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Finding the right note: the strategy use of eighth grade choral students during vocal sight-reading

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BOSTON UNIVERSITY
COLLEGE OF FINE ARTS

Dissertation

**FINDING THE RIGHT NOTE:
THE STRATEGY USE OF EIGHTH GRADE CHORAL STUDENTS
DURING VOCAL SIGHT-READING**

by

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DEDICATION

This dissertation is dedicated to my parents, Stephany and Bruce Houghton.

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I will be forever grateful for the many people who have influenced my academic journey. First, to the students, teachers, and administrators who participated in the pilot and main studies, your participation was instrumental; thank you for your time and effort. Second, I am indebted to Dr. James Imhoff for his insightful comments, patience, and unfailing levity. Thanks, Jim! Third, Dr. Diana Dansereau has been a mentor from the very beginning. Thank you for the many discussions, opportunities, and for introducing me to Music Learning Theory! Fourth, thank you, Dr. Karin Hendricks, for your feedback and vision; you helped me see the bigger picture. Thank you also, Dr. Lee Higgins, for your guidance and trust. A special thanks to those who donated time, read drafts, and gave feedback, including: Dr. Paul Carlile, Dr. Jill Reese, Dr. Beth Etopio, Dr. Cami Condie, and Dr. Lyle Davidson. Finally, with deep gratitude I thank all of my friends and family who gently nudged me forward with each new challenge and stumbling block. Thank you Colin, Justin, Angela, Joy, Joo, Jonathan, Cami, Ashlee, Sara, Katie, and Katy. Thanks Mom, Dad, Papa, Nana, Britt, Clint, James, Sienna, McKay, Corinne, Brad, Julie, JJ, and Connor; your kindnesses, support, and sacrifices fueled this paper to finally come to fruition.

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ABSTRACT

Students' strategy use is an assessment of their ability to assimilate, synthesize, and actualize knowledge shown to be directly related to success in sight-reading. The purpose of this exploratory, collective case study was to investigate the strategy use, and possible underlying cognitive music processes, of eighth grade middle school choral students when vocally sight-reading. More specifically, the objective of this research was to better understand the relationship between strategy use and accelerated learning in vocal music notation reading.

To create a coalesced conceptual lens, I merged the construct of audiation and pertinent findings from cognitive science research, specifically music reading literature in cognitive psychology. Seeing students' strategy use through this combined lens allowed me to concentrate on the role of cognitive processes (perception, attention, memory, audiation) in the vocal sight-reading process and begin to distill how participants' strategies improved or reduced sight-reading performance.

Fourteen eighth-grade middle school choral students participated ($N = 14$, 4 males, ages 13 to 14). Students participated in research activities individually, in one 30-

minute session, in a nearby practice room at their middle school. I collected two types of quantitative data. First, I tallied scores from a sight-reading instrument, the Vocal Sight-Reading Inventory (Henry, 1999). Second, I categorized data from a researcher-designed Sophistication of Strategy Use Index (an accumulation of scores in five music cognition-based categories: looking behavior, chunking, long-term memory, auditory representations, and audiation). Furthermore, I gathered qualitative data through interviews, retrospective think-alouds (Ericsson & Simon, 1993), and video-stimulated recall interviews.

All students employed strategies, both cognitive and non-cognitive, singularly and in combination. Three major findings emerged:

1. Students employed strategies in three domains of knowledge, visual-only (most frequent), aural-only (least frequent), and visual-aural, and two underlying systems, self-awareness and music vocabulary.
2. Those who scored in the highest 50% on the sight-reading indicator employed these strategies (two or three times) more frequently than those who scored in the lowest 50%
 - read in visual chunks and by analogy;
 - created and manipulated auditory representations;
 - paired singular pitches with discrete staff placement locations;
 - employed self-awareness in production and commission of errors; and
 - remained aurally grounded in the tonality.

3. There was a positive and strong correlation ($r = .84, p < .00$) between students' sophistication of strategy use scores and vocal sight-reading scores.

Results from the current study have implications for choral music educators in designing and implementing sight-reading curricula, especially with regards to content and pedagogy. Suggestions for sight-reading pedagogy include (a) scaffolding sight-reading instruction to guide sophisticated strategy use, (b) strengthening underlying musical cognitive processes, (c) emphasizing higher order relationships, especially chunking, and (d) increasing students' meta-cognition surrounding vocal production and commission of errors.

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CHAPTER 1

INTRODUCTION

“Next, please look at the paper on the music stand. It’s time to sight-read. Take a look at example one. Here is the starting pitch. Start whenever you are ready,” I slowly explained.

Nora, a fifth-grade student, looked anxiously at the paper. She shuffled her feet and craned her neck, turning her body to look at the paper from a different angle, as she sought to make sense of the dots and lines on the page. Nora was sight-reading in a chorus audition. After a minute she finally exclaimed, “I can’t,” drooping her shoulders and sounding defeated.

“Just do your best. Here’s the first pitch. Try again,” I encouraged.

She stared at the exercise a little longer. She began to approach the piano bench and asked, “Can I play it on the piano, or can you sing it to me? I have to hear it first.”

During an audition I administered, Nora struggled to sight-read; she admittedly had to rely on hearing the notes from an outside source *before* she could sing them herself. Nora could not effectively employ strategies that resulted in successful vocal sight-reading. Vocal sight-reading, the ability to sing music notation at first sight, is synonymous with sight-singing (Killian & Henry, 2005). A ubiquitously utilized diagnostic tool, vocal sight-reading remains an indicator of an underlying difficult and complex process, composed of musical, cognitive, perceptual, and kinesthetic processes and subskills (Lehmann & McArthur, 2002). In other words, the analytic tool of vocal sight-reading performance may reveal degrees of essential musical understanding (or

misunderstanding). One way to examine musical understanding during vocal sight-reading is through strategy use. In the aforementioned sight-reading scenario, Nora's strategy was limited to imitation, either from the instructor or the piano. In a choral setting, singers often rely on neighbors for pitch-finding support (Henry & Demorest, 1994).

Strategies are “deliberate, goal-directed mental operations that are aimed at solving a problem” (Bjorklund & Causey, 2018, p. 266). Strategy use in vocal sight-reading is the way students “employ deliberate, goal-directed mental operations” in order to complete the task of vocal sight-reading, such as tonicizing the key or scanning the music for potential difficulties (Bjorklund & Causey, 2018, p. 266; Killian & Henry, 2005). Imitation, Nora's primary strategy, is a strategy to negotiate vocal sight-reading challenges. Knowing more about Nora's strategies, or her “goal-directed mental operations” while trying to navigate and reproduce notation, might aid in ascertaining her misunderstandings regarding the process of reading (Bjorklund & Causey, 2018, p. 266).

Problem

Students' ability to successfully implement strategies can accelerate learning and increase problem-solving skills' efficacy (Bjorklund & Causey, 2018). Choral students execute strategies when sight-reading (Killian & Henry, 2005). However, the inability to effectively employ strategies that result in successful vocal sight-reading might be slowing or impeding students' progress in vocal sight-reading ability, and, more importantly, might contribute to slower learning and delayed development in underlying cognitive music processes (McPherson, 2005). Accordingly, these students may have low

sight-reading achievement scores, may progress in universal music skills at a slower rate than their peers, and may ultimately discontinue music participation (Killian & Henry, 2005; McPherson, 2005).

Background

Students who effectively employ sight-reading strategies frequently perform better on sight-reading measures (McPherson, 1997, 2005). Across a battery of music skill measures including sight-reading, McPherson (2005) found that the children most likely to improve in musical performance across tasks (in comparison with their peers) were those who began employing musically appropriate strategies early in their learning. In fact, strategy use was a consistent and strong predictor of sight-reading scores (McPherson, 1997, 2005). Participants' sight-reading scores in McPherson's (1997, 2005) studies significantly increased each year over three years of instrumental instruction, and those who began sight-reading well tended to continue sight-reading well when compared with their peers. Interestingly, strategy use explained 11%, 33%, and 42% (years 1, 2, and 3, respectively) of the variance on sight-reading achievement, while practicing their instrument only explained 6%, 8%, and 11% percent of the variance. This study suggests that strategy use propels student learning in underlying cognitive musical processes common across many musical skills.

Subjects in Killian and Henry's (2005) study who performed in the high-accuracy vocal sight-reading group (the top 26% of participants) employed effective strategies significantly more frequently than the middle- and low-accuracy groups both in the 30-second practice session and during the performance of the exercise that directly followed

the practice session. Furthermore, high-accuracy sight-readers scored significantly higher than the low-accuracy group in the 30-second preparation and melody condition. Thus the students who scored significantly higher on sight-reading in the 30-second preparation condition were the same students who employed significantly more effective strategies. In the other condition (after the no-practice melody), high-accuracy participants tonicized previous to singing significantly more often than the low-accuracy group members. Taken all together, results from Killian and Henry's (2005) study suggested strategy use may be a differentiating factor between those who perform well and poorly on sight-reading measures. Indeed, Bjorklund and Causey (2018) asserted that strategy use can activate faster and more resourceful learning.

Conversely, participants in the same two studies who could not effectively execute sight-reading strategies performed poorly on the sight-reading indicators. When measured over 3 years in McPherson's (2005) study, low scoring students on a sight-reading measure made little progress over the three years, in fact, some even declined in scores (8% lower in the second year and 20% lower in the third year) from year to year despite continued music participation (whereas 87% and 78% of students improved their sight-reading score, from year 1 to 2 and 2 to 3, respectively). Furthermore, those who scored below the mean on the first year's sight-reading score were significantly more likely to cease instruction by year 3 (McPherson, 2005). This divergence of sight-reading skill, combined with high correlations that showed students retained the same rank position over 3 years, suggests students who began struggling with sight-reading continued to struggle over 3 years with the same skill (McPherson, 2005).

Similarly, in Killian and Henry's (2005) study those who were in the low-accuracy group (lowest 16% of participants) displayed significantly more, as they described, ineffective performance strategies (abandoned steady beat, stopped during the melody, took eyes off the music, and shifted the body). Participants in the low-accuracy group also demonstrated significantly less effective behaviors (Killian & Henry, 2005). Furthermore, the 30-second preparation time given did not significantly improve sight-reading scores for low-accuracy singers when compared with the high- and middle-accuracy groups, which implies that low-accuracy singers may not be aware of or may not attempt effective strategies in orienting towards and preparing for sight-reading exercises. Without any practice time, participants in the low-accuracy group tonicized before performance significantly less often than subjects in the high-accuracy group, which may indicate that a lack of implementing a tonicizing strategy leads to lower accuracy scores for high school age students. In both McPherson's (2005) and Killian and Henry's (2005) studies, a lack of effective strategy use implementation was related to poor sight-reading achievement, and, McPherson (2005) found that this possibly indicated delayed development in underlying cognitive music processes.

Further, results from Henry's (2008) study suggested effective strategy use implementation can increase sight-reading achievement. In this study, low-accuracy sight-readers both scored significantly higher on a sight-reading posttest and performed significantly more desirable behaviors during the sight-reading posttest. These changes in strategy use occurred after half of the students received one 30-minute instruction session regarding desirable and adverse behaviors during sight-reading and participated in peer

teaching (experience performing sight-reading in pairs according to a checklist of desirable and adverse behaviors). If a significantly higher frequency of desirable behaviors co-occurs with significantly higher sight-reading scores for low-accuracy sight-readers, this suggests low-accuracy sight-readers may be at a disadvantage when not implementing strategies.

Although participants in McPherson's (2005) study increased in strategy use over 3 years, it was their ability to use the strategies that predicted sight-reading scores; the ability to enact strategies was one of the differentiating factors between sight-reading achievement scores, not age or years of experience. That is, the practice of employing significantly more effective strategies in vocal sight-reading is not based on age, years of experience in choir (self-reported), or formal rehearsal time spent on sight-reading (self-reported) (Killian & Henry, 2005).

The motivation for studying strategy use in students is that understanding students' thought processes (attention, problem-solving, tactics) while performing a task better informs our understanding of their current abilities and their varying rates of progress (McPherson, 2005). Strategy use reveals the types of knowledge students utilize. Declarative knowledge, or knowing *about*, is recalling "specific isolated pieces of knowledge such as facts, definitions, terminologies, concepts, etc." (Abu-Zaid & Khan, 2013, p. 1). Declarative knowledge is factual, simply measured, "easily and rapidly acquired," but "relatively slow and clumsy to apply" (Dowling, 2014, p. 7). Students show declarative knowledge with verbal or written statements (Annett, 1996), such as "G major has one sharp." This type of verbally-expressed knowledge, however, does not

immediately aid students in finding upcoming pitches when sight-reading.

Procedural knowledge, or knowing *how*, is “the ability to execute action sequences to solve problems” (Rittle-Johnson, Star, & Durkin, 2009, p. 837). Procedural knowledge includes “understanding concepts, assembling knowledge, ... making rational predictions, applying critical judgments, arriving at conclusions, and deciding on the best course of actions” (Abu-Zaid & Khan, 2013, p. 1), and all of these culminate in the desired action. This type of knowledge is action-oriented; often it can only be demonstrated and not articulated because the actions are automatic. In music, for example, students enact procedural knowledge when singing, playing an instrument, improvising, and composing. According to Dowling (2014), procedural knowledge is more difficult to measure because “procedural knowledge is often consciously accessible only through its results, and not often explicitly present to consciousness as such” (p. 7). Students demonstrate procedural knowledge by performance (Annett, 1996), such as by vocally sight-reading, although they may not be able to articulate how they are accomplishing the task. Zurbriggen, Fontenot, and Meyer (2006) argued “the ultimate form of procedural knowledge ... is the motor program used to sing a melodic note” (p. 959).

Strategy use is a manifestation of both declarative *and* procedural knowledge, through which researchers can gain access to a student’s explicit and implicit understanding of vocal sight-reading. McPherson (1997, 2005) found through interviewing elementary and high school age students that high-achieving sight-reading students use declarative knowledge in their strategies by looking at the key and time

signatures. For example, knowing *that* a sight-reading task is in G major and 4/4 time, two examples of declarative knowledge, allows a student to become calibrated to a tonality and meter and prepare for a sight-reading task. McPherson also found through observation that high-achieving sight-reading students utilize procedural knowledge in their strategies by studying the first measure of a task and skimming the exercise for potential problem areas. Knowing *how* to assess potential challenges and incorporate practiced spots into a sight-reading task (two examples of procedural knowledge) enable a student to demonstrate their knowledge through action.

Students' strategy use is a mechanism whereupon students enact information; within sight-reading, this lies at the intersection of their previous knowledge, processing of relevant information, planning ability, and motivation to accomplish the task (Lehmann & McArthur, 2002). Students may use multiple strategies simultaneously (Siegler & Svetina, 2006; Vujović & Bogunović, 2012). Proficiency in strategy application changes over time as students gain consciousness regarding their own memory processes and increase intentionality in strategy use (Moely et al., 1992; Moely, Santulli, & Obach, 1995; Scripp, 1995). Bjorklund and Causey (2018) suggested that, when using strategies, students are "increasingly able to direct their own learning and problem-solving" (p. 266). Students' ability to effectively implement strategies during sight-reading may enable students to become more independent learners and music makers.

Because cognitive processes are internal, accessing students' strategy use can be problematic. To observe strategies, researchers must utilize tasks that involve cognitive

processes or strategy use, and vocal sight-reading tasks demand just such strategy use. In contrast to an instrumental sight-reading indicator, a vocal sight-reading strategy indicator remains ripe with challenges or events (such as lack of an external and visible pitch-changing mechanism). Without a means to physically see, examine, and manipulate the pitch-changing mechanism, vocal sight-reading tasks demand employing internal strategies, such as: determining the aural distance between pitches, differentiating and labeling (solfege or letters) pitches, assessing current pitch performance, planning future pitch targeting, and deciding and strategizing which pitches are and are not appropriate and applicable. All of these challenges become events where students must make decisions and problem-solve to execute vocal sight-reading. Thus vocal sight-reading may necessitate and reveal a more authentic understanding (or misunderstanding) of the symbol system, beyond which can be seen in instrumental sight-reading. Within these decision-making events, choral singers must inevitably rely on other methods than kinesthetic or visible references.

