detection.

Three significant interactions further illustrate the complexity of the error detection process and support the findings in previous research. The interaction among error location, texture, and treatment group illustrates not only similarities in performance

between aural and free group participants, but also how certain musical contexts may impede detection of errors. The interaction among error focus, error type, and texture suggests that directing attention to parts in homophonic excerpts may improve pitch perception while having minimal effect on rhythm error detection and errors in general in polyphony. The interaction between texture and location points to top voice perceptual dominance in homophonic texture. Implications regarding score study are discussed.

CHAPTER 1: INTRODUCTION

> The ears by themselves can hear nothing. The ear can only hear what it is the brain directs it to hear. And if the mind doesn't know something, then the ear will not hear it; whatever [the mind] doesn't know, the ear cannot hear. Conversely, anything that the mind knows and is concentrating on, then the ear will hear it. It's that simple. That's an absolute physiological fact and phenomenon. (Harris, 2001, p. 57)

The thoughts of notable conductors collected from interviews were compiled by Frederick Harris in his book, *Conducting with Feeling* (2001), and are grouped into various topics. The quote above is taken from the chapter regarding the training of conductors and illustrates the need to concentrate, or direct attention, to specific dimensions of the musical stimuli. Gunther Schuller not only states the above in his book, *The Compleat Conductor* (1997), but espouses the importance of its message in the chapter from Harris's book on the training of conductors. Whether or not this is a "physiological fact" does not diminish the significance of the message to music educators, especially the teacher/conductor. The quote suggests that perhaps through intentional attentional manipulation, teachers/conductors could increase their ability to aurally discriminate in musical performance, lessen inaccurate repetitions by students, maximize music's expressive potential, and improve their assessment of student performance.

In a practical setting, teachers/conductors choose to rehearse a section of music after detecting/perceiving inaccurate performance. The intent is to identify the location and type of performance inaccuracies and eliminate them. Though the teacher/conductor may not be able to immediately identify the precise location (beat in a measure or voice) of an error or the type of performance inaccuracy, their identification of a portion of music to rehearse indicates that they have detected something inaccurate. This initial

global detection of inaccuracies is often necessary to identify specific performance errors in a large ensemble setting.

Perhaps the most important function of any teacher is to accurately assess student performance in order to provide the feedback necessary to effect change in future performances. Accurate assessment may be straightforward in some disciplines, especially when individual student assessment is convenient and the norm. In contrast, assessment of music performance is complex, particularly in a group setting. Accurate assessment of music performance rests almost solely on accurate perception of music performance. The previous statement is nearly undeniable and illustrates perhaps the most pervasive difficulty in the assessment of group ensemble performance since accurate perception involves a complex interaction of an individual's musical knowledge and skill and environmental, acoustical, and social contexts.

The teacher/conductor's ability to parse through sounds for inaccuracies is especially important when leading student musicians. Not only does accurate and prompt detection of performance errors increase the quality of musical performance, it also provides the teacher/conductor with information regarding the current level of students' musical understanding and skill. These revelations about student performance are the foundation on which teachers should initiate immediate, short- and long-term curricular decisions. Thus, detection of performance errors is of pivotal importance in quality music teaching.

Although pivotal, results from investigations of performance error detection suggest that musicians struggle with this skill. Prior to any type of intervention or treatment, participants in most of the performance error detection investigations correctly

identify, at best, just over half of the errors inserted into musical excerpts (Byo, 1993, 1997; Sheldon, 2004; Van Oyen & Nierman, 1998). Treatments such as repeated experiences in contextual sight-singing and aural skills (Sheldon, 1998) and learning musical excerpts by accurately singing each individual part (Byo & Sheldon, 2000) resulted in improvements in accuracy. Hedden and Johnson (2008) had participants assess the pitch accuracy of second-grade singers. Overall accuracy of freshman and senior music education majors, along with pre- and post-induction teachers was about sixty-five percent. This accuracy percentage seems surprisingly low for what could, perhaps should, be a relatively simple assessment task, especially for teachers with more than ten years of experience. Perhaps most surprising is the lack of significant differences among the four groups' accuracy: post-induction music teachers, all with at least ten years of teaching, were no different in their assessment of the pitch accuracy of second-grade singers than were freshman music education majors. Attempts to identify component musical skills influencing error detection ability have yet to demonstrate conclusively those that are most critical to increasing sensitivity to and detection of performance errors. Multiple studies have investigated the potential relationship between achievement in music theory/aural skills and performance error detection, with results indicating little to no association between these skills (Brand & Burnsed, 1981; Doane, 1989; Grunow, 1980; Killian, 1991; Larson, 1977; Sidnell, 1971). Identifying the variables that influence error detection ability could subsequently lead to strategies and pedagogical materials to be used in conjunction with curriculum revisions, all of which could greatly benefit those charged with the training of prospective music teachers.

To assess the accuracy of a performance, musicians listen to a musical stimulus and diagnose the “incorrect” portions. This may necessitate directing attention to specific dimensions/portions of the musical stimulus, resulting in other dimensions/portions being ignored. The ability to attend to only select portions of an auditory stimulus has been a facet of research by psychologists for several decades. Research in focused auditory attention may illuminate aspects of prime concern to musicians while possibly explaining why detecting errors in a musical stimulus is a difficult task.

The research in this area began when Cherry (1953) sent different messages to each ear of subjects, and instructed them to attend to only the messages sent to one ear while ignoring the messages sent to the other ear. To ensure attending to the correct ear, subjects repeated or “shadowed” the attended-to material. Of prime concern was the participants’ memory of the content in unattended-to messages. To assess this, subjects were asked what they remembered about the unattended-to messages, most of which were physical properties of the stimulus, such as speaker’s sex and volume/intensity, rather than on the contextual meaning of the message. Ignoring a message in one ear while attending to the message and its content in the other ear is a dichotic listening task. These tasks developed first by Cherry enabled psychologists to identify the content that would be perceived and attended to despite a perceptual block.

Based on his research and that of others, Broadbent (1952, 1958) proposed the first theory of focused auditory attention as a means of describing selective attention. The theory suggests that people can attend only to one message at a time and that the physical properties of the unattended-to message are contained in short-memory stores. A “detector” processes the information that is brought to it, with only important messages

passing into the “filter” (Goldstein, 2008, p. 103). The filter then identifies and receives the auditory information and “channels” permit the message to enter the consciousness. The filter theory could not explain though why certain words were detectable in an unattended-to message. Moray (1959) found that one’s name was almost always identified when it was presented in the unattended-to ear. Moray concluded “subjectively important” messages could penetrate the perceptual block.

This ability of an “important” message to penetrate a perceptual block led Treisman (1960, 1964a, 1964b) to adapt Broadbent’s filter theory. Treisman (1960) proposed that highly familiar words or words that were “contextually highly probable” could be detected even if this content was heard in a message which was to be ignored. Treisman hypothesized that acutely familiar content was stored in “dictionary units,” a part of the neural mechanism. If an “item” was in the dictionary unit, it had a much lower threshold for activation, perhaps as by-product of acute familiarity. Items in the dictionary unit had the potential to bypass and penetrate a perceptual block. This could explain Moray’s (1959) results where participants were able to hear their name when it was presented in the unattended-to channel/ear. Regarding the ability to select certain auditory information on which to focus, Treisman postulated the content of auditory information to be more influential than the amount of auditory material (Treisman, 1964a, 1964b).

Deutsch and Deutsch (1963) continued the adaptation of the filter theory by suggesting the importance of the message, rather than its physical characteristics, was the pivotal criterion for detection and attention to an auditory stimulus. This theory eliminates initial filter and the reliance on the physical characteristics for attention and

continues to support Treisman's (1960) postulation of lowered threshold and acute familiarity as the factors that influence whether material is attended to or detected.

Since music is an auditory phenomenon, the research on auditory focused attention has obvious implications. Though music is primarily an aural experience, there is a visual component to the musical experience, primarily when reading a score or part while listening to or performing music. This visual component is also demonstrated when musicians "write" in their music, often as a visual reminder of what requires attention at that moment. The visual cue directs attention to a particular aspect of the musical material, either in the performance of the material or while listening to and subsequent parsing of the material. Therefore, literature on the detection of changes in a visual scene could also provide insights and implications regarding the detection of musical performance errors (changes).

The probability of a visual change may have implications for the detection of musical "changes" primarily when instructing student musicians. Beck, Angelone and Levin (2004) theorized that consideration of probable/possible "changes" in a visual scene could increase aid in the detection of change in a visual scene thereby lessening change blindness, the inability to detect change in a visual scene. Results from their study supported this postulation and led researchers to define the change probability effect, which suggests that the more probable a change is to occur, the easier it is to detect. Subsequent investigations have shown probable changes are detected more often than improbable changes, especially when dealing with information in short-term memory stores. The effect is diminished when dealing with information retrieved from long-term

memory, with equal performance for probable (expected) and improbable (unexpected) changes (Beck, Peterson, & Angelone, 2007).

The change probability effect suggests that expected errors are the ones that are detected most easily, especially when the encoded material has been learned recently and has yet to be encoded into long-term memory stores. Attention and expectation, perhaps by-products of probability, may also be critical components in the ability to detect change (Rensink, O'Regan, & Clark, 1997). Detection of changes in human faces was influenced by the expectation of observers (Austen & Enns, 2003). Other research has suggested that expectation may aid in change detection (object perception) but may also hinder it (Puri & Wojciulik, 2008)

Though the previous research is outside of the traditional body of music research, the results may have application for the approaches musicians utilize during score study. This application is more apparent if the processes musicians choose to use in their learning of a musical score are viewed as a type of musical encoding process. Beck, Peterson, and Angelone (2007) illustrate this application stating, "Successful change detection depends on encoding an accurate and sufficiently detailed representation of the pre-change aspect. Several studies have arrived at the conclusion that change blindness occurs because memory representations of the visual world are largely gist based and contain little visual detail" (pp. 610-611). "Gist-based" suggests a knowledge lacking a sufficient depth of detail, a surface and potentially insufficient knowledge that, according to the research, inhibits change detection. Thus, this line of research suggests a relationship between the process by which one encodes and orients themselves to a stimulus and the ability to detect changes to that stimulus. Perhaps these results have

implications in a musical scenario, where the process by which one learns a score influences the ability to detect errors in the performance of the learned score.

Musicians have investigated the potential relationship between the musical encoding process (score study approach) and the subsequent effects on musical performance error detection of that process (Crowe, 1996; Grunow, 1980; Hochkeppel, 1993; Hopkins, 1991; Van Oyen & Nierman, 1998). Grunow (1980) investigated the effect of four approaches to score study: study of the score only, study with score and recorded examples, study with recorded examples only, and no preparation. Results indicated no significant differences on participants' aural discrimination as a result of the four methods. Van Oyen and Nierman (1998) investigated the effects of time spent in score study and access to a correctly performed recorded example on error detection. Results indicated that neither extending time from thirty seconds to two minutes nor multiple hearings of a correctly performed recording of the music were effective methods for increasing participants' ability to detect pre-determined inserted errors in recordings of the studied scores.

In contrast to the above findings of no difference among score study approaches, Hopkins (1991), Hochkeppel (1993) and Crowe (1996) all found differences in comparisons of score study approaches. Hopkins (1991) investigated the effects of using a piano, using a recording, sight-singing, and silent study on error detection. Results indicated that use of a recording was more beneficial than use of the piano on participants' detection of errors. Crowe (1996) also found score study with a correct aural example to be significantly more effective than no score study, study with score alone, and study with use of a keyboard on participants detection of pitch and rhythm errors

inserted into band literature excerpts. In contrast, Hochkeppel (1993) found that participants who engaged in silent study had significantly higher error detection scores in comparison to those engaged in keyboard study, recorded example study, and score singing study. Participants in the silent study and score singing treatment groups did have significant gains from pre- to posttest scores.

A consistent and reliable relationship between the approach utilized in learning a musical score and the subsequent ability to aurally detect performance errors in the studied score has yet to be established through experimental findings. Despite this lack of evidence, both skills are of such pivotal importance in successful music teaching that further examinations are warranted.

There is evidence to suggest that acute familiarity suggests a low threshold (greater potential) for reception and recognition, thereby lessening the amount of attentional resources necessary for reception and detection of performance errors. As implied by Treisman (1960), “items” with a lower threshold/higher familiarity are most likely to be attended to and thus detected. This may be why our name is so easily detectable, even when spoken at a low intensity level, as found by Moray (1959). For that with which we are less familiar, requires more attention, suggesting an inverse relationship between knowledge of the music and amount of attention necessary to detect errors/changes in that music.

If attention is spread among fewer dimensions of a musical stimulus, does aural discrimination improve? Does score study lessen the amount of attention necessary to detect performance errors? If the above are true, an investigation examining the effect of

intentional attentional manipulation on the ability to detect errors have implications regarding score study and assessment of musical performance.

Familiarity with music occurs through both visual and aural processes. Conductors often mark their music to create a visual cue in order direct their hearing to a particular dimension of the musical stimulus. The pervasive use of visual cues marked in music by a conductor suggests a reliance on visual cues as means of directing attention. Circling or highlighting musical points of interest and importance may also lessen the visual density of a full score. Listening to accurate performance of the music, playing parts and/or singing parts of the musical score, are often-used score study behaviors, all of which involve an aural visual approach to studying of the score. These aural strategies have been effective in increasing performance on error detection tasks (Byo & Sheldon, 2000; Hochkeppel, 1993; Sheldon, 1998). Silent score study has also been found to be an effective score study approach (Hochkeppel, 1993).

Content may also influence how one attends to a musical stimulus. Research has indicated that as the number of parts increase in a musical score, errors become more difficult to detect (Byo & Sheldon, 2000; Crowe, 1996; Sheldon, 2004). Though parts may increase, perhaps it is the variety within the parts, especially musical texture that leads to difficulty in error identification. Multiple studies have suggested the type of rhythm within a single part, along with the amount of variety between parts affects how one attends to the musical stimulus (Crawley, Acker-Mills, Pastore, & Weil, 2002; Jones, Jagacinski, Yee, Floyd, & Klapp, 1995; Klein & Jones, 1996). A homophonic texture may enable integrative listening/attending due to the integration of musical lines, possibly due to the sameness of rhythm. According to Crawley et al. (2002), "homophonic musical

pieces, which are generally defined by synchrony of notes across frequency regions (voice), should support a vertical organization" (p. 367), illustrating the use of integrative, wholistic attending while listening.

Sloboda (1985) suggests polyphonic music is capable of 'figure-ground reversal', stating, "In music we propose that only one melodic line can be treated as 'figure' at any one time. When so treated, we may say that this line is being given 'focal attention' (p. 169). Sloboda's proposition suggests that it is difficult, if not impossible, to listen to polyphonic music in a wholistic and integrative manner, thus necessitating selective attending/listening. Music with this texture is likely attended to in a horizontal and selective manner, where only one voice is given focal attention while the other voices fall into the attentional "background".

Is there a relationship between musical texture and score study process as measured by the detection of performance errors? Could directing attention to individual voices result in greater aural acuity as measured by the detection of more performance errors? Should the nature of directing attention be through the use of a visual or aural process?

Experimental endeavors seeking to answer the above questions could have pedagogical implications for the training future music teachers receive in conducting and score study. If an objective of aural skill courses is to train and improve aural acuity and performance error detection, answers to the above questions could also have implications for the teaching of music theory at all levels.

CHAPTER 2: REVIEW OF LITERATURE

Previous research in musical performance error detection has focused mostly on variables affecting error detection accuracy along with methods to improve error detection ability. Effects on error detection ability due to error detecting while conducting, personal qualities and abilities, and musical context have all been investigated. The use of technology and programmed instruction, instruction in conducting, approach to score study and sight-reading/singing skills are the most frequently studied areas for improving this pivotal skill.

Research outside of music may also yield insight and implications regarding factors of influence and means to improve error detection ability. The psychology literature investigated the extent of change blindness and deafness, the inability to see and hear changes in a visual or auditory stimulus, to be pervasive. Directing attention to particular aspects of a stimulus has been found to be effective in lessening and even in some cases eliminating change blindness and deafness. Musicians have also found directing attention to be beneficial in a variety of musical situations. The review of the music research in error detection coupled with related research from psychology in change detection and directed attention form the conceptual basis from which the current investigation was derived.

The wide variety of foci in music performance error detection research lends credence to the argument that this skill is critical for successful music teaching, complex, and perhaps an amalgamation of multiple abilities and experiences and their depth. In addition, research has suggested that a large proportion of rehearsal time is spent on

correcting and refining errors in performance. Cavitt (2003) examined the amount of error correction occurring in the rehearsals of ten expert band directors approximately one to two weeks prior to a spring festival. Also examined was the nature of the rehearsal based on targeted error types, along with rehearsal pace during target error types. Results indicated that approximately 49% of rehearsal time was spent correcting performance errors. Regarding error type, results indicated that intonation/tone quality errors were the most frequently addressed errors. The ratio negative versus positive feedback given by these band director participants was two to one. According to the investigator, "The most important finding in this study was that pace of instruction or level of interaction between teacher and student performance varied with the error correction task" (p. 224). Since these rehearsals were in such close proximity to a performance, it would be interesting to compare how rehearsals differ in regards to error detection and correction, when a performance is not in such close proximity.

Other findings have implied that the ability to identify errors in one's own practicing effects overall performance success. In a study investigating the characteristics of practice behavior, Duke, Simmons and Cash (2009) found that the ability to identify errors in their performance and eliminate them was characteristic unique to the practice sessions of top piano participants. This suggests that the prompt and accurate detection of errors is a critical component for effective practice and perhaps, ensemble rehearsal.

Doerksen (1999) compared the error detection and correction skills of preservice and expert teachers by having participants evaluate recorded performances on the following nine performance categories: tone quality, intonation, balance/blend, rhythm/precision, articulation, technical facility, musical interpretation, phrasing and

dynamics. Experts (n = 37) and undergraduate instrumental music education majors (n = 23) rated wind-band performances of varying difficulty (difficult and moderate) and performance-quality (excellent and average). Participants rank-ordered the categories in terms of performance quality and diagnosed problems associated within each. Results indicated that undergraduates rated intonation lower than expert teachers and significant interactions were found among performance types and participants' ratings of tone quality, intonation, articulation and dynamics. Interactions suggested undergraduates might be more critical and less accurate in their evaluations and "error" detections in comparison to expert teachers. Also, expert teachers ranked blend/balance and musical interpretation, which are less objective performance categories to assess, as the weakest performance areas, which may suggest that expressive and subjective musical issues are more important to expert teachers than pre-service teachers. These results suggest undergraduates tended to focus on more objective performance categories when evaluating musical performances, rather than those associated with musical expression.

Hedden and Johnson (2008) examined undergraduates (freshman and seniors) and teachers (pre- and post-induction) ability to accurately assess the pitch performance of second graders. The latency of participant assessment was also measured. Surprisingly, though the freshman were significantly slower when assessing pitch accuracy, there were no significant differences among the four groups assessment accuracy of pitch. This would run contrary to an assumption that error detection accuracy increases with training and experience.

Factors Influencing Error Detection: Conducting

Multiple studies have investigated the accuracy of error detection while conducting. These studies have produced conflicting results, some suggesting that conducting does not have a significant effect on subjects' error detection accuracy (Blocher, 1986; Doane, 1989; Stuart, 1979) and other studies suggesting otherwise (Forsythe & Woods, 1983; Stiffler, 2004). Results have also indicated superior error detection performance during a conducting test by those trained via on-podium conducting experiences (DeCarbo, 1982).

While Stuart (1979) did not pose research question specifically investigating the role of conducting, all subjects in the study were enrolled in a conducting course in which those receiving treatment via videotapes, slide, textual materials and class discussions, were removed from class for the treatment, thus reducing their time in class. Results from the comparison of pretests and posttests indicated that both the use of videotape recordings, slides, textual materials and discussions along with in-class conducting significantly increased all participants' error detection abilities.

Blocher (1986) had participants detect errors in brass trios (two trumpets and trombone), with all of the subjects being members of ensembles at Florida State University. The sample ($N = 141$) was much larger than that of most error detection studies, though it comprised music majors and non-majors. Recorded examples were heard three times, with about one-quarter of the subjects conducting while listening to the examples. Results indicated that conducting did not significantly affect music majors' error detection accuracy. Non-conducting music major scores were higher, though not

significantly so. Conducting did significantly affect the error detection scores of the non-music majors.

Doane (1989) found no significant difference in the error detection scores of subjects who conducted while error detecting and those who did not. The scores of those who did conduct while error detecting were lower than those who did not conduct while error detecting, but the difference between the two groups was not significant. Doane stated, "The conclusions of this study do not corroborate the findings of earlier studies that found that the physical act of conducting somehow interfered with the accuracy of student conductor aural perceptions" (p. 14).

DeCarbo (1982) investigated the effects of two treatments in error detection training—conducting and programmed materials The same music was used in both treatments. Professional musicians recorded the excerpts for the programmed materials group. Live musicians were used for the conducting group. During 16 class sessions, subjects in the programmed materials group listened to the error filled performances while the conducting group conducted live musicians. Both groups identified errors by measure, part, type, and exactness of the error. All participants took a written test along with a conducting test in which they identified errors (measure, part, type, and exactness of the error). Results indicated no significant differences due to treatment group on the written test. Results of the conducting test, in which subjects detected errors while conducting, indicated that the conducting group scored significantly higher than the programmed materials group. Results suggest that error detection training with the use of on-podium experiences is feasible. This scenario more closely resembles what students would be doing in future teaching/conducting situations those promoting transfer and

demonstrates that error detecting while conducting may not have an adverse effect on error detection ability.

Results from investigations by Forsythe and Woods (1983) and Stiffler (2004) question the positive effect of conducting found in other research. In an investigation by Forsythe and Woods (1983), subjects detected errors in 12 excerpts, conducting six of the excerpts. Results indicated that conducting had a significant effect on decisions regarding general impressions of tempo, balance, articulation and intonation are made: subjects judged the elements as acceptable, unacceptable, or questionable. Researchers suggest that expressive conducting should come later in the score study process. Since ensemble directors must error detect while conducting, this area of investigation needs further research.

Stiffler (2004) also found that conducting decreased detection of performance errors. Participants who conducted while error detecting had significantly lower score than those who did not. Results indicated that subjects in the non-conducting group detected pitch, rhythm and articulation errors with greater accuracy than did those in the conducting group. No differences between groups were found for errors in dynamic level.

Factors Influencing Error Detection: Personal Qualities

The identification of significant predictors of error detection ability could have important implications for the field of music teacher education. Multiple studies (Brand & Burnsed, 1981; Doane, 1989; Gonzo, 1971; Grunow, 1980; Killian, 1991; Larson, 1977; Sidnell, 1971) have examined multiple factors thought to affect skill in error detection. Results have been conflicting, especially regarding the potential relationship between error detection and achievement in music theory skills. Sidnell (1971) found that

aural harmony achievement, as measured by the total grade point achievement in sophomore or second-year aural theory study, was not significantly with correlated score reading/error detection skills. Doane (1989) found a correlation of .11 between theory grades and aural discrimination skills, supporting findings of Sidnell. Killian (1991) found that among junior high students, those with the highest sight-singing scores also had the highest error detection scores. Larson (1977) found error detection skills had a stronger relationship with melodic dictation than with melodic sight-reading.