Lehmann, Sloboda and Woody (2007) suggested one such underlying cognitive process, creating mental representations of sound (or auditory representations), underlies all musical behaviors. Mental representations are mentally imagined reconstructions of the external world (Lehmann et al., 2007). According to some philosophers and researchers (Brodsky, Henik, Rubinstein, & Zorman, 2003; Gordon, 2007; Mainwaring, 1941, 1951) the ability to “think in sound,” or create and manipulate auditory representations, remains *the* crucial skill for music making and listening. As the ability to form, organize, and exercise control over auditory representations increases, in turn, other

musical skills improve simultaneously (McPherson, 2005; Palmer & Meyer, 2000). In fact, Scripp (1995) concluded that it is the “development of internal representations of rhythm and pitch that defines music reading skill development” (p. 315). Because auditory representations are not directly observable or measurable, strategy use remains one way to perceive students’ descriptions, explanation, application of knowledge, and progress in developing internal auditory representations of pitch and rhythm.

Vocal sight-reading skill is typically measured with accuracy-based scoring methods, yet this type of scoring cannot detect students’ rationales and motivations in decision making and problem solving. Strategy use further explains how or why students make decisions; in vocal sight-reading this can be even more apparent since vocalists have to make more decisions and create the sound, thus establishing more events and instances for demonstrating underlying musical knowledge. Ideally, sight-reading ability indicates many cognitive processes including the process of creating auditory representations elicited from notation. Many music teachers and choral directors employ sight-reading tests, especially in audition and summative evaluation settings; however, accuracy-based grading systems can obfuscate students’ underlying cognitive processes, as the correct or incorrect performance of a sight-reading exercise cannot explain students’ reasoning or intentionality.

In studying strategy use, it is crucial to employ methods that allow for harnessing of such data. These methods should utilize tasks that elicit these processes and capture students’ decisions and perspectives on their intentions and actions during specific performed events. Examining verbal data (or students’ explanations) is valuable, but

simultaneously considering sight-reading performance data leads to more comprehensive and representative analysis. Thus, combining sight-reading performance with verbal data for better recall and accuracy of strategies, as well as confirming matches/mismatches between self-reported and accuracy of performance, allow for investigating strategy use in untapped methods and with unemployed analysis.

Analyzing multiple data streams regarding the same specific sight-reading events may result in clearer understanding of the efficacy of employed strategies and possibly the component skills in vocal sight-reading. Indeed, after studying participants' strategy use over many musical tasks, McPherson (2005) recommended investigating the extent to which self-reported and researcher-observed data correspond or conflict. Henry (2008) and Killian and Henry (2005) have analyzed participants' strategy use considering researcher-observed behavior, and Edgington (2005) and Vujović and Bogunović (2012) have studied strategy use employing participants' self-reported interview and survey data, but these types of data are infrequently corroborated (Scripp, 1995; Thompson, 2003). Of those that collected both sight-reading performance and interview data, Scripp (1995) made no reference to combining the data streams for analysis, and Thompson (2003) compared and contrasted the two data streams for very little data (one vocal sight-reading exercise and companion interview per 11 participants). Examining choral singers' strategies during sight-reading, or the ways in which they negotiate and transform notation orthography into sounds, probes vocal sight-reading into deeper levels, such as within decision-making and self-evaluation. This, in turn, may provide explanations

regarding singers' actions, and therefore insight into their underlying skills and knowledge.

If strategy use can positively influence vocal sight-reading achievement, then studying strategy use on deeper levels using synthesized data streams might better disambiguate sight-reading impediments. Furthermore, if the ability to form and manipulate auditory representations is indeed a most crucial musical marker, then studying students' articulations of creating and manipulating auditory representations might better enlighten understanding of underlying musical cognitive processes. More research is necessary to help researchers, teachers, and choral directors better understand differences in efficacy of strategies employed and deficits and proficiencies in the component skills of sight-reading, and this will, in turn, aid in better understanding the reasons why some students succeed and some struggle in sight-reading (and potentially in overall music). With this information, choral directors might be more cognizant of these patterns in students and might better design music literacy acquisition and sight-reading curricula.

Purpose Statement

The purpose of this exploratory, collective case study was to elucidate the strategies that might or might not be employed by eighth grade choral students during vocal sight-reading. The goal of this study is to better understand the relationship between strategy use and accelerated learning in vocal music notation reading for the ultimate end of better informing music literacy acquisition pedagogy and curricula. The conceptual framework for this collective case study combines the theoretical construct of

audiation and empirical findings regarding sight-reading from the field of cognitive science.

Conceptual Framework

Audiation. *Audiation*, a term popularized by Gordon beginning in the 1970s (Gordon, 2007), is a process of both hearing (externally or internally) *and* simultaneously assimilating and comprehending music. Audiation is a cognitive process (Geake, 1999) and theoretical construct, characterized by the brain assigning meaning to incoming or imagined musical sounds (Gordon, 2007). Although unavailable to direct observation, Brodsky et al. (2003) deduced the occurrence of audiation with a highly developed task. In this study, participants silently read an embedded melody task (where the originally-notated melody was visually masked by extra pitches and rhythms), then listened to a sounded melody, and indicated a “match” or “mismatch” response. The researchers deduced that subjects had to audiate in order to “hear” the visually-hidden melody, and concluded that for these participants, silent reading did, indeed, result in auditory imagery.

As a theoretical construct, researchers and educators know little about what occurs during audiation. During this process, Gordon (2007) conjectured, listeners analyze and synthesize the heard or imagined music pattern content based on its musical context and then use this information to predict upcoming material. Audiation, therefore, is a highly individualized process and entirely dependent upon what experience, knowledge, and skills an individual brings to the task.

Accordingly, Gordon considered audiation the “foundation of musicianship”

(Audiation, n.d., para. 1). Likewise, other philosophers and researchers (Mainwaring, 1951; Seashore, 1938) have conceptualized “thinking-in-sound,” or sound as the unit of thought, as the basis for purposeful and independent music making (Gordon, 2007, p. 1; McPherson, 1994, 1997; Schleuter, 1997). Seashore (1938) claimed this as a “condition for learning, for retention, for recall, for recognition, and for the anticipation of musical facts” (p. 6).

Fundamental to the constructs of audiation and thinking-in-sound, Lehmann et al. (2007) hypothesized that the ability to construct and manipulate mental representations of music is present across the range of musical behaviors. They also concluded that increasing mental representation manipulation proficiency might lead to improved musical skills. Moreover, Pfordresher and Halpern (2013) found that vocal imitation abilities were significantly correlated with self-reported vividness ratings for music imagery. The vividness subscale centered around forming auditory imagery, thus results suggested poor-pitch singers struggled to create musical imagery. Furthermore, musical imagery induces expectancy (Janata, 2001; Kraemer, Macrae, Green, & Kelley, 2005). As forming, manipulating, and expecting auditory representations is central to audiation, audiation might be an underlying cognitive process common to all music behaviors, including vocal sight-reading. In this way, monitoring and investigating audiation during strategy use may provide insight into students’ ability to form and manipulate auditory representations during vocal sight-reading.

Audiation is a unique term, similar to, yet fundamentally different than, other terms from the field of cognitive science, such as auditory imagery, musical imagery,

subvocalization, and inner hearing. These terms signify a one-time event, or singularly experiencing a mental representation, which does not necessitate former experience. Conversely, audiation is a process of assigning meaning to the perceived/imagined sound and requires former assimilation and comprehension of music to facilitate the process.

Gordon (2007) theorized that skill in audiation increases over six, hierarchical Stages of Audiation. They are:

1. momentary retention,
2. imitating and audiating tonal and rhythmic patterns and recognizing and identifying a tonal center and macrobeats,
3. establishing objective or subjective tonality or meter,
4. retaining in audiation tonal and rhythmic patterns that have been organized,
5. recalling tonal patterns and rhythmic patterns organized and audiated in other pieces of music, and
6. anticipating and predicting tonal and rhythmic patterns. (Gordon, 2007, p. 20)

These theorized stages provide structure and sequence to a generally unseen cognitive process, and delineate a progression of sophistication in audiation. It is plausible that choral students' sight-reading strategies may evidence these audiation stages.

Researchers refer to the skill of audiating music notation as *notational audiation* (Brodsky et al., 2003; Brodsky, Kessler, Rubinstein, Ginsborg, & Henik, 2008; Gordon, 2007), and Gordon (2004) defined it as the “ability to hear the musical sound of and give contextual meaning to music notation, before it’s performed, performed by someone else, or when being written” (p. 5). Notational audiation is an advanced audiation skill,

requiring the combination of many specific audiation skills (Walters, 1989). This suggests students may employ individual or combined notational audiation skills when sight-reading, such as audiating the tonal center or a dominant chord from notation. Simoens and Tervaniemi (2013) suggested that when reading notation, sight-readers use auditory feedback to audiate upcoming notation. In other words, several types of audiation are occurring simultaneously when reading. Cognitively, notational audiation exists as a complex operation, requiring many processes, including actualizing knowledge, referencing short- and long-term memory, comprehension, evaluation, labeling, and problem solving. Using the term “notational audiation” enables researchers to more accurately label strategies used by students.

Notational audiation might be advantageous (if not essential) for choral singers, because singers receive limited *proprioceptive feedback* from the vocal cords (Sundberg, 1987). Proprioception “is our sense of the location in space of a part of our body, and of its movement between locations” (Nettheim, 1979, p. 37). Without an external mechanism for changing pitches, such as keys or positions (as is the case for instrumentalists), and little internal feedback from the vocal cords when movement occurs, singers must rely either on their own skills or nearby singers to sight-read (Bennett, 1984; Henry & Demorest, 1994; Middleton, 1984). Without audiation, Gordon (2007) claimed students are merely echoing and copying, never internalizing concepts or growing in skills.

The theoretical construct of audiation underpins this study because it provides (a) more precise labels for students’ strategies; (b) the theoretical need for notational

audiation when vocally sight-reading; and (c) a framework for understanding choral students' sophistication in moving through theoretical stages. Along with audiation, this study warrants a framework encompassing empirical research in *how* students accomplish the task of sight-reading; therefore, we integrate findings from the field of cognitive science to further outline this study's conceptual framework.

Pertinent findings from cognitive science. Fundamentally, studies in the field of cognitive science center around the mind, brain, and cognition (Dawson, 2013). Research in cognitive science can provide concrete and observed measurements of the mind and brain, thus generating insight into musical cognitive processes and procedures that remain otherwise unobserved (such as audiation).

Although term *audiation* itself is rarely found in cognitive science literature, researchers have accumulated an abundance of empirically-based information regarding sight-reading skills. These studies are typically conducted with expert adults, showing domain expertise (Waters, Underwood, & Findlay, 1997), and usually with instrumentalists, mainly pianists (Drost, Rieger, Brass, Gunter, & Prinz, 2005). Few cognitive science researchers have investigated the developmental process of becoming music literate, music literacy and notation pedagogy, or reading music notation with children as subjects; this study will address that gap in the literature. Nevertheless, it is beneficial to review the characteristics of mature sight readers and their sight-reading methodologies, which can provide insight into the patterns and behaviors of high and low achieving sight readers and the enabling and impeding strategies they employ. Middle school choral students may also utilize these behaviors and knowing the patterns within

adult sight readers may facilitate better understanding of students' current abilities. The following sight-reading process will be described briefly here, then in depth in Chapter 2.

According to Thompson and Lehmann (2004), when reading and performing music notation there are three sequential events: perceiving, processing, and executing. When perceiving, eyes view music notation symbols and the brain directs eye movement according to the brain's ability to process the information (Kinsler & Carpenter, 1995). During the second stage, processing, the brain chunks incoming material into meaningful patterns, decodes visual information, encodes input into auditory representations (possibly in the memory buffer), and draws from long-term and short-term memory for analysis (Hoppe et al., 2014; Kalakoski, 2001; Lehmann et al., 2007). Finally, in the execution stage, the brain completes motor processes by recruiting different areas of the brain (Meister et al., 2004), and often these motor programs become automatic (Wolf, 1976).

Considering all three stages together, visual perception, processing, and execution, there is an ongoing "dialogue" between the eyes, brain (short-term and long-term memory), and motor programs for execution. For example, there is less cognitive load and the brain works more efficiently when the reader can chunk larger patterns of material. In this way, the eyes relay larger chunks of material, therefore having time to intake other material (e.g., dynamics), and processing happens faster, because the information is drawn from memory in one chunk.

Based on collective research findings, Lehmann and McArthur (2002) suggested sight-reading is a reconstructive process, which involves two steps. In the first step, in a

multifaceted reconstructive process, the musician considers structural and technical characteristics while encoding the notation orthography. Second, the musician executes necessary motor programs to create the sound. Lehmann and McArthur further describe that in the first step, the performer scans the notation orthography and automatically encodes typical musical attributes, and the attributes are seen as chunks and matched with information in long-term memory storage. When attributes cannot be automatically encoded, the musician conscientiously reconstructs the notation by combining previously learned information and extracted data. They even propose that the performer's main challenge might be in providing enough information and patterns from memory that the process is fairly automatic, not in decoding the notation. This view positions sight-reading as (a) based on ones' previous learning and knowledge and (b) an accumulation of many musical skills. This implies that (a) former learning impacts current sight-reading abilities, and (b) deficits in overall musical skills impact sight-reading skills. To use Gordon's (2007) language, the reconstructive process (sight-reading) requires using previously learned knowledge and skills to construct understanding of unfamiliar notation. This reconstructive sight-reading perspective pairs closely with audiation, as the process of audiation requires assimilation and comprehension to assign meaning to actual/imagined sound.

Considering pertinent findings from cognitive science remains integral to this study because these findings provide empirical manifestations and potential evidence of underlying musical cognitive processes, including audiation. Though the aforementioned conclusions pertain to mainly expert adults, they can guide researchers in knowing what

skills are developed for eventual domain expertise and what processes are eventually automatic (such as harmonic chunking). As a result, researchers may more easily study the progression of these variables as students advance in learning how to sight-read music notation.

Conceptual framework. The combination of the theoretical construct of audiation and empirical research from cognitive science comprise the conceptual framework for this study. The conceptual framework is represented in the following figure.

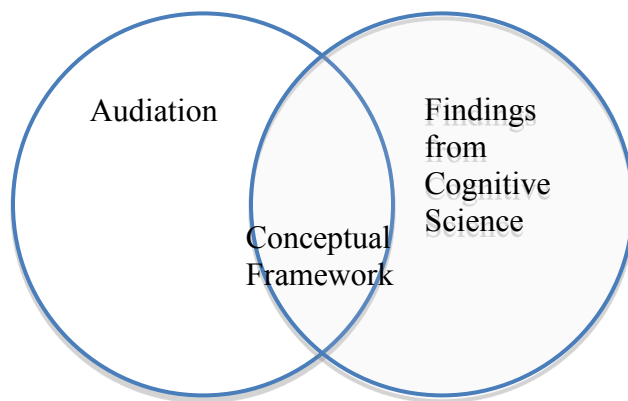


Figure 1. The conceptual framework.

The relationship between audiation, empirical findings from cognitive science, and the overall conceptual framework is such that audiation (an underlying musical cognitive process) informs empirical findings manifested in studies in cognitive science. The combination of audiation and audio/imagined-cognition findings, therefore, results in a conceptual framework that compliments and supports each other in several respects.

First, and most importantly, the components of this conceptual framework have a reciprocal relationship. Theoretically, underlying musical cognitive processes drive

musical behaviors (Lehmann & McArthur, 2002) and musical behaviors and manifestations can be empirically investigated by cognitive science researchers. Studies in cognitive science allow researchers to indirectly study and measure underlying musical cognitive processes that otherwise remain unobservable, and findings substantiate audiation (Brodsky et al., 2003; Brodsky et al., 2008; Hoppe et al., 2014). Indeed, studies in cognitive science provide evidence that the ability to encode written pitches into auditory representations (or using notational audiation) might be *the* central factor for reading music notation (Brodsky et al., 2003).

Second, the framework components merge to produce a multifaceted progression of skills. The theoretical stages of audiation and findings from cognitive science regarding sight-reading, when juxtaposed, generate a parallel and complimentary sequence of musical understanding. As researchers in cognitive science employ more advanced and sophisticated technology, the more researchers and educators understand the development and progression of mechanisms and structures involved in creating and manipulating auditory representations.

Third, the components of this conceptual framework view music reading as a reconstructive activity and ideas from both support this notion. Gordon (2007) theorized and findings from cognitive science show that the ability to read music notation depends on previously assimilated and comprehended music to assign meaning to imagined/sounded pitches as well as read notation. These components both suggest that underlying musical cognitive processes are common across musical tasks. Both also honor the observed progression of reading acquisition, where aural learning becomes the

foundation on which visual learning occurs.