Brand and Burnsed (1981) examined various abilities and experiences of undergraduate instrumental music education majors' ($N = 21$) to determine the predictability of skill in error detection. Academic grades in theory, sight-singing, and ear training as the data source for defining ability in music theory and skill in sight-singing and ear training as predictor variables. Additional predictor variables included number of instruments played, ensemble experience and extent of precollege private instruction. Results indicated no significant relationships between the predictor variables and a researcher developed error detection measure. The dependent measure in this study had a reliability coefficient, determined through test-retest with a ten-day interval, of .59, suggesting that the instrument may not have been reliable or valid.

Grunow (1980) utilized multiple regression analyses that revealed no significant differences for between subject characteristics (years of experience, grade level taught, and degree earned). Gonzo (1971) found differing results regarding degree earned and years of experience. Participants ($N = 100$) in a stratified sample were either undergraduate music majors ($n = 62$) or experienced secondary school choral teachers ($n = 38$). These participants detected pitch errors while reading the choral score. Gonzo

found that teaching experience was a significant factor in the detection of pitch errors. Teachers were stratified into groups based on the extent of their experience, as follows: 1-5 years (n = 11), 6-10 years (n = 16), 11-15 years (n = 5), and 16-34 years (n = 6). Scores of the undergraduates and teachers with 1-5 years were not significantly different. However, teachers with six to ten years of teaching experience scored significantly higher than all undergraduates and significantly higher than the seniors in the undergraduate group. Music theory grades of the undergraduates were also a significant factor in these results. Students achieving with an A average in music theory scored significantly higher than those with a B or C average in the first two years of music theory. Subjects who had course work in choral arranging also scored significantly higher than those who did not. This stands in contrast to the findings that Hedden and Johnson (2008) found where experienced teachers with more than ten years of experience were not significantly more accurate than freshman music majors when assessing the pitch accuracy of second-grade singers. Also, Forsythe and Woods (1983) did not find that graduate student performance was significantly differently than undergraduate participants. The relationship between experience and error detection accuracy still remains unclear.

Methods to Improve Error Detection: Technology

Methods to improve the error detection skills of students have been the focus of a vast number of empirical investigations. Many of those methods have utilized various forms of technology. Stuart (1979) utilized videotape recordings and slides, along with textual materials and class discussion, to determine whether these multimedia resources would increase error detection skill. The subjects who used these materials significantly outperformed those who did not.

Many studies have focused on the use of programmed materials as a means of increasing error detection skill (Costanza, 1971; Deal, 1985; DeCarbo, 1982; Dolbeer, 1969; Ramsey, 1979; Sidnell, 1971; Stiffler, 2004). All of the investigations have found programmed instruction to be helpful in increasing error detection skills and have used examples from wind band literature and inserted errors "typical" of those made by student musicians.

Dolbeer (1969) examined the viability of creating a self-instructional program to improve error detection skills by utilizing tape recordings and excerpts from condensed instrumental scores. The exploratory nature of the study coupled with the positive response from those who used the materials led to subsequent further investigations examining the use of programmed materials to increase error detection ability. Sidnell (1971) investigated the effectiveness of programmed materials, where errors were heard in isolation, compared to non-programmed materials, where participants detected the errors after two hearing of the excerpts. Results on a researcher-designed score reading test indicated that the junior level instrumental music education majors who used the programmed materials score outperformed those that did not.

Costanza (1971) designed the *Self-Instructional Program in Score Reading* (SIPSR) and investigated if its use by undergraduate music majors would improve their melodic and harmonic score-reading skills. Results indicated that the SIPSR improved subjects' score reading skills on task significant gains in posttest scores. It is interesting to note that the musical examples in Costanza's pre- and posttest were not those studied and practiced in the SIPSR. Both Costanza and Sidnell extracted excerpts from wind band literature when developing these programmed materials.

Ramsey (1979) selected excerpts from wind band literature in the creation of the Program in Error Detection (PED), which contained typical pitch and rhythm errors (obtained via a researcher-developed questionnaire given to instrumental music teachers). Members of a college band made recordings for the PED. Three forms of the PED were constructed, each with differing numbers of excerpts: Form A had 114 items, Form B had 76 items, and Form C had 38 items. Participants were randomly put into one of four groups: a group for each form type (A, B, and C) and a control group which received no programmed instruction. A pretest/posttest design was used to determine the most effective amount of programmed instruction for increasing error detection ability. All groups participating in programmed instruction had significant gains. Further results indicated that longer the form, the larger the increase skill. There was no significant difference between participants using the short form and those in the control group, suggesting that there may be a minimum level of drill necessary that likely exceeds 38 items. Programmed instruction and the PED, particularly the longest form, significant increased skills in the identification of pitch and rhythm errors.

Deal (1985) adapted Ramsey's (1979) Program in Error Detection (PED) and created the CA-PED, Computer-Assisted Program in Error-Detection. This program included 98 of Ramsey's excerpts, organized in the CA-PED by difficulty, and did not allow the subjects, undergraduate instrumental music majors, to proceed to the next excerpt without answering the current one. The interactive features of the program allowed subjects to hear the excerpts as many times as desired. After listening to the excerpt, subjects identified the location of the error (measure and voice), error type (pitch and rhythm) and what was played in place of what was notated. The program also counts

the number of times the subjects listened to the excerpt and records the number of correct answers. Through the use of a pretest/posttest design, Deal compared the effectiveness of CA-PED to Ramsey's original PED. Both tests were demonstrated to be effective in teaching error detection skills, though neither was significantly more effective than the other. DeCarbo (1982) also utilized programmed instruction as means of increasing error detection ability though the results of his investigation suggested that the rehearsal of live musicians might be a more effective method.

Palmer (1996) investigated the use of a digital synthesizer, Yamaha SY-77, to aid in the formation of aural image in upper-level instrumental undergraduate music education majors of William Latham's *Three Chorale Preludes.* Participants recorded individual parts to create a synthesized recording. The synthesizer also enabled participants to listen to various combinations of parts at once. An error detection task served as the measure of the synthesizer's effectiveness. Palmer found significant improvement in participants' error detection accuracy between the first and third preludes and the second and third preludes**.** Participants detected significantly more pitch than rhythm errors. Palmer concluded that the synthesizer was an effective tool in the creation of aural images and expectancies, thus increasing error detection acuity.

Methods to Improve Error Detection: Conducting

Results from studies investigating how the physical act of conducting affects error detection abilities have resulted in different conclusions. Some findings imply the physical act of conducting interferes with the ability to accurately detect performance errors, though this result is consistently found in the literature.

DeCarbo (1982) investigated how conducting experiences may be helpful in the development of error detection abilities. Participants, undergraduate instrumental music majors, were separated into a conducting and non-conducting group. The conducting-group treatment was podium-based: participants conducted college musicians and detected the errors in their performance. The non-conducting group treatment was based on the use of programmed materials: participants listened and detected errors in recordings. The same music was utilized for both treatments. Results indicated that subjects in the non-conducting group scored significantly lower in a conducting error detection task. Providing pre-service teachers with opportunities to teach and rehearse live musicians and detect errors in a live performance would be similar to the experience they will have working with student musicians.

Hayslett (1996) hypothesized that training subjects in movement may lead to an increase in aural acuity. Subjects were band and orchestra directors along with graduate and undergraduate music majors. The pretest measure of aural acuity was the pitch discrimination portion of the Seashore Measures of Musical Talent. Subjects conducted during every other test item on the pretest. Half of the subjects were randomly selected for membership in the experimental group, in which subjects were trained in movement techniques developed by von Laban, T'ai Chi studies, and physical and musical independence exercises. This training occurred during eight training sessions over a period of four weeks. At the conclusion of the training period, all subjects, including those in the control group who did not undergo movement training, completed the pitch discrimination portion of the Seashore Measures of Music Talent. The experimental group scored significantly higher on the posttest, suggesting that the movement training

increased experimental subjects' aural acuity. It was suggested that the training enabled subjects to become more comfortable with conducting, thus lessening interference from the physical movement during pitch discrimination.

Methods to Improve Error Detection: Sight-singing/Reading

Increasing skill in sight-singing and sight-reading has also been a popular strategy in the development of greater error detection acuity. Killian (1991) investigated the relationship between junior high singers singing accuracy and their ability to detect errors in performance of simple diatonic sight-singing exercises. Subjects were grouped according to their scores on a sight-singing measure into high-, medium- and low-scoring sight-singers. Analysis of the error detection measure showed that the high-scoring sight-singers also had the highest scores in error detection, with medium-scoring sight-singers following a similar trend and both exhibiting no significant difference between their sight-singing and error detection scores. Low-scoring sight-singers had significantly different error detection and sight-singing scores, with error detection scores being much higher than the sight-singing score. Though the highest-scoring sight singers were also the highest scoring error detectors, the results of the low-scoring sight singers make it difficult to conclude that a reliable relationship exists between sight-singing and error detection.

Contextual sight-singing, in which subjects practiced sight-singing parts from wind band literature excerpts for eleven weeks, resulted in significantly higher error detection scores when tested on their ability to detect errors in these excerpts. Sheldon (1998) equally split subjects from an instrumental methods course into control and experimental groups. All subjects participated in class activities with the experimental

group receiving extra instruction in contextual sight-singing outside of class. The experimental group scored significantly higher than the control group. These results suggest that contextual sight-singing increased subjects "contextual" error detection abilities.

Kostka (2000) investigated the effects of error detection practice on the keyboard sight-reading achievement of undergraduate music majors. Participants were non-piano majors and were enrolled in group-piano class. Error-detection treatment consisted of listening to three repetitions of a prerecorded piano piece while looking at the score. The prerecorded piano piece contained three errors (two pitch, one rhythm). Utilizing a pretest/posttest design, results revealed that the subjects in the group engaging in error detection practice, had modest but not significantly different gains from those in groups that did not engage in error detection practice. This suggests that practicing error detection may have some effect on other musical skills.

Listening to a recording was found to be more effective than sight-reading in the detection of harmonic errors in class piano literature (Stwolinski, Faulconer, & Schwarzkopf, 1988). Perhaps melodic material, which is a horizontal arrangement of pitches sounding individually, is easier to generate internally than is harmonic material, the vertical arrangement of pitches sounding simultaneously.

Methods to Improve Error Detection: Approaches to Score Study

Research investigating the effects of various approaches to score study on error detection accuracy have demonstrated relationships between score study approach and error detection. Though Byo and Sheldon (2000) were primarily concerned with the effects of singing while listening on error detection, they noted an increase between pre-

and posttest error detection scores following a score study treatment in which participants learned each individual part in three-part excerpts by singing. Though singing while listening was found to impede detection of pitch and rhythm errors, the score singing treatment improved detection accuracy. The increase in posttest scores were not the result of error detection practice and may have been the result of the " . . . aural expectations during the posttest that were largely absent during the pretest" (p. 36).

Palmer (1996) examined not only the viability of the Yamaha SY-77 digital synthesizer as a tool for score study, but also the effects of a score study approach that involved playing and recording each individual line that eventually led to creating a synthesized recording of the piece. Participants listened to these synthesized recordings during sessions designed by the investigator and alone during individual, independent sessions. Prior to the creation of the recordings, participants heard a synthesized recording of their prelude and detected pitch and rhythm errors. This pretest score was compared to the score participants achieved on the posttest error detection measure that was administered after participants created and listened to the synthesized recording. Significant differences were found in the gain scores from pretest to posttest for two of the three preludes, suggesting that not only was the synthesizer an effective tool for score study, but also that the approach of playing and recording individual lines may be an effective means of score study, ultimately leading to a stronger aural image of the score and an increased ability to detect musical performance errors.

Stwolinksi, Faulconer, & Schwarzkopf (1988) compared the effect of sight-reading and listening to a recorded performance on the ability of undergraduate non-piano majors ability to detect harmonic alterations in piano excerpts. Results indicated

that listening was a more effective approach as measured by subjects' detection of the harmonic alterations. Within four weeks of initial treatment, all subjects experienced the other treatment: Sight-reading subjects experienced the listening treatment and listening subjects sight read the excerpts and then detected the inserted harmonic alterations. Those who first experienced the listening treatment showed no increase in detection after sight-reading the excerpts. Subjects who first sight-read the excerpts significantly improved in their detection of harmonic alterations. Investigators concluded that a combination of sight-reading and listening at the keyboard would be more efficient than either method on its own.

Hopkins (1991) investigated four score study approaches and their effect on error detection. All subjects studied a different motet utilizing each of the following four approaches to score study: using a piano, using a recording, sight-singing, and silent study. Subjects were also coded as pianist or non-pianists based on their piano proficiency scores. In the detection and notation of pitch and rhythm errors, use of a recording was better than use of the piano and subjects were more accurate in their detection and notation of rhythm errors.

Similar results were found by Crowe (1996) who investigated four score study styles: no score study, study with score alone, study with score and correct aural example and score study at the keyboard. Crowe also focused solely on pitch and rhythm errors and utilized a computer program to administer 31 musical examples. Subjects, undergraduate members of a beginning conducting class, experienced all four score study styles due a counterbalanced design. Of the four score study styles, score study with correct aural example was found to be more effective than study with the score alone.

This result is one of many suggesting an aural reference or image to be helpful in the error detection process.

Though Hopkins (1991) and Crowe (1996) found the use of a correct aural example to be advantageous, results from an investigation by Van Oyen and Nierman (1998) found that neither extending participants' score study time nor pairing the extended score study with an accurate recording produced significantly different results from those participants who had less time and no recording. Thus, the influence of an accurate aural example has yet to be clearly established in the research literature.

Grunow (1980) investigated the effects of four score study modes on the error detection ability. The four types of score study modes were study of the score only, study of the score with recorded examples, study with only recorded examples, and no preparation. Participants in the Band Conductors Art Symposium at the University of Michigan detected multiple types of performance errors including: tempo, balance, style of articulation, tone quality and intonation. Grunow categorized these elements of musical performance as "General Music Criteria" with note accuracy, pitch accuracy, phrasing, dynamic contrast, and ensemble labeled elements of "Specific Technical Criteria." The four score study modes had no significant effect on performance error detection.

Hochkeppel (1993) investigated the effectiveness of four methods of score study: keyboard study, recorded example study, study through score singing, and silent study. Undergraduate music majors were put into one of the four score study groups, with each group receiving instruction in that specific method of score study. The effectiveness of each method was determined through the use of a researcher-constructed error detection

test, a combination of the MLR developed by Grunow and Froseth (1979) and the Program in Error-Detection (PED) developed by Ramsey (1979). Results indicated that silent study and score singing methodologies resulted in significant improvements in error-detection skill. Hochkeppel suggested that score singing and silent study may be effective for learning and “internalizing the larger, more complex, transposed instrumental scores” (p. 189). These results demonstrating the potential benefits of singing as a score study technique were also found by Byo and Sheldon (2000).

Approaches to Score Study

Among the writing of conductors, there seems to be extensive agreement regarding the stages of the score study process, especially regarding initial experiences with the score. Expert conductors and conducting teachers advocate that initial score study include thoroughly reading all of the information on the title page and any program notes followed by an initial perusal through the score (Battisti & Garofalo, 1990; Ellis, 1994; Green & Malko, 1985; Junkin, 1998; McBeth, 1990). Battisti and Garofalo refer to this initial stage as “score orientation,” the first of their proposed four-stage process that includes: score orientation, score reading, score analysis and score interpretation. Markoch (1995) refers to this initial experience as “familiarization,” to be followed by exploration and conclusions.

There is less agreement about strategy use during score study, mostly as a result of disagreements about effectiveness and impairments to inner hearing, the ability to mentally “hear” music in the absence of sound. The review of the score study literature and textbooks therefore examines not what knowledge one should have after studying a score, but the processes and strategies that one should employ to acquire and internalize

this knowledge. These strategies include singing, use of the piano and other instruments, listening to recordings, score markings, and score memorization.

There seems to be extensive agreement regarding the use of singing as a score study strategy. Ellis (1994) interviewed wind conductors, Harry Begian, Kenneth Bloomquist, James Keene, Craig Kirchhoff, and H. Robert Reynolds, about many facets of their professional lives. Score study procedures and score marking were prominent portions of this work. All of the conductors spoke of singing as a strategy they used, primarily when having hard time hearing a something. Both Kirchhoff and Begian indicated their use of solfege and Bloomquist stated that he tries " . . . to sing through the score at a tempo I can manage" (Ellis, 1994, pp. 60-61). McBeth (1990) advocates singing the sequence of events in the score from beginning to end and Junkin (1998) indicates that performing every line of the piece is important and indicates that this can be done by singing or playing the piano. Interestingly, Battisti and Garofalo (1990) did not list singing among the multiple strategies that should be avoided in score study.

Munch (1955) suggested that use of the piano is essential to avoid having performance errors to go undetected, stating, "To be sure of suffering no slips of the ear, the wisest thing to do is to take your scores to the piano and pick out the notes" (pp. 50-51). Many conductors in their discussion and writings often mention the use of the piano during score study, often as a means for harmonic realization. Junkin (1998) also utilizes the piano in order ". . . to understand how the harmonies work" (p. 44). Begian (Ellis, 1994) stated that though he rarely uses the piano, he does so when he must hear a thick and highly involved harmonic sonority. Kirchhoff avoids using the piano due to its tone color, stating, "The more you work at the piano (it's not that you deaden the inner ear),

the more you become dependent upon the piano itself. I encourage my student that if you have to go the piano to figure it out, great. I do the same thing, but the more you can do it away from the piano the better." (p. 111).

The concerns expressed by Kirchhoff are often mentioned as reasons to limit piano use. Battisti and Garofalo (1990) assert that using the piano " . . . diminishes the challenge of developing inner hearing ability. The conductor should go to the piano only as a last resort." (p. 23). Battisti and Garofalo affirm that score reading is about the ability to hear music internally and has nothing to do with piano playing ability. Green and Malko (1985) fear that use of the piano subjects a conductor to potential imitation rather than creation.

The fear of imitation rather than creation is often stated as the reason to avoid using recordings in the score study process (Battisti & Garofalo, 1990; Green & Malko, 1985). Keene believes that the imitation /duplication consequence can be avoided if student listening is guided (Ellis, 1994). He stated, "I do not think recordings inhibit if that student is guided. I think if you tell the student you want an exact imitation of a recording (that) obviously hurt and inhibits." (p. 85).

In the initial familiarization stage proposed by Markoch (1995), a recording is often used even without the score " . . . as a means of considering the work first as a whole" (p. 37). In the initial familiarization phase, one would listen to a recording of the piece multiple times, with and without the score, in order to develop questions about the piece that would serve as a basis for deeper analysis in the next phase of this score analysis model, exploration.

Bloomquist (Ellis, 1994) avoids listening to recordings once rehearsals start, though both he and H. Robert Reynolds use them early in the score learning process and not as the sole means of learning the score. This early use of recordings is similar to how Markoch (1995) proposed they be used in his score analysis model. McBeth (1990) stresses the importance of quality recordings and Begian, Kirchhoff, Keene (Ellis, 1994), and Junkin (1998) articulate the benefits on interpretation from listening to recordings. These conductors listen to recordings because they are interested in hearing others' interpretative opinions, though they all stress the need to avoid duplication.

Regarding marking the score, all of the conductors interviewed by Ellis (1994) indicated that they marked their scores more early in their careers and less so as their careers progressed. Marking the score was symptomatic of not knowing the score (McBeth, 1990). Conductors, especially less experienced ones, may be prone to read the markings rather than the score. Despite this, marking the score is viewed as favorable by most. Most conductors have developed personalized marking systems that include the enlargement of meter signatures, information about page turns, and successive entrances (Hunsberger, 1980) and tempo changes, melodic lines and cues (Ellis, 1994) . Some of these systems incorporate colored highlighters and pencils and dynamic-specific color codes and (Keene, Kirchhoff, and Reynolds in Ellis, 1994).

Munch (1955) spoke of the benefits of memorizing a score stating: "There is no better way to be absolutely sure of gaining insight into a score's every secret then to learn it by heart. Memorization requires the highest degree of concentration and attention to the most minute detail." (p. 51). Green (2004) considered memorization to be the final step of thorough score study and suggested that memorization occurs because of the mind's

ability to create of a sequence of events (p. 205). This sequence of events is also advocated as a tool for score memorization by McBeth (1990).

In contrast, all of the following conductors interviewed by Ellis (1994) found memorization to be unnecessary. Bloomquist considers score memorization to some degree to be a byproduct of score study. Begian and Keene suspect that only the melodic line and a few cues are actually memorized and not the entire piece. Reynolds described a memorized score as the ability to know what is coming next. Kirchhoff believes an attempt to memorize the score shortchanges the score learning process.

Depending on the complexity on the musical content, learning a score, whether or not one is intending to commit it to memory, can be a long process. Regarding the time necessary to learn a score, Kirchhoff (Ellis, 1994) stated, " . . . you just have to live with it. There is no shortcut and if you find one it probably is one" (p. 117). Begian, Keene, and Kirchhoff indicated that score preparation is a neglected aspect in the education of students, primarily undergraduates. Kirchhoff remarked on that the emphasis on the physical movement and gestures of conducting leads to the neglect of the ear (p. 116).

There is much debate surrounding which strategies of score study are beneficial in the development of a strong inner aural image. Reynolds states, "Again I go back to the idea of trying to have the strongest internal aural image you can. Now if you need to sing to do that, if you need to play the piano, whatever you've go at your disposal to do to get that strong internal image, you should do it" (p. 137). Despite articulating the importance of score study as a method for developing an internal aural image, undergraduate subjects demonstrated little evidence of actually working toward developing an internal image of the score during their solo practice and score study sessions (Lane, 2004). Research

efforts investigating the pedagogical processes for creating an internal image of the score is warranted.

Musical Context

Multiple studies have investigated the qualities of music that may influence one's ability to detect errors in musical performance. If certain music qualities, elements, or contexts are consistently shown to be aggravating factors in the detection of errors, techniques and materials may be developed to increase exposure and provide opportunities to practice error detection within those musical scenarios. Sheldon (2004) examined if multiple hearings enable students to be more accurate in their detection of errors in multivoice, multitimbral musical examples. Prior to listening to the error-filled examples, participants (undergraduate instrumental music education majors) heard a correct, error-free recording of the wind band literature excerpt, followed by three hearings of the error-filled excerpts. Results indicated participants correctly detected significantly more errors in the first listening, less in the second, and least in the third. This trend was also apparent in the labeling of the error types. Pitch errors were correctly identified more than any other error type, including rhythm.

Byo (1993) also examined the influence of texture and timbre on graduate and undergraduates' ability to detect performance errors. Using excerpts from wind literature, two timbre conditions were created: single timbre and multitimbre (four voices). A total of 32 typical performance errors were inserted into the excerpts, with an equal distribution of pitch and rhythm errors. The main effects of error type and timbre were significant with the subjects achieving significantly higher accuracy in rhythm errors and in single timbres. On average, subjects missed more than half of the errors within the

excerpts with graduate students having a lower mean score than the undergraduates, though the difference was not significant.

In an extension of the previous study, Byo (1997) investigated graduate and undergraduate music majors' accuracy in detecting pitch and rhythm errors in one-, two-, and three-part settings in homorhythmic and polyrhythmic examples. Thirty-six errors were inserted into twelve excerpts. The errors were equally distributed between pitch and rhythm errors. Errors were inserted at locations where typical student musicians would be most likely to err. Results indicated that number of parts had a significant main effect on error detection accuracy. Subjects detected the most errors in the one-part examples. Degree status and error type were also significant main effects. Graduate students performed significantly better than undergraduates. Rhythm errors were detected significantly more often than pitch errors. Scores were also significantly higher in homorhythmic than in polyrhythmic textures. These results suggest a negative linear relationship between complexity of music and error detection accuracy: as music becomes more complex, with multiple timbres and thicker textures, error detection accuracy decreases. The finding of a linear relationship between number of parts and difficulty was also found by Crowe (1996) and Byo and Sheldon (2000). Byo and Sheldon espouse one-line aural discrimination to be fundamentally important in the ability to accurately perceive and detect errors in thicker textures.