The conceptual framework was used in this study in three main ways. First, this framework was applied to position sight-reading as a reconstructive activity that employs underlying cognitive processes, including audiation, which guide and facilitate reading. Second, the general behaviors and principles of better and poor sight-readers (the pertinent results from empirical studies) were utilized as a way to better understand, interpret, and categorize students' strategies in accomplishing sight-reading tasks. For example, students may be able to audiate the tonal center throughout, which enables quick re-centering after a mistake. Third, the resulting lexicon and catalog of behaviors from the conceptual framework were employed to a) design a sophistication of strategy use index, and b) assign strategy use scores to students' overall strategy use throughout the tasks. I viewed empirically studied skills from cognitive science through a sophistication lens, seeing skills in terms of efficiency. Based on the efficiency of observed strategies, I created an index of the sophistication of strategies (in 5 cognitive categories), which I then used to assign sophistication of strategy use scores to individual participants. For example, strategies that relied on note-to-note reading were inefficient and slow and received a low score. Strategies that involved gestalt thinking aligned more closely with reading principles, and entailed recognizing and classifying according to higher order relationships translated into faster and more accurate reading and, therefore, received higher scores.

The uniqueness of this study, in comparison to other sight-reading and strategy use studies, lies primarily in the conceptual framework, methods, and data analysis. The

conceptual framework provides a distinctive lens from which to sieve strategy use in middle school aged students and consider the efficacy of strategies employed. Secondly, the methods allow access to deeper thoughts and information and contextualized decisions, providing the observance of a previously untapped data source. Studying strategy use using untapped methodologies (beyond accuracy based quantitative assessments) can enable unique access to sight-reading subskills during the reconstructive process. Finally, the data analysis procedures synthesize data streams in a previously unused manner.

Research Questions

1. What are the characteristics of strategies employed by middle school choral students during vocal sight-reading?
2. How does the strategy use of higher scoring sight readers differ from those of lower scoring sight readers?
3. Does the use of more sophisticated strategies influence sight-reading scores?

Need For The Study

As a choral director, I believe the ability to sight-read music notation leads to greater independence for students as both singers and musicians. I am interested in the sight-reading strategies employed by eighth grade choral singers: I believe there are common misconceptions and potential traps, and studying the strategies utilized by eighth grade choral students might make those strategies accessible to all students. Cognitive science offers insights into the sensory input and processes involved in these strategies,

including empirical data related to the mental representation of music, or, as Gordon (2007) labeled this, *audiation*. Music educators, both vocal and instrumental, are concerned with the same processes of cognitive strategies in sight-reading (Gromko, 2004; Grutzmacher, 1987). My music teaching colleagues and I are unsettled regarding the disparity between students who assimilate knowledge quickly, and those who continue to flounder, within vocal sight-reading (Bolton, 2009; Demorest, 2001).

The current study may improve or expand the practices of music education in several areas. First, better understanding the enhancing strategies utilized by eighth grade choral students might better inform sight-reading pedagogy and curricula and make those strategies accessible to all students. Better understanding the impeding sight-reading strategies employed by eighth grade choral singers might increase music educators' awareness of and sensitivity to common misconceptions and potential traps in vocal sight-reading. This study may aid teachers in knowing how to better implement strategy use into sight-reading curricula to improve sight-reading achievement, might lead teachers to examine aspects of sight reading beyond correct-note scores, and might enable some teachers to better implement sight-reading scaffolding in the classroom and potentially retain more students in the music program.

According to researchers in cognitive development, secondary age students are capable of using strategies (Bjorklund & Causey, 2018). For students, success in school and in music is, in part, regulated by the quality and intentionality of their strategies, and ultimately managing their own learning. Understanding the differences in strategy use between those who are able to assimilate and use new information quickly and those who

struggle is an important concern for cognitive scientists.

The results of this study might aid cognitive scientists in better knowing how students make decisions in vocal sight-reading, and thus design more finely-tuned and fitting studies (what to look for, where to look, and what age groups) in discovering the cognitive processes underlying sight-reading. Furthermore, in studying the music literacy acquisition process and developing a theory regarding how people learn to read music notation, this study might aid cognitive scientists in understanding the cognitive processes involved in the component parts of sight-reading as well as the underlying reasons of if and how strategy use accelerates overall learning.

CHAPTER 2

LITERATURE REVIEW

An extensive body of literature on music reading and vocal sight-reading exists, but within these studies few researchers have investigated the use of strategies. Those researching sight-reading skills among singers have mostly focused on descriptive studies regarding vocal sight-reading practice (Goss, 2010; Myers, 2008), methods or treatments to improve vocal sight-reading (Demorest, 1998; Mishra, 2014; Parks, 2005), or factors or predictors of vocal sight-reading success (Daniels, 1986; Demorest & May, 1995; Killian & Henry, 2005).

To gain a foundation in the explicit and implicit strategies students may be utilizing, I reviewed studies from the fields of both cognitive science and music education regarding the underpinnings of music reading and sight-reading skills. Music reading includes any employment of a score while reading (though the purpose may vary); sight-reading involves the performance of notation on first viewing and is most often used as a diagnostic tool to measure musical abilities (Demorest, 2001). I review both studies in music reading and sight-reading, as both are applicable to sight-reading. It is not clear, however, from the literature whether these are the same or different processes; some studies suggest they might be related but slightly different. For example, the differences in results between two studies (Hoppe et al. (2014) and Brodsky et al. (2008)), suggest related but not identical music reading processes when anticipating or not anticipating an out loud execution. My study, to be clear, is focused specifically on the act of vocal sight-reading, not the more general practice of music reading.

Throughout, I especially highlighted elements of procedural knowledge, employed in sight-reading and studied in cognitive science, that students and even professional musicians may not be able to self-report due to automaticity or habit (Wolf, 1976). Manifestations of this happen in “proof reader’s error” (correcting misprinted pitches when sight-reading) or the size of the “eye-hand span” (the number of notes a player can read farther than he is currently playing) (Gilman & Underwood, 2003; Sloboda, 1976). These are behaviors of expert sight-readers, yet participants may not have recognized their behavior and therefore may have been unable to report them. Also, imagery mismatch negativity (iMMN), a brain response to mismatches between imagined and perceived sounds, is an automatic response that is not conscious to the participant (Herholz, Lappe, Knief, & Pantev, 2009; Yumoto et al., 2005a). Studies from cognitive science permeate the chapter, linking empirical research to theoretical ideas in education, and forming the basis for collecting and analyzing students’ strategies while vocally sight-reading.

This chapter is divided into three main sections: the cognitive process of sight-reading, musical auditory expectancy, and studies with strategy use and sight-reading. In the first section, I outline the cognitive process of sight-reading by reviewing studies from cognitive science; this section will be divided into three parts: perceiving, processing, and executing. The second section, drawing from studies in education as well as cognitive science, will be divided into four segments (a) musical auditory expectancy, (b) expectancy elicited from notation, (c) error detection, (d) brain responses to mismatched audiovisual stimuli. In the third section, I survey studies in which researchers

focus on strategies employed while vocally sight-reading. The last section is divided into strategy use and sight-reading skills with instrumentalists, singers, and singers/instrumentalists, and summaries of high-achievement strategy use, notational audiation as a strategy, and overall.

The Cognitive Process of Sight-Reading

According to Thompson and Lehmann (2004), when reading and performing music notation there are three sequential events: *perceiving*, *processing*, and *executing*. Perceiving notation includes eye movement, looking behavior, and the transmission of symbols into the brain. Processing perceived notation involves interpreting and evaluating symbols through chunking, pattern recognition, and memory (Thompson & Lehmann, 2004). Finally, in the last step of the sequence, executing the task entails motor processes, vocal skills, and automaticity. Reviewing this process provides a platform from which to analyze students' sight-reading behaviors and thought-processes.

Perceiving. When perceiving notation, the brain directs and controls eye movements according to how it will perceive, analyze, and store incoming material. Goolsby (1994a) and other researchers have found that better readers had consistently different eye movement behavior than novices. After 72 volunteers participated in the Belwin-Mills Singing Achievement Test, Goolsby (1994a) chose the 12 highest and 12 lowest scoring students, and compared their eye behavior while sight-reading. The subjects were graduate students at a major university's school of music. The researcher presented all 24 participants with four single-line melodies and monitored and recorded eye movement (measured with Stanford Research Institute [SRI] eye-tracking equipment)

while the subjects performed the melodies, three times for each melody. Goolsby concluded that more skilled readers used fewer but longer fixations, looked further ahead in the notation, and returned to the point of performance while reading (Goolsby, 1994a, 1994b). Furthermore, less skilled readers had significantly longer fixations than skilled readers, suggesting they spent more time perceiving notation (Goolsby, 1994a). Similar to Goolsby (1994a, 1994b), Lehmann and Kopiez (2009) also deduced that beginning readers used many fixations, long pauses during fixations, and read unsystematically, whereas expert readers employed fewer fixations than notes (meaning they potentially either chunked the material or made educated guesses) and read more systematically (Truitt, Clifton, Pollatsek, & Rayner, 1997).

In a follow up study, Goolsby (1994b) further investigated the eye behavior of the least-skilled and one of the most-skilled readers in the 1994a study. These two sight-readers represented those of the same skill level. The participants sight-read three melodies, while the researcher collected eye-tracking data. Goolsby analyzed the eye movements and developed profiles for each reader. Goolsby determined that the less-skilled reader advanced through the notation note-by-note and fixated on the notation for its rhythmic length; whereas, the higher-skilled reader had a more horizontal and vertical perceptual range (including more regressions than the less-skilled reader). Goolsby's (1994b) results suggest proficient readers quickly recognize higher order relationships in incoming material, and, presumably, therefore do not need to fixate on single notes for longer periods.

In several research studies, researchers have determined that for musicians the

“eye-voice span” was significantly larger in more skilled readers (Furneaux & Land, 1999; Gilman & Underwood, 2003; Sloboda, 1984; Thompson, 1987; Truitt et al., 1997). The “eye-voice span” or “eye-hand span” number is the distance between the articulated (or played) note and the read note. The term is borrowed from the language sciences, where the “eye-voice span” (EVS) is the distance “between the viewing and subsequent articulation of a word” (Inhoff, Solomon, Radach, & Seymour, 2011, p. 544). The eye-voice span can be measured with eye-tracking equipment, synchronized with a computer (Gilman & Underwood, 2003). Interestingly, better readers’ “eye-voice span” numbers fluctuated, because they organized looking ahead around phrase boundaries or “structural markers.” In contrast, poorer readers had more consistent “eye-hand spans” (Sloboda, 1977, 1984; Waters et al., 1997).

Salis (1980) also found that musicians took in significantly more visual stimuli at a time in chordal form than non-musicians; however, when the dots were random, both skilled and unskilled musicians remembered the same amount of information. Other researchers, as well, have ascertained that musicians more accurately remember groups of notes when they can be grouped hierarchically (Halpern & Bower, 1982; Sloboda, 1978; Waters et al., 1997).

Kinsler and Carpenter (1995) suggested that ultimately the brain directs the eyes “not in relation to specific aspects of either the immediate visual stimulus, or of the final manual response, but as part of a mechanism for *regulating the flow of information* into and through the system that converts retinal images of musical notation into performance” (p. 1455; italics in original). In other words, eye movement and looking behavior are

based on the rate at which the brain can process incoming information, not on eye motor skills.

In the perceiving stage of sight-reading, better readers organized looking ahead around phrase boundaries or structural markers (Sloboda, 1977, 1984; Waters et al., 1997), and perceived and remembered organized tonal sequences present in hierarchical structures (Halpern & Bower, 1982; Meinz & Salthouse, 1998; Sloboda, 1978; Waters et al., 1997). Concepts such as “eye-hand span,” the number of notes a player can read farther than he is currently playing (Gilman & Underwood, 2003), and “proof-reader’s error,” correcting misprinted pitches when sight-reading (Sloboda, 1976), indicate that better sight-readers audiated, anticipated, and predicted incoming information (Goolsby, 1994a, 1994b). If the better readers in these studies exhibited these patterns of eye movement and looking behavior, then students’ strategies to perform in these ways may indicate advanced musical cognitive processes.

Processing. The second step of the sequence is processing. By interpreting and evaluating symbols through chunking, pattern recognition, and drawing from memory, the brain decodes perceived notation, encodes information into auditory representations, and processes material (Thompson & Lehmann, 2004). The perceiving and processing stages are interrelated (Thompson & Lehmann, 2004).

Chunking and memory. Many researchers have established that the brain organizes incoming information (letters or symbols) into meaningful units (chunks or musical patterns) for easier understanding and interpretation (Drake & Palmer, 2000; Fine, Berry & Rosner, 2006; Gilman & Underwood, 2003; Goolsby, 1994b; Gromko,

2004; Sloboda, 1977, 1978; Waters, Townsend, & Underwood, 1998). Chunking allows individuals to absorb and make sense of more information at one time by “link[ing] our perception to previously stored knowledge” (Lehmann et al., 2007, p. 112). The cognitive process of chunking is integral to reading music notation (Lehmann et al., 2007).

Waters et al. (1998) investigated the perceiving, processing, and underlying skills involved in chunking with 30 collegiate pianists. While there were differing degrees of piano skills among subjects, all had taken piano lessons for five years and also played a secondary instrument. The researchers performed six experiments (a) verbal protocols of preview; (b) note-naming task; (c) recall of briefly presented chords; (d) pattern matching task; (e) priming study (the degree to which chords were related); (f) visual-auditory matching task; (g) musical problem-solving task (the musical “cloze” task). Taken together, experiments two, three, and four indicated there was a relationship between sight-reading skill and pattern-recognition abilities. The highly skilled readers more quickly coded written notation in larger chunks and more accurately recalled significantly more briefly-presented chords than less skilled readers. Of all the experiments, the pattern-recognition task was most closely related to sight-reading ability; however, when scores for the visual-auditory matching task and the priming task were entered into a multiple regression analysis, the results from the three experiments more fully predicted sight-reading ability than pattern-recognition alone. The researchers, therefore, concluded that employing auditory representations and predicting were important in combination with pattern-recognition skills.

Other researchers have also found that more skilled readers absorbed more

information at a time, essentially reading larger units (Kinsler & Carpenter, 1995; Rayner & Pollatsek, 1997; Truitt et al., 1997; Waters et al., 1997). Furthermore, Sloboda (1978), after finding that memory decreased for melodies that did not conform to conventional music harmony practices, concluded that organizing printed notes into higher-order relationships enabled good readers to recall larger chunks of musical material. If the better readers in these studies were more proficient in dividing up and recalling musical material when sight-reading, then students' strategies to perform in these ways may indicate advanced musical cognitive processes in recognizing higher-order relationships and the degree to which participants have assimilated tonality.

Mechanisms for memory may be directly integral in the process of sight-reading and indirectly related to students' strategies in sight-reading. Land and Furneaux (1997) found the brain held new information in a memory buffer and Simoens and Tervaniemi (2013) and Hoppe et al. (2014) concluded the incoming image may be transformed from visual to auditory form and held in auditory form for processing. After studying the eye movements involved in table tennis, driving, and reading text and music, Land and Furneaux (1997) determined that subjects held incoming information in a memory buffer for about a second.

When comparing the EEG ($n = 15$) and behavioral ($n = 39$) data from a matching task (visual to auditory, auditory to visual, and visual to visual), Simoens and Tervaniemi (2013) found visual information was held in the memory buffer as an auditory cue, rather than a visual cue. They concluded when reading music notation, musicians probably first encoded the raw visual stimuli into an auditory image, and then processed and

manipulated the image.

With functional MRI scans taken during a delayed notes/tone-sequence matching task, Hoppe et al. (2014) found that during the retention interval singers shifted activation from the visual to auditory brain areas. Simultaneously, Hoppe et al. (2014) discovered a deactivation of visual areas during the modality transfer. These two phenomena were heightened in expert singers, where more auditory brain was activated and more visual brain was deactivated during the transfer from visual to auditory representations. Interestingly, they did not find motor processes were activated, which is in opposition to Brodsky et al. (2003) and Brodsky et al. (2008) who found motor processes were activated during notational audiation. Hoppe et al. (2014) noted, however, that the tasks required did not involve execution, or even anticipation of, motor skills; therefore, motor programs may or may not be activated when vocal sight-reading is the end product.

Findings from three studies (Hoppe et al., 2014; Land & Furneaux, 1997; Simoens & Tervaniemi, 2013) suggest incoming information was held in a memory buffer and transformed cross-modally. It is possible that in proficient score-reading musicians, the mode of analysis for notation stimuli is auditory, not visual, and that fixating on a visual image for a long time may signify a slow transformation from visual to auditory form. If students' strategies reflect these phenomena, they may indicate less skill in the auditory modality, and more deeply, a lack of understanding of the auditory modality.

Information regarding the storage, retrieval, and usage of data in short-term, working, and long-term memory (LTM) when sight-reading is disparate. Researchers

have raised differing theories to explain how the brain processes perceived information, such as that working memory capacity may influence individual sight-reading skill (Kopiez & Lee, 2008; Kopiez, Weihs, Ligges, & Lee, 2006; Meinz & Hambrick, 2010). For example, when studying representation construction, Kalakoski (2007) employed a musical task involving the relationship between working and long-term memory. Researchers in music practice and performance, such as Williamon and Valentine (2002), have cited Ericsson and Kintsch's (1995) theory of Long-Term Working Memory, where "reliance on acquired memory skills enables individuals to use long-term memory as an efficient extension of short-term working memory in particular domains and activities after sufficient practice and training" (p. 211). Ericsson and Kintsch's (1995) theory accounts for musicians' ability to quickly access extensive domain knowledge in LTM. Still, Kalakoski (2007) claimed researchers disagree as to the methods in which the brain employs previously learned information in LTM to segment and organize incoming visual stimuli. For example, Highben and Palmer (2004) found that "individual differences exist in the extent to which memory for musical sequences is encoded in motor movements and in auditory images" (in Palmer, 2005, p. 248).

Several studies suggest the involvement of long-term memory and working memory are crucial in sight-reading (Halpern & Bower, 1982; Kalakoski, 2007; Sloboda, 1976). While looking at the expertise effect in musicians and non-musicians, Kalakoski (2007) suggested that the creation of representations in the working memory is affected by access to the information stored in long-term memory.

Researchers have also studied differing aspects of long-term memory of sight-

readers. Halpern and Bower (1982) found that musicians have more efficient coding and storage systems for music notation than non-musicians and Thompson (1987) concluded better flute sight-readers have superior encoding abilities. Skilled readers more quickly recognized harmonically related chords versus harmonically distant chords, showing a weak, but present, harmonic priming effect (Waters et al., 1998).

Other information measured from long-term memory includes letter names. Waters et al. (1998) discovered that the recognition of pitch names on the grand staff is faster for experienced than less experienced musicians. However, Thompson (1987) found sight-reading ability was not correlated with letter recall ($r = -.39$).

Despite the divergence in research clarifying how the brain references memory when reading, overall evidence from these studies suggests previously assimilated music syntax and knowledge seem to drive chunking and music imagery formation, and this is important with regards to strategy use. The participants with domain expertise in studies conducted by Kalakoski (2007), Thompson (1987), and Waters et al. (1998) did not have better general memory recall than those without domain expertise, but were better able to apply information from short and long-term memory to process, chunk, and retrieve musical material; they were essentially more efficient (Vicente & Wang, 1998). Overall, the long-term, working, and short-term memory appear to have a symbiotic relationship when it comes to perceiving and processing music notation. If students employ LTM when enacting strategies, this may indicate students possess musical domain information stored in LTM.

Auditory representations and processing. As part of processing chunked material and cross-referencing with memory, some researchers have concluded the brain encoded visually perceived pitches into auditory representations or auditory imagery in trained musicians (Brodsky, Henik, Rubinstein, & Zorman, 1999; Brodsky et al., 2003; Herholz et al., 2009; Hubbard, 2010; Hubbard & Stoeckig, 1992; Schön & Besson, 2005; Simoens & Tervaniemi, 2013; Waters et al., 1998). For example, Waters et al. (1998) observed that very skilled readers were significantly better than both intermediate- and low-skilled readers in producing an auditory representation from a visual representation.

Along with auditory representation creation, some researchers have found that the auditory representation created an expectation or prediction (Schön & Besson, 2005; Sloboda, 1976, 1978). One manifestation of creating auditory expectations is “proof-reader’s error,” another term borrowed from linguistics. Sloboda (1976) investigated the similarities and differences between prose and music reading. For the prose reading, Sloboda misspelled 36 out of 354 words, and then directed 21 subjects to read a passage aloud, write down misspelled words, and summarize the passage after finishing. For the music reading, Sloboda introduced 72 musical errors into four short musical abstracts from little-known Baroque/Classical composers, and then asked 7 subjects to sight-read the abstracts on the piano twice, as accurately as possible, with the second time improving on the first. Sloboda discovered that, first, experienced piano students usually corrected misprinted pitches when sight-reading and the most often corrected pitches were in the middle of right hand phrases. Secondly, Sloboda found subjects corrected even more misprinted pitches the second time through, further predicting and replacing

incorrect notation. Sloboda (1978) suggested subjects employed previously learned musical material and expectancy to insert or replace stimuli, instead of solely decoding the notation. Sloboda (1978) concluded “good sight-reading is based upon, at least in part, the ability to decide on probable continuations within an idiom” (p. 12). Furthermore, Schön and Besson (2005), after studying the behavioral and electrophysiological brain responses in a matching task, concluded that from this auditory representation creation, readers expected and predicted certain pitches (I fully review this study later in the chapter). Participant strategies in the current study may involve the more sophisticated techniques of anticipation and prediction.

In the field of cognitive neuroscience, two research teams have found indications from the brain that music imagery was not just imaginary, but a verifiable neurological event (Herholz et al., 2009; Yumoto et al., 2005a). Musicians experience imagery mismatch negativity (iMMN), which is an event-related brain response commonly measured across all scientific fields, when an imagined tone does not match a sounded tone (Herholz et al., 2009; Yumoto et al., 2005a). After a sound-to-symbol mismatch task with eight subjects, Yumoto et al. (2005a) (reviewed later) suggested the “iMMN may represent the neural process of sensory deviance detection against an imagery memory trace” (p. 1178), or, in other words, the negative response emitted by the brain during mismatches may be evidence of the brain physically experiencing an imagined tone. In this study, skilled readers predicted upcoming sounds from music notation and experienced “mismatch negativity” when sounds did not match symbols (Yumoto et al., 2005a). In a similar study, Herholz et al. (2009) discovered musicians, not non-musicians,

experienced iMMN when a sounded pitch did not match an imagined pitch. In these two studies, evidence of imagery mismatch negativity (iMMN) suggests musicians audiated and predicted pitches, because if musicians did not audiate and predict pitches they would not have experienced mismatch negativity.

In summary, as part of the organization of incoming information, researchers have found the brain grouped letters or symbols together into meaningful chunks or patterns for easier comprehension, interpretation, and recall (Drake & Palmer, 2000; Fine et al., 2006; Gilman & Underwood, 2003; Goolsby, 1994a; Gromko, 2004; Sloboda, 1977, 1978; Waters et al., 1998). Schön and Besson (2005) and Waters et al. (1998) concluded that better reading subjects encoded visual stimuli into auditory representations. From these auditory representations, subjects expected and predicted certain pitches (Schön & Besson, 2005), which manifested in proof-reader's error and imagery mismatch negativity in skilled readers (Sloboda, 1976, 2005; Yumoto et al., 2005a). If participants in the current study employ strategies that involve chunking and auditory representations, it might indicate participants engage in musical cognitive processes.

Executing. Finally, when executing, the brain coordinates motor programs to complete the task. Motor processes are necessary to sight-reading. Most commonly, psychomotor movement, measured by the speed at which subjects perform psychomotor tasks such as tapping and trilling, has been found as an integral piece and predictor of sight-reading ability (Kopiez & Lee, 2008; Kopiez et al., 2006; Lee, 2004).

Of the three sequential actions, perceiving, processing, and executing, execution remains the least researched. For example, in one of the rare studies in execution and

sight-reading, Halsband, Binkofski, and Camp (1994) observed motor skills progressed from less efficient to more efficient, mirroring participants' perception of increasingly larger metrical rhythm groupings. Furthermore, through studies in neuroscience, researchers have discovered the brain recruits other areas to execute motor processes, such as, according to Brodmann's areas, the superior parietal lobule (area 7), the left premotor cortex (area 6), left inferior frontal gyrus (area 44), and the dorsal region of area 44 (Sergent, Zuck, Terriah, & MacDonald, 1992, p. 108), and the left hemisphere's primary sensor motor cortex and the bilateral premotor cortex (Meister et al., 2004, Section 3.2).

For instrumentalists, sight-reading is sometimes reduced to a visuo-motor activity. At its simplest behavioral description, sight-reading includes "perception (encoding of visual symbols on the page) and action (production of the musical response)" (Stewart, 2005, p. 377). Sloboda (1984) disproved this hypothesis, however, by detailing how musicians must use musical knowledge in sight-reading; in other words, sight-reading is not a strictly visuo-motor task, but involves cognitive processing. Indeed, there is a danger of associating music notation directly with pushing keys, without cognitive engagement; Schleuter (1997) called this occurrence "button-pushers," to whom "notation only indicates what fingers to put down rather than what sounds are desired" (p. 48).

For singers, motor processes may be different, because singers are both the instrument and the operator; therefore, singing can be abstract and intangible. Singers only produce one note at a time and proprioceptive cues are weakest for singers, making

producing pitches more intangible (Fine et al., 2006; Sundberg, 1987). Singers may develop muscle memory for pitches through training and experience (Fine et al., 2006; Sundberg, 1987). Without a button, string, or key to push, singers must rely either on their own skills or the skills of nearby singers for pitches. Often using what is called “split-second singing,” vocalists sometimes sing notes a split second after their neighbors sing the pitch (Bennett, 1984; Henry & Demorest, 1994). Fine et al. (2006) suggested that without a kinesthetic reference, “preformed internal auditory representation therefore seems necessary in enabling correct pitch production in singing” (p. 443).

In a rare study on motor programs when singing, findings from Zurbriggen, Fontenot, & Meyer’s (2006) study suggest the ability to sing the tonic pitch may be more crucial than for only aural skills. For singers, notes are represented in motor programs as semitone offsets from an anchoring pitch, instead of as exact frequencies. In other words, motor programs are calculated on the relationship of pitches to an anchoring pitch, not in executing separate and specific numerically-based frequencies. Furthermore, for motor program creation and execution, the initial pitch seems to be more important than the key of the short melody. With relation to strategy use, if motor programs are relationally based, it may be that a strategy to match the initial pitch is much more important than for aural priming; it may be important in vocal production of the notes in the key as well.

For instrumentalists and singers, motor processes may become automatic and unconscious. Dr. Goldovsky (conductor, pianist, lecturer) suggested:

I have come to the conviction that sight-reading has something to do with the speed at which the visual image is converted into a muscular act; and with some

people this is a very rapid transformation. As a matter of fact, it is so rapid, that the transformation of a visual image into its pianistic result is so rapid that a great deal of what happens escapes awareness—it just happens. (Wolf, 1976, p. 163)

Little research exists regarding the execution of motor programs for sight-reading, and especially vocal sight-reading. Research from several studies suggests during the execution phase, the third phase in the reading process, the brain recruits other parts (such as the motor cortex) (Meister et al., 2004), and often these motor programs become automatic (Wolf, 1976).

Perceiving, processing and executing combined. When combining the three stages of the cognitive process of sight-reading, it becomes clear there exists an ongoing dialogue or interchange between eyes, brain, and motor programs. Overall, the reading brain does not read individual notes, but sees chunks or patterns of information (Drake & Palmer, 2000; Gilman & Underwood, 2003). Aural familiarity with music syntax guides notation perception and comprehension (Meinz & Salthouse, 1998; Waters et al., 1997). Creating auditory representations is necessary in reading visual symbols (Fine et al., 2006; Schön & Besson, 2005). Furthermore, previously learned information is crucial in present reading skills (Lehmann et al., 2007; Truitt et al., 1997), or more broadly, domain expertise underlies and propels notation reading and comprehension.

Prior knowledge dictates the rate of uptake and analysis of visual stimuli and directs how incoming information will be read, stored, remembered, and performed. Faster note and chord recognition took place within proficient sight-readers; faster encoding from visual to auditory cues took place in musicians; anticipating and

predicting notes happened within better readers; all these data suggest the process of sight-reading is a window into musicians' understanding. Sight-reading skills are therefore highly dependent upon previously assimilated material and limited to the extent to which a person can couple visual symbol patterns with aural sound patterns.

Examining this process provides places where students' strategy use may accelerate or impede; this gives concrete descriptions to necessary components and enables labeling of missing steps or weaknesses.

Musical Auditory Expectancy

One byproduct of the combination of the perceiving and processing stages of vocal sight-reading is musical auditory expectancy. Musical auditory expectancy is anticipating auditory imagery not stimulated by out-of-body events (Schön & Besson, 2005). Musical auditory expectancy has been established in cognitive science, with adult participants (Aleman, Nieuwenstein, Böcker, & de Haan, 2000; Halpern & Zatorre, 1999; Herholz et al., 2009; Navarro-Cebrian & Janata, 2010; Yumoto et al., 2005a; Zatorre, Halpern, Perry, Meyer, & Evans, 1996), and with children (Magne, Schön, & Besson, 2006). These studies physically demonstrate a confirmable, as opposed to imagined, response that signifies the brain's ability to predict and anticipate sound. Isolating and measuring musical auditory expectancy is valuable because it provides evidence that auditory representations are not just imagined, but are real occurrences in the brain.

Audiation is related to, but broader than, musical auditory expectancy. Whereas audiation is the ability to "think in sound," musical auditory expectancy is experiencing and anticipating sound internally. In other words, musical auditory expectancy may be a

component of audiation. Gordon (2007) might label musical auditory expectancy as falling within the six stages of audiation: in Stage five, recalling previously heard music, or in Stage six, anticipating and predicting music.

Musical auditory expectancy elicited from notation. With the advent and proliferation of new technologies, studies in neuroscience increasingly have the ability to capture empirical evidence of musical auditory expectancy elicited from notation. Auditory images generated by reading music notation seem to be an integral part of the process of sight-reading, as seen in the many studies in auditory representations during the processing phase of sight-reading. Studies in error detection (Killian, 1991; Sheldon, 2004; Thompson, 2003, 2004) demonstrate musical auditory expectancy educed from notation. In these studies, participants detect similarities and differences between printed notation and sounded pitches, essentially recognizing and identifying mismatches. Although not discussed directly, results from error detection studies suggest musical auditory expectancy (or notational audiation) is a fundamental skill and, potentially, part of sight-reading. Studies that measure brain responses to matches and mismatches in audiovisual stimuli (Schön & Besson, 2005; Yumoto et al., 2005a) corroborate that the brain actually creates and retains an auditory image from notation. Although participants are not producing the sound (as required in vocal sight-reading) when participating in error detection or brain response tasks, these studies provide further understanding into the strategies participants use to audiate written pitches and cross-reference with actual sound.

Error detection and musical auditory expectancy. Error detection is the skill of detecting errors between notated and sounded pitches, requiring the comparison of audible sounds and musical auditory expectancy. The studies I review here are limited to only those that dealt with error detection from notation. Studies that included error detection, but also involved differing listening conditions (such as background noise), simultaneous tasks (such as singing), or experimental studies in improving error detection skills were excluded.

Killian (1991) investigated the relationship between error detection and vocal sight-reading abilities in Junior High School students. Participants ($N = 75$) performed two tasks. First, they vocally sight-read eight, two-measure examples, from both traditional notation and solfege syllables. Second, they listened to the same examples performed vocally (on a neutral syllable) and doubled by the piano, and determined whether or not the sounded voice matched the written notation. Killian awarded each whole example a point, if correct, for a total of 24 points. The researcher divided the sample by vocal sight-reading achievement into low, medium, and high scorers, then compared achievement levels with (a) sight-reading from a score, (b) sight-reading from syllables, (c) error detection.

Singers with high and medium level achievement scored at about the same level for all three activities (high scorers [$n = 26$]: 100% sight-reading from notation, 98% sight-reading from syllables, and 83% error detection; medium scorers [$n = 24$]: 73% sight-reading from notation, 74% sight-reading from syllables, and 68% error detection). Low scorers ($n = 25$) did not follow this pattern, in fact, their error detection scores (62%)

were significantly higher ($p < .01$) than scores from both sight-reading from notation (30%) and sight-reading from syllables (37%). Moreover, low-achieving singers' scores (62%) for error detection were just short of the medium scorers' (68%). For junior high singers, differences between sight-reading and error detection skills varied per sight-reading achievement level. In other words, sometimes notational audiation skills (cognition) and vocal sight-reading skills (performance-based) are not related; some middle school students may be able to notationally audiate, but not reproduce the sounds accurately, as seen in the low-scoring participants. Investigating both vocal sight-reading and notational audiation skills are critical to this process, because students may excel in one and lack skills in another. This finding may manifest in the current study if students observe inconsistencies between internally heard and externally produced sounds.