The influence of texture has been investigated regarding not only its effects on detection of errors but also how this affects musical listening. Results regarding the effects of differing textures on listening would have immediate implication regarding texture's effect on the detection of performance errors.

Sloboda (1985) discusses the difficulties of listening to multiple melodies (polyphony) at once stating, “ . . . our difficulties in attending to two concurrent melodies are not so much due to an incapacity to take them in as to an incapacity to subject them to the same kind of analysis simultaneously” (p. 167). This textural influence may also affect one’s ability to parse musical performances for errors, primarily in the location of wrong notes (pitch errors). This may necessitate deliberate attending in order to process one of the multiple, simultaneously sounding melodies.

Results from research in change detection may be related to results found in error detection. In this line of research, participants attempt to identify changes in a stimulus. Specifically, research that examines the ability to hear changes similar to what one does when error detecting. A change is detected when one hears something other than what was expected. Changes in this literature are not necessarily errors. They are deviations from what was one expected to hear resulting from extensive exposure to a stimulus. Score study should engender aural expectations in teachers/conductors such that violations from these expectations result in detection of the change. Said another way, score study should engender aural expectations in teachers/conductors such that violations from these expectations result in the detection of the errors. Thus, the term “change” used in this strand of literature is analogous to the term “error” used in the music literature. The following change detection literature examines how musical context(s) affects one’s ability to hear changes.

Acker and Pastore (1996) investigated the influence of homophonic and polyphonic contexts on the ability to detect pitch changes in a previously studied melody studied. Participants in this study were musicians with at least 10 years of formal lessons

and course work in music theory and history. This melody was located in the top, middle, or bottom voice in either a homophonic or polyphonic context. In the homophonic context, participant performance was best when melody was located in the low voice. In the polyphonic context, participants' detection accuracy of melodic changes was similar for the both the high and middle voices, but was significantly less accurate when the melody was located in the bottom voice. This suggests that texture and error location (voice placement) influence perception of pitch changes.

Palmer and Holleran (1994) also found error location and texture to have an effect on the detection of pitch changes. Two original melodies, one high and one low, were each paired with two other parts to create three-part homophonic and polyphonic excerpts. Pitch changes were either harmonically related or unrelated to the original melody. Pitch changes located in the middle voice were detected least often while the pitch changes located in highest voice were detected most often. Harmonically related errors were more difficult to detect though when placed in a polyphonic context, with multiple melodies, detection was higher in comparison to the homophonic context.

Change Detection, Change Deafness and Attention

Psychologists have examined variables that inhibit one to hear auditory changes. The inability to hear changes between two voices, known as change deafness (Vitevitch, 2003), is the auditory corollary to change blindness, or the inability to see changes in a visual scene. Though psychologists are not driven to investigate change deafness for the benefit of music educators, findings from these investigations may have direct applicability to the music education community. Often, participants in these

investigations are not musicians and the stimuli may be difficult to categorize as musically authentic and ecologically valid.

Vitevitch (2003) found that participants were unable to identify changes in the sex of a speaker that was verbalizing words of varying lexical difficulty. After hearing the words, Participants, all of which spoke English as their primary language, immediately repeated these words. Vitevitch concluded that these results supported the hypothesis of Rensink et al. (1997) that attention must be directed for changes (errors) to be detected. The inability to detect of changes in an auditory stimulus was found to be quite pervasive even with familiar stimuli that were well encoded (Gregg & Samuel, 2008). As the amount of sounds in the auditory scene increased, change detection became more difficult. When acoustical sounds are similar, changes were more difficult to detect. Though the stimuli in this study were not musical, the result regarding number of sounds and the acoustical similarity of the sounds may have implications for musicians.

Agres and Krumhansl (2008) investigated the ability to detect changes in musical stimuli. The musical stimuli were intentionally composed as examples of one of three compositional categories, each exhibiting differing amounts of structure. Stylistic stimuli conformed to musical conventions, thus having the greatest amount of structure. Non-stylistic stimuli sounded awkward due to unconventional melodic leaps and/or unusual tonal progressions, thus having less structure. Random stimuli, where pitches were selected via the use of a random number generator, had the least amount of musical structure. Participants in were either undergraduate non-musicians or were professional musicians from the Indianapolis Symphony Orchestra. These participants heard two-measure melodies and determined if the second was the same or different in comparison

to the first. Professional musicians were more accurate than non-musicians except on random trials. Overall, results suggested change detection is more difficult when music lacks tonal and melodic structure. Investigators hypothesize a relationship between memory and musical structure, stating that relatively large changes go undetected because some tones are not retained in working memory. It was suggested that what is encoded is a "musical gist", a aural expectation that includes only salient properties of music, a postulation similar to one made by Beck, Peterson and Angelone (2007) in the visual domain.

Though attention may be needed for change detection, the type of attention may differ between different types of musical stimuli, requiring an amount of attentional flexibility, where one adjusts the manner in which they attend to a musical stimulus regardless of the musical context. Musical training may enable greater attentional flexibility. This tenet was investigated by having participants listen to polyrhythmic patterns and afterwards detect timing (rhythmic) changes (Jones, et al., 1995). Musicians and non-musicians served as participants in this experiment and completed four listening tasks, with the tasks differing in the type of attending required by the task. The tasks required subjects to listen to high and low tones and detect timing errors. The interval size between the high and low tones was manipulated as a component of the investigation. In the integrative attending experiments, participants were told that their detection of timing changes would improve if they could integrate the high and low tones as a unified sequence. In the selective attending experiments, participants were instructed to focus on the low tones. In the integrative tasks, participants were significantly less accurate in conditions with wide frequency separations (intervals). The results reversed in

the selective attending experiments, as participants were most accurate detect changes with wide frequency separations. Musicians did not exhibit a greater ability in attentional flexibility, primarily in the selective attending tasks. The results suggest that musical content and pattern structure greatly affect perception, even more so than musical background and training.

Crawley, Acker-Mills, Pastore and Weil (2002) investigated the ability of musicians and non-musician to detect pitch changes/errors in polyphonic and homophonic music. The investigators contended that the homophonic pieces would encourage integrative listening/attending since pieces in this texture " . . . are generally defined by synchrony of notes across frequency regions (voice), should support a vertical organization and therefore bias a listener toward perceiving a series of chords" (p. 367). In contrast, polyphonic pieces would encourage selective listening/attending since pieces in this texture " . . . contain temporal asynchrony of notes across frequency regions, as is typical in polyphonic music will be more likely to produce horizontal (within-voice) integration" (pp. 367-368). The researchers hypothesized that detection of changes would be easier in a homophonic setting since all information can be monitored simultaneously. Two experiments and stimuli were created to compare the effects from integrative and selective attending. The homophonic stimulus contained three voices, was twelve measures long and contained only whole notes. Two of the voices in the polyphonic stimulus contained only whole notes, while the third voice contained half notes tied over the bar lines composed to create onset asynchrony between the voices.

As a means of familiarization, participants, musicians and non-musicians, listened to four repetitions of the stimulus. Based on their group assignment, they either heard the

homophonic (synchronous) or polyphonic (asynchronous) stimulus. Following the familiarization phase, participants were tasked with assessing if pitch changes occurred in the subsequent stimulus. The inserted pitch changes were either chord related (another chord tone) or chord-unrelated (a diatonic tone) and could occur in any voice. Investigators hypothesized that changes would be easier to detect in the homophonic stimulus since the onset synchrony among the three voices would enable participants to monitor all voices simultaneously thus enabling integrative attending.

Participants used an 8-point confidence scale with "1" representing the participant was "very sure" the comparison stimulus heard was the same and 8 indicating that the participant was "very sure" the excerpt was different. A rating of 5 or higher indicated a belief that change had occurred within the excerpt while a rating of 4 or low indicated a belief that no change had occurred. Half of the trials contained no pitch changes.

There were no significant differences in the no-change trials. Confidence ratings of the changing trials were dependent upon training: Musicians were more confident of their responses in the change trials. Participants were also more apt to detect chord-unrelated changes than chord-related changes. Training did not result in a significant difference in the pattern of performance: What was difficult for non-musicians was also difficult for musicians, just to a lesser extent.

Additional analysis, based on participants' rates of hits (responding accurately when a change occurred) and false alarms (responding a change had occurred when no change had been presented) indicated that musical texture had a significant main effect on participant sensitivity to changes. Participants were more sensitive to changes to the

homophonic stimulus. Change type was also significant in this analysis with significantly higher participant sensitivity to chord-unrelated changes.

In experiment two, participants were instructed to follow the melody and to indicate if changes occurred in the melody. Changes/errors could occur anywhere though subjects were assessing only the melody. This experiment consisted of four phases: melody familiarization, detection of changes in the isolated melody, context familiarization and detection of changes in the melody. No confidence ratings were used in this experiment, with participants simply indicating if the melody in context was the same or different.

Training had a significant main effect, as musicians outperformed non-musicians in the detection of changes. Despite the significant main effect, musical training did not interact with any other factor. Change detection was more difficult in the polyphonic context than in the homophonic. The researchers concluded, " . . . the relative ability to detect and discriminate a single note change as a function of compositional style was the same for musicians and non-musicians. It thus appears that performance in the present study reflects the operation of processes shared by both musicians and non-musicians" (p. 377).

Effects of Attention on Change/Error Detection

The research in auditory and visual change detection suggest attention is necessary for changes to be detected (Rensink, et al., 1997; Vitevitch, 2003). Though differing in the auditory context, research outside of music found that after listening to an auditory presentation of a unique sound sources (cello solo, female voice, hen clucking and others), the use of a cue enabled participants to determine if the cued sound was

deleted from the next auditory presentation (Eramudugolla, Irvine, McAnally, Martin, & Mattingley, 2005). Accuracy in the detection of the deleted sound source increased to almost perfect with the presence of a cue. Though this auditory "scene" contains musical sounds, it can hardly be considered music due to a lack of musical organization and intent. Despite this, implications abound for music research in terms of how one can structure an experience to more accurately perceive the musical environment.

Sloboda (1985) refers to attending to a single melodic line in polyphonic music as giving that melody "focal attention" and refers to this melody as the 'focal melody' (p. 169). Sloboda discusses how detection of errors in a focal melody occurs: "If the wrong note is in the focal melody it will be detected as a deviation from the known melodic pattern. If, however, the focal melody 'matches' the listener's memory of it, then the interference is that the wrong note must be in the other, non-focal melody" (p. 170). This would suggest that focusing attention on one line in a multi-voiced, polyphonic texture, may improve detection of errors in that line assuming that one has an aural expectation of how the music should sound.

Hayslett (1991) utilized three-voice excerpts in an investigation of the effect of direct focus on undergraduate instrumental music majors' peripheral hearing. While participants focused on one of the three voices in the excerpt, their task was to determine if one of the other two parts were deleted at any time from the musical stimulus. Pitch and rhythm errors, known operationally as focus reinforcers, were inserted to keep attention focused on the directed voice. Hayslett found that participants whose focus had been directed on a particular musical line detected significantly fewer deleted parts in comparison to when their focus was not directed. Directed focus significantly increased

the participants' detection of focus reinforcers (pitch and rhythm errors). The voice of focus (melody, harmony or bass) also had a significant effect on the detection of deleted parts and focus reinforcers (errors). Though directed focus hindered participants' peripheral hearing ability, its effect on errors in pitch and rhythm suggest benefits from directing attention to specific portions of a musical stimulus.

Mount (1982) hypothesized that if conductors focused their listening to one individual voice in a four-part Bach chorale, more pitch and rhythm errors would be detected. All subjects, graduate students majoring in choral music, had an equal number of opportunities to listen to a five-phrase Bach chorale. For each phrase, subjects experienced one of the five listening treatments: parts alone (SATB), paired voices (SA/TB; ST/AB; SB/AT) and all four parts at once. Subjects were familiarized with the chorale prior to error detection by hearing the chorale played on the piano without the inserted errors. The selected chorale was relatively unknown and in English. Results supported the hypothesis: Subjects detected significantly more errors when listening to parts alone, less when listening to pairs of voices and detected the fewest errors when listening to all four voices at once.

Beckett (1997) investigated the effect of directing student attention in two-part dictation. Participants were undergraduate music majors in their second year of ear training. Participants completed the two-part dictation in three separate sessions, two of which directed their attention first to either pitch or rhythm. The third dictation session was non-directed and functioned as a control. In the pitch-first condition, participants dictated pitch before attending to rhythm. In the rhythm-first condition, participants dictated the rhythmic content before attending to pitch. The effect of the attention

manipulation was measured in terms of dictation accuracy. The rhythm-first condition resulted in the highest mean for the rhythm scores, followed by the non-directed and then pitch-first. Post-hoc analysis indicated that rhythm marks achieved under the rhythm-first condition were significantly higher to those achieved under the non-directed condition and the pitch-first condition. For pitch scores, non-directed strategy produced the highest means, followed by pitch-first and then rhythm first. The difference between these means was not significant.

Highest rhythm accuracy was found in the rhythm-first condition. The case was not the same for pitch accuracy, where no differences were found among any of the conditions and directing attention to pitch did not increase pitch dictation accuracy, indicating that directing attention first to rhythm improved rhythmic perception and dictation. Perception and dictation of pitch did not increase as a result of directing attention. Beckett suggests that while rhythm may be processed independently of pitch, the same may not be true for pitch. Accurate processing of pitch may require the organizational structure found in rhythm in order for accurate reception and dictation. Beckett also suggests that perhaps rhythm is just easier to accurately dictate. All of these postulations yield insight as to why rhythmic errors are often detected more than pitch.

Though results suggest directing attention may aid in the detection of musical performance errors, research in inattentional blindness suggests that focusing attention on one aspect of a complex event may impair one's ability to detect very obvious changes. Simons and Chabris (1999) asked participants to view a video in which six people, three dressed in black and three in white, pass a basketball among their like-dressed teammates. Participants were asked to either count the total number of passes (easy) or

the number of aerial and bounce passes (hard) between either the black or white team. During the video, one of two unexpected events happens: either a woman carrying an umbrella or a woman dressed in a black gorilla suit walked amongst those passing the basketball. Participants were asked four questions regarding what they saw while they were counting, the last of which explicitly asked participants if they saw a gorilla/woman walk across the screen. Nearly half (46%) of the participants (88 of 192) never saw either of the two expected events. The implication here is that focus on one aspect of a stimulus, perhaps one part in a multi-part musical stimulus, may impair perception of unexpected changes. The researchers' claim that " . . . there is no conscious perception without attention" (p. 1071) would seem still to support the notion that attention is a requisite component for perception and detection of errors/changes in any stimulus (Rensink, et al., 1997; Vitevitch, 2003).

Recent research in inattentional deafness also illustrates the potential impediments that may result from directing attention to various portions of a musical stimulus. Koreimann, Strauß, and Vitouch (2009) inserted an improvised guitar solo into *Also Sprach Zarathustra*. Participants in this study were non- and amateur musicians. Experimental group participants counted the number of timpani strokes in the piece while control group participants simply listened to the piece. At the conclusion of the piece, participants were asked three questions, similar to those asked by Simons and Chabris (1999), the last of which explicitly asked participants if they noticed the guitar. Experimental group participants noticed the guitar far fewer times than did participants who merely listened to the piece. Though musicians noticed the guitar more times than non-musicians, 38% of the musicians in the experimental group did not notice the guitar while only 11% of control musicians missed the guitar. Non-musicians results were similar, with 76% of experimental and 27% of control non-musicians failing to notice the

unexpected guitar intrusion. It would seem that inserting a guitar into a well-known piece of music, one known by all participants, would be easily detected. The data suggest otherwise.

Conclusions

Evidence suggests that if teachers/conductors direct their attention to a particular aspect of a piece of music, perhaps even a single part, their ability to perceive and detect performance errors may improve. The caveat is that there is evidence to suggest that when attention is directed to a particular aspect in piece of music, perhaps only a single part, that teachers/conductors may fail to notice unexpected errors, errors that may seem obvious once detected. The likely effects that musical context has on attention while listening paired with an inadequate level of attentional flexibility to evade those effects illustrates the complexity of musical performance error detection. Therefore, the need for further research in this area is imperative.

If the organization of the musical material influences perception and attention, music dominated by rhythmic synchrony and melodic similarity may enable the listener integrate and fuse individual parts. In contrast, music dominated by rhythmic asynchrony, melodic variety and subsequent independence may make integration and fusion difficult if not impossible. It would seem this would naturally create differences in how one attends to music, especially when attempting to parse through the music for errors.

Though some music may enable a more wholistic, integrative, and horizontal organization of the musical sounds, an ensemble director must divide their attention when all members are performing. The teacher/conductor must be able to focus on one musical stream, voice, or part to assess its accuracy. Effective rehearsing does not allow a teacher/conductor to only hear and attend to individual parts in isolation. Rather, a

director must be able to divide and direct their attention to a musical part in the midst of full ensemble performance.

Results have suggested that selective attention is more likely to occur when musical content permits and enables horizontal organization, such as multi-voice music containing melodic and/or rhythmic independence from the other voices. The perceptual processes necessary for accurate assessment of polyphonic music may require an amount of attentional flexibility, the ability to modulate attention from one musical part to another. Sloboda (1985) refers to this attentional process as focal attention and the melody receiving focal attention is the focal melody.

Does the integrative or wholistic listening/attending that is likely to occur in homophonic musical context create greater difficulty in the parsing of a musical stimulus for performance errors? Could it be that this type of musical structure and resultant attentional focus enable a more comprehensive evaluation of the musical stimulus, thus enabling a listener to detect a performance error due to the resulting contextual violation? In a homophonic context, melodic errors are more likely to create harmonic dissonance due to wholistic/integrative nature of the texture, a phenomenon that is less likely to occur in a polyphonic texture. Could this integrative/wholistic type of attending impede the ability to determine where the errors occur? Would this type of attending in this musical style impede a teacher/conductor from making the most accurate diagnosis and resultant prescription?

In contrast, the selective/focal attending that is likely to occur in a polyphonic context will almost certainly force listeners to divide their attentional focus in order to parse the musical stimulus for performance errors. Does the melodic and rhythmic

independence characteristic of polyphonic music interfere when attending to only one line or does it actually enable one to direct one's attention to one musical line, therefore freeing the listener from the contextual bondage? Could it be that the rhythmic and melodic variety and independence leads to greater distraction when attending to polyphonic music?

If one directs their attention to one voice in a multi-voice composition, is there an effect on error detection ability due to musical texture? Is the effect form directing attention one that results in greater aural acuity leading to the detection and correct identification of musical performance errors or does directing/focusing attention impede detection of errors? If an effect exists, will it be mediated through differing methods of familiarization through score study? From familiarization comes expectation, a critical component in the detection of errors. Without an aural expectation of the music, performance errors are less likely to be detected. Perhaps efforts need to be concentrated on developing the most efficient and comprehensive methods for familiarization.

The overarching theme derived from review of this literature is that though error detection may be a pivotal skill for successful music teaching, it is often not a skill that is well developed in musicians. Additionally, attempts to identify the component musical skills with the most influence on error detection ability have yet to identified and verified in the literature. What this review does suggest is that the ability to detect errors is influenced to varying degrees by musical context, experience and practice, score study process and attentional focus.

The psychology literature demonstrating the improvement of change (error) detection due to methods of directing (focusing) attention may have immediate

implications for musicians. The findings of Eramudugolla et al., (2005), Rensink (1997), Vivevitch (2003) and Crawley et al., (2002) along with the musical findings of Hayslett (1991), Mount (1982) and Beckett (1997) suggest that directing attention in a visual and/or auditory scene may increase change and error detection. Though there may be perceptual benefits from directing attention, there is evidence suggesting costs due to such attentional manipulation (Koreimann, et al., 2009; Simons & Chabris, 1999).

Due to the visual and auditory nature of reading musical scores, these findings may provide insights that could yield effective techniques in the training of music teachers at all levels and areas. This investigation sought to determine not only the effect of directing attention on error detection ability but also the effect from directing attention through aural and visual means, along with the influence of homophonic and polyphonic texture.

Research Questions

This inquiry was designed to answer the following questions: What are the effects of directed attention on music majors' ability to detect errors in three-voice music excerpts? What are the effects of aural-, visual-, and free-based methods of score study on the ability of music majors to detect performance errors? How does an error's location (top, middle, or bottom voice) type (pitch or rhythm) texture (polyphonic or homophonic) affect participants' ability to detect it? How, if at all, do these variables of musical context interact?

CHAPTER 3: METHODOLOGY AND PROCEDURES

Introduction

This investigation examines the effects of directed attention on music majors' ability to detect pitch and rhythm errors in three-voice homophonic and polyphonic music excerpts. Specifically, the study is designed to test the effects of auditory-, visually-, and free-based methods of score study on the ability of music majors to detect pitch and rhythm errors in varied-texture music excerpts. Results from empirical investigations in music and psychology have suggested that directing attention may be an effective strategy for increasing ability in error detection. Error detection, which one might view as change detection in psychology, is a pivotal skill for all musicians. Musical content also affects one's ability to detect errors/changes, primarily in regards to texture. Homophonic music may encourage integrative/wholistic attending due to the high degree of rhythmic sameness, while polyphonic music, due to its characteristic melodic and rhythmic independence among voices, may encourage selective attending.

Definitions and Variables

The following are the independent variables used in this study:

1. Directed attention technique. Attention was directed in two ways, visually through the colored highlighting of musical lines and aurally through active participant engagement in singing/playing individual musical lines. Voice of directed attention is the voice (or part) in three-voice textures to which participants' attention is directed.
2. Performance error. Purposeful performance errors marred the stimulus recordings that participants heard while viewing correctly notated scores. These errors are

referred to by type (pitch or rhythm) and location (voice and beat). A pitch error occurred when a pitch other than the one notated in the score was performed. This error type represented “wrong notes,” not out of tune pitches. A rhythm error occurred when a rhythm other than the one notated in the score is performed.

3. Error focus. A focused error is a performance error located in a voice to which attention was directed. A non-focused error is located in a voice to which attention was not directed.
4. Error location. Errors were inserted into the top, middle, or bottom voice.
5. Homophonic or polyphonic musical excerpt. Homophonic excerpts were dominated by sameness of rhythmic content across voices. Polyphonic excerpts were dominated by independence of rhythm across voices.

The following were the dependent variables in this study:

1. Error detection ability. Participants listened to marred performances while looking at correctly notated scores. Their task was to detect and identify performance errors. A fully detected error was one for which the participant identified the correct error type and its location (voice and beat). A partially detected error was one for which the participant identified one or two of three criteria (beat location, voice, and error type). In analysis, each error was worth three points, one point for each facet of identification.
2. Phantom error (Byo, 1993). This is when the participant indicated having heard a performance error when in fact one did not occur.

Selection of Excerpts and Development of Stimulus Recordings

Three-voice and four-voice excerpts have been used in multiple studies (Blocher, 1986; Byo, 1993, 1997; Byo & Sheldon, 2000; Costanza, 1971; Crawley, et al., 2002; DeCarbo, 1982; Hayslett, 1991; J. Palmer, 1996; Ramsey, 1979; Sheldon, 1998, 2004). I chose to limit the aural experience to three-voice excerpts because previous research showed them to present ample challenge for university music majors in error detection tasks (Byo, 1993, 1997; Byo & Sheldon, 2000; Hayslett, 1991). In addition to effects from directed attention, the study investigated the influence of texture on participants' detection of performance errors. Crawley et al. (2002) suggest that homophonic textures encourage integrative attending/listening while polyphonic/ polyphonic textures encourage selective attention/listening, with results suggesting that detection of changes is easier in homophonic textures. Byo (1997) found subjects were more accurate in detecting errors in homophonic than in polyphonic excerpts. Due to results from multiple investigations suggesting influence on detection, musical texture was included as a variable in this investigation.

The work of Hayslett (1991) and Crawley et. al (2002) influenced the design of this study, especially regarding treatment. Subjects in Hayslett's research underwent treatment for 35 minutes. In Crawley et al., treatment lasted approximately an hour. This suggested that treatment and testing in the present study last somewhere within the 35-60 minute time frame not only as a means of replication but to engage maximum participant effort and avoid confounding effects from task demands and cognitive fatigue. It was necessary, therefore, to find and select musical excerpts that were of appropriate number

and length. Since I sought to determine the effect of directing attention to each of three voices, multiple instances of directed attention to each voice necessitated the selection of at least three excerpts. The selection of six excerpts allowed for three examples each of two textures and multiple opportunities for participants to direct attention on each voice within the 35-60 minute time frame.

The excerpts for this investigation were taken from a variety of sources. The homophonic excerpts are *Tandem Trio* (Grunow & Froseth, 1982), *Divertimento No. 1* (Grunow & Froseth, 1979), and *Nocturne in D, Opus 28, No. 3* (Grunow & Froseth, 1979). The polyphonic excerpts are measures (mm.) 120-128 from *Trio in C Major, Opus 87* (Beethoven, 1941), mm. 17-24 of "Sarabande" from *Suite in D Minor* by Handel (Voxman, 1952), and mm. 9-19 of "Passepied" from *Suite in C* by Bach (Voxman, 1953). To provide acclimation to the treatment and the acoustical environment of the room, measures 1-9 of Gavotte "Les Moissonneurs" from *Pieces de Clavecin* was selected for use as a practice excerpt (Rosenthal, 1946).

The instrumentation of the original excerpts was altered to present three distinct voices. The key of the "Sarabande" excerpt was altered since its change from a flute trio to a brass trio necessitated a change in key and register. Four experienced musicians, including the researcher, evaluated the excerpts and determined them to be suitable in rhythmic and tonal complexity given the purposes of this study. Excerpts were converted to concert pitch to eliminate as a confounding variable participants' varying skill in transposition. Detailed information about each excerpt is shown in Tables 1 and 2. Excerpts are located in Appendix A.

Table 1

Excerpt Length, Meter, Tonality, Melodic Contour, and Rhythmic Complexity

Title	Measures	Meter	Tonality	Melody/Contour	Rhythmic Complexity
Nocturne in D	8	6/8	D	diatonic/stepwise	characteristic of meter
Tandem Trio	8	4/4	Eb	mostly diatonic/stepwise	minimal
Trio, Opus 87	8	4/4	F – d	diatonic/some leaps	dotted and syncopated
Divertimento No. 1	10	3/4	Bb	mostly diatonic/some leaps	dotted
Passepied	11	3/4	G-d-g	diatonic/mostly stepwise	minimal
Sarabande	8	3/4	g - c	mostly diatonic/some leaps	dotted and syncopated
Gavotte (practice)	9	4/4	C	diatonic/some leaps	minimal

Table 2

Excerpt Texture, Tempo Indication, Selected Tempo and Voice of Directed Attention

Title	Texture	Tempo Indication	Selected Tempo	Voice of Directed Attention
Nocturne in D	Homo	Allegretto	112	top voice
Tandem Trio	Homo	Allegro	144	bottom voice
Trio, Opus 87	Poly	Allegro	120	top voice
Divertimento No. 1	Homo	Allegro	120	middle voice
Passepied	Poly	Allegretto	92	middle voice
Sarabande	Poly	Slow	76	bottom voice
Gavotte (practice)	Poly	Gayement	120	middle voice

Excerpts were notated in *Finale® 2009,* and Garritan Instrument™ sounds were used. Pilot testing revealed the Garritan sounds to be realistic and similar enough to

acoustic timbres to be viable for use in this investigation. Multiple investigators (Byo, 1993, 1997; Crowe, 1996; Deal, 1985; Palmer, 1996; Ramsey, 1979; Sheldon, 1998, 2004) have used synthesized timbres in the study of error detection and music perception. Therefore, the use of these synthesized timbres in this study was deemed appropriate. Excerpts were exported from *Finale 2009* as audio files (.wav) and were combined with verbal instructions, which were created and recorded in Audacity (Mazzoni, 2006) and burned to compact disc.

Selection and Distribution of Performance Errors

The selection of errors was based on those identified in previous research (Byo, 1997; Ramsey, 1979; Sheldon, 1998), many of which were deemed as "typical" of high-school instrumentalists in initial readings of unfamiliar music. Typical errors were used in an attempt to create the most authentic error detection task possible. My concern for authenticity notwithstanding, various issues necessitated the use of only pitch and rhythm errors. Since the musical stimuli for this task were electronically generated, pitch and rhythm were the most objective error types. The dichotomous nature of these types of errors eliminates any subjectivity in defining "error." Pitch and rhythm errors have been frequently investigated in error detection research (Byo, 1993, 1997; Byo & Sheldon, 2000; Crawley, et al., 2002; Deal, 1985; Gonzo, 1971; Hayslett, 1991; Jones, et al., 1995; Larson, 1977; Locy, 1996; Palmer, 1996; Ramsey, 1979; Sheldon, 1998, 2004; Sidnell, 1971; Stuart, 1979). The inclusion of only two error types also focuses the scope of the investigation and reasonably limits task demands.

In attempting to design a task with high ecological validity, musical context and error plausibility needed to be the determining factors regarding the location of errors.

While I was able to equally balance the number of pitch and rhythm errors inserted into the voice of directed attention and across the six excerpts, I was unable to balance the distribution of the errors equally across all three voices because to do so would have necessitated inserting errors that were not plausible. Focused errors, those inserted into the voice of directed attention, were equally distributed across voices, while non-focused errors, those located in the other two voices, were not. In total, four errors were included in each excerpt, two of which were located in the voice of directed attention with one error placed into each of the other voices. No errors occurred in the first measure of any excerpt to allow for acclimation to the tempo, timbre, and tonality of the excerpt. Table 3 lists the various errors inserted throughout the excerpts. Excerpts with inserted errors are located in Appendix B.

Pilot Testing

In an effort to design an error detection task that was appropriate for the skill level of participants and given the importance of avoiding ceiling and floor effects in the responses of participants, extensive pilot testing was conducted on the detectability of the inserted performance errors. Five accomplished musicians with significant music teaching/conducting experience were allotted time to silently study the excerpts. Following study time, experts heard the flawed performance of the excerpt three times and listened for the inserted pitch and rhythm errors. Participants identified perceived errors by circling the beat location and voice in which it occurred and indicated error type (pitch or rhythm). An error was considered detectable and retained for use if three of the

Table 3

Performance Error Descriptions and Identification Number

Error description	Identification Number
Pitch Errors	
Incorrect partial	9
Major 2nd high	2, 13
Major 2nd low	6, 10
Minor 2nd high	7, 18
Minor 2nd low	4, 15, 19, 21, 22
Rhythm Errors	
Notes of equal duration performed unevenly	1, 23
Two notes/gesture played in reverse	3, 11, 24
Dotted figure performed as notes of equal duration	8
Sustained note not held for full value	12, 16
Rests not “held” for full value (early entrance)	14
Rests/tied note held too long (late entrance)	20
Three eighth notes performed as an eighth note triplet	17
Dotted-quarter note, three eighth note figure in 3/4 time performed as quarter note/two eighth notes,/and a quarter note	5

five music experts were able to identify it. Participants were asked to comment regarding perceived timbre authenticity, balance of parts, acoustical concerns in the testing room, volume/velocity of error, contextual interference, and any other issue that seemed to

impede the detection process that could be adjusted. These comments illuminated potential factors impeding the detection of errors not perceived by participants. Based on these comments, the error's volume (velocity) was adjusted or the error was replaced with another. These piloting procedures continued until all twenty-four errors were deemed detectable.

Treatment

Participants underwent one of three score study treatments (aurally-based, visually-based or free) designed purposefully to direct attention to specified single voices and effectively isolate directed attention as a variable. Participants in the free group functioned d as a control group. These group members had no specific strategy suggested to them for any of the six excerpts though they were given time to study the scores, access to a piano, and freedom to sing, make markings on the score, and strategize however they chose.

Participants in the aurally- and visually-based group had their attention directed to one of the particular voices within the three-voice excerpts. Visual group participants' attention was manipulated with the use of colored highlighting of the voice of directed attention, similar to the treatment participants underwent in Haylsett's (1991) research. Participants did not use the piano or their own voice in score study. The participants were free to make any markings on the score. Aural group participants' attention was manipulated though active engagement with the score in three phases: sight-singing the voice of directed attention, using the piano to rehearse difficult spots within the voice of directed attention, and singing the voice of directed attention a second time. All participants were free to make any markings on the score.

Score study time per excerpt was equal for all participants. In pilot testing, five participants completed each of the three phases of the aural group's treatment. Participants were afforded as much time as necessary to complete each phase. Each phase was timed per participant. Though times for sight-singing phases (one and three) were similar among the five participants, times for rehearsal with piano (phase two) had a very wide range. Times for all five participants in this pilot are presented in Appendix C.

Mean duration was calculated for each phase per excerpt. These means were used to determine the length of score study time all participants would have for each excerpt. Though all participants had an equal amount of score study time, only the aural group had their score study time segmented due to each of the phases. Times were combined for the free and visual group participants. Though only the aural group had their score study time partitioned for phase completion, both the aural and visual group would use the last thirty seconds of score study time to study the other two voices in the excerpt. Based on pilot testing results and literature suggesting that extended score study does not produce significant increases in the number of errors detected (Van Oyen & Nierman, 1998), thirty seconds was deemed sufficient for study of the other two voices in these excerpts of 8-12 measures. The brevity of this portion of score study was also deemed necessary in order to maintain participant attention on the specific voice. Table 4 lists the score study times for each excerpt based on pilot testing. All times were rounded to the nearest second.

The score study times do not represent the entire time of the testing experience, as all instructions were recorded and combined with the times for each phase. Participants

were also allotted time to ask questions of the researcher prior to error detecting each excerpt.

Table 4

Score Study Times in Seconds per Excerpt Based on Pilot Testing

	Sight Sing	Study with piano	Sing	Total (plus 30)
Nocturne in D	21	59	22	131
Divertimento	26	132	18	206
Trio, Opus 87	19	55	17	121
Tandem Trio	30	143	20	223
Sarabande	26	192	21	269
Passepied	27	154	29	239
Totals	149	735	127	1190
Means per phase	25	122	21	
Gavotte (practice)	25	122	21	198

Procedures

Participants (N = 60) were undergraduate and graduate vocal/choral and instrumental music majors from a large southern university, a mid-sized university in the mid-west, and a mid-sized university in the southeast. All participants had completed courses in music theory, music history, and at least one conducting course. No participants had more than one year of formal teaching/conducting experience beyond

student teaching. Participants were randomly placed into one of the treatment groups, which were balanced with equal numbers of vocalists and instrumentalists.

A request for exemption from institutional oversight was requested and granted by the LSU Institutional Review Board (IRB) for Human Research Subject Protection. Before undergoing treatment, participants gave informed consent to participate in this investigation and completed a participant data form regarding their degree status, undergraduate or graduate, and major instrument, which indicated their musical emphasis as either a vocalist or instrumentalist. All participants had the same amount time to study the score per excerpt (see Table 4), though this time was divided differently based on their group assignment. To control for order effect, participants listened to one of two excerpt orders. All participants heard recorded instructions, with the researcher present in the room to answer questions and to ensure that all treatment procedures were understood and followed.

In order to further isolate and direct participant attention to the one specific voice in each excerpt, aural and visual group participants first received only a copy of the voice of directed attention (VDA). The aural group participants then completed a three-phase aural treatment as means of directing their attention to the VDA. In contrast, visual group participants studied the VDA in silence. These directed attention participants viewed the voice of directed attention within the context of the full score during the last thirty seconds of score study.

Before any error detection data were collected, participants experienced all phases of their assigned group's treatment via a practice excerpt. Score study time for this excerpt was determined by calculating the mean duration from each of the treatment

phase mean duration. Determining score study time for the practice excerpt in this manner differs from the other excerpts because the practice excerpt was not part of pilot testing. Since the pilot excerpt's function was to expose to participants to the treatment they would experience and was not a source from which data were collected, there was no need to utilize pilot testing for this excerpt. To orient participants to treatment procedures and the acoustical environment of the testing room, participants completed the practice excerpt at the beginning of the treatment session. All instructions were recorded to compact disc to control for any variations in voice inflection, vocal variety, and rate of speech by the investigator. All participants were videotaped to provide an additional means of verifying treatment.

Aural group participants directed their attention to the voice of directed attention (VDA) in three phases: sight-singing the VDA in its entirety, use of the piano to correct perceived errors in their sight-singing performance, and singing the VDA again in its entirety. Participants viewed the VDA separately before viewing it within the context of the full score. Following the completion of theses three phases, participants silently studied the full score of the excerpt for thirty seconds. Following study of the VDA and the full score, participants detected the inserted performance errors by listening to a recording of the excerpt that contained performance errors. Participants heard three repetitions of the recording with ten seconds of silence inserted between each repetition to provide participants time to write on the score. The full script of the instructions for this group is located in Appendix F.

In preparing music for rehearsal, visual cues are often used as reminders to direct hearing towards various dimensions of the musical stimulus. Due to this prevalence,

colored highlighting of the VDA was used to direct participant attention for the visual group. Similar to those in the aural-group, participants in the visual-group first viewed and studied the VDA separate from the full score. In contrast to the aural group, the visual group participants studied the VDA in silence. Following directed attention score study treatment procedures, these participants viewed the VDA in the context of the full score, which was highlighted in color when presented within the context of the full score. These participants studied the full score in silence for thirty seconds and then detected the performance errors in a recording of the excerpt. Participants heard the recorded excerpt three times and had time in between each play of the excerpt to write on the score and completed the practice excerpt at the beginning of the treatment session. The full script of the instructions for this group is located in Appendix G.

To determine any potential benefit from directing attention, participants in the free-based (control) group had no manipulation of their attention. Any foci of their attention were based on their own proclivities and musical intuition. Since their attention was not be manipulated, these participants viewed the full score for the entire score study period. They were free to use any score study strategy including, but not limited to singing, playing the piano, and marking the score. Participants heard the recorded excerpt three times. Ten seconds of silence were inserted between each repetition of the excerpt to provide participants time to write on the score. As with other groups, participants completed the practice excerpt at the beginning of the treatment session. The full script of the instructions for this group is located in Appendix H.

After completing the error detection task, all participants answered two open-ended questions regarding their perception of strategy effectiveness. Participants

indicated what they did that was most helpful in detecting errors. These strategies could be the result of the treatment or strategies selected on their own. Participants also indicated what would have enabled them to be more successful. These questions are located on the participant data form located in Appendix E.

Participant answers to these questions provided a means for comparing participant behaviors, assessed via video analysis, to their responses to the questions regarding treatment effectiveness. This comparison between data obtained from video analysis of their score study behaviors and data obtained from participants' self-reported responses regarding effective score study/error detecting behaviors enabled a comparison of participants actual performance and their perception of their performance.

Scoring the Dependent Variable

In quantifying accuracy in performance error detection, the numerical depiction of participants' aural perception should reflect the tripartite nature of the task. Therefore in scoring participants' responses, I awarded partial credit where partial credit was warranted by designating three points for each inserted error, one for each facet of identification: beat location (when), error location (where), and error type (what). With one exception described below, participants received one point for each correctly identified facet of detection. This scoring process provided the numerical data from which statistical analyses were calculated. Therefore, a circled response could receive a total 1, 2, or 3 points. With twenty-four errors each worth three points, the total possible score for each participant was 72.

Though the vast majority of participant responses were easily assessed, some necessitated the formation of guidelines to ensure reliable scoring. In rare instances, a

circled response was not accompanied by an indication of error type: pitch (P) or rhythm (R). A circled response had to be accompanied by an error type indication to be deemed at least partially correct. A circled response, even if encompassing the performance error, was considered merely a marking to the score when not accompanied by an error type indication. This was necessary since all participants were permitted to write on the score and to determine if a circled response was lacking an error type indication or was merely a marking on the score was not possible.

With regard to beat, if a participant's circled response, accompanied by an indication of error type (P or R), was within one beat of the inserted error, the response was considered partially correct. For instance, if a participant circled beat two in a measure in which the performance error occurred on beat one, this circled response would not receive credit for beat detection. A circled response within one beat of the error but in the wrong voice could still receive credit for error type.

In addition to the scoring procedures described above, the number of phantom errors was also analyzed in this investigation. A phantom error was operationally defined as an indication of a performance error occurring more than one full beat before or beyond the actual error. For instance, if a participant circled beat three in a measure in which the performance error occurred on beat one, this response would be coded as a phantom error. Phantom errors were coded by error type and the voice in which they were indicated.

Most phantom errors were easily identified because they bore no apparent relationship to an inserted error (e.g. an error was marked in a measure where no error had been inserted). There were two response types that required further delineation, the

first of which occurred when a participant’s circled response encompassed more than two beats. A circled response of more than two beats would encompass more incorrect than correct material and was thus coded as a phantom error.

The rule above is applicable to all pitch errors and to most rhythm errors, except for rhythm errors that cause more than one beat in a measure to be inaccurate. In *Divertimento No. 1* (Grunow & Froseth, 1979), the rhythm error located in the middle voice of measure two causes all beats to be incorrect. Figure 1 displays this measure in the correctly notated score and the measure with the error inserted. Note that the error caused all three beats to rhythmically differ from the correctly notated score. A circled response of two or more beats would actually encompass more correct than incorrect material. Multiple rhythm errors created this issue, specifically errors 5 (displayed below), 8, 11, 12, 23, and 24. These errors are described in Table 3 and are displayed within the context of the full excerpts in Appendix B.

Correctly notated Error notated

Figure 1. Measure 2 of Divertimento No. 1

Using the criteria outlined above, an independent observer scored participants' responses to twenty-percent of the excerpts and reliability was calculated using the formula agreements divided by agreements plus disagreements. Agreement indices of .94 for errors detected and .96 for phantom errors were found. Error detection scores were therefore considered reliable, and the data set was finalized for use in statistical analysis.

CHAPTER 4: RESULTS

Introduction

This investigation sought to determine the effects of directed attention procedures on music majors' error detection in three-voice instrumental music. Participants studied three-voice instrumental scores according to researcher-created directed attention score study treatments, focusing visually or aurally on one of the three voices per excerpt, prior to studying the entire score.

Visual group participants (n = 20) studied this voice in silence and were permitted to make any markings to the score. When these participants studied the entire score, the voice of directed attention (VDA) was highlighted to further direct participant attention to this voice, a facet of treatment unique to this group. Participants studied the full score in silence for thirty seconds. Aural group participants (n = 20) studied the VDA in three phases: sight singing, correcting the errors they perceived in their sight-singing performance through use of piano and their own singing, and then singing the voice again. Participants then studied the full score in silence for thirty seconds. Free group participants (n = 20) utilized any strategy in their study of the full score, which they had for the entirety of their score study session. Since free group participants experienced no intentional manipulation of attention, this group functioned essentially as a control group.

Prior to data collection, all participants studied a practice excerpt designed to orient them to the score study processes unique to their treatment group and then detected performance errors heard in a recording of that excerpt. After completing practice procedures, participants studied and detected errors across six, three-voice instrumental excerpts. In question were the effects of directed attention, method of focus (visual and

aural), musical texture (homophonic and polyphonic), error location (top, middle, bottom voice, and VDA) and error type (pitch and rhythm).

Data Analysis: Error Detection Scores

Each error was worth a total of three points, one for each facet of identification: beat location, error location, and error type. A total of twenty-four errors were inserted across six excerpts resulting in 72 possible points. These points provided the numerical data from which multiple, factorial analyses of variance (ANOVA) with repeated measures were calculated.

Though pitch and rhythm errors were equally distributed across excerpts, they were not equally balanced across voices. Therefore, error type and error location could not be combined in the same analysis, thus necessitating that two, three-way factorial analyses of variance (ANOVA) with repeated measures be used to analyze the data collected from all participants.

To determine whether error detection scores were influenced by excerpt order, two random orders were created. Initial data analysis was conducted to determine potential effects of excerpt order. A two-way ANOVA [group (3) by order (2)] was calculated with the total score from all six excerpts functioning as the dependent variable in the analysis. Results indicated no effect due to order, $p = .33$ and no interaction with treatment group, $p = .45$. Therefore, all data were considered as one data set.

To determine the effects of error type and texture on all participants' (visual, aural, and free) detection of performance errors, a three-way factorial ANOVA with repeated measures was conducted with texture and error type functioning as the within-subjects factors and treatment group functioning as the between-subjects factor. With two

pitch/rhythm errors in each of three homophonic/polyphonic excerpts, there were a total of six errors. Each error was worth three points and means were out of 18 possible points.

Results indicated no effect due to treatment group, F (2, 57) = 2.24, p = .12. Mean accuracy scores for all treatment groups (aural M = 10.25, SD = 3.86; free M = 10.39, SD = 3.91; visual M = 8.53, SD = 4.29) were not significantly different. Texture also had no significant main effect on accuracy, F (1, 57) = .45, p = .50. Mean accuracy scores for homophonic (M = 9.6, SD = 4.01) and polyphonic excerpts (M = 9.84, SD = 4.1) were not significantly different.

Error type had significant main effect on participants' error detection accuracy, F (1, 54) = 28.18, p < .0001, partial η^2 = .331. Mean pitch detection (M = 8.73, SD = 4.12) was significantly lower than rhythmic detection (M = 10.72, SD = 3.83). This effect accounts for more than 33% of the variance in scores. No significant interactions were found among any of these factors. The source table for this analysis can be found in Table 5.

To determine effects of texture and error location on all participants' detection of performance errors, a three-way factorial ANOVA with repeated measures was conducted with error location and texture functioning as the within-subject factors and treatment group functioning as the between-subjects factor. With one error located in each non-directed voice and two in the VDA, a total of four errors were in each voice across both homophonic and polyphonic excerpts. Each error was worth three points and means were out of 12 points. Again, results indicate no significant effect due to treatment group, F (2, 57) = 2.24, p = .12. Means for the aural group (M = 6.83, SD = 3.1), free group (M = 6.93, SD = 3.1), and visual group (M = 5.68, SD = 3.35) were not

significantly different. Texture also had no significant effect on accuracy, F (1, 57) = .45, p = .50. Mean error detection accuracy scores for homophonic (M = 6.4, SD = 3.4) and polyphonic excerpts (M = 6.56, SD = 3.06) were not significantly different.