Sheldon (2004) also studied error detection, but with collegiate woodwind ($n = 36$) and brass ($n = 40$) instrumentalists. Participants listened to 12 examples, hearing each example three times, and marking errors on the score with a different color pen each time. There were 120 errors over twelve examples, and errors could have been made in articulation, dynamics/balance, intonation, pitch, rhythm, and tempo. Sheldon drew the examples from band literature, and created examples by entering them into Finale notation software, condensing them into multitimbral, four-voice reductions, and using synthesized sounds for each of the four parts. All errors were consistent with typical beginning band student mistakes.

Sheldon conducted repeated-measures analyses of variance (ANOVA) for all analyses. In total correct error-identification responses, the results were significant ($F(2,$

150) = 161.98, $p < .001$); and in total incorrect error-identification responses, the results were significant ($F(2, 150) = 42.32, p < .001$). In both correctly and incorrectly identifying errors, participants identified significantly more on the first listening, than on the second listening, and more on the second listening than the third listening. Results suggest woodwind and brass instrumentalists most correctly identified errors in articulation, pitch, and rhythm; they struggled to correctly assign error to mistakes in tempo, intonation, and dynamics/balance. When considering the four-part listening example, participants inaccurately labeled mistakes most often in the bottommost voice. Following this pattern, middle school students may attend more to articulation, pitch, and rhythm than tempo, intonation, and dynamics/balance.

Thompson (2004) used error-detection and auralization tasks to gain insight into the way undergraduates audiate notation. Thompson recruited 23 participants, with ages between 18 and 22, who were enrolled in music theory courses at a liberal arts university. Thompson gathered both quantitative and qualitative data, including: a test for absolute pitch, interviews regarding past musical experience and thoughts about sight-singing, multiple-choice and fill-in audiovisual tasks, four sight-singing tasks, researcher observations during preparation-time, and post sight-reading interviews for strategy confirmation and self-evaluation. For the audiovisual tasks, participants studied the notation, the administrator played example, the participants noted if the sounded melody was between two options, and, if neither, dictated what was sounded. To confirm data and analyses' accuracy, Thompson treated interviews as discussions, ensured student anonymity, and provided many member checks.

Based upon the combined data showing the processes students used to perceive pitches from notation, Thompson characterized students into six categories: the Follower, the Button-pusher, the Contour-singer, the Tonal-thinker, the Builder, and the Pitcher. The Follower was one who must hear pitches from an outside source before being able to sing it. The Button-pusher used fingering movement (of an imagined instrument) to auralize the pitches. The Contour-singer saw and followed the contour of the melody line, but could not accurately auralize discrete pitches. The Tonal-thinker often utilized audiation (of the tonal center and/or tonic chord) and relied on a sense of Western harmony to make educated guesses. The Builder employed interval sight-reading, though often became lost and re-established the tonal center for grounding. A Pitcher was one who had absolute pitch, and could recall sounded pitches from letter names. Some students used a combination of strategies, such as the Tone-builder, who combined thinking tonally and intervallically. With regards to the current study, Thompson's categorizations influenced the research design; I sought to create a research design that encompassed both the quantitative and qualitative elements of sight-reading, in order to observe a broad range of strategy characteristics such as seen in Thompson's study, from several perspectives.

Throughout the study, Thompson found several obstacles to data collection. Thompson found some singers reluctant to sing very loudly, wanting to first hear it externally and softly before they committed to singing it loudly. Second, some students were unable to articulate their strategies; despite using key words (i.e. "interval" or "think F#"), suggesting that even collegiate students may mislabel or remain unaware of the

strategies they use. Relevant to the current study, middle school students, who are likely less advanced and less experienced, may also demonstrate these behaviors as well.

After studying pitch perception elicited from notation with undergraduate students (Thompson, 2004), Thompson (2003) sought to better understand *pitch internalization* with professional musicians. Pitch internalization is “the process of imagining pitch and/or pitch relationships in the absence of physical sound” (Thompson, 2003, p. 11) or the “process of creating or recreating pitches in one’s mind” (Klonoski, 1998, p. 81). Pitch internalization is a different process from, but related to, audiation and notational audiation. In Gordon’s (2007) stages of audiation acquisition, the first stage of audiation, “momentary retention,” is akin to pitch internalization, where students momentarily retain an auditory representation. Furthermore, pitch internalization may be a prerequisite to the ability to audiate, as pitch internalization involves the awareness of and ability to access auditory representations, and audiation assumes this skill when assigning meaning to auditory representations. Pitch internalization as opposed to audiation, however, does not include assigning meaning to or understanding imagined pitches.

Thompson collected mostly qualitative data, with open-ended interview and questionnaire space. Thompson recruited 100 participants, which consisted of 30 independent teachers, 25 Kindergarten through 12th grade teachers, 22 college faculty members, and 23 orchestra members. Thompson administered an Aural Skills Questionnaire (ASQ) to gain insight into their musical history and experience. As part of the ASQ, participants indicated their confidence level in accurately auralizing an unfamiliar melody. Furthermore, Thompson administered an auralization task, where

participants decided if a sounded melody was notated correctly within two options, and, if in neither, dictated what was sounded, and then described their decision-making process. For the sight-singing task, participants prepared a sight-singing example, wrote down how they prepared to sight-sing, listened to the example, and then wrote down how their auditory representations were similar to or different from the sounded melody. Finally, participants read Thompson's descriptions and decided if the descriptions matched their process for auralizing, vocally sight-reading, and sight-reading on an instrument.

When asked about strategies used to audiate notation, participants chose from pre-written options and an open-ended blank space. For the pre-written options, participants could choose (a) solmization; (b) thinking intervals from note to note; (c) imagining the sound of each tone individually; (d) thinking about the relationships of the letter names; (e) imagining fingering on an instrument; (f) no particular strategy (p. 55). In the "other" option, participants supplied: "underlying harmony," "harmonic structure," "tonic-dominant and other functional interval relationships," "chordal outlines vs. scalar, relating to tonic triad and other triads," and "harmonic relationships" (p. 56).

Thompson transplanted most of the 2004 study's strategy-classifications, such as the Button-Pusher, Contour-Singer, Tonal-Thinker, and Builder; however, omitted the Follower (because no one used the strategy) and added Chunker. A Chunker was one who grouped information according to melodic or harmonic relationships, relying heavily on previously assimilated music syntax.

When comparing strategies used in the composite Aural and Sight-singing tasks,

Thompson found the most effective strategy was having absolute pitch, not surprisingly, as in Pitcher (97% correct). Among those with relative pitch, the three most effective strategies were Harmonic Thinking (94% correct), “Other” combination of strategies not combined by Thompson (91% correct), and Tonal-Thinker (86% correct). The entire sample, combining all strategies, earned 79% correct responses. The least effective strategies were Contour-Singer (38% correct) and Button-Pusher (40% correct). Interestingly the Builder, one who relies on interval thinking, earned 73% correct answers, which was lower than participants who used a tonal framework (harmonic thinking 94%, tonal thinker 86%), and also less than the total sample’s mean of 79% correct.

Searching for deeper and richer strategy descriptions, Thompson then interviewed 11 participants selected from among those in the highest quartile of self-reported confidence level in auralizing and asked them to sight-read (sight-reading out loud was optional) a tonal melody and auralize an atonal melody. When interviewing, Thompson interspersed interview questions surrounding the tasks. After a few seconds of preparation time, Thompson asked participants' observations regarding the melody, and after singing or humming the melody, Thompson asked general and specific questions about how participants completed tasks and clarifying questions when participant answers were not clear. Thompson also asked about tonal recovery moments, if they occurred. With regards to the current study, I patterned some of the data collection prompts and protocols around Thompson’s study.

When considering the study as a whole, Thompson substantiated few verbalized

strategies with sight-reading performance data; Thompson collected one vocal sight-reading exercise from eleven participants which she compared with interview data, among auralizing tasks and interview questions. Furthermore, participants recalled memories of the task unaided (the memories were not stimulated by video recall). Only one paired performance and verbal data set for each participant may not be enough data from which to draw reliable conclusions regarding strategy implementation.

Participants indicated they used many strategies, but that all could internalize the pitch (or experience musical auditory expectancy). Among the interview questions, Thompson asked participants when they first began auralizing. Interestingly, there was a trend among those with relative pitch. The mean ages of first auralization mirrored growth in scores of the tasks: the highest score quartile (Mean 13.52, SD 5.35, range 5-23 years), the second quartile (Mean 15.71, SD 5.99, range 8-30 years), the third quartile (Mean 17.54, SD 6.45, range 9-35 years), and the lowest quartile (Mean 21.13, SD 13.22, range 10-50 years). These data generally suggest children are capable of notational audiation and that the earlier notational audiation begins, the better skilled they become.

Caution should be used in interpretation because only some participants vocally sight-read in this study—most mentally auralized an exercise, whereupon the researcher played the example and participants confirmed or denied that their mental image matched the example. Only several participants sight-read out loud during the secondary set of deeper interviews. Auralizing a melody and actually singing a melody are two different tasks that may require different but related cognitive processes. It remains inappropriate to assume participants employ these actions when sight-reading out loud. Because

participants auralized instead of sight-reading aloud, all comments remained self-reported and thus strategies could not be confirmed as implemented or effective. This study was heavy in self-reflection, and lack of memory, self-censoring, and difficulty in articulating semi-automatic skills may have been confounding variables.

When capturing procedural knowledge, the knowledge is bound in the action, meaning that often one must do the action and observe oneself in order to articulate one's actions. In this case, participants were asked to accomplish a task and then immediately describe it. This aspect strengthens the study when considering audiation, because answering questions regarding procedural knowledge without close proximity to a task decreases accuracy of recall. These results do not, however, directly transfer to vocal sight-reading, because some participants did not vocalize while they were sight-reading.

Error detection tasks provide insight into the strategies participants use to audiate notation. These tasks are also a strong marker of the ability to experience musical auditory expectancy, because if participants cannot internally hear a pitch, they will have to rely on guessing and chance to match external and audiated pitches. Error detection also highlights participants' ability to filter pitches through tonality. Presumably musical auditory expectancy is a part of vocal sight-reading, because the most successful sight-readers create an auditory representation of the notation as part of vocal sight-reading (Waters et al., 1998).

Mismatched audiovisual stimuli and expectancy. From the field of neuroscience, Yumoto et al. (2005a) and Schön and Besson (2005) investigated brain responses to matching and mismatching audiovisual tasks. Yumoto et al. (2005a)

explored mismatch negativity (MMN), an event-related brain response commonly measured across all scientific fields. “MMN represents a neural process of mismatch detection between the deviant auditory input and a sensory memory trace developed by the standard stimuli,” and imagery mismatch negativity (iMMN) is the version that is “produced by dissonance with expectant imagery” (Yumoto et al., 2005a, p. 1175; Alho, 1995; Janata, 2001). After detecting iMMN in a linguistics study (Yumoto et al., 2005b) focused on audiovisual phonological mismatches, Yumoto et al. hypothesized an iMMN-like response might occur in a music-notation reading context, when an imagined tone does not match a sounded tone elicited from written notation.

The researchers presented ten blocks of notes, each block consisting of seven staves and 16 quarter notes on each staff, to eight participants aged 22-45 years, all with absolute pitch. The researchers presented pitches in random order (all 12 pitches in the chromatic scale) to minimize contextual and musical structure cues, and asked participants to imagine the pitch and notice for mismatched visual and auditory stimuli. Participants showed a significant difference of root mean square (RMS) amplitude values between matched and mismatched responses ($p < .01$). In other words, the brain emitted a significantly stronger negative response when the audiovisual stimuli mismatched than when the audiovisual stimuli matched. These results suggest the brain expects to hear a certain pitch or experiences musical auditory expectancy from notation, and the existence and measurement of imagery mismatch negativity indicates musical auditory expectancy is an actual and measurable physical event. The researchers concluded musicians with absolute pitch experienced the same imagery mismatch negativity as those in the

linguistics study.

Schön and Besson (2005) examined brain responses to matched and mismatched audio-visual examples through behavioral (response times and error rates) and electrophysiological (event-related brain potentials [ERPs]) data. Participants ($N = 14$) averaged 25-years-old and none had absolute pitch. The researchers created 320 examples; in each example, there were five notes presented simultaneously on a staff. The first four pitches were played exactly as written, and the fifth pitch played may or may not have matched the written notation. For the visual component, written notes could be either visually stable, where the fifth written note was in the same tonal context as previous four notes, or visually unstable, where the fifth written note was not in the same tonal context as previous four notes. For the auditory component, sounded pitches could either (a) match the written pitch; (b) be a plausible mismatch (in the same tonal context, but not the written pitch); or (c) be an implausible mismatch (not in the same tonal context and also not the written pitch). Grouping the variables allowed for six possible conditions (a) visually stable with an auditory match; (b) visually stable with a plausible auditory mismatch; (c) visually stable with an implausible auditory mismatch; (d) visually unstable with an auditory match; (e) visually unstable with a plausible auditory mismatch; (f) visually unstable with an implausible auditory mismatch. From the written examples presented on a computer screen, participants judged (as quickly as possible) whether auditory examples matched (or mismatched) written notes.

Among the behavioral results, responses were shorter and more accurate for audio-visual matches (5.6% error, vs. 9.3% error in the unstable-endings). From visual

stimuli, participants were able to more strongly anticipate stable endings than unstable endings. In other words, participants were better able to anticipate pitches that were tonally in context, versus unstable endings, which were pitches out of the previous tonal context. Relevant to data analysis for the current study, Schön and Besson's study highlights the potential for participants to experience musical auditory expectancy, which varies according to tonal structure.

When comparing the ERPs for mismatches (plausible and implausible), the researchers found larger differential effects for implausible than plausible auditory mismatches. This finding suggests "different ERP components are sensitive to specific musical expectancies" (Schön & Besson, 2005, p. 701). Not only does the brain emit a negative response to unfulfilled expectancies, these brain responses are mediated by tonal structure—the further a pitch is from a tonal structure, the more ERPs. Measuring ERPs remains one method of verifying and quantifying musical auditory expectancy.

There is evidence that musicians' brains "show enhanced pre-attentive responses to unexpected tones in melodies," or in other words, musicians' brains can conclude a sound does not match their auditory imagery *before* the conscious brain realizes it (Herholz et al, 2009, p. 173). Several studies have detected pre-attentive responses, when measuring brain responses to expected and unexpected sounds (Fujioka, Trainor, Ross, Kakigi, & Pantev, 2004; Besson, Faïta, & Requin, 1994). Although Schön and Besson (2005) aimed to study this, they found the brain is slower to detect unstable versus stable audio-visual endings, and therefore unable to conclude musicians' brains show enhanced pre-attentive responses. Measuring pre-attentive responses is yet another means to assess

and quantify musical auditory expectancy.

In summary, musical auditory expectancy is an actual and verifiable neurological event, akin to audiation, and seems to provide the foundational skills for notational audiation (Brodsky et al., 2008; Navarro-Cebrian & Janata, 2010). Musical auditory expectancy elicited from notation, seen in error detection and brain response studies, provides tangible evidence of the necessity and automaticity of creating auditory representations when reading music notation (Killian, 1991; Yumoto et al., 2005a). These studies suggest some of the cognitive skills used in vocal sight-reading may be (a) anticipating and predicting pitches, or musical auditory expectancy (Schön & Besson, 2005); (b) detecting errors, when visual and auditory modalities match and mismatch auditory images (Killian, 1991); (c) audiating the tonality, tonal center, harmonic structure, or chords (Thompson, 2003, 2004); (d) computing the distance between pitches by interval or solemnization (Thompson, 2003, 2004); (e) creating auditory representations from notation (Brodsky et al., 2008); (f) creating auditory representations from notation filtered through tonal structure (Schön & Besson, 2005). Studies in cognitive science and education surrounding error detection, musical auditory expectancy, and musical auditory expectancy elicited from notation provide direction in the current study for data collection, and mostly, data analyses.

Strategy Use and Sight-Reading Skills

Studies reviewed in the third section are studies in which the researcher(s): observed students sight-reading for strategy use, interviewed students regarding their strategy use pre- or post- sight-reading task, or collected information from participants

focused on their strategies while sight-reading; studies in which strategies were not considered are not included. This section is divided into four segments: strategy use and sight-reading skills with instrumentalists; strategy use and sight-reading skills with singers; high-achievement strategy use; and, finally, notational audiation as a strategy. These studies will deepen our understanding of strategies used and the influence of strategy use on sight-reading. These studies also highlight some of the cognitive strategies students employ when vocally sight-reading.