Table 5

Source Table for Three-Way ANOVA with Repeated Measures: Texture * Error Type * Treatment Group

Source	df	Sum of Squares	Mean Square	F	p	η^2
Treatment Group (G)	2	172.36	86.18	2.24	.12	.073
Error	57	2198.19	38.57			
Texture (T)	1	3.50	3.50	.45	.50	.008
T * G	2	3.81	1.90	.25	.78	.009
Error	57	439.94	7.72			
Error Type (R)	1	238.00	238.00	28.18	< .0001	.331
R * G	2	28.81	14.4	1.71	.19	.056
Error	57	481.44	8.45			
T * R	1	9.20	9.2	1.25	.27	.022
T * R * G	2	16.46	8.23	1.12	.33	.038
Error	57	418.59	7.34			

Error location had a significant main effect on error detection accuracy scores, F (2, 114) = 3.92, p = .02, partial η^2 = .064. Mean error detection scores for errors in the top voice (M = 7.01, SD = 3.06), middle voice (M = 6.18, SD = 3.45), and bottom voice (M = 6.25, SD = 3.13) were significantly different. Scheffé post-hoc procedures for multiple comparisons indicated top and middle voice means were significantly different, (p = .046), while middle and bottom (p = .98) and top and bottom voice means (p = .07) were not. As a significant main effect, error location accounts for more than 6% of the variance in scores.

Though texture and treatment group did not have significant main effects on error detection accuracy, both were involved in a significant three-way interaction with error location, F (4, 114) = 3.09, p = .02, partial η^2= .098, indicating that these factors do not behave independently of each other. This interaction accounts for almost 10% of the variance in scores. This interaction is illustrated in Figure 2.

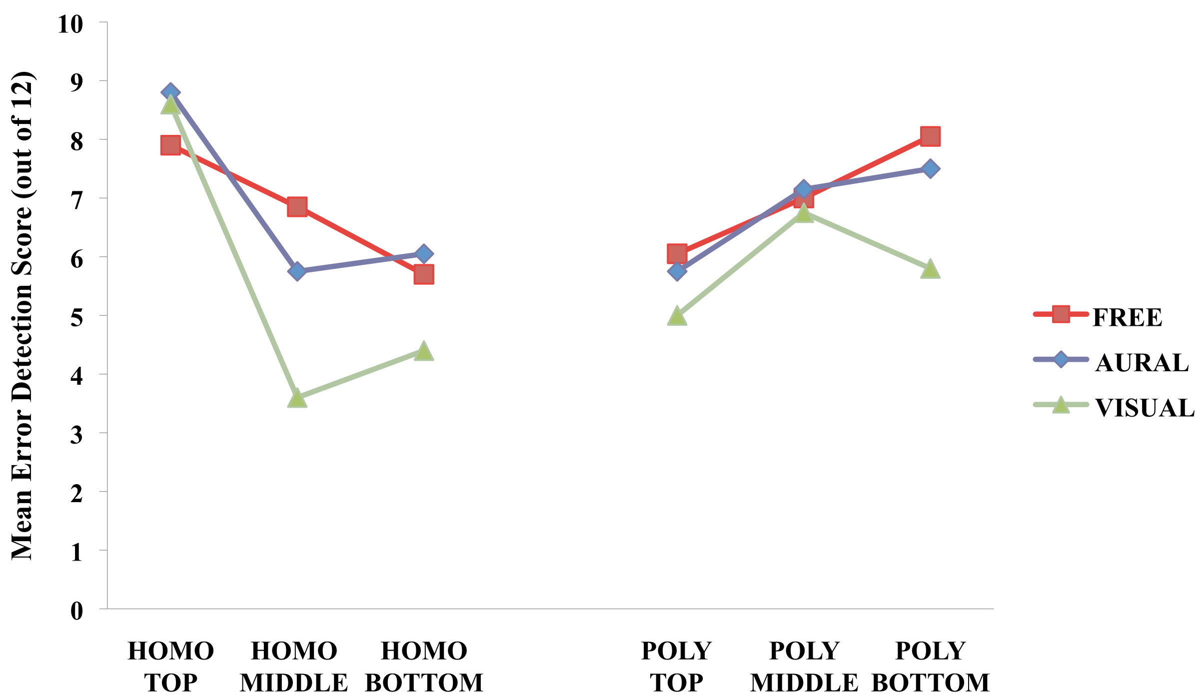

Figure 2. Three-Way Interaction among Error Location (Top, Middle, Bottom), Texture (Homophonic/Polyphonic) and Treatment Group (Aural, Free, Visual)

This interaction illustrates the lack of independence between texture and voice. Note the low detection accuracy score for errors in the middle voice of the homophonic excerpts compared to the top voice in all three groups. Errors in this musical context (middle voice of a homophonic texture) were particularly difficult for participants in the visual treatment group though these participants' detection accuracy for errors in the

middle voice of the polyphonic texture was actually slightly higher than the errors in either the top or bottom voice of the polyphonic excerpts. This lack of independence between texture and voice is evident in the significant interaction between these two variables, an interaction accounting for more than 40% of the variance in error detection scores, F (2, 114) = 38.65, $p < .0001$, partial $\eta^2 = .404$. Note that the only instance in which a visual group score is not lower than those of the free and aural group is when errors were located in the top voice of the homophonic excerpts. The complete results of this analysis are shown in the source table in Table 6.

Table 6

Source Table for Three-Way ANOVA with Repeated Measures: Texture * Error Location * Treatment Group

Source	df	Sum of squares	Mean Square	F	p	η^2
Treatment Group (G)	2	114.91	57.45	2.24	.12	.073
Error	57	1465.46	25.71			
Texture (T)	1	1.88	1.88	.45	.50	.006
T * G	2	2.54	1.27	.25	.78	.009
Error	57	293.29	5.15			
Error location (V)	2	50.41	25.2	3.92	.02	.064
V * G	4	35.23	8.81	1.37	.25	.046
Error	114	733.37	6.43			
T * V	2	399.44	199.72	38.65	<.0001	.404
T * V * G	4	63.86	15.97	3.09	.02	.098
Error	114	589.03	5.17			

Because aural and visual group participants spent more time studying the VDA in comparison to the full score, errors in the VDA were labeled as “focused” errors with those residing in the other two voices labeled as “non-focused” errors. This “error focus”

variable could only be combined for analysis with aural and visual group participants, since free group participants spent the entirety of their score study time with the full score. Therefore, the data obtained from the free group participants were excluded from any analysis examining the influence of error focus. As with the previous analyses, error type and error location could not be combined in the same analysis. The following two, four-way factorial ANOVAs with repeated measures, were conducted with error focus as a variable and did not include the data obtained from free group participants.

To determine the effects of error focus, texture, error type, and treatment group, a four-way factorial ANOVA with repeated measures was conducted with texture, error focus, and error type functioning as the within-subjects factors and treatment group (aural and visual only) functioning as the between-subjects factor. One pitch and one rhythm error was inserted into the VDA (focused errors) and was compared to the pitch and rhythm errors inserted into the other voices (non-focused errors). These errors were balanced across the three polyphonic and homophonic excerpts, resulting in three errors in each category (e.g. homophonic, pitch, focused). Since each error was worth three points, means were out of nine points.

Again, results indicate treatment group did not have a significant main effect on accuracy, F (1, 38) = 3.00, p = .09. Aural (M = 5.13, SD = 2.49) and visual (M = 4.26, SD = 2.56) group means were not significantly different. Also, texture did not have a significant main effect, F (1, 38) = .19, p = .67. Mean accuracy scores for homophonic (M =4.64, SD = 2.53) and polyphonic excerpts (M = 4.74, SD = 2.48) were not significantly different.

Error type had a significant main effect on error detection accuracy, $F(1, 38) = 37.35$, $p < .0001$, partial $\eta^2 = .496$. Pitch ($M = 4.08$, $SD = 2.55$) and rhythm ($M = 5.31$, $SD = 2.43$) means were significantly different. This variable accounts for almost 50% of the variance in error detection scores. Error focus also had a significant main effect on error detection accuracy, $F(1, 38) = 8.77$, $p = .005$, partial $\eta^2 = .187$. Detection accuracy of focused errors ($M = 5.08$, $SD = 2.55$) was significantly higher than non-focused errors ($M = 4.31$, $SD = 2.52$). This variable accounts for more than 18% of the variance in error detection scores.

Though texture did not have a significant main effect in this analysis, it was involved in a significant three-way interaction with error type and error focus, $F(1, 38) = 7.49$, $p = .009$, partial $\eta^2 = .165$. This interaction, accounting for 17% of the variance in scores, illustrates the lack of independence between these variables and is displayed in Figure 3.

There was little difference (pitch $M = 5.28$; rhythm $M = 5.08$) in detection accuracy between focused pitch and rhythm errors located in homophonic excerpts. There was greater difference (pitch $M = 4.2$; rhythm $M = 5.78$) in detection accuracy between focused pitch and rhythm errors located in polyphonic excerpts, with focus having a more positive effect on rhythm. Pitch errors scores were noticeably lower than rhythm errors in both textures on the non-focused errors. In summary, focusing had the largest effect on detection accuracy for pitch errors in the homophonic texture as opposed to the polyphonic texture. There was little effect on all errors in the polyphonic excerpts, where rhythm errors had consistently higher mean detection scores than pitch errors regardless of focus. This lack of independence between error focus and error type is evident in the

significant interaction between these two variables, an interaction accounting for 17% of the variance in error detection scores, F (1, 38) = 7.79, p = .008, partial η^2 = .17. The complete results of this analysis are shown in the source table in Table 7.

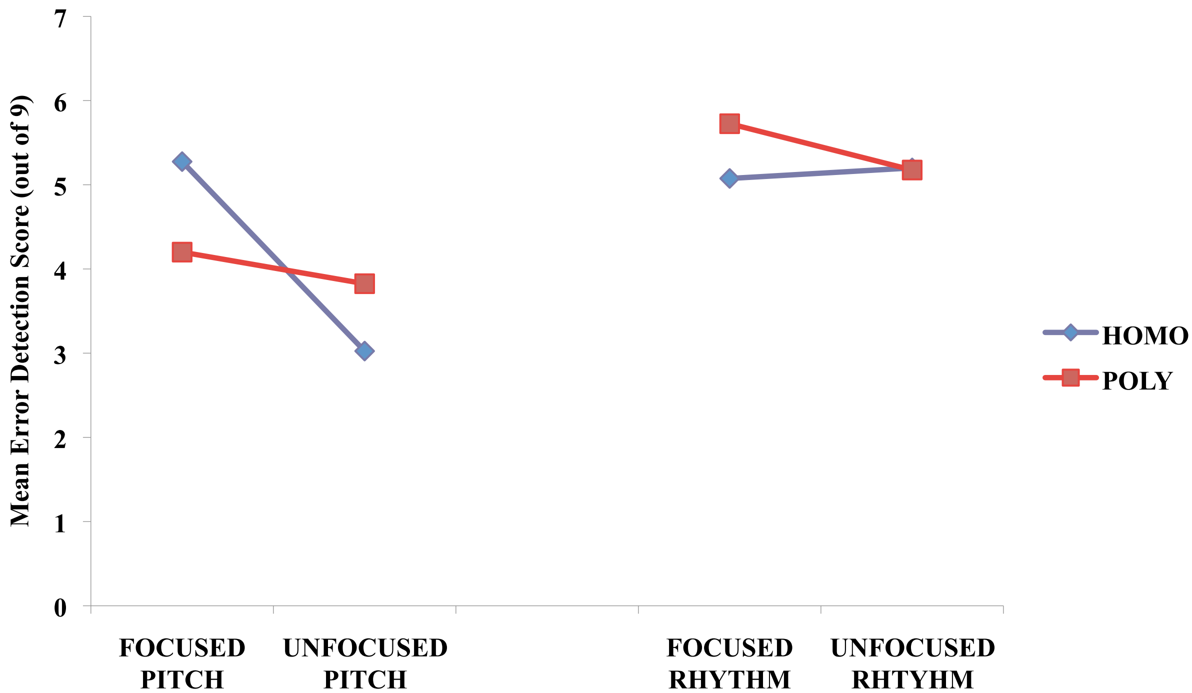

Figure 3. Three-Way Interaction among Error Focus (Focused/Non-focused), Error Type (Pitch/Rhythm), and Texture (Homophonic/Polyphonic)

To determine if an error's location had an effect on detection accuracy of focused and non-focused errors, a four-way factorial ANOVA with repeated measures was conducted with the error focus, texture, and error location functioning as within-subjects factors and treatment group (aural and visual only) as the between-subjects factor. Across the three-voice homophonic and polyphonic excerpts, a total of four errors were found in each voice with focused and non-focused errors balanced across each of the voices. The

focused errors (e.g. homophonic top focused) were compared to the non-focused errors that were located in the same voice (e.g. homophonic top non-focused). Since each error was worth three points, means were out six points.

Table 7

Source Table for Four-Way ANOVA with Repeated Measures: Texture * Error Focus * Error Type * Treatment Group

Source	df	Sum of squares	Mean Square	*F*	*p*	η^2
Treatment Group (G)	1	59.51	59.51	3.00	.09	.073
Error	38	753.48	19.81			
Texture (T)	1	.80	.80	.19	.67	.005
T * G	1	1.80	1.80	.42	.52	.011
Error	38	163.40	4.30			
Error Focus (F)	1	48.05	48.05	8.77	.005	.187
F * G	1	.20	.20	.04	.85	.001
Error	38	208.25	5.48			
Error Type (R)	1	120.05	120.05	37.35	<.0001	.496
R * G	1	1.80	1.80	.56	.46	.015
Error	38	122.15	3.21			
T * F	1	6.61	6.61	2.42	.13	.060
T * F * G	1	.11	.11	.04	.84	.001
Error	38	103.78	2.73			
T * R	1	4.51	4.51	1.24	.27	.032
T * R * G	1	7.81	7.81	2.14	.15	.053
Error	38	138.68	3.65			
F * R	1	23.11	23.11	7.79	.008	.170
F * R * G	1	.61	.61	.21	.65	.005
Error	38	112.78	2.97			
T * F * R	1	33.80	33.80	7.49	.009	.165
T * F * R * G	1	7.20	7.20	1.60	.21	.04
Error	38	171.50	4.51			

Treatment group did not have a significant main effect on error detection accuracy, $F(1, 38) = 3.00$, $p = .09$. Aural ($M = 3.42$, $SD = 2.01$) and visual ($M = 2.84$, $SD = 2.01$) group means are not significantly different. Texture did not have a significant

main effect on error detection accuracy, F (1, 38) = .19, p = .67. Mean error detection scores in homophonic (M = 3.1, SD =2.12) and polyphonic (M = 3.16, SD = 1.94) excerpts are not significantly different.

Error focus did have a significant main effect on error detection accuracy, F (1, 38) = 8.77, p = .005, partial η^2 = .187. Focused (M = 3.39, SD =2.0) and non-focused (M = 2.87, SD = 2.03) mean error detection scores were significantly different. This variable accounts for more than eighteen percent of the variance in error detection accuracy.

Error location did have a significant main effect on error detection accuracy, F (2, 76) = 6.27, p =.003, partial η^2 = .142. This variable accounts for more than fourteen percent of variance in the error detection scores. Mean detection accuracy for errors located in the top (M = 3.51, SD = 2.01), middle (M = 2.91, SD = 2.15) and bottom (M = 2.97, SD = 1.87) are significantly different from each other. Scheffé post-hoc procedures for multiple comparisons indicated the top and middle voice means are significantly different, p = .008, as are top and bottom voice means, p = .02. Middle and bottom voice means are not significantly different from each other, p = .95.

Error location was involved with texture in a significant two-way interaction, F (2, 76) = 37.61, p <.0001, partial η^2 =.497, indicating a lack of independence between these two variables and accounts for almost fifty percent of the variance in error detection scores. This interaction was significant in the previous analysis with these variables as can be seen in Table 6. This interaction is displayed in Figure 4.

In the homophonic excerpts, errors located in the top voice (M = 4.39) had much higher detection accuracy in comparison to errors located in the middle (M = 2.34) and bottom (M = 2.61) voice. In the polyphonic excerpts, errors located in the top voice

(2.69) had slightly lower detection accuracy in comparison to errors located in the middle (M = 3.48) and bottom (M = 3.33) voice. The complete results of this analysis are shown in the source table in Table 8.

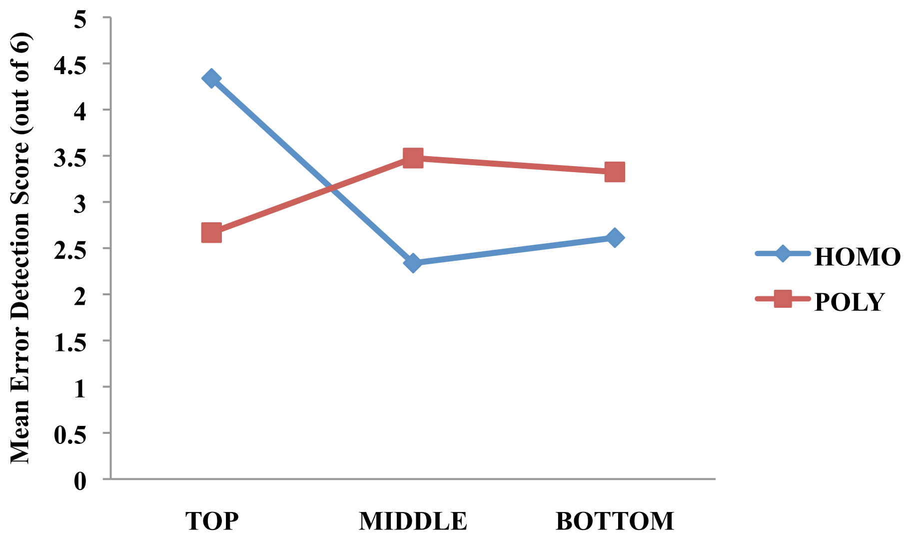

Figure 4. Two-Way Interaction between Error Location and Texture

Analysis of Phantom Errors

Phantom errors, or incorrect indications of error, were analyzed to determine if differences existed in the frequency of pitch and rhythm errors in both textures and three error locations. Participants indicated a total of 316 phantom errors across the six excerpts: 103 incorrect indications of rhythm errors versus 213 incorrect indications of pitch errors, a ratio of more than two to one. The contingency table representing the distribution of these phantom errors between the two textures is located in Table 9. A two-way chi-square analysis between error type and texture revealed significant differences in the distribution of pitch and rhythm errors across homophonic and

polyphonic excerpts, $\chi 2$ (N = 316, df = 1) = 5.90, p = .02, suggesting that the musical texture influenced accuracy of perception and detection of performance errors. Note the ratio of pitch to rhythm errors in the homophonic textures is almost three to one.

Table 8

Source Table for Four-Way ANOVA with Repeated Measures: Texture * Error Focus * Error Location * Treatment Group

Source	df	Sum of squares	Mean square	F	p	η^2
Treatment Group (G)	1	39.68	39.68	3.00	.09	.073
Error	38	502.32	13.21			
Texture (T)	1	.53	.53	.19	.67	.005
T * G	1	1.20	1.20	.42	.52	.011
Error	38	108.93	2.87			
Error Focus (F)	1	32.03	32.03	8.77	.005	.187
F * G	1	.13	.13	.04	.85	.001
Error	38	138.83	3.65			
Error Location (V)	2	35.58	17.79	6.27	.003	.142
V * G	2	7.14	3.57	1.26	.29	.032
Error	76	215.78	2.84			
T * F	1	4.41	4.41	2.42	.13	.060
T * F * G	1	.08	.08	.04	.84	.001
Error	38	69.18	1.82			
T * V	2	180.43	90.22	37.61	< .0001	.497
T * V * G	2	7.09	3.54	1.48	.24	.037
Error	76	182.32	2.40			
F * V	2	13.55	6.78	2.99	.06	.073
F * V * G	2	13.38	6.69	2.95	.06	.072
Error	76	172.57	2.27			
T * F * V	2	13.05	6.53	2.16	.122	.054
T * F * V * G	2	.01	.01	.002	.998	.000
Error	76	229.77	3.02			

A contingency table representing the distribution of phantom pitch and rhythm errors across the three voices is located in Table 10. A two-way chi-square analysis

between error type and error location indicated significant differences in the distribution of pitch and rhythm errors across each of the three voices, $\chi 2$ (N = 316, df = 2) = 32.603, p < .0001, indicating that error location influenced accuracy of perception and detection of performance errors. The ratio of pitch to rhythm phantom errors in the top voice is nearly equal while the ratios of pitch to rhythm errors is almost four to one in both the middle and bottom voices.

Table 9

Distribution of Phantom Errors across Homophonic and Polyphonic Excerpts

	Homo	Poly	Total
Pitch	122	91	213
Rhythm	44	59	103
Total	166	150	316

Table 10

Distribution of Phantom Errors across Top, Middle, and Bottom Voices

	Top	Middle	Bottom	Total
Pitch	56	76	81	213
Rhythm	61	18	24	103
Total	117	94	105	316

Item Analysis

Item analysis was conducted to determine not just the difficulty of each individual error but also its discriminatory power. Item difficulty values are expressed as the proportion of participants correctly detecting the error. Item discrimination values are derived by calculating point-biserial correlation values, which are an indication of " . . . the relationship between performance on one test item and performance on the test as a whole (Hinkle, Wiersma, & Jurs, 2003, p. 525)." As with any correlation, these values range from positive 1 to negative 1. A point-biserial correlation/item discrimination value closer to one is an indication those with the highest scores also correctly answered/detected this item. A value closer to zero indicates a weaker relationship between one's total score and their answer on this item. A positive value indicates those scoring higher on the test answered/detected the item correctly, while a negative value indicates that those scoring lower on the test answered the item correctly.

Only those responses receiving full credit (correct identification of the beat, voice and error type) were coded in this analysis as a correct response. All other responses were coded as incorrect. The item difficulty and item discrimination values for the twelve rhythm errors are located in Table 11.

Eight of twelve rhythm errors have an item difficulty value above .50, indicating that more than half of the participants correctly detected all three facets of the error (beat location, error location, and error type). In analyzing error conditions, no obvious relationship between item difficulty level and error condition is apparent. The two most difficult rhythmic errors (lowest item difficulty score) are located in the middle voice, with the least difficult item (highest item difficulty score) appearing in the bottom voice

of a polyphonic excerpt and was an error on which participants were focused. Note that all participants' responses are included in this analysis; therefore, error focus is not a variable applicable to one-third of responses included in this data set.

Table 11

Item Difficulty and Discrimination Values for Rhythm Error Conditions

Error #	Difficulty	Discrimination Power	Error Condition
17	.90	.38	Poly; bottom voice; focused
8	.72	.26	Homo; top voice; non-focused
16	.68	.45	Homo; bottom voice; focused
20	.68	.26	Poly; middle voice; non-focused
23	.67	.31	Poly; top voice; non-focused
14	.62	-.11	Homo; top voice; non-focused
24	.57	.35	Poly; middle voice; focused
1	.57	.31	Homo; top voice; focused
3	.35	.12	Homo; middle voice; non-focused
11	.32	.26	Poly; top voice; focused
12	.30	.27	Poly; middle voice; non-focused
5	.28	.27	Homo; middle voice; focused

Item difficulty and discrimination values for pitch error conditions are located on the next page in Table 12. These data, in comparison with those in Table 11, are an additional illustration of significantly higher detection accuracy of rhythm errors over pitch errors. Only three of twelve pitch errors exceed an item difficulty value of .50, while eight of twelve rhythm errors exceeded this value. Similar to the item difficulty and discrimination values for rhythm errors, no obvious relationship seems to exist between item difficulty level and error condition. For pitch errors, the four with the highest item difficulty values are all focused errors in either the middle or top voice, while the two

items with the lowest item difficulty value were both non-focused. This error focus result may have no practical importance since one-third of the participants in this data set (free group) did not experience a manipulation of attention.

Table 12

Item Difficulty and Discrimination Values for Pitch Error Conditions

Error #	Difficulty	Discrimination Power	Error Condition
22	.65	.44	Poly; middle voice; focused
4	.60	.54	Homo; top voice; focused
6	.57	.50	Homo; middle voice; focused
10	.47	.41	Poly; top voice; focused
21	.47	.26	Poly; bottom voice; non-focused
2	.42	.40	Homo; bottom voice; non-focused
13	.30	.27	Homo; middle voice; non-focused
9	.30	.19	Poly; bottom voice; non-focused
15	.18	.54	Homo; bottom voice; focused
19	.18	.41	Poly; bottom voice; focused
7	.17	.40	Homo; bottom voice; non-focused
18	.10	.29	Poly; top voice; non-focused

Verification of Treatment

In this study, participants detected errors following one of three specific treatments. Participants in the aural treatment group studied the voice of directed attention by sight-singing the voice, correcting errors in their sight-singing performance with the use of the piano and their own singing. Participants then sang the voice again, studied the entire score in silence for thirty seconds, and then detected errors in the full excerpt. Visual group participants spent the same amount of time studying the VDA but did so in silence. These participants were free to make marks to the score. Following their

study of the VDA, these participants also studied the entire score in silence for thirty seconds. As a means to further direct their attention to the VDA, it was highlighted in color in the full score. Participants then detected errors in the full excerpt. Participants in the free group choose for themselves how to study the score. They were able to choose any strategy in their study of the excerpt including use of the piano and their own voice.

Treatment was verified in two ways. First, to insure that all prescribed treatment procedures were followed, the researcher was present for the entire duration of treatment and subsequent error detection session. Second, all sessions were videotaped to enable further analysis of the participants' score study behaviors. The analysis of these behaviors, specifically the proportion of score study time spent in sound and in silence and the combination of both, enable an additional verification of treatment.

Participants in each treatment group were ranked according to their total error detection scores across the six excerpts. The videos of participants ranked in the top three, bottom three, and middle three (rank nine, ten, and eleven) were analyzed, providing a profile of the most, moderate, and least successful error-detecting participants in each treatment group. Each video was edited to remove the practice session portion of the treatment and the final error detection task. This editing removed portions of the video where neither treatment nor score study was occurring.

Digital videos were imported into Scribe software (Duke & Stammen, 2009) and were analyzed to determine the proportion of time spent in sound by: singing, playing piano or singing and playing; in silence by: studying/looking at the score, writing on the score; and proportion of time participants were off-task, defined as an obvious demonstration of behavior not related to studying the score. An independent observer

analyzed twenty percent of the videos. Each second of both observers behavioral analysis was compared to assess reliability of the researcher's analysis. An agreement was defined as any instance where both observers identified the same behavior. An agreement index (agreements divided by agreements plus disagreements) of .88 suggests the researcher's analysis to be reliable.

The total number of seconds spent in each score study behavior was converted to percentages and are presented in Table 13. Video analysis indicates that the aural group spent time in both sound- and silence-based score study behaviors, spent less than half of one-percent in off-task behaviors, and did very little writing on the score. The video analysis also confirms that the visual group spent no time in sound-based score study behaviors, spent more time writing on the score, and spent the most time in off-task behavior. The measure of off-task behavior is relatively conservative since only obvious examples of off-task behavior were coded as such.

As would be expected, free group participants utilized the time allotted for score study differently than did aural and free group participants. More than half of their time was spent playing the piano and about one-third of their score study time was spent silently inspecting the score. Though these participants were free to choose any behavior in their study of the excerpts, the distribution of their time across behaviors resembles aural group participants more so than visual group participants.

The behaviors listed in Table 13 could be combined into sound-based behaviors (sing, play, sing and play) versus silenced-based behaviors (look/study score and write on score). If viewed this way, the data demonstrate consistent score study behaviors of those in the aural and visual group, thus verifying the intent of the treatment: aural participants

used a sound-based score study approach while visual participants used a silence-based score study approach. Free group participants spent about two-thirds of their score study time in sound and one-third in silence.

Table 13

Treatment Verification by Group: Mean Proportion of Time Spent in Specific Behaviors Based on Top, Middle, and Bottom Three Scores in Each Group (A Sample of 9 Participants from Each Group)

	Sing	Play	Sing and Play	Look/Study Score	Write on Score	Off-Task
Aural	29.1%	19.6%	26.4%	24.6%	.2%	.2%
Visual	0.0%	0.0%	0.0%	86.8%	11.6%	1.6%
Free	7.6%	56.2%	2.1%	33.5%	.5%	0%

Participant Perceptions Derived from Post-Treatment Questionnaire

After completing the error detection task, participants answered the following questions: “What did you do that was most helpful in preparing yourself to detect errors?” and “What else would have enabled you to detect more errors?” Participant responses to each question were analyzed to determine the most frequent responses to each question. Comparing these results across treatment groups yielded insights regarding how participants behaved as a result of the prescribed treatment. Participants’ written responses for each question were transcribed and a list of behaviors/factors indicated in these responses was generated. A response was considered prominent if

indicated by four or more participants; therefore, only behaviors/factors indicated by four or more participants are presented in the Tables 14 and 15. All indicated behaviors/factors and frequency of each are presented in Appendix J. Because no interpretative analysis was applied to participant responses, no measure of reliability was necessary.

Table 14 lists participants' indications of the most helpful behaviors/strategies and the frequency of that response. The only response common to all treatment groups was hear/sing/play in the mind (audiation). This result is not surprising for visual group participants, whose sole means of hearing pitch was to mentally convert the notated score into an aural expectation. Free and aural group participants did not have to rely on their ability to convert the notated score into sound: they could sing and/or play the piano. Yet, these participants at least perceived that attempting to mentally convert notation into sound to be helpful. Though free and aural group participants' found value in mentally converting notation into sound, free participants found playing piano to be the most helpful behavior utilized in their score study, a behavior that aural group participants also found to be very helpful in the detection of errors. This suggests that while silent, mental conversion of notation to sound may be helpful, participants found that external realization of the notated score, preferably via the piano, is more helpful than attempting to realize the score mentally.

The effects of directing attention are evident in these responses. Both aural and visual participants found listening/focusing on one voice per hearing to be helpful. This was the most frequently indicated helpful strategy of the aural treatment group. Though less than four free group participants indicated behavior to be helpful, eleven participants

did indicate that playing individual lines was a helpful strategy. This strategy of playing individual lines, a form of de-contextualization, chosen organically by these participants, is a form of directed attention.

Table 14

Participant Reports of Helpful Behaviors/Strategies in Detection of Errors

Group	Behavior	Frequency of response (out of 20)
Aural		
	Listen/focus on one part per hearing/at a time	10
	Play piano	9
	Hear/sing/play in mind/audiate	4
	Focus on accidentals/notes outside of key	4
	Conduct/keep beat	4
Visual		
	Use solfege (written or heard in mind)	11
	Hear/sing/play in mind/audiate	6
	Listen/focus on one part per hearing/at a time	4
	Focus on rhythm	4
Free		
	Play piano	15
	Play individual lines	11
	Hear/sing/play in mind/audiate	5
	Use solfege	4
	Play lines together	4
	Sing	4

Table 15 lists participants' indications of factors that would have improved their detection of performance errors. Only factors indicated by at least four participants were included in this list. Overall, there is much less consensus among participants regarding what would have improved their detection of performance errors. Not surprising, the sole

response common to all treatment groups was “more score study time.” Visual group participants indicated playing piano most frequently as a factor that would have improved detection of performance errors. This is not a surprising response since these participants were not permitted to sing or play.

Table 15

Participant Report of Factors That Would Have Improved Their Detection of Errors

Group	Behavior	Frequency of response (out of 20)
Aural		
	More score study time	6
	Opportunity to sing/hear/play other parts	5
	Issues regarding key	4
Visual		
	Play piano	7
	More opportunities to hear excerpts	4
	More score study time	4
	Sing	4
Free		
	Better piano skills	4
	More opportunities to hear excerpts	4
	More score study time	4

CHAPTER 5: DISCUSSION

> "When a conductor is rehearsing a group, he will often hear 'something go wrong' but be unable to say with certainty which part went wrong without going back and hearing the section again. It appears he was focally processing a part which did not go wrong, and needs to redirect his focal attention to locate the mistake" (Sloboda, 1985, p. 170)

Introduction

In the assessment of large group ensemble performance, the teacher/conductor must aurally navigate through an auditory maze in order to diagnose performance inaccuracies and prescribe appropriate remedies, all as a means of improving musical performance and thereby maximizing the music's expressive potential. Sloboda's reference above illustrates the complexity of the task. This study was designed based on the assumption that effective navigation through this maze of sound is related to the process of orientation occurring before sounds are produced by an ensemble. In essence, this study investigated whether manipulating attention during the score study process influenced participants' detection and identification of performance errors. The experimental treatments were designed to reflect a process teachers/conductors could use prior to the aural navigation experienced during rehearsal.

Directed Attention

Results indicated that score study treatments involving directed attention (aural), directed attention (visual), and free study neither helped nor hindered error detection accuracy. The hypothesis that directed attention created an attentional impediment, which would support the findings of Simon and Chabris (1999) and Koreimann et al. (2009) is not supported by these data because analysis revealed no differences among groups.

On the post-treatment questionnaire, more than 25% of the participants (17 of 60) indicated that listening to one voice per hearing was one of the most helpful strategies in their detection of errors. This was an organically chosen strategy of the participants, not a derivative of the treatment—or perhaps it was. Fifty percent of the aural group (10 of 20) and twenty-percent of the visual group participants (4 of 20) indicated this specific strategy to be helpful. Perhaps this focus on individual voices was an outgrowth of the directed attention treatment during which the majority of score study time was spent attending to only one voice rather than the entire score.

Aural and visual participants were significantly more accurate in detecting focused errors than of non-focused errors. This significant result gives credence to Sloboda's hypothesis regarding detection of errors, where wrong notes located in a focal melody are detected as a "deviation from the known melodic pattern" (p. 170), thus implying that knowledge of and focus on each individual voice may enable improved detection of errors.

Sloboda presents this single focus idea within the context of listening to polyphonic music. A facet of the present investigation sought to determine whether directing attention to an individual voice is influenced by musical texture (polyphonic/homophonic). A significant interaction between texture, error type, and error focus suggests that focusing is most helpful in the detection of pitch errors in homophonic contexts. Perhaps the temporal synchrony of the homophonic excerpts, if not homophony in general, results in a fusion of the multiple voices such that each voice cannot be easily perceived separately as an individual voice. Focusing and having greater familiarity with one of the three voices may have engendered sufficient perceptual

separation such that the more familiar voice could be parsed out of the texture, resulting in greater pitch acuity.

Focusing had little effect on the detection of rhythm errors, regardless of the musical texture in which they were located. In a study of two-part dictation, focusing first on rhythm significantly improved dictation accuracy; focusing first on pitch did not (Beckett, 1997). In the current study, focus improved detection of pitch errors. In the results of item analysis, located in Table 12, the four pitch errors detected by the highest percentage of participants were those located in the voice of directed attention (VDA), suggesting that directing attention to a single voice in multi-voiced music may improve pitch perception.

Though treatment groups' error detection scores were not significantly different, there are indications of benefits from directing attention to one voice during score study, results that may have implications for teachers/conductors and those instructing pre-service teachers. The significant interaction between treatment group, texture, and error location displayed in Figure 2 illustrates the strikingly similar results between free study and aural group participants. This may initially seem surprising since the free group experienced no attentional manipulation during their score study: they had full score access for the duration of their study time, and thus functioned as a control group. It was assumed that this setting would foster a lack of attentional bias to any one voice, thus enabling these participants to attend to all voices in study and during the error detection task. This assumption loses credibility given results that portray little difference between aural and free group participants on error accuracy.

Maybe the similarity in error detection performance between free and aural group participants is due to the tendency of the free group participants' proclivity to isolate one of the voices in the three-voice excerpts by playing and/or singing it in isolation, void of its relationship among the other voices in the excerpt. This directed attention strategy was often used when participants studied the polyphonic excerpts, where the characteristic asynchronous rhythm between voices which made playing all three voices at once much more difficult. I observed many free group participants initially attempt to maintain the context of the excerpt by playing all three voices at once, only to discover the difficulty of doing this, resulting in isolation of an individual voice.

Where differences are most noticeable is in the visual group performance in to those of the aural and free groups. With some exception, the performance of the visual group is the lowest of the three treatment groups. Though the free group treatment was specifically designed to create a control group, the visual group functioned in some ways like a control group. Though free group participants experienced no attentional manipulation, the visual group lacked any sound-based score study experiences.

Approaches to Score Study

The similar results between aural and free participants may suggest that score study procedures incorporating sound are more likely to lead to higher error detection accuracy. This hypothesis is consistent with results from other investigations that have shown improved error detection following sound-based score study behaviors such as score singing (Byo & Sheldon, 2000; Hochkeppel, 1993) and study with a correct aural example (Crowe, 1996; Hopkins, 1991).

Though the interaction between treatment group, texture, and error location demonstrates differences between treatments, in this case study with sound (aural and free) versus study without sound (visual), the differences are not significant. These data provide evidence that participants may have been able to mentally convert the written notation into an aural expectation, even though they did not sing or play the piano. Hochkeppel (1993) found silent score study to be an effective method of improving error detection. It is surprising more participants in the visual group did not indicate audiation (hearing in the mind) to be a helpful strategy in error detection. Only six of twenty visual group participants indicated as such, despite their limited choice in score study strategies since they were not permitted to sing or play the piano. Many visual group participants seemed unsure of how to spend their score study time, and spent some amount of time off-task, which was defined as an obvious demonstration of behavior not related to studying the score. Is this off-task behavior indicative of a lack of skill in mentally converting notation into sound? Or is it about an awareness deficit that prevents participants from making a connection with 'hearing in the mind' as a viable study technique? Is lack of skill or awareness the source of differences among groups displayed in Figure 2, differences which are not significant?

Also, there is no way of knowing what was actually happening mentally while the participants were looking at the score. Though they were looking at the score, there is no way to measure what, if anything, they were "hearing" in their mind. Interestingly, twenty-percent of free and aural group participants reported that attempts to hear the music in their mind during study was a helpful strategy in their detection of errors, suggesting that even though these aural and free group participants had the option to

realize the notated score through the use of singing and/or the piano, they attempted to mentally convert notation into sound. These data do also suggest that there is value in attempting to mentally convert notation into aural expectations without the use of a piano.

Expert conductors overwhelmingly say that score study should involve sound-based behaviors such as singing and use of the piano coupled with attempts to mentally convert musical notation into aural expectations. Results from this study suggest this may be an effective score study approach, where time is based in silence, mentally converting musical notation into aural expectations of the score and is paired with time based in sound, where one tests hypothesized aural expectations resultant from mental conversion of musical notation through singing and use of a piano. The strikingly similar performance of aural and free group participants illustrates the value of score study when based in sound. According to H. Robert Reynolds, the goal of score study is to have the s strong aural image and to use whatever means accessible and necessary in its creation (Ellis, 1994, p. 170). Free group participants could use whatever means were accessible and necessary and perhaps were successful because they were forced to problem solve on their own.

Could students left to their own devices, surrounded by divergent thinking and innate instincts, solve the problem just as well if not better than if we had devised the problem-solving strategies for them? Do musicians lacking in teaching/conducting experience tend to focus on individual lines? If so, this could be an explanation for why the score study treatments did not have a significant main effect on error detection scores. If this single line focus is a tendency of young teachers/conductors, it is possible that

more experienced and successful teachers/conductors utilize a score study processes that is more wholistic and comprehensive.

Musical Context: Texture, Error Location, and Error Type

Perhaps the result of no differences among the score study approaches is a result of the various musical contexts of which the inserted errors were a part. Three variables in this study determined the musical context of the inserted error: texture, error type, and error location all of which had differing effects on perception. Results from the current study do not support the findings of Byo (1997) and Crawley, et al., (2002) where results indicated participants identified more errors located in homophonic textures. Although texture did not have a significant main effect on error detection accuracy, its involvement in three significant interactions with the other musical context variables, error location and error type, illustrate its influence on detection of the inserted errors. The interaction between texture and error location is particularly striking. These results, consistent with other research (Acker & Pastore, 1996; Palmer & Holleran, 1994), demonstrates the lack of independence between musical texture and the error's location. Error location was most influential on errors located in the top voice of the homophonic excerpts. Detection accuracy for errors in the top voice of the homophonic was much higher than for errors located in the middle and bottom voices. Error location had much less effect on the polyphonic excerpts. These results are consistent with those of Palmer and Holleran (1994), who also found participant detection accuracy to be highest for pitch changes located in the top voice. Acker and Pastore (1994) found that participant detection of errors in a homophonic context was best when errors were located in the bottom voice.

All of this illustrates the dominance of musical context as a critical variable in one's ability to detect errors in musical performance.

The item difficulty results complicate the task of determining how musical context influences error detection. These results show no consistent pattern of influence, other than the higher detection accuracy of rhythm over pitch errors, a result supported by the findings of Beckett (1997), Byo (1993, 1997), Hopkins (1991) and Sheldon (1998). Rhythm's perceptual dominance is also illustrated upon examination of the phantom error results in Tables 9 and 10. The total of pitch phantom errors far exceeds the number rhythm errors, results that are consistent with previous research (Byo, 1993; Sheldon, 1998). Accurate pitch perception may require the temporal organization that rhythm provides, a postulation articulated by Beckett (1997), who suggested that perhaps rhythm is easier than pitch in dictation tasks.

It is somewhat surprising that error type and error location had significant main effects on error detection accuracy while texture did not, especially when multiple studies demonstrated influence from texture on the detection and perception musical changes/errors (Acker & Pastore, 1996; Byo, 1993, 1997; Crawley, et al., 2002; Palmer & Holleran, 1994; Sloboda, 1985). Perhaps texture's influence on perception was mitigated by the three repetitions of the stimuli or even from score study process. This would suggest that texture's influence on perception and detection of performance errors is most potent when music is unfamiliar. Perhaps certain musical contexts force our attention such that only intentional attentional manipulation enables one to remain focused on particular aspects of the score. Perhaps those easily distracted in life and have

a global difficulty focusing attention and are more apt to be influenced by a musical texture dominated by independence of musical voices.

Ecological Validity

Overall, these data support previous findings that indicate undergraduate and graduate musicians with little to no ensemble conducting experience often struggle to consistently detect the musical performance errors. The mean error detection score for all participants was 38.88 out of 72, a score just beyond chance. The highest score among the sixty participants was 61 of 72 (84.72%) points; the lowest 10 of 72 (13.89%), thus illustrating the wide range of success participants had with this task. Participants in other error detection studies demonstrated the same difficulties detecting musical performance errors, with mean error detection rates below chance (Byo, 1993, 1997). Initial inspection of these scores might suggest concern about the aural perceptive abilities of these participants, but does this task actually predict participants' skill at identifying performance errors in a rehearsal situation?

In an authentic scenario with live musicians and acoustic timbres, these results may be different. Perhaps the subtle individual differences in timbre among players in the same section aid in music perception and performance error detection. The stimuli used for this study represented three different timbres. The intent was to create and utilize stimuli with the highest ecological validity possible that were still viable for use in an experimental setting. Despite attempts to create ecologically valid stimuli, the electronic generation results in stimuli with no attacks or releases. The presence of the initial attack has been demonstrated to be a critical component for accurate musical instrument identification (Cassidy & Schlegel, 2009; Elliott, 1975; Paul, 2005). This may have

limited participant ability to discern individual timbres or may have even resulted in distraction to participants due to expectation of what the timbres indicated on the scores would sound like. In live performance, a teacher/conductor may hear something “go wrong” on one side of the ensemble, thus eliminating those on the other side of the ensemble as the portion of the ensemble needing to be rehearsed. Perhaps this supplemental acoustical information that is characteristic of live performance aids in detecting performance inaccuracies in live performance.

Teachers/conductors likely consider the abilities and tendencies of the performers in their ensemble when studying a score as a facet of rehearsal preparation, thus developing rehearsal priorities and expectations of where errors are likely to occur. Expectation of error as a form of score study in the present study was not a viable facet of participants’ score study procedures due to the contrived nature of this task. One particular visual group participant articulated this very argument, that the contrived nature of the task and the process he utilized to learn the score was not how he would study a score in preparation for rehearsal. Though stated here by a visual group participant, it is likely that all participants had limited means of deriving an expectation of error for this type of task. This suggests participants’ selected score study strategies may not be in all cases indicative of how they typically and innately prepare unfamiliar music in anticipation of rehearsal.

Perhaps this is an issue of ecological validity of not only the stimuli, but also, the error detection task itself. What, if anything, does this task reveal about the participants? Perhaps it is simply a measure of their aural discrimination abilities void of context. How valuable and predictive of future success is such a measure? Do the results on the task in

this investigation, or any error detection task predict any other music teacher behaviors? The research investigating these questions has yielded some insight. Gonzo (1971) found teaching experience to be a significant factor in the detection of pitch errors though Hedden and Johnson (2008) found that freshman music majors were just as accurate as teachers with at least 10 years of teaching experience at detecting the pitch accuracy of second graders. The assumption that increased training and teaching/conducting experience will improve the ability to detect errors is not consistently found in the literature.

Is it possible that this task is actually harder than what teachers/conductors do in real life? Perhaps the scores on this task are artificially low, a result of completing a task that is harder than necessary. Will practicing "error detection" devoid of an actual performance context improve the ability to detect errors in the context of musical performance? In authentic rehearsal settings, teachers/conductors must detect errors while looking at the score and conducting, both of which may inhibit aural acuity. Creating tasks that simulate what teachers/conductors must do when error detecting have the most ecological validity and greatest implications for the field.

Perhaps the differing rhythm results between the current investigation and Beckett (1997) are due to the task, a difference between detecting performance errors and dictation. Does this suggest that one's ability in musical dictation is unrelated to musical performance error detection, a result that would run counter to results found by Larson 1977)? Is this an issue related to transfer? Do we assume honing dictation, sight-reading and other theory skills will automatically improve ability to detect musical performance errors?

Perhaps activities and exercises designed to improve error detection ability need to have higher ecologically validity, in that they mirror of what teachers/conductors do. Opportunities to detect errors in live performances would seem t have the highest ecological validity, as it what teachers/conductors do on a daily basis. Are we improving and honing the skills that musicians "need" to be successful performers and teachers/conductors, or are we training them to improve their ability to succeed on tasks that are disjunct and unrelated to their musical lives? Further research will aid in answering these questions.

Implications for Future Research

This investigation sought to determine the effects of manipulating participants' attention via specific score study procedures on error detection ability. The influence of an error's musical context (error location, error type, and texture) was considered in this analysis. My hope was that the results would elucidate effective score study strategies that could be utilized in preparation for rehearsal along with listening/attending strategies that should be utilized during rehearsal, in the moments when assessment and subsequent feedback of music performance must be accurate and as immediate as possible.

Does directing attention to one aspect of musical performance impede the ability to perceive performance errors and undesired musical performance? If one is too focused on the performance of one section within an ensemble, will they be unable to hear poor intonation, imprecise articulation, and wrong notes in other sections? The literature on change blindness/deafness and inattentional blindness/deafness has numerous implications for future research by musicians. If we are less likely to detect that we which did not expect to see, such as a gorilla in the midst of group of basketball players, are we

also less likely to detect/perceive that which we did not expect to hear (Koreimann, Strauß, & Vitouch, 2009; Simons & Chabris, 1999)? Perhaps errors deemed improbable by teachers/conductors are the ones that are not detected. Research in visual change detection has proposed that changes that are more probable are those that are detected more often (Beck, et al., 2004). Are teachers/conductors to some extent "deaf" to the errors they did not expect would occur, or those they would deem improbable? Further research investigating the relationship between an error's perceived probability of occurring and its rate of detection would illuminate this potential association.