Strategy use with instrumentalists. For student instrumentalist sight-readers, using strategies improves sight-reading skills (McPherson, 1994, 1997, 2005). Strategy use in sight-reading has been studied more extensively in an instrumental context than in choral settings, as seen in the following studies by McPherson (1997, 2005) and Deen (2012). Researchers also observed some students using cognitive strategies.

Seeking longitudinal data on the relationship between four music achievement measures (including sight-reading) and cognitive strategies used by instrumental students ages 12 to 18, McPherson (1997) re-tested a sample of students three years after an initial study (McPherson, 1994). Trumpeters ($n = 22$) and clarinetists ($n = 21$), who were initially tested in grades 7 through 9 (McPherson, 1994), were tested in grades 10 through 12 during the follow-up study. McPherson gathered quantitative data in four measures: Test of Ability to Play by Ear (TAPE), Test of Ability to Play from Memory (TAPFM), Test of Ability to Improvise (TAI), and the Watkins-Farnum Performance Scale (WFPS) to measure sight-reading ability. He also gathered qualitative data in structured, face-to-face interviews, asking students how they prepared to complete required measurement

tasks. To gain strategies used during the sight-reading portion, McPherson covered up the last exercise just before students began to play, and asked them to articulate how they had prepared to sight-read. The researcher then compared four test scores (sight-reading, playing by ear, improvising, and playing rehearsed music) with matching self-reported strategies gained through semi-structured, post-task interviews.

McPherson found that sight-reading scores were significantly correlated ($r = .70$, $p < .001$) with the number of strategies used to complete the task. The researcher allocated strategy use points if students verbalized that they (a) looked at the time-signature; (b) looked at the key signature; (c) studied the first measure; (d) scanned the whole exercise for potential difficulties (p. 69). McPherson did not award points if the comments fell outside of these four strategies or evaluate the quality of cognitive strategies, only that students mentioned them. Also, the researcher did not verify comments with actual behaviors. Cognitive skills illuminated in this study are: anticipating and predicting pitches, or musical auditory expectancy, and creating auditory representations from notation, when students commented they “tried to work out how the first part goes,” and “I looked for the really hard bits. I was trying to figure out how I could cut them into sections that I could play” (p. 69). To elicit rich responses such as previously mentioned, I modeled a task and prompt in the current study after McPherson’s.

In a similar longitudinal study, McPherson (2005) tested beginning instrumentalists on five musical tasks (including sight-reading), within three testing episodes over three years. The children began as 3rd and 4th graders (between seven and

nine years old) and by the end of the study were in 5th and 6th grade (between nine and eleven years old). Students ($N = 157$; 87 girls) from eight primary schools in Sydney, Australia, participated initially; by the end of the study, 107 students were still playing an instrument, 44 had ceased playing, and 6 had moved away. McPherson administered tests to measure: performing rehearsed music, sight-reading (The Watkins-Farnum Performance Scale, WFPS, forms A and B; Watkins & Farnum, 1954), playing by ear, improvising, and playing from memory, at the end of the first, second, and third years of playing. In addition to the five quantitative musical task measures, McPherson also interviewed students regarding strategies used, by asking students to describe their thoughts and actions while preparing; McPherson also administered these at the end of the first, second, and third years of playing. Finally, McPherson interviewed children's mothers 10 times over 3 years, covering a range of topics and, specifically, to verify practice amounts.

To gather strategies used during the sight-reading portion, McPherson covered up the last exercise just before students began to play, and asked them to articulate how they had prepared to sight-read (as initially established in McPherson, 1997). Through a content analysis of children's comments, McPherson's (2005) ascertained five strategies for efficient sight-reading: "studying first measure, identifying key-signature, identifying time-signature, establishing an appropriate tempo before commencing performance, and scanning music to identify obstacles" (p. 20). Students earned a point for each if they articulated they used any of the five strategies. McPherson reported the frequency, but did not look at the quality or implementation of self-reported strategy statements. Also,

students may have used more strategies, although they were unable to articulate them. The cognitive skills apparent from students' comments are the same as in the 1997 study: anticipating and predicting pitches, or musical auditory expectancy, and creating auditory representations from notation.

While McPherson (2005) collected both sight-reading performance and verbal data, he did not integrate sight-reading performance and verbal data. While the researcher asked participants about sight-reading strategies in close proximity to the task, the questions were generally about the process, not about specific instances when sight-reading or clarification on comments. Furthermore, the reported strategies were actually sight-reading preparation strategies, not strategies used while sight-reading. McPherson's treatment of verbalized strategies, such as the absence of confirming strategy implementation and efficacy, influenced this study's research design, as I sought to integrate, compare and contrast students' sight-reading performance and verbal data and investigate strategy implementation efficacy.

McPherson found that cognitive strategies were a consistently more powerful predictor of sight-reading ability than repertoire/technique practice time. In fact, strategy use accounted for 11% (year 1), 33% (year 2), and 42% (year 3) of the variance in ability, whereas practice time only added 6%, 8% and 11% respectively (p. 24). Over the three-year period, most sight-reading scores increased gradually, which correlated to an increase of strategy use, and, correspondingly, lack of sight-reading improvement mirrored lack of strategy use. For these students, it seems that mental strategies have a stronger impact on sight-singing scores than does physical practicing. It should be noted

that students were practicing repertoire and drills on their instrument, not practicing sight-reading.

Furthermore, if students scored in the bottom half of scores in sight-reading or playing by ear in their first year, they were more likely to eventually quit playing their instrument. These first-year, low-scoring sight-reading students tended to continue struggling with sight-reading through their second and third years of playing (if they did not quit first), scoring in the same (low) relative position when compared with their peers over three years. This finding suggests that a lack of strategy use in general (across many measures of musical ability) impacts more than only sight-reading skills, such as level of perceived overall success and potentially decreasing motivation to continue playing.

In another study with instrumentalists, Deen (2012) used a case-study approach to investigate the sight-reading strategies and techniques used by ten sixth-grade, middle-school string players, before, during, and after treatment. The researcher administered the Watkins-Farnum Performance Test, form A, as a pre- and post-test. As a participant-observer, and in between testing situations, Deen taught students five sight-reading lessons and strategies (20 minutes once a week) and then collected five sets of sight-reading scores and interview data (40 minutes once a week). The initial and follow-up interviews centered around students' perceptions of and feelings towards sight-reading. The five, intermediate, pre-and post-sight-reading task interviews focused on students' intended strategies and reflections on strategies employed. Deen video recorded all sessions, and documented field notes in subsequent video analysis.

The combined sight-reading scores, interviews, and observations showed a

progressive increase in sight-reading scores paired with gradual growth in explicit articulation of sight-reading strategies and confidence when sight-reading. Deen found students knew generally to which music symbols to attend, but did not always possess the vocabulary to express it. Furthermore, students had practical ideas when explaining their intended actions, yet infrequently put the strategies into action when preparing and sight-reading. Finally, Deen concluded students often used sight-reading strategies without articulating they would beforehand. These findings corroborate findings from Thompson's (2004) study and suggest students do not often possess the vocabulary to express their actions or intentions, and, in some cases, are not even aware they are implementing strategies. In terms of cognitive skills, this finding may imply students are anticipating and predicting pitches, creating auditory representations from notation automatically, and some strategies have become automatic (unconsciously executed).

Overall, these results with instrumentalists indicate strategy use is a critical part of sight-reading, manifests early in development, coincides with sight-reading acquisition, and, if missing, damages students' ability to progress. The data from McPherson's (2005) study especially show strategy use may have more influence and impact on sight-reading than previously expected. Because these studies were completed with instrumentalists, however, they may or may not transfer to strategies used by vocal sight-readers.

Strategy use with singers. As with instrumentalists, vocal sight-reading scores for singers also improve with strategy use (Henry, 2008; Killian & Henry, 2005).

Strategy use in vocal sight-reading has been studied less extensively in choral settings than in instrumental contexts. Without the use of an instrument to depend on for pitches,

these studies expose students' underlying aural skills.

Killian and Henry (2005) investigated the high-frequency use of preparation and performance strategies during two vocal sight-reading tasks with high- ($n = 52$), middle- ($n = 115$), and low-accuracy ($n = 31$) sight-readers. Participants in the sample attended two high school all-state choir camps in Texas. Participants filled out a questionnaire and sang two melodies from sight, only one included a 30-second preparation (practice) period. Killian and Henry labeled behaviors as “targeted” and “ineffective” strategies, according to the relationship between behaviors and high-, medium-, or low-accuracy singers' scores.

The researchers identified five effective practice strategies, students: tonicized, used hand signs, sang out loud during practice, finished the melody in 30-seconds, and/or isolated problem areas. Cognitive skills in practice strategies seen as effective were: audiating the tonality, and anticipating and predicting pitches, or musical auditory expectancy, from notation. High- and medium-accuracy singers scored significantly higher on the first (with preparation) than the second (no preparation) sight-singing tasks. In contrast, the low-accuracy singers did not score significantly higher with practice time; therefore, low-accuracy singers did not seem to benefit from the 30-second preparation period.

The researchers named four effective performance strategies, participants: tonicized (on the second task), used hand signs, kept the beat in the body, and/or kept a steady tempo. Cognitive skills in performance strategies seen as effective were: audiating the tonality, and anticipating and predicting pitches, or musical auditory expectancy, from

notation. The low-accuracy group demonstrated four *ineffective* performance strategies significantly more than the other groups: they abandoned steady beat, stopped during the melody, took eyes off the music, and/or shifted the body. Cognitively, these ineffective performance strategies suggest students were not anticipating and predicting pitches.

Although they gathered qualitative data in the form of observations, and translated the data into comprehensive lists, qualitative data were the medium only to correlate the frequency of “targeted” or “ineffective” behaviors with vocal sight-reading scores (high, medium, or low). These observations were purely external; it is unclear what students were thinking. Because the researchers did not have self-reported motivations and explanations from interview data, the researchers could not assess how and why participants employed strategies. The researchers identified strategies used, but did not evaluate students’ quality or accurate usage of the strategies. For example, some students employed hand signs as a strategy, but the researchers did not evaluate accuracy of hand signs, or whether or not correctness of hand signs affected performance. It is unclear if Killian and Henry considered any cognitive strategies. This study influenced the current study in research design; in the current study, I sought to collect and integrate verbal data, in order to contextualize participants’ sight-reading performance.

As a further extension of the 2005 study, Henry (2008) sought to study the effect of formal sight-singing strategy instruction on vocal sight-reading scores. In a pretest-posttest control group design, Henry recruited high school students ($N = 63$) from a summer All-State-choir-audition-preparation camp in Texas, where all participants completed a questionnaire, pre-test, and post-test. Between testing situations, the

experimental group received 30 minutes of strategy instruction, including reviewing effective and ineffective behaviors and peer teaching, whereas the control group received 30 minutes of vocal production instruction. Due to diffusion among the groups (members of the experimental group shared what they were learning with members of the control group), Henry forewent the initial purpose of the study (to study separate groups), combined the experimental and control groups into one group, and measured the effects on achievement level for the whole sample (instead of on each group).

The combined group did not attain a significant change in scores, and, furthermore Henry found a regression to the mean for both the low- and high-scoring groups; these results imply the intervention did not have that strong of an impact on scores (which seems logical and inevitable considering half the sample did not receive the treatment), and also that the sample was too homogenous in sight-singing achievement level at the onset. All achievement levels displayed significantly more desirable behaviors during the posttest, although participants did not display significantly lower amounts of undesirable behaviors in the posttest. Henry did not employ interviews, therefore could not ascertain how students' thoughts and rationale for behaviors changed over the treatment period, especially among low-scoring students.

Strategy use with singers and instrumentalists. Scripp (1995) addressed the development of music notation reading skills with a sample of incoming and beginning undergraduate music and non-music major students at a well-known conservatory. Although students were not necessarily vocalists, the participants sight-read both vocally and on instruments (called in this study "sight-playing"). Scripp measured sight-reading

skills and error detection skills, and collected reflective interview data for a period of two years. Scripp employed graduate students to collect data, specifically in conducting interviews. Participants were divided into two samples: longitudinal ($n = 20$), students who participated for the full length of the study, and cross-section ($n =$ from 8 to 64, depending on the semester), students who participated for only one semester. Scripp analyzed data within and between the two samples.

Scripp found students with less tonal grounding frequently guessed, meaning that without placing written pitches in an aural framework of tonality, students estimated more often. Scripp also concluded “accurate error detection depends on internalized music reading skills” (Scripp, p. 314). In terms of cognitive skills, these findings suggest that without the ability to create auditory representations from notation filtered through tonal structure, students must guess; error detection is reliant on the ability to create auditory representations from notation and compare them mentally. Similar to Deen (2012), Scripp found meta-cognition skills also correlated with sight-reading ability.

The most crucial finding was that vocal sight-reading “performance benefits very little from rehearsal in early stages of development”; instead, it is the “development of internal representations of rhythm and pitch that defines music reading skill development” (Scripp, p. 315). In other words the catalyst for improving notation-reading skills was developing musical auditory expectancy skills, not doing more sight-reading. In cognitive science terms, these skills are developing the ability to: anticipate and predict pitches or gain musical auditory expectancy; audiate tonal and harmonic structure; and create auditory representations from notation filtered through tonal structure.

Scripp used the term “reflection-in-action” to discuss students’ self-assessing and changing actions while performing tasks (p. 320). Cognitively, this suggests students alternate between detecting errors and creating auditory representations from notation. Middle school students may or may not demonstrate this action.

Ultimately, Scripp developed a cognitive-developmental model of music-reading development, which included four levels:

1. *Disorientation*: sight-singing is approximate and unstable, and reflections are focused on accuracy.
2. *Differentiation*: increasingly stable sight-singing, and reflections are more focused on strategies than accuracy.
- 3/4. *Coordination and Integration*: involve stable, flexible, and accurate sight-reading, internalized skills, control over cognitive processes, and reflections are about “the assessment of categorical differences in approach to the music reading tasks, on the complexity of reading processes, and on evidence of the internalization of reading skills” (p. 308).

Cognitively, Scripp’s model suggests students first develop the ability to create musical auditory expectancy, then develop the ability to create auditory representations from notation filtered through tonal structure.

Scripp (1995) gathered both sight-reading performance and interview data, yet it is unclear if Scripp cross-referenced self-reported intentions with observed efficacy of strategies. As described in the study, the interview questions after sight-reading or sight-playing tasks were general questions, either self-reflective (“What process did you use

to...") or self-evaluative ("How did you do on the test?"). While interviewers (graduate students) were asked to listen to participant responses and create follow-up probes, it is not clear if interviewers asked for explanation regarding specific instances within a performance or clarification regarding strategies used. Accordingly, it is also unclear if the researcher compared and contrasted comments to performance; this would be unfeasible without specific, event-driven comments (moments of error, tonal recovery, etc.).

Scripp performed a content analysis of interview data and scored for levels of articulation ("richness and specificity of description") and complexity ("level of relational coordinations"), yet interview questions were (although close in proximity to sight-reading tasks) general in nature. In other words, Scripp does not appear to compare the level of complexity of comments to the strategy implemented.

This study was highly influential in the development of the conceptual framework, research design, and scoring procedures for the current study. Akin to Scripp, I employed cognitive science as part of the conceptual framework, investigated both sight-reading performance and verbal responses, and included elements such as tonal recoveries in the scoring procedures. Additionally, and differing from Scripp, I examined participants' strategy efficacy and the relatedness between self-reports and enacted behaviors. Furthermore, Scripp scored interview responses according to articulation and complexity, and I scored participants' responses by the sophistication of strategy use (according to empirical evidence in cognitive science research literature).

Like Scripp (1995), Vujović and Bogunović (2012) also investigated the

strategies used by collegiate musicians while sight-reading. More specifically, the researchers sought to study (a) the kinds of strategies used and cognitive processes involved in sight-reading; (b) strategies involved in problem solving; (c) student self-evaluation perspectives; (d) the connection between strategies used and learning experiences. Students ($N = 89$) from two universities participated, 55 performers (pianists [$n = 20$], string players [$n = 24$], wind players and vocalists [$n = 19$]) and 34 music theory/pedagogy students. Participants filled in a questionnaire separated into three parts:

1. General music education background.
2. Aspects of vocal sight-reading (initially gaining skills, problem solving, self-reflection, and self-evaluation).
3. Reflection on vocal sight-reading (after singing three melodic examples out

loud). Students filled out the questionnaire independently, either during a solfege lesson or at home. In preparing to sight-read, 51% reported they “mak[e] an analysis before singing,” and 55% reported they “determin[e] the meter and the key before singing” (p. 1108). This is akin to results in Killian and Henry’s (2005) and McPherson’s (2005) studies where students reported scanning the music example and looking for key music symbols.

The researchers separated participants’ sight-reading strategies into three categories: cognitive, intuitive, and no-strategy. For the cognitive strategies, researchers divided the responses into three levels of “musical structure organization and representation” (Vujović & Bogunović, 2012, p. 1108). The most fundamental cognitive level involved recognizing pitches singularly (note-to-note, the tonic, or other important

tones) and in small groupings according to interval or sequential relationships; this level included responses like “I focus on stable tones” (44% of participants) and “I recognize known intervals, motives, tonal relations” (46% of participants) (p. 1108). The next cognitive level involved chunking on a larger level of familiar tonal, harmonic, and/or rhythmical patterns; this level included responses like “I think of the harmonic progression” (28%) and “I think of the tonal plan of the melody” (5%) (p. 1108). The most advanced cognitive level incorporated creating mental representations of melodic, rhythmic, or harmonic structure; this level included responses such as “I often sing tonic in my ‘inner hearing’” (23%) and “I ‘hear’ the tones before I sing them” (33%) (p. 1108). The only comment for the intuitive category included “I rely on my musical intuition” (35%) and the only comment for the no-strategy category was “immediate start of singing” (18%) (Vujović & Bogunović, 2012, p. 1108).

On the questionnaire, students checked any strategy used when sight-reading, which allowed for participants to check multiple strategies. The highest percentage was 46%, meaning that students did not favor any one strategy. It is noteworthy that individual students employed many strategies simultaneously.

In another section of the questionnaire, students marked the easy and difficult parts of a melody with different color pens. Students identified “problematic” parts and then described strategies to solve it. Participants’ strategies included: “feeling of key” (67%), “intervals” (49%), “memory of previously-sung tones” (40%), “following the harmony flow” (35%), “recognition of melodic patterns” (25%), “recognition of rhythmical patterns” (10%), and “concentration and abilities” (3%) (Vujović &

Bogunović, 2012, p. 1109). Once again students reported using multiple strategies to problem-solve.

For the self-evaluation aspect, students evaluated their level of skills as: excellent (12%), very good (13%), average (42%), sometimes good, sometimes bad (27%), and poor (6%). The higher a person regarded their sight-reading skills, the 1) less often they had to recall the tonic ($r = -0.31; p < .00$), and the 2) more often they created a mental representation of the notes ($r = 0.45; p < .00$). Self-reported excellent sight-readers also performed some analysis before singing significantly more often ($r = .25; p < .02$) than those who self-reported less-than-excellent sight-reading skill. These results corroborate those in Thompson's (2004) and Scripp's (1995) studies, in that proficient sight-reading students often employ musical auditory expectancy and peruse the sight-reading example to anticipate potential problematic areas.

In the third part of the questionnaire, participants sight-read three melodic examples (not in the researcher's presence) and then answered self-reflection questions. This provided an opportunity to access procedural knowledge, possibly increasing the validity of students' responses. Participants also marked groups of notes they perceived on the melodic notation. Researchers divided students' segmentations into type and level. There were five types of segmentation: "structural grouping (59%), melodic figures and motives (26%), visual perceptive chunks (16%), non-logical grouping (13%) and rhythmic figures and motives (0%)" (Vujović & Bogunović, 2012, p. 1108). There were four levels of segmentation: micro level (one bar; 16%), medium level (two bars; 24%), macro level (four bars and more; 4%), and combination/mix (31%). Some participants

(22%) chose not to segment the melodies, while 64% of participants segmented the examples throughout.

Several findings are important. Students who had learned solfege for between one and five years reported using the tonic to find other pitches ($\chi^2 = (2) 11.34; p < .00$), and reported modulation as “always difficult” ($\chi^2 = (2) 13.90; p < .00$) (Vujović & Bogunović, 2012, p. 1111). On the other hand, students who had learned solfege for between five and sixteen years more often relied on the “harmonic flow of the melodic example” ($\chi^2 = (2) 6.31; p < .04$) (p. 1111).

This study used entirely self-reported data, and like Thompson’s (2003) study, this study was heavy in self-reflection. Researchers did not observe students vocally sight-reading, confirm self-reported behaviors, measure sight-reading skill, or interview participants. While participants were asked to sight-read out loud (which would be closer to the actual task of sight-reading), researchers cannot confirm participants actually sight-read out loud; therefore, these data need to be interpreted with caution. Furthermore, participants may or may not employ the same strategies when sight-reading entire exercises (in a more formal setting) versus having the opportunity to start and stop (in a less formal, unobserved setting). Given the research design, researchers were unable to verify participants’ implemented self-reported strategies, and researchers were unable to ask follow-up questions regarding confusing responses or specific instances when sight-reading. This study heavily influenced the development of the Sophistication of Strategy Use Index and the coding and analysis of data for the current study.

Adult, facile sight-readers and sight-singers commented on their reliance of

audiating in a study in which Edgington (2005) was interested in the ways students ($n = 13$), faculty ($n = 17$), and professional musicians ($n = 16$), utilized information learned in aural and other collegiate music classes to accomplish the task of vocal sight-reading. Edgington used Q-methodology, a “research method designed to demonstrate personal perspectives rather than deductive reasoning, diagnosis, and prediction,” where participants ranked thirty-six ready-made statements into hierarchies (p. 13). Participants sorted possible answers according to the question: “What best describes your approach to sight-reading a new piece of music?” (p. 9).

Edgington used principal components factor analysis and varimax rotation to group replies into clusters, and retained the three-factor solution, because it accounted for 57% of all variance (4 of the 46 variables failed to define a single factor). The factors were focused perspectives or commonalities among subjects’ responses, where each factor represented a different set of beliefs and strategies in sight-reading. According to the three-factor solution: “25 of the 46 sorts significantly defined Factor One (32% of the variance), 8 sorts significantly defined Factor Two (11% of the variance), and 9 sorts significantly defined Factor Three (14% of the variance)” ($p < .05$) (p. 55). Edgington qualified and labeled each factor, where Factor One was a Demonstrative Musician with Expression in Sight-Singing, Factor Two a Physical Musician with Expression in Sight-Singing, and Factor Three a Reserved Musician with Expression in Sight-Singing.

Participants in Factor One were very confident in relying on their inner sense of tonality to recover after mistakes, changing tonalities mid-melody, and confidently blending their voice with neighboring singers. Factor One participants strongly felt they

did not read note-to-note. Factor Two participants felt strongly that “before I sight-read a melody, I usually sing internally my scale up and down, the tonic triad and perhaps a few other triads. I then sing the melody in my mind” (p. 63). Factor Two musicians had a “strong, stable tonal reference” and highly valued the statement, “when I am working on a sight-reading exercise I have a mental image of the sound of tonic and dominant” (p. 66, 68). For both Factor One and Factor Two participants, the cognitive skills of audiating the tonality, tonal center, harmonic structure, or chords, and creating auditory representations from notation filtered through tonal structure seemed to drive their processes. Edgington did not gather data on participants’ actual behaviors, only perceptions, therefore did not correspond perceptions with behaviors or abilities. With regards to the current study, Edgington’s study impacted my conceptual framework and data analysis.

Collectively, these findings suggest that vocal sight-reading scores improve with strategy use in high school and undergraduate students, and expert sight-readers demonstrate strategy use (Edgington, 2005; Henry, 2008; Killian & Henry, 2005; Scripp, 1995). In addition, preparation and performance time can highlight similarities and differences in planning and executing strategies (Killian & Henry, 2005). High-school students used a variety of strategies, and strategies differed per achievement level (i.e., lower scoring students demonstrated fewer or lack of strategies, and this constrained their ability to vocally sight-read) (Henry, 2008; Killian & Henry, 2005). These findings are important in understanding strategy use in high-school and collegiate singers; however, it is not clear if middle school choral sight-readers use the same strategies. Both Killian and

Henry (2005) and Henry (2008) included types of *observable* behavior as data, and did not address the cognitive skills involved in sight-reading. It is also not clear what mental strategies students employed in Killian and Henry's (2005) and Henry's (2008) studies. Of the four studies discussed in this section, only Scripp (1995) addressed the cognitive aspect and collected interviews regarding participants' strategies; while Vujović and Bogunović (2012) studied the cognitive aspect, they did not gather interview data.

Summary: High-achievement strategy use. High-achieving sight-readers, in both instrumental and choral settings, use different strategies than low-achieving sight-readers (McPherson, 2005; Killian & Henry, 2005). Within general cognitive development, high achievement, in part, can be attributed to skill in purposeful strategy use (Bjorklund & Causey, 2018). This has been seen and studied primarily with collegiate and professional musicians (Fine et al., 2006; Goolsby, 1994). In studies in cognitive science with adults, researchers generally attribute high sight-reading achievement to domain expertise (Ericsson & Lehmann, 1996; Waters et al., 1997; Waters et al., 1998) and strategy use has been shown to contribute to domain expertise (McPherson, 2005; Scripp, 1995). Whereas high-achieving adults provide insight into the cognitive strategies involved in the mature task of sight-reading, this may not be the case for young learners. McPherson (2005) concluded, "the sophistication of children's mental strategies provides an important means for understanding why some progress effortlessly in contrast to others who struggle and fail" (p. 5). The difference in strategies used by high-achieving and low-achieving students, as seen in the previously mentioned studies, further illuminates the benefits of strategy use.

McPherson (2005) found that high achieving elementary school instrumentalists possessed highly evolved strategy skills early in their playing: They applied strategies more intentionally in appropriate ways, and this propelled them to faster learning and higher quality playing. Similarly, McPherson (1994) discovered the highest scoring secondary age instrumentalists on a sight-reading measure used the same quality strategies as McPherson (2005). In middle school string players, Deen (2012) observed that students who improved in sight-reading measures simultaneously increased in strategy use. Thompson (2003, 2004) concluded that the most effective strategies used by participants included harmonic-thinking, or organizing pitches around higher-order relationships.

In Killian and Henry's (2005) study, choral high-school singers employed similar strategies to those found in McPherson (1994, 1997, 2005) in that students scanned the whole example and isolated problematic areas. Henry (1999) observed that for high school choral singers using tonal strategies (for example: tonicizing) was associated with sight-reading performance. In a more recent study (2008) she found that strategy use is what separated high-achieving from low-achieving high-school choral students on vocal sight-reading tasks. According to Scripp (1995) students in the later stages of the cognitive-development model of music reading had more and deeper strategies, and that these strategies led students to have more stable and flexible sight-reading skills; students in the last two stages also were able to reflect-in-action, meaning that they could detect errors and quickly correct mistakes. Vujović and Bogunović (2012) observed that the most successful sight-readers grouped and created mental representations of melody,

rhythm, or harmony according to structure.

These studies suggest high-achieving students benefit from strategy use, and conversely, low-achieving students suffer from the lack thereof. In secondary school instrumentalists, McPherson (1994) observed that low achieving students tended to skip over critical symbols (key signature, meter signature), focus on the first few notes (neglecting of the rest), and disregard dynamic markings. For low-achieving elementary instrumental sight-readers, lack of strategy use foreshadowed lagging behind peers and persistent struggling, and significantly raised the likelihood of ceasing formal instruction (McPherson, 2005). Thompson (2003, 2004) concluded that the least effective strategies used were the Follower, those who relied on others, and the Builder, who read from pitch to pitch without a reference point or global awareness.

Some of the strategies used by low-achieving instrumental students have also been seen in choral students. Low-achieving choral students in Killian and Henry's (2005) study underutilized practice (preparation) time, abandoned steady beat, stopped during the melody, took eyes off the music, and shifted their body. Low-scoring high-school students increased sight-reading scores by applying strategy use (Henry, 2008). Students who were in the first stage of Scripp's (1995) model lacked a strong and stable tonal reference, approximated pitches, and focused on accuracy in self-reflection.

In summary, high-achieving sight-readers have more sophisticated strategies, employ intentional strategies more often, and begin using strategies early in development. Cognitively, high-achieving students often create auditory representations from notation filtered through tonal structure (Schön & Besson, 2005). Low-achieving sight-readers

employed fewer strategies, overlooked key symbols, forewent preparation time, and lacked tonal anchoring. Cognitively, low-achieving students infrequently (or never) create auditory representations from notation filtered through tonal structure (Schön & Besson, 2005).

Summary: Using notational audiation as strategy. High-achieving sight-readers often report utilizing audiation and notational audiation, which is the ability to internally hear and give contextual meaning to written music notation without having heard it from an external source. Expert and adult sight-readers often demonstrate notational audiation strategies, and studies suggest this is advantageous in sight-reading for singers (Edgington, 2005; Kornicke, 1995). Frequent strategies in sight-reading involving audiation are audiating the tonal center (audiating only the tonic pitch) and audiating the tonality (audiating the anchoring tonic, dominant, and subdominant chords); employing these strategies while reading gives vocal sight-readers an inner aural framework from which to cross-reference music notation, auditory representations, and expected tonal guidelines.

In terms of musical auditory expectancy pedagogy, Klonoski (1998) discussed the necessity of developing aural skills, as preparation for dictation and sight-reading. When students struggle in sight-reading, Klonoski suggested one of the main factors might be a lack of aural skills, or, more fundamentally, the inability to hear a pitch internally. This skill, which Klonoski terms *pitch internalization*, is related to, but different than, audiation. Where audiation encompasses hearing and comprehending on both pattern and gestalt levels, Klonoski described pitch internalization as “develop[ing] the ability to

access imagined pitches. Internalization seeks first and foremost to teach the process of creating or recreating pitches in one's mind. Once this has been achieved, student can begin to incorporate larger patterns and contexts into the learning process" (p. 81). Pitch internalization may be the first steps to audiation, and therefore a precursor to notational audiation. In other words, the first steps in sight-reading are internalizing pitch relationships. In effect, Klonoski suggested improving musical auditory expectancy by developing one's sense of tonality, and thereby implied high-achieving sight-readers have developed these skills.

Few researchers have investigated notational audiation with secondary age students. According to Gordon (2007), students begin notational audiation with the ability to audiate the tonal center because that allows aurally measuring tonal relationships. Rappaport and Brown (2004) supposed that when reading, the "student identifies where the tonal center is on the staff, and then all of the other notes fall into place" (p. 9). MacKnight (1975) argued, "in order to read tones effectively, the reader must recall an aural referent from what he sees in notational form. Possession of aural-visual skill is an indication of the reader's ability to organize and conceptualize melodic sounds" (p. 25). Essentially, choral students when vocally sight-reading must "recall an aural referent," or audiate notation, by hearing what the eye sees (MacKnight, 1975, p. 25). A singer's ability to notationally audiate frees the student from depending upon other notation readers, especially the choral teacher. Participants' strategy use in Killian and Henry's (2005) and Henry's (2008) studies suggested they used notational audiation techniques when they tonicized the key, used solfege, and scanned the whole exercise to

mentally sing through potential challenges. Students in Killian and Henry's (2005) and Henry's (1999) studies, however, who did not use these strategies did not perform as well as their peers on sight-singing tasks.

Both expert sight-readers and successful student sight-readers often employ notational audiation to anchor their sight-reading. Often, these notational audiation strategies center around tonal structure and harmonic relationships. It is unclear if middle school choral students also employ notational audiation when sight-reading.

Summary: Overall

The results of several studies indicate strategy use may play an important role in vocal sight-reading (Deen, 2012; Henry, 2008; Killian & Henry, 2005; McPherson, 1997, 2005; Scripp, 1995; Thompson, 2003, 2004). Studies with instrumentalists suggest (a) strategy use may have more impact on sight-reading than practice; (b) strategy use begins early; (3) may be a strong indicator of future success; furthermore, students may not be able to articulate (or even recognize) their strategies (Deen 2012; McPherson, 1997, 2005). Studies in strategy use and vocal sight-reading with choral students suggest that high-achieving sight-readers use more strategies, make use of the preparation time, and employ tonal strategies; whereas low-achieving sight-readers use fewer strategies, do not make use of preparation time and employ fewer tonal strategies (Henry 2008; Killian & Henry, 2005). High-achieving sight-readers applied strategies more intentionally and in appropriate ways, scanned the whole example, isolated problems, and used notational audiation to mentally hear the tonality or melody (McPherson, 2005; Killian & Henry, 2005; Edgington, 2005).