Directing attention is likely a necessary manipulation of one's focus in order to hear individual voices, let alone perceive quality and accuracy, most especially in polyphonic music. Sloboda (1985) writes that if one is actually able follow all voices in a polyphonic composition simultaneously, it is due to " . . . a high degree of familiarity with the individual parts, through repeated hearing" (p. 170). This would suggest that musical texture may affect musical perception and perhaps should inform score study. Maybe the study of polyphonic music should focus on learning individual lines during score study in order to develop the high degree of familiarity that may be necessary to effectively and accurately assess musical performance. Perhaps this focus would be effective when studying homophonic music as well. Future research that utilizes a score study approach focusing on learning the individual lines in homophonic and polyphonic music would reveal if this approach increases the ability to accurately assess group musical performance.

Byo and Sheldon (2000) found a score study approach focusing on learning of individual lines to be an effective method for improving detection of performance errors.

Does focusing on individual lines impede the development of a comprehensive image of the piece? Could focusing on individual lines—a horizontal focus—limit the ability to hear the totality of the piece and how it fits together vertically as well as horizontally?

Maybe one should not focus on individual lines in score study since to do so would change the musical context of the score being studied. The complexity of any one voice a polyphonic texture is likely no more difficult than of the other voices. The difficulty arises when individual melodic lines are performed simultaneously. Not only does this create perceptual difficulties, as discussed by Sloboda (1985), but also performance difficulties as evidenced by the participants when they attempted to maintain the context by playing all three voices at once. Once difficulty arose, most participants resorted to playing the individual lines rather than maintaining the context of that individual line.

Perhaps what is more effective to compensate for the effect of texture is to manipulate attention while listening to musical performance. If so, it would seem logical to assume that listening to individual lines would be an effective strategy to utilize when rehearsing polyphonic music. In initial rehearsal scenarios of unfamiliar polyphonic music, perhaps there should be less "tutti" rehearsal and more time spent rehearsing individual lines, as a means to orient everyone, including the teacher/conductor, to the perceptual intricacies of the music. If nothing else, knowledge of musicians' perceptual tendencies may influence how teachers/conductors choose to study and rehearse music of differing textures.

Research efforts should seek to determine effective score study strategies. The results of this study suggest that score study in silence, where participants, most of whom

were undergraduates in a music teacher preparation program, utilize only the ability to mentally convert the notated score into an aural expectation, may not be as effective as a score study strategy that utilizes both mental conversion of notation coupled with sound-based strategies, by either singing and/or playing voices of the score.

The ability to remember content following study of it is one measure of the effectiveness of that study process. Agres and Krumhansl (2008) illustrated this potential relationship stating, " . . . the reason relatively large changes in melodies go undetected is because some tones are not retained in working memory" (2008, p. 974). Does one's working memory capacity influence the ability to retain the information encoded during score study? How would musical working memory be measured in order to determine whether such a relationship exists? Even if a relationship between working memory and error detection exists, unless there are reliable and valid means of improving musical working memory, this finding may only reveal another complex dimension of music perception. The goal of score study is to create expectations of how the music should sound, to make interpretative decisions regarding the music's expressive potential, and produce the highest quality performance possible. This area of research is ripe for investigation, for it deals directly with music teacher effectiveness, assessment, and feedback.

All participants in this study had some portion of their score study time where strategy choice was theirs. This provided interesting data regarding participants' innate practice procedures when learning unfamiliar music. Free group participants provide the largest amount of practice data because all of the choices made regarding score study strategies were theirs to make. There was great variety in how participants in this group

chose to study the excerpts. Some chose to never sing, some did a combination of singing and playing, some played only individual lines, some played multiple voices together, and some wrote on the score. There were a few participants who used the piano sporadically, only playing a few isolated chords or melodic gestures. They sat in silence, looking at the score, singing or humming at random moments, playing a few chords or melodic gestures on the piano before returning to a silent state. These participants seemed to use the piano only to verify their expectation of the music, an expectation derived from mental conversion. This is a description of the upper strata of free group participants. Visual group participants were not allowed to sing or play the VDA and one must assume could only rely on mental conversion and markings to the score. Some participants wrote furiously all over the score, writing in solfege syllable for each pitch, circling portions of the music and marking intervals. Then, there were those who wrote nothing, sitting in silence and doing what one could only assume was an attempt mentally convert notation into aural expectations. Is a relationship between the amounts of added visual material, markings made by the participant, and their aural acuity? Does "writing in the score" help or hinder one's ability to accurately assess musical performance?

Aural group participants were free in their score study choice following initial sight-singing of the voice of directed attention (VDA), where they were allotted time to correct the errors they perceived in their sight-singing performance. For many participants, errors that were made in their sight-singing performance did not get corrected via practice and were still present when the participants sang the VDA in the third phase. It was interesting to watch participants not rehearse the mistakes they made in this initial phase. Perhaps they did not perceive the errors in their own performance, a

performance of a single melodic line. Byo and Sheldon (2000) suggest that the ability to accurately perceive a score is predicated on one's ability to accurately perceive one line of music as a starting point in score preparation. This begs the questions as to whether these participants would detect the errors when practicing on their major instrument, let alone when rehearsing an ensemble.

Is there a relationship between one's practice effectiveness of unfamiliar music for performance on their major instrument, and one's score study effectiveness study as measured by the detection of errors in a subsequent performance of the practiced/studied music? It seems if one is unable, perhaps unwilling, to detect the flaws in his own musical performance that he may just as unable, perhaps unwilling, to detect the flaws in the performance of others. The findings of Duke, Simmons, and Davis (2009) indicated that the ability to detect errors in one's own performance during practice is a related to subsequent performance accuracy. This would suggest that if one does not accurately assess their own practice, as evidenced by their ability to anticipate errors, identify their precise location, and rehearse the error until it is no longer present, that one would be no more accurate assessing someone's performance. Therefore it seems reasonable to expect that accuracy with which a teacher/conductor assesses their performance is a revealing glimpse at how accurately they will assess the performance of others.

What are the implications here then for music teacher training? It seems that those who one day aspire to stand in front of other musicians and make decisions regarding performance quality need to practice the necessary problem solving strategies that they will need when rehearsing an ensemble. Future research could examine the potential relationship between one's ability to detect errors in their own performance and the

ability to detect errors made by others. Perhaps efforts requiring students to evaluate their performance would foster more accurate detection in the performance of others.

Error detection is not a perfunctory task that one experiences in ear training classes; rather, it is a derivative of one's musical perceptive prowess and awareness resulting from consciously attending to and contemplating music's accuracy. How can teachers/conductors hone their musical perceptive prowess? How can error detection be presented to pre-service teachers as a necessary and vital component of their musicianship and teaching effectiveness? Perhaps those participating in error detection tasks view this as something separate and unrelated to ensemble rehearsing. Perhaps they are right: if stimuli and tasks lack ecological validity, in that they are too different from the music and music teaching tasks that one is likely to encounter when rehearsing an ensemble, then there would seem to be no long-term value for the efforts one expends to improve performance on such tasks.

Results support the findings that though error detection is a critical skill for effective music teaching, participants struggle in their attempts to do it well. Future research needs to begin establishing how this type of task relates to one's effectiveness in an authentic music teaching environment. If there is no relationship between tasks like the one designed for this investigation, leaders in music education need to develop more relevant methods to train future teachers/conductors.

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APPENDIX A: EXCERPTS (ERROR-FREE)

Practice Excerpt

Gavotte "Les Moissonneurs" from Pieces de Clavecin

Book II, 1717

Couperin
Carl A. Rosenthal

Excerpt from Nocturne in D, Opus 28, No. 3

Louis Gianella
Edited by E. A. Wienandt

Excerpt from Divertimento 1

W. A. Mozart

Trio, Opus 87

L. V. Beethoven

Excerpt from Tandem Trio

Edward S. Solomon

Sarabande excerpt

from Suite in D minor

G. F. Handel

Passepied

from Suite in C

Bach

APPENDIX B: EXCERPTS WITH ERRORS

Practice Excerpt

Excerpt from Nocturne in D, Opus 28, No. 3

Louis Gianella
Edited by E. A. Wienandt

Excerpt from Divertimento 1

W. A. Mozart

Trio, Opus 87

L. V. Beethoven

Excerpt from Tandem Trio

Edward S. Solomon

Sarabande excerpt

from Suite in D minor

G. F. Handel

Passepied

from Suite in C

Bach

APPENDIX C: PILOT TESTING DATA FOR SCORE STUDY TIMES

	Nocturne in D				**Divertimento No. 1**				**Trio Opus 87**			
	Sing 1	Study	Sing 2	Total	Sing 1	Study	Sing 2	Total	Sing 1	Study	Sing 2	Total
Sub 2	22.7	16.9	19.0	88.6	23.4	49.0	17.5	119.9	17.6	11.0	20.5	79.1
Sub 1	24.2	26.2	22.9	103.3	24.0	72.0	21.0	147.0	19.5	27.3	14.0	90.8
Sub 3	17.1	18.6	12.6	78.3	18.3	136.3	13.9	198.5	13.4	39.7	10.7	93.8
Sub 4	29.1	189.5	40.2	288.8	36.0	217.3	26.0	309.3	25.7	131.7	20.3	207.7
Sub 5	10.6	43.2	14.0	97.8	26.7	183.4	12.5	252.6	20.8	64.9	17.7	133.4
	103.7	294.4	108.7	656.8	128.4	658.0	90.9	1027.3	97.0	274.6	83.2	604.8
Means	**20.7**	**58.9**	**21.7**	**131.4**	**25.7**	**131.6**	**18.2**	**205.5**	**19.4**	**54.9**	**16.6**	**121.0**
FINAL	**21**	**59**	**22**	**131**	**26**	**132**	**18**	**206**	**19**	**55**	**17**	**121**

	Tandem Trio				**Sarabande excerpt**				**Passepied**			
	Sing 1	Study	Sing 2	Total	Sing 1	Study	Sing 2	Total	Sing 1	Study	Sing 2	Total
Sub 2	21.2	32.4	15.8	99.4	21.6	43.9	19.0	114.5	30.3	60.2	27.4	147.9
Sub 1	24.3	59.2	17.9	131.4	23.0	52.4	21.7	127.1	23.3	58.7	22.0	134.0
Sub 3	25.0	139.5	13.2	207.7	24.0	197.5	10.9	262.4	26.8	221.7	16.9	295.4
Sub 4	33.4	311.3	27.2	401.9	30.7	499.9	22.0	582.6	31.1	277.0	32.6	370.7
Sub 5	46.1	171.7	27.7	275.5	32.1	165.5	29.1	256.7	23.6	151.0	43.8	248.4
Sub 2	150.0	714.1	101.8	1115.9	131.4	959.2	102.7	1343.3	135.1	768.6	142.7	1196.4
Means	**30.0**	**142.8**	**20.4**	**223.2**	**26.3**	**191.8**	**20.5**	**268.7**	**27.0**	**153.7**	**28.5**	**239.3**
FINAL	**30**	**143**	**20**	**223**	**26**	**192**	**21**	**269**	**27**	**154**	**29**	**239**

Times were rounded to the nearest second

APPENDIX D: INSTRUCTIONS USED IN PILOT TESTING AURAL GROUP TREATMENT

This is an error detection task during which you will attempt to locate and identity performance errors. The inserted errors are typical of high school musicians during initial readings of unfamiliar music. There are errors in pitch and rhythm throughout the excerpts. **Note that an error in pitch refers to a discrepancy between notated and performed pitch. It does not refer to intonation discrepancies**.

Before detecting performance errors, you will direct your attention to a specified instrumental part. Though your attention is directed on one of the three instrumental parts, errors may occur in any part. Note that though these are instrumental scores, **all parts are in concert pitch**.

Turn to excerpt one, an excerpt from "Nocturne in D, Opus 28, No 3" by Gianella. Direct your attention to the flute part. In a moment you will sight-sing this part. You will be free to sing at a tempo slower than the one marked and are welcome to adjust the octave in which you are singing at any time. Be aware that though you may sing in another octave, all parts will sound in the octave in which they are written in the recordings of the excerpt.

Sing through the part in its entirety even if you make multiple mistakes. Though you may struggle with pitch accuracy, strive for precision in your performance of the rhythmic content. At this time, play **only** first note of the flute part on the piano and begin singing the part. (wait for this to be completed – TIME THIS FOR EACH PILOT PARTICIPANT)

Now, select portions of the line where you perceived yourself to be inaccurate and play those parts on the piano. You may isolate and play multiple sections numerous times

and may play the part in its entirety. Feel free to sing as you play, though you may play **only** the flute part. You may take as much time as you need in order to sing the entire part with complete accuracy. Indicate once you believe you can accurately sing this line it its entirety. You may begin at this time. (wait – RECORD TIME)

You are about to sing the flute part again. Sing through the entire line even if you make mistakes. You may sing at a slower tempo and adjust the octave in which you are singing at any time. At this time, play only the first note of the flute part and begin singing. (wait – RECORD TIME)

For the next 30 seconds, you may study the other two parts. Do not play or sing.

(wait – RECORD TIME – RECORD TOTAL TIME:)

You are now ready to error detect. You will hear the flawed performance of this excerpt **three** times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the **error type** by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the circled errors. Note that errors may occur in **any** part. In order acclimate you to the tempo and tonal center of the excerpt, no errors will occur in the first measure. There will be time provided in between excerpts for you to write on the score.

Do you have any questions? (wait) Answer questions.

Listen to the flawed performances of Nocturne in D, Opus 28, No 3. You will hear this performance three times.

Now turn to excerpt two, an excerpt from “Divertimento No. 1” by Mozart. Direct your attention to the clarinet part. In a moment you will sight-sing this part. You will be free to sing at a tempo slower than the one marked and are welcome to adjust the octave in which you are singing at any time. Be aware that though you may sing in another octave, all parts will sound in the octave in which they are written in the recordings of the excerpt.

Sing through the part in its entirety even if you make multiple mistakes. Though you may struggle with pitch accuracy, strive for precision in your performance of the rhythmic content. At this time, play the **only** first note of the clarinet part on the piano and begin singing this part. (wait for this to be completed – TIME THIS FOR EACH PILOT PARTICIPANT)

Now, select portions of the line where you perceived yourself to be inaccurate and play those parts on the piano. You may isolate and play multiple sections, numerous times and may play the part in its entirety. Feel free to sing as you play, though you may play **only** the clarinet part. You may take as much time as you need in order to sing the entire part with complete accuracy. Indicate once you believe you can accurately sing this line it its entirety. You may begin at this time. (wait – RECORD TIME)

You are about to sing the clarinet part again. Sing through the entire line even if you make mistakes. You may sing at a slower tempo and adjust the octave in which you are singing at any time. At this time, play only the first note of the clarinet part and begin singing. (wait – record time)

For the next 30 seconds, you may study the other two parts. Do not play or sing.

(wait – RECORD TIME – RECORD TOTAL TIME:)

You are now ready to error detect. You will hear the flawed performance of this excerpt **<u>three</u>** times. Your task is to circle the errors you hear. Circle the specific <u>beat(s),</u> in the specific instrumental <u>part</u> where the errors occur and indicate the **<u>error type</u>** by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the circled errors. Note that errors may occur in **any** part including the clarinet part. In order acclimate you to the tempo and tonal center of the excerpt, no errors will occur in the first measure. There will be time provided in between excerpts for you to write on the score.

Do you have any questions? (wait) Answer questions.

Listen to the flawed performances of Divertimento No. 1 excerpt by Mozart. You will hear this performance three times.

Turn to excerpt three, an excerpt from "Trio, Opus 87"by Beethoven. Direct your attention to the <u>flute</u> part. In a moment you will sight-sing this part. You will be free to sing at a tempo slower than the one marked and are welcome to adjust the octave in which you are singing at any time. Be aware that though you may sing in another octave, all parts will sound in the octave in which they are written in the recordings of the excerpt.

Sing through the part in <u>its entirety</u> even if you make multiple mistakes. Though you may struggle with pitch accuracy, strive for precision in your performance of the rhythmic content. At this time, play the **only** first note of the flute part on the piano and begin singing this part. (wait for this to be completed – TIME THIS FOR EACH PILOT PARTICIPANT)

Now, select portions of the line where you perceived yourself to be inaccurate and play those parts on the piano. You may isolate and play multiple sections, numerous

times and may play the part in its entirety. Feel free to sing as you play, though you may play **only** the flute part. You may take as much time as you need in order to sing the entire part with complete accuracy. Indicate once you believe you can accurately sing this line it its entirety. You may begin at this time. (wait – RECORD TIME)

You are about to sing the flute part again. Sing through the entire line even if you make mistakes. You may sing at a slower tempo and adjust the octave in which you are singing at any time. At this time, play only the first note of the flute part and begin singing. (wait – record time)

For the next 30 seconds, you may study the other two parts. Do not play or sing.

(wait – RECORD TIME – RECORD TOTAL TIME:)

You are now ready to error detect. You will hear the flawed performance of this excerpt **<u>three</u>** times. Your task is to circle the errors you hear. Circle the specific <u>beat(s),</u> in the specific instrumental <u>part</u> where the errors occur and indicate the **<u>error type</u>** by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the circled errors. Note that errors may occur in **any** part including the flute part. In order acclimate you to the tempo and tonal center of the excerpt, no errors will occur in the first measure. There will be time provided in between excerpts for you to write on the score.

Do you have any questions? (wait) Answer questions.

Listen to the flawed performance of Trio, Opus 87 by Beethoven. You will hear this performance three times.

Turn to excerpt four, an excerpt from "Tandem Trio" by Edward Solomon. Direct your attention to the <u>trombone</u> part. In a moment you will sight-sing this part. You will be free to sing at a tempo slower than the one marked and are welcome to adjust the octave

in which you are singing at any time. Be aware that though you may sing in another octave, all parts will sound in the octave in which they are written in the recordings of the excerpt.

Sing through the part in <u>its entirety</u> even if you make multiple mistakes. Though you may struggle with pitch accuracy, strive for precision in your performance of the rhythmic content. At this time, play the **only** first note of the trombone part on the piano and begin singing this part. (wait for this to be completed – TIME THIS FOR EACH PILOT PARTICIPANT)

Now, select portions of the line where you perceived yourself to be inaccurate and play those parts on the piano. You may isolate and play multiple sections, numerous times and may play the part in its entirety. Feel free to sing as you play, though you may play **only** the trombone part. You may take as much time as you need in order to sing the entire part with complete accuracy. Indicate once you believe you can accurately sing this line it its entirety. You may begin at this time. (wait – RECORD TIME)

You are about to sing the trombone part again. Sing through the entire line even if you make mistakes. You may sing at a slower tempo and adjust the octave in which you are singing at any time. At this time, play only the first note of the flute part and begin singing. (wait – record time)

For the next 30 seconds, you may study the other two parts. Do not play or sing.

(wait – RECORD TIME – RECORD TOTAL TIME:)

You are now ready to error detect. You will hear the flawed performance of this excerpt **<u>three</u>** times. Your task is to circle the errors you hear. Circle the specific <u>beat(s),</u> in the specific instrumental <u>part</u> where the errors occur and indicate the **<u>error type</u>** by

writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in **any** part including the trombone part. In order acclimate you to the tempo and tonal center of the excerpt, no errors will occur in the first measure. There will be time provided in between excerpts for you to write on the score.

Do you have any questions? (wait) Answer questions.

Listen to the flawed performance of Tandem Trio” by Edward Solomon. You will hear this recording three times.

Turn to excerpt five, an excerpt from “Sarabande” from Suite in D minor by Handel. Direct your attention to the trombone part. In a moment you will sight-sing this part. You will be free to sing at a tempo slower than the one marked and are welcome to adjust the octave in which you are singing at any time. Be aware that though you may sing in another octave, all parts will sound in the octave in which they are written in the recordings of the excerpt.

Sing through the part in its entirety even if you make multiple mistakes. Though you may struggle with pitch accuracy, strive for precision in your performance of the rhythmic content. At this time, play the **only** first note of the trombone on the piano and begin singing this part. (wait for this to be completed – TIME THIS FOR EACH PILOT PARTICIPANT)

Now, select portions of the line where you perceived yourself to be inaccurate and play those parts on the piano. You may isolate and play multiple sections, numerous times and may play the part in its entirety. Feel free to sing as you play, though you may play **only** the trombone part. You may take as much time as you need in order to sing the

entire part with complete accuracy. Indicate once you believe you can accurately sing this line it its entirety. You may begin at this time. (wait – RECORD TIME)

You are about to sing the trombone part again. Sing through the entire line even if you make mistakes. You may sing at a slower tempo and adjust the octave in which you are singing at any time. At this time, play only the first note of the flute part and begin singing. (wait – record time)

For the next 30 seconds, you may study the other two parts. Do not play or sing.

(wait – RECORD TIME – RECORD TOTAL TIME:)

You are now ready to error detect. You will hear the flawed performance of this excerpt **<u>three</u>** times. Your task is to circle the errors you hear. Circle the specific <u>beat(s),</u> in the specific instrumental <u>part</u> where the errors occur and indicate the **<u>error type</u>** by writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in **any** part including the trombone part. In order acclimate you to the tempo and tonal center of the excerpt, no errors will occur in the first measure. There will be time provided in between excerpts for you to write on the score.

Do you have any questions? (wait) Answer questions.

Listen to the flawed performance of Sarabande from Suite in D minor by Handel. You will hear this recording three times.

Turn to excerpt six, Passepied from Suite in C by Bach. Direct your attention to the <u>clarinet</u> part. In a moment you will sight-sing this part. You will be free to sing at a tempo slower than the one marked and are welcome to adjust the octave in which you are

singing at any time. Be aware that though you may sing in another octave, all parts will sound in the octave in which they are written in the recordings of the excerpt.

Sing through the part in its entirety even if you make multiple mistakes. Though you may struggle with pitch accuracy, strive for precision in your performance of the rhythmic content. At this time, play the **only** first note of the clarinet part on the piano and begin singing this part. (wait for this to be completed – TIME THIS FOR EACH PILOT PARTICIPANT)

Now, select portions of the line where you perceived yourself to be inaccurate and play those parts on the piano. You may isolate and play multiple sections, numerous times and may play the part in its entirety. Feel free to sing as you play, though you may play **only** the clarinet part. You may take as much time as you need in order to sing the entire part with complete accuracy. Indicate once you believe you can accurately sing this line it its entirety. You may begin at this time. (wait – RECORD TIME)

You are about to sing the clarinet part again. Sing through the entire line even if you make mistakes. You may sing at a slower tempo and adjust the octave in which you are singing at any time. At this time, play only the first note of the clarinet part and begin singing. (wait – record time)

For the next 30 seconds, you may study the other two parts. Do not play or sing.

(wait – RECORD TIME – RECORD TOTAL TIME:)

You are now ready to error detect. You will hear the flawed performance of this excerpt **three** times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the **error type** by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the

circled errors. Note that errors may occur in **any** part including the clarinet part. In order acclimate you to the tempo and tonal center of the excerpt, no errors will occur in the first measure. There will be time provided in between excerpts for you to write on the score.

Do you have any questions? (wait) Answer questions.

Listen to the flawed performance of Passepied from Suite in C by Bach. You will hear this recording three times.