Of those that collected both sight-reading performance and interview data, none integrated both forms of data into one sight-reading picture. Killian and Henry (2005) and Henry (2008) observed students' strategy use when vocally sight-reading, but did not collect interview data, therefore could not determine students' thought processes and rationales. Although McPherson (1997, 2005) collected both interview and sight-reading ability data, McPherson did not verify self-reported strategies with observed behavior and did not account for strategies used outside of students' articulated strategies. While Vujović and Bogunović (2012) and Edgington (2005) gathered thoughts and impressions about strategy use when sight-reading, these researchers did not verify responses with observed behaviors or abilities. Deen (2012) gathered both interview and sight-reading data, but Deen gathered interviews focusing on metacognition and reflection rather than focusing on the strategies themselves. Both Thompson (2004) and Scripp (1995) gathered both sight-reading performance and interview data, yet Thompson interweaved these data streams for very few examples (one sight-reading example for each of 11 participants) and Scripp made no reference to comparing and contrasting the differing data types. Multiple data streams regarding the same specific events may result in clearer understanding of the efficacy of employed strategies and possibly the component skills in vocal sight-reading.

These studies, particularly McPherson's (2005), Killian and Henry's (2005), Thompson's (2004), Scripp's (1995), and Vujović and Bogunović's (2012) studies, have influenced the conceptual framework, research design, scoring procedures, and data analysis for the current study. In the next chapter, I will detail the research design, data

collection methods, site and participant selection, and data analysis procedures.

CHAPTER 3

METHODS

To meet the purposes of this study, I employed an exploratory, collective case-study approach (Compton-Lilly, 2013; Deen, 2012) and collected both quantitative and qualitative data (Creswell, 2003). I collected qualitative data in structured interviews, retrospective think-alouds (Ericsson & Simon, 1993), video-stimulated recall interviews, and researcher observations. The quantitative data were twofold (a) a vocal sight-reading measure (Vocal Sight-Reading Inventory, Leveled and Revised version; Henry, 1999) and (b) I assigned participants sophistication of strategy use scores using a researcher-designed index. To frame data collection and analysis, I utilized the combined conceptual framework of audiation and pertinent findings from research studies in cognitive science. The following topics will be discussed: research design, data collection measures, research site and researcher access, participants and participant selection procedures, refining procedures and scripts in the pilot, pilot and main study procedures, data preparation, incorporation of data, data analysis, and trustworthiness.

Research Design

An exploratory, descriptive, collective case-study research design is sensitive enough to extract the varied ways, differences, and degrees to which students use strategies in as natural setting as possible. I also included an objective measure to compare across subjects. I incorporated both qualitative and quantitative data to enrich individual data streams and further explain and clarify phenomena. While I collected and merged both qualitative and quantitative data, this remained a qualitative study. The

qualitative data functioned as verbal data, where I, as completed in verbal analysis, quantified the “the subjective or qualitative coding of the contents of verbal utterances” (Chi, 1997, p. 272). In addition, I employed the quantitative data for more concrete and comparable measures across cases and to tether and contextualize the verbal data.

Because strategy use is an individualized cognitive task and participants must externalize their thoughts and motivations, making explicit what is implicit, students were considered informants (Spradley, 1979).

Data Collection Measures

Vocal Sight-Reading Inventory. The first data source was the Vocal Sight Reading Inventory (VSRI), developed by Henry (1999). The VSRI has been used in studies with high school and middle school students, with beginning sight-readers in high school (Henry, 2004; Parks, 2005), advanced sight-readers in high school (Henry, 2008, 2011; Killian & Henry, 2005), and sight-readers in both middle and high-school (Henry 1999). Henry generated and piloted the original version. Alexander and Henry (2012), Killian and Henry (2005), and Henry (2008, 2011) employed a slightly modified version. Parks (2005) utilized the Leveled and Revised version. Henry (1999) established content validity, or descriptive validity, which means the test “adequately measures the behaviors in the identified domain” (p. 95), and validity of the component scoring system.

The test contains purposeful melodic patterns (or targeted pitch skills) arranged throughout the examples in major tonalities; it does not include rhythmic content or tonalities other than major. Henry categorized the pitch skills by harmonic function (ascending or descending conjunct, tonic, dominant, subdominant, cadential, modulatory,

and chromatic) and interval size. For chordal patterns, Henry distinguished between skips (intervals of a third) and leaps (intervals of fourths or greater).

The test includes four possible forms. The original forms, A and B, have eight exercises each (the length is either four measures in 4/4 or eight measures in 3/4). In the Leveled Revised version there are nine exercises, divided into easy, moderate, and difficult levels, and each exercise includes eight measures (in either 4/4 or 3/4 time). The Comprehensive Revised version has six exercises total, and each exercise has eight measures (in either 4/4 or 3/4 time). In all forms, the difficulty of pitch skills gradually increases over the length of the test.

In the original study, there were 139 middle school students (in seventh and eighth grade) who completed forms A and B. Collectively, participants earned a mean of 3.41, standard deviation of 7.14, with the lowest score 0 and the highest 20 (out of 28 possible points). For only eighth grade, the mean was 3.52, the standard deviation was 3.8, the lowest score was 0 and the maximum was 20. Eighth grade participants in the current study did not complete forms A or B, as the eighth graders in the original study performed poorly on forms A and B. Instead, participants in the current study sight-read only the first two levels (examples 1 – 6) of the Leveled and Revised version (which includes three levels and three exercises per level total).

In order to witness strategy use among varied levels of sight-reading ability, the instrument must present both simple and exigent exercises, thus facilitating the conditions by which students must make decisions, problem-solve, and, potentially, negotiate errors. Participants in the current study completed the first two levels of the Leveled Revised

version; this version was used for several reasons. First, this version graduates from easy to moderate, so even beginning sight-readers can demonstrate success. Second, the test includes step-wise and skipping motion (in the tonic, dominant, and subdominant chords), so students are also challenged to perform at a more advanced level. Third, the test content of both step-wise and skipping motion allowing opportunities to differentiate between thinking linearly and globally. Furthermore, students had the freedom to sing on any syllable (such as solfege or a neutral syllable), thus prompting students to further show their strategies (Henry, 1999). The sight-reading measure was audio and video recorded in order to capture student responses, facial and body language, and kinesthetic strategies, thus displaying more strategies not observed by the researcher while initially collecting data (Killian & Henry, 2005). Permission to use the VRSI can be found in Appendix G.

Retrospective think-aloud protocol. Directly after sight-reading, students participated in a retrospective think-aloud protocol (RTAP) (Ericsson & Simon, 1993). Like Younker (2000), I sought to collect “rich descriptions” of strategies across ability levels (Thompson, 2003). A think-aloud protocol is a data collection method whereby participants verbalize thoughts as they perform a task or solve a problem (Ericsson & Simon, 1993). In retrospective think-alouds, devised especially for perceptual-motor tasks executed in short episodes (e.g. ski racing), participants verbalize memories of their thinking while completing the task (Ericsson & Simon, 1993). When reporting thoughts or memories in RTAPs, students were remembering the engagement, because “only in the context of a task analysis can one make sound inferences about the sequence of

underlying cognitive processes” (Ericsson & Simon, 1993, p. xxxv).

The purpose in employing think-aloud protocol was to elicit thought-processes during strategy use and better understand the course of cognitive processes. It was not my intent to devise a generalizable process model to predict behavior. Rather, the think-aloud protocol “provides a detailed diagnosis of the types of problems encountered, and, above all, the fundamental difference of approach adopted by different learners” (Black, 1995, p. 25). The think-aloud allows researchers to obtain stream-of-consciousness thoughts, which are not accessible when using observations or interviews.

To increase validity, I followed Ericsson and Simon’s (1993) protocol, exclusively employed a priori verbal prompts and language, provided clear directions and models to participants (Richardson & Whitaker, 1996), and included practice examples (Keller, 2008). To minimize the effects of an unnatural task and setting, students completed a familiar task (vocal sight-reading) in a familiar setting (a school practice room).

Think-alouds are beneficial because they allow access to data previously unexplored with students while sight-reading. Also, think-alouds are a small but valuable window into the process of accomplishing tasks. Much care must be taken in interpreting meaning from stream-of-consciousness data, because data are not linear or logical.

Structured interviews. Immediately after the sight-reading and think-aloud measures and again after the video-stimulated recall interviews, students participated in a short, structured interview. The purpose was to provide participants an opportunity to verbalize their strategies in a straightforward manner. These interviews occurred post-

sight-reading tasks because procedural knowledge can often only be brought to conscientiousness by performing the task (Dowling, 2014), and closer proximity to an actual sight-reading task leads to higher detail and accuracy in responses (McPherson, 2005).

A structured interview is a “formalized, structured exchange,” comprising questions and answers (Fontana & Frey, 2003; Trainor, 2013, p. 126). Interviews were used rather than a closed-option survey, to gather participants’ ideas, explanations, and descriptions in their words. Questions were open-ended (Maxwell, 1996). The structured interviews were audio and video recorded to capture gestures, facial expressions, and kinesthetic demonstrations (Keller, 2008). I asked interview questions immediately after sight-reading, following the procedures employed by McPherson (1994, 1997, 2005), Deen (2012), Thompson (2004), and Scripp (1995).

Video-stimulated recall interviews. To further understand retrospective think-aloud data and ascertain students’ rationales and explanations of specific examples in think-alouds, I utilized video-stimulated recall interviews (O’Brien, 1993). These interviews are necessary in conjunction with think-alouds, because recall interviews provide context and clarification of stream-of-consciousness data from think-alouds (Op’t Eynde, De Corte, & Verschaffel, 2001, 2006; Reitano & Sim, 2005; Swing, Stoiber, & Peterson, 1988). In video-stimulated recall interviews, participants watch a video recording of themselves performing a task; the video stimulates memories of the original event and participants verbalize their decision-making processes. Some participants were not able to verbalize tacit knowledge (Calderhead, 1981).

This type of interview allows the researcher to focus on particular instances and improves participants' recall of specific situations (Schepens, Aelterman, & Van Keer, 2007), two beneficial aspects when working with students. Here, students expounded on decision-making, thoughts, motivations, and strategies used during task completion, thus providing clarification of think-alouds. In the current study, the criteria for choosing several places to pause the video and examine in depth were (a) unclear think aloud data; (b) unusual actions; (c) periods of silence; (d) points of incredible success or derailment, fixing a mistake, or returning to correct tonal context.

Akin to retrospective think-alouds, video-stimulated recall interviews afford participants the opportunity to clarify and defend their thoughts post-task. Recalling and voicing thoughts *post*-task, as opposed to *during* the task, is ideal, as verbalizing thoughts during the task may lead to the disruption of original thought processes. For this reason, video-stimulated recall interviews took place after all sight-reading and think-aloud protocol were complete.

As advised by Calderhead (1981), Hoffman, Shadbolt, Burton, and Klein (1995), Tjeerdsma (1997), Gass (2001), Gass and Mackey (2000), Yinger (1986), and Lyle (2003), I sought to ensure proper participant treatment and gather trustworthy verbal data. To reduce student anxiety in watching videos, first, I sought to develop "rapport" by being positive and warm (Calderhead, 1981). Second, I minimized concerns about one's appearance on camera by video recording students at a flattering and positive angle (Rowe, 2009). Third, I began video recording approximately one minute before the first sight-reading task, thus creating relaxed viewing time, or "giggle time," before more

serious viewing time (Pirie, 1996). Fourth, I ensured privacy while watching the videos, by viewing the videos in a restricted-access room (Miksza & Austin, 2010).

Another potentially confounding variable can be timing. Recall decay and re-ordering of perceptions due to distance from the task are serious considerations (De Grave, Boshuizen, & Schmidt, 1996; Gass, 2001; Gass & Mackey, 2000; Lyle, 2003). Students therefore participated in video-stimulated recall interviews directly after sight-reading performance and think-aloud protocol.

In order to elicit participants' original thoughts, thereby uncovering genuine thought-processes, I sought to minimize participants' desire to censor or provide commentary on their video-taped performance (Calderhead, 1981; Tjeerdsma, 1997; Yinger, 1986). To mitigate this potential problem, Lyle (2003) recommends the research design and method "stimulate rather than present a novel perspective/insight" (p. 865). To this end, I asked neutral, open-ended questions and reassured participants the study was about uncovering "thought-processes" and not providing "correct answers." I also initially introduced the research as helping me understand the thought-processes of students while sight-reading; thus mitigating students' desire to respond in a correct way by censoring or re-analyzing thoughts.

Other suggestions in improving the trustworthiness of verbal reports, Lyle (2003) recommended the design must: "limit the perception of judgmental probing; reduce the intrusion into the action; allow the subject a relatively unstructured response" (p. 865-866). To limit the perception of judgmental probing and allow the subject a relatively unstructured response, I asked open-ended, non-leading questions, such as, "what were

you thinking here?” and “tell me about your thought process here,” or “what was going through your mind?” (Calderhead, 1981). Furthermore, to reduce the intrusion into the action I responded neutrally and encouragingly so students would not feel embarrassed about sharing normally undisclosed thoughts.

Observations. I collected and recorded written observations regarding all 14 participants throughout the study. I noted participants’ behavior sequences while sight-reading during initial data collection and also post-collection while reviewing video-taped sessions. While recording observations, I especially monitored participants’ behaviors that would not be captured by the sight-reading instrument, such as long pauses and exclamations, such as, “Lost it” (Kurt, exercise 1). Observations were integral in the current study, because observations “might provide insight into the timing of when and in response to what contextual cues students use particular types of strategies” (Wolters, Benzón, & Arroyo-Giner, 2011, p. 305). I employed observations as a point of triangulation, as students sometimes remain unaware of and cannot verbalize their actions (Patton, 2002). After transcribing the sight-reading performances of each participant, I integrated my observations onto the sight-reading performance transcriptions, thus further providing context and explanation for students’ strategies and behaviors.

Sophistication of Strategy Use Level Index. To evaluate the sophistication level of participants’ strategies, I created a Sophistication of Strategy Use Level Index for use in the main study (not in the pilot study). The sophistication of strategy use, according to Vujović and Bogunović (2012), can be defined as the extent to which a strategy involves efficient or effective means to quick and accurate sight-reading. For example, the more a

sight-reader chunks incoming material, the quicker and more accurate performance will be (Fine et al., 2006). Thus, with regards to chunking, a rudimentary strategy would be no apparent use of chunking, and a sophisticated strategy would be chunking according to harmonic function. Some of these strategies have already been seen in high-school students; in Henry (1999) students often returned to the tonic after straying, as well as chunked certain pitch combinations (such as *Do, Mi, So* and *Do, Re, Mi*). Other possible strategies that may be used on rudimentary or sophisticated levels are: reading around phrase boundaries or “structural markers” (Sloboda, 1977, 1984), employing pattern recognition (Fine et al., 2006), and audiating the tonal center or tonality (Edgington, 2005).

Consulting the literature on cognitive science and music learning theory, I designed an Index to determine participants’ sophistication of strategy use. I drew from the perceiving and processing stages of the reading process, and divided the categories into Looking Behavior (perceiving), Chunking and Patterning (processing), Long-Term Memory (processing), Auditory Representations (processing), and Audiation / Notational Audiation (processing). I did not include a category from the executing stage of reading, because this was a thought-process based study and I did not include a means to measure motor skills or the relationship between vocal potential and vocal production. Drawing from the literature, I extracted higher and lower sophisticated strategies and organized them into five graduated sophistication levels in each category. The index is pictured below, in figure 2.

Points awarded	Points possible	Looking Behavior (perception)
	5	Looking ahead to use phrase boundaries or pattern boundaries
	4	Looking ahead/looking behind as reference while performing current note
	3	Looking ahead/looking behind as reference and slowing or stopping tempo to analyze
	2	Analyzing one note at a time, possibly slowing tempo to analyze
	1	Analyzing one note at a time and slowing or stopping tempo to analyze

Award	Possible	Chunking and Patterns (processing)
	5	Recognizing/using visual-aural patterns in harmonic functions
	4	Recognizing/using visual-aural patterns in tonic chord/tonality
	3	Recognizing /using short visual-aural patterns and guessing aural patterns
	2	Analyzing one note at a time without using patterns and occasionally guessing aural patterns
	1	Analyzing one note at a time without using patterns

Award	Possible	Long-term Memory (processing)
	5	References previously learned information (in chorus, in lessons, in general) and generalizes information to and implements in new contexts
	4	References previously learned information (in chorus, in lessons, in general) and implements (such as recalling singing a triad in chorus, and reproducing)
	3	Draws implicitly from strongly assimilated musical skills and knowledge (they are automatic)
	2	References previously learned information (in chorus, lessons, general), but cannot implement
	1	Draws implicitly from weakly assimilated musical skills and knowledge (they are inconsistent)

Award	Possible	Auditory