APPENDIX E: PARTICIPANT DATA FORM

Participant Number: _____________

Major Instrument: ____

Degree Status: Graduate Undergraduate

Treatment Group Assignment

AB VB FB

Post-Treatment Questionnaire

1. What did you do that was most helpful in preparing yourself to detect errors?

2. What else would have enabled you to detect more errors?

APPENDIX F: SCRIPT OF AURAL GROUP TREATMENT INSTRUCTIONS

Note: Excerpt order will affect the order of instructions.

This is an error detection task during which you will attempt to locate and identify pitch and rhythm errors. Note that an error in pitch refers to a discrepancy between notated and performed pitch. It does not refer to intonation discrepancies. Though all of the excerpts are instrumental scores, all parts are in concert pitch.

Turn to the practice excerpt, Gavotte "Les Moissonneurs" from Pieces de Clavecin by Couperin. Before studying the entire score, you will first study the oboe part. In a moment you will sight-sing this part. You are free to sing at a tempo slower than the one marked and are welcome to adjust the octave in which you are singing at any time. Sing through this part only once. Sing through the part in its entirety even if you make mistakes. Strive for precision in your performance of the rhythmic content. At this time, play the first note of the oboe part on the piano and begin singing the part. (Time for this phase for practice excerpt: 25 seconds Recording will indicate when time has expired for this segment).

Now, select portions of this part where you perceived yourself to be inaccurate and play those parts on the piano. You may isolate and play multiple sections numerous times and may play the part in its entirety. Feel free to sing as you play. Your time for this phase of preparation is limited so make full use of it. You will be informed when 30 seconds of preparation time remains. At this time, you may begin to play and/or sing. (Time for this phase for practice excerpt: 122 seconds. Recording will indicate when 30 seconds of time remains.)

You are about to sing the oboe part again. Sing through the entire line even if you make mistakes. You may sing at a slower tempo and adjust the octave in which you are singing at any time. You will sing through this line only once. At this time, play the first note of the oboe part and begin singing. (Time for this phase for practice excerpt: 21 seconds Recording will indicate when time has expired for this segment).

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. (Recording will indicate when time has expired for this segment is over).

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the oboe part. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (Pause recording and answer questions.) Listen to the flawed performance of this excerpt. You will hear it three times.

The previous practice excerpt was designed to orient you to the score study process and error detection task to be followed across six excerpts. You will sight-sing a specified part, correct any of the errors you perceived in your sight-singing performance via the use of the piano and your own singing. You will then sing the specific part again. Following an additional 30 seconds to study the other two lines, you will then be ready to

error detect. You will hear the flawed performance three times. Your task will be to circle the errors you hear. At this time, please turn to excerpt one.

For excerpt one, “Nocturne in D, Opus 28, No. 3” by Gianella, you will study the flute part before studying the entire score. Play the first note of this part on the piano and begin sight-singing this part. (Recording will indicate when time has expired for this phase.) Now use the piano to rehearse and correct the mistakes you made during your sight-singing of the flute part. You will be informed when thirty seconds of time remains. Your time begins now. (Recording will indicate when 30 seconds of time remains). Time is up. At this time, play the first note of the flute part on the piano and sing this part again. (Recording will indicate when time has expired for this phase.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. You may begin. (Recording will indicate when time has expired for this segment is over)

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the specified part you studied first. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt two, an excerpt from Divertimento No. 1 by Mozart. For this excerpt you will first study the clarinet part. Play the first note of this part on the piano and begin sight-singing this part. (Recording will indicate when time has expired for this phase.)

Now use the piano to rehearse and correct the mistakes you made during your sight-singing of the clarinet part. You will be informed when thirty seconds of time remains. Your time begins now. (Recording will indicate when 30 seconds of time remains). Time is up. At this time, play the first note of the clarinet part on the piano and sing this part again. Please begin. (Recording will indicate when time has expired for this phase.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. You may begin. (Recording will indicate when time has expired for this segment is over)

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the part you studied first. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt three, an excerpt from Trio, Opus 87 by Beethoven. For this excerpt you will first study the flute part. Play the first note of this part on the piano and begin sight-singing this part. (Recording will indicate when time has expired for this phase.)

Now use the piano to rehearse and correct the mistakes you made during your sight-singing of the flute part. You will be informed when thirty seconds of time remains. Your time begins now. (Recording will indicate when 30 seconds of time remains). Time is up. At this time, play the first note of the flute part on the piano and sing this part again. Please begin. (Recording will indicate when time has expired for this phase.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. You may begin. (Recording will indicate when time has expired for this segment is over)

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the part you studied first. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt four, an excerpt from Tandem Trio by Edward Solomon. For this excerpt you will first study the trombone part. Play the first note of this part on the piano and begin sight-singing this part. (Recording will indicate when time has expired for this phase.)

Now use the piano to rehearse and correct the mistakes you made during your sight-singing of the trombone part. You will be informed when thirty seconds of time remains. Your time begins now. (Recording will indicate when 30 seconds of time remains). Time is up. At this time, play the first note of the trombone part on the piano and sing this part again. Please begin. (Recording will indicate when time has expired for this phase.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. You may begin. (Recording will indicate when time has expired for this segment is over)

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the part you studied first. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt five, an excerpt from *Suite in D Minor* by Handel. For this excerpt you will first study the trombone part. Play the first note of this part on the piano and begin sight-singing this part. (Recording will indicate when time has expired for this phase.)

Now use the piano to rehearse and correct the mistakes you made during your sight-singing of the trombone part. You will be informed when thirty seconds of time remains. Your time begins now. (Recording will indicate when 30 seconds of time remains). Time is up. At this time, play the first note of the trombone part on the piano and sing this part again. Please begin. (Recording will indicate when time has expired for this phase.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. You may begin. (Recording will indicate when time has expired for this segment is over)

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the part you studied first. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt six, Passepied from *Suite in C* by Bach. For this excerpt you will first study the clarinet part. Play the first note of this part on the piano and begin sight-singing this part. (Recording will indicate when time has expired for this phase.)

Now use the piano to rehearse and correct the mistakes you made during your sight-singing of the clarinet part. You will be informed when thirty seconds of time remains. Your time begins now. (Recording will indicate when 30 seconds of time remains). Time is up. At this time, play the first note of the clarinet part on the piano and sing this part again. Please begin. (Recording will indicate when time has expired for this phase.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. You may begin. (Recording will indicate when time has expired for this segment is over)

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the part you studied first. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Thank you for participating in this study.

APPENDIX G: SCRIPT OF VISUAL GROUP TREATMENT INSTRUCTIONS

Note: Excerpt order will affect the order of instructions.

This is an error detection task during which you will attempt to locate and identify pitch and rhythm errors. Note that an error in pitch refers to a discrepancy between notated and performed pitch. It does not refer to intonation discrepancies. Though all of the excerpts are instrumental scores, all parts are in concert pitch.

Turn to the practice excerpt, Gavotte "Les Moissonneurs" from Pieces de Clavecin by Couperin. To prepare for error detection, you will be allotted an amount of time to study the score. Before studying the entire score, you will first study the oboe part. You are free to make any marks to the score in your preparation prior to error detection. You may not sing or play the piano. This recording will inform you when 30 seconds of score study time are remaining for study of this part. Do you have any questions? (Pause recording and answer any questions). Your score study time begins now. (Start recording. The recording will indicate when 30 seconds of score time remains and when time is up.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. (Recording will indicate when time has expired for this segment is over).

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the oboe part. No errors

will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (Pause recording and answer questions.) Listen to the flawed performance of this excerpt. You will hear it three times.

The previous practice excerpt was designed to orient you to the score study process and error detection task to be followed across six excerpts. You will first study one of the parts from the excerpt. Following an additional 30 seconds to study the other two lines, you will then be ready to error detect. You will hear the flawed performance three times. Your task will be to circle the errors you hear. At this time, please turn to excerpt one.

For excerpt one, “Nocturne in D, Opus 28, No. 3” by Gianella, you will study the flute part before studying the entire score. You are free to make any other marks to the score in your preparation prior to error detection. You may not sing or play the piano. This recording will inform you when 30 seconds of score study time are remaining for study of this part. Do you have any questions? (Pause recording and answer any questions). Your score study time begins now. (Start recording. The recording will indicate when 30 seconds of score time remains and when time is up.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. You may begin. (Recording will indicate when time has expired for this segment is over)

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by

writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the specified part you studied first. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt two, an excerpt from Divertimento No. 1 by Mozart. For this excerpt you will first study the clarinet part. You are free to make any other marks to the score in your preparation prior to error detection. You may not sing or play the piano. This recording will inform you when 30 seconds of score study time are remaining for study of this part. Do you have any questions? (Pause recording and answer any questions). Your score study time begins now. (Start recording. The recording will indicate when 30 seconds of score time remains and when time is up.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. You may begin. (Recording will indicate when time has expired for this segment is over)

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the part you studied first. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause

recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt three, an excerpt from Trio, Opus 87 by Beethoven. For this excerpt you will first study the flute part. You are free to make any other marks to the score in your preparation prior to error detection. You may not sing or play the piano. This recording will inform you when 30 seconds of score study time are remaining for study of this part. Do you have any questions? (Pause recording and answer any questions). Your score study time begins now. (Start recording. The recording will indicate when 30 seconds of score time remains and when time is up.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. You may begin. (Recording will indicate when time has expired for this segment is over)

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the part you studied first. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt four, an excerpt from Tandem Trio by Edward Solomon. For this excerpt you will first study the trombone part. You are free to make any other

marks to the score in your preparation prior to error detection. You may not sing or play the piano. This recording will inform you when 30 seconds of score study time are remaining for study of this part. Do you have any questions? (Pause recording and answer any questions). Your score study time begins now. (Start recording. The recording will indicate when 30 seconds of score time remains and when time is up.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. You may begin. (Recording will indicate when time has expired for this segment is over)

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the part you studied first. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt five, an excerpt from *Suite in D Minor* by Handel. For this excerpt you will first study the trombone part. You are free to make any other marks to the score in your preparation prior to error detection. You may not sing or play the piano. This recording will inform you when 30 seconds of score study time are remaining for study of this part. Do you have any questions? (Pause recording and answer any

questions). Your score study time begins now. (Start recording. The recording will indicate when 30 seconds of score time remains and when time is up.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, study the other two parts. Do not play or sing. You may begin. (Recording will indicate when time has expired for this segment is over)

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the part you studied first. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt six, Passepied from *Suite in C* by Bach. For this excerpt you will first study the clarinet part. You are free to make any other marks to the score in your preparation prior to error detection. You may not sing or play the piano. This recording will inform you when 30 seconds of score study time are remaining for study of this part. Do you have any questions? (Pause recording and answer any questions). Your score study time begins now. (Start recording. The recording will indicate when 30 seconds of score time remains and when time is up.) Time is up.

Turn to the next page. This is a full score of the excerpt. For the next 30 seconds, you may study the other two parts. Do not play or sing. You may begin. (Recording will indicate when time has expired for this segment is over)

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including the part you studied first. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Thank you for participating in this study.

APPENDIX H: SCRIPT OF FREE GROUP TREATMENT INSTRUCTIONS

Note: Excerpt order will affect the order of instructions.

This is an error detection task during which you will attempt to locate and identify pitch and rhythm errors. Note that an error in pitch refers to a discrepancy between notated and performed pitch. It does not refer to intonation discrepancies. Though all of the excerpts are instrumental scores, all parts are in concert pitch.

Turn to the practice excerpt, Gavotte "Les Moissonneurs" from Pieces de Clavecin by Couperin. To prepare for error detection, you will be allotted an amount of time to study the score. You may use any strategy in your study of the excerpt, including use of the piano. You are also free to sing. This recording will inform you when 30 seconds of score study time are remaining for each excerpt. Do you have any questions? (wait). Your score study time begins now.

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (Pause recording and answer questions.) Listen to the flawed performance of this excerpt. You will hear it three times.

The previous practice excerpt was designed to orient you to the score study process and error detection task to be followed across six excerpts. Following the time

allotted for score study, you will hear the flawed performance three times. Your task will be to circle the errors you hear. At this time, please turn to excerpt one.

For excerpt one, “Nocturne in D, Opus 28, No. 3” by Gianella. Remember that you use any strategy in your study of the excerpt, including use of the piano. You are also free to sing. This recording will inform you when 30 seconds of score study time are remaining for this excerpt. Do you have any questions? (wait). Your score study time begins now.

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt two, an excerpt from Divertimento No. 1 by Mozart. You are also free to sing. This recording will inform you when 30 seconds of score study time are remaining for this excerpt. Do you have any questions? (wait). Your score study time begins now.

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the

circled errors. Note that errors may occur in any part. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt three, an excerpt from Trio, Opus 87 by Beethoven. You are also free to sing. This recording will inform you when 30 seconds of score study time are remaining for this excerpt. Do you have any questions? (wait). Your score study time begins now.

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing "P" for a pitch error and "R" for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt four, an excerpt from Tandem Trio by Edward Solomon. You are also free to sing. This recording will inform you when 30 seconds of score study time are remaining for this excerpt. Do you have any questions? (wait). Your score study time begins now.

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by

writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt five, an excerpt from *Suite in D Minor* by Handel. You are also free to sing. This recording will inform you when 30 seconds of score study time are remaining for this excerpt. Do you have any questions? (wait). Your score study time begins now.

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Please turn to excerpt six, Passepied from *Suite in C* by Bach. You are also free to sing. This recording will inform you when 30 seconds of score study time are remaining for this excerpt. Do you have any questions? (wait). Your score study time begins now.

You are now ready to error detect. You will hear the flawed performance of this excerpt three times. Your task is to circle the errors you hear. Circle the specific beat(s), in the specific instrumental part where the errors occur and indicate the error type by

writing “P” for a pitch error and “R” for a rhythm error. Place these letters near the circled errors. Note that errors may occur in any part including. No errors will occur in the first measure. There will be a brief amount of time provided in between excerpts for you to write on the score. Do you have any questions? (pause recording and answer questions). Listen to the flawed performance of this excerpt. You will hear it three times.

Thank you for participating in this study.

APPENDIX I: IRB EXEMPTION APPROVAL

Application for Exemption from Institutional Oversight

Unless qualified as meeting the specific criteria for exemption from Institutional Review Board (IRB) oversight, ALL LSU research/projects using living humans as subjects, or samples or data obtained from humans, directly or indirectly, with or without their consent, must be approved or exempted in advance by the LSU IRB. This Form helps the PI determine if a project may be exempted, and is used to request an exemption.

Institutional Review Board
Dr. Robert Mathews, Chair
203 B-1 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.6792
irb@lsu.edu | lsu.edu/irb

- Applicant, Please fill out the application in its entirety and include the completed application as well as parts A-E, listed below, when submitting to the IRB. Once the application is completed, please submit two copies of the completed application to the IRB Office or to a member of the Human Subjects Screening Committee. Members of this committee can be found at http://www.lsu.edu/irb/screeningmembers.shtml
- A Complete Application Includes All of the Following:
  (A) Two copies of this completed form and two copies of parts B thru E.
  (B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1 & 2)
  (C) Copies of all instruments to be used.
  - If this proposal is part of a grant proposal, include a copy of the proposal and all recruitment material.

  (D) The consent form that you will use in the study (see part 3 for more information.)
  (E) Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing or handling data, unless already on file with the IRB.
  Training link: (http://phrp.nihtraining.com/users/login.php.)

1) Principal Investigator: Amanda L. Schlegel **Rank:** Graduate student **Student*? Y/N** Y

Dept.: Music Education **Ph:** 724-301-4448 **E-mail:** aschle2@lsu.edu

2) Co Investigator(s): please include department, rank, phone and e-mail for each
* If student, please identify and name supervising professor in this space
Dr. James Byo,
Carl Prince Matthies Professor of Music Education
225-578-2593
jbyo@lsu.edu

3) Project Title: The effect of directed attention procedures on music majors' error detection in three-part instrumental music

Study Exempted By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 | www.lsu.edu/irb
Exemption Expires: 8-30-2012

4) LSU Proposal?(yes or no) No **If Yes, LSU Proposal Number** ______

Also, if YES, either ◯ **This application completely matches the scope of work in the grant**
OR
◯ **More IRB Applications will be filed later**

IRB# E4698 LSU Proposal# ______
X Complete Application
X Human Subjects Training

5) Subject pool (e.g. Psychology Students) Undergraduate/graduate music majors
- Circle any **"vulnerable populations" to be used**: (children <18; the mentally impaired, pregnant women, the aged, other). Projects with incarcerated persons cannot be exempted.

6) PI Signature Amanda L. Schlegel **** Date** 8/24/09 (no per signatures)
****I certify my responses are accurate and complete.** If the project scope or design is later changed I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at LSU for three years after completion of the study. If I leave LSU before that time the consent forms should be preserved in the Departmental Office.

Screening Committee Action: Exempted X Not Exempted ____ Category/Paragraph 2
Reviewer S. Kim MacGregor **Signature** S. Kim MacGregor **Date** 8/31/09

Consent Form

1. Title: The effect of directed attention procedures on music majors' error detection in three-part instrumental music

2. Performance Sites: Louisiana State University

3. Contacts: The following investigators are available for questions about this project: Amanda L. Schlegel (aschle2@tigers.lsu.edu)

4. Purpose of Study: This inquiry is designed to answer the following primary question: What are the effects of directed attention on music majors' ability to detect pitch and rhythm errors in three-part homorhythmic and polyrhythmic music excerpts? Secondarily, it is designed to answer the question: What are the effects of score study on music majors' ability to detect pitch and rhythm errors in varied-texture music excerpts?

5. Participants: Participants will be undergraduate and graduate music majors at Louisiana State University. No participants will be under 18 years of age

6. Number of Participants: 60

7. Study Procedures: Participants will complete a data form in which they will indicate their age, degree status, and musical emphasis. They will also give informed consent. They will then study musical excerpts based on prescribed procedures. Following allotted score study time, participants will listen three times to a flawed excerpt and identify performance errors. Following treatment, participants will answer questions regarding their perception of treatment effectiveness. Participants will be videotaped to allow for analysis of the their score preparation behaviors and singing accuracy.

8. Benefits: There will likely be no immediate benefits to participants. Potentially, study results will provide evidence regarding conditions under which aural acuity and music perception is most accurate and the nature of effects on error detection accuracy.

9. Risks/Discomforts: There is no known risk involved in this project. Participants are musicians and are skilled in listening, singing and playing the piano, though participants will have different skill level in each of these musical domains. The process poses no physical or mental discomfort. Recorded audio volume levels will be equalized for all participants.

10. Right to Refuse: Participation in this study is voluntary. At any time, the subject may withdraw from the study without penalty or loss of any benefit to which the subject may otherwise be entitled.

11. Privacy: The study is confidential. Codes will link data to identity. Records will be maintained in secure office storage by the principal investigator only. Results of the study may be published but no names or identifying information will appear in publication. Data will be kept confidential unless release is legally compelled.

12. Financial Information: Participants will not receive financial compensation for participation and will not incur financial cost.

The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have questions about subjects' rights or other concerns, I can contact Robert C. Matthews, Chairman, LSU Institutional Review Board, 225-578-8692, irb@lsu.edu, www.lsu.edu/irb. I agree to participate in the study described above and acknowledge the researchers' obligation to provide me with a copy of this consent form if signed by me.'

Subject age: ______

Subject Signature: ____________________________________ Date: ___________

Study Exempted By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 | www.lsu.edu/irb
Exemption Expires: 8-30-2012

APPENDIX J: PARTICIPANT POST-TREATMENT QUESTIONNAIRE RESPONSES

Participant-reported helpful strategies/behaviors

	Code	Definition	AURAL	VISUAL	FREE	TOTAL
1	SOL	Solfege	2	11	4	17
2	MNA	hear/sing/play in mind/audiate	4	6	5	15
3	KEY	determining key	2	2	0	4
4	REL	how parts relate to each other	1	0	0	1
5	PP	play piano	9	0	15	24
6	OPH	one part per hearing	10	4	3	17
7	TAP	tap rhythms	0	3	1	4
8	ACC	accidentals/notes outside of key	4	1	0	5
9	LI	leaps/intervals	1	3	3	7
10	CON/KB	conducting/keep beat	4	2	3	9
11	IL	individual lines	0	0	11	11
12	TOG	play lines together	0	0	4	4
13	CH	Chords	1	0	3	4
14	SAME	same rhythm/repetition	2	2	0	4
15	SING	Sing	3	0	4	7
16	IS	isolate/direct attention	1	0	0	1
17	ENT	entrances- focusing on entrances	1	0	0	1
18	DS	dissonances - playing them	0	0	1	1
19	RF	focus on rhythm	3	4	2	9
20	FI	fingering part	0	1	0	1
21	KOP	knowing one part really well	1	0	0	1
22	OOP	order of parts listened to/focused on	1	0	1	2
23	UAT	use all time to study	1	0	0	1
24	SB	steady beat (silent) - not conducting	0	0	1	1
25	IPS	indentify problem spots	0	1	1	2
26	OP	study other parts	3	0	0	3
27	TF	tap foot	1	0	1	2

Participant-reported factors that would have improved error detection

	Code	Definition	AURAL	VISUAL	FREE	TOTAL
1	ET	more/better ear training	3	0	0	3
2	MH	more hearings/recording/listening	3	4	4	11
3	MT	more time	6	4	4	14
4	KEY	anything related to key/setup/tonic dominant	4	1	0	5
5	FI	finger along	1	0	0	1
6	PP	play piano	3	7	0	10
7	SING	sing	0	4	0	4
8	TIM	interference due to synthetic timbre/real instruments	2	1	0	3
9	UI	unfamiliar with instrumental timbre	0	2	1	3
10	UIS	unfamiliar with instrumental scores	0	0	1	1
11	INS	use of major instrument	0	1	2	3
12	ST	slower tempo	3	2	3	8
13	BPS	better piano skills	0	0	4	4
14	IL	individual lines	2	1	2	5
15	BPA	better personal approach to score study/ED	0	0	1	1
16	CV	hear correct version	1	2	1	4
17	CO	count off - clicks before excerpts begin playing	0	3	1	4
18	AFS	access to full score	3	3	0	6
19	RNP	researcher not present	0	0	1	1
20	OP	Other parts (sing, play, hear)	5	1	0	6
21	METRO	metronome	0	0	1	1
22	FAM	more familiar with piece/parts	1	0	0	1
23	MTBH	more time between hearings	1	1	0	2
24	DA	direct attention inhibited detection	0	1	0	1
25	GOAL	have a goal - know # of errors	1	0	0	1
26	BR	better recording	0	0	2	2
27	SP	starting pitch	1	0	0	1
28	LDAT	less directed attention time	0	1	0	1
29	BAL	balance between voices in stimuli	1	0	1	2
30	ART	articulation	1	0	0	1
31	INT	intervals - paying attention to	1	0	0	1
32	PLT	play lines together	0	0	2	2

VITA

Amanda Lynn Schlegel holds a Bachelor of Music degree from Grove City College (1998) and a Master of Music from Northwestern University (2002). From 1998-2005, Ms. Schlegel taught instrumental music in the public schools of western Pennsylvania. In addition, she taught secondary vocal music, elementary general music, drama, and directed several musical theater productions. As a graduate teaching assistant at Louisiana State University, she taught courses in the instrumental and choral music education curricula, including supervision of students' in-the-schools fieldwork. In the fall of 2010 she served as an adjunct lecturer in music education at Southeastern Louisiana University in Hammond.

Schlegel has presented research at regional, national, and international conferences, notably, the National Biennial In-Service Conference of MENC: The National Association for Music Education, the Annual Music Education Week in Washington D. C. (MENC), and the International Conference on Music Perception and Cognition (ICMPC). Following graduation in December 2010, Ms. Schlegel will pursue a college teaching career in music education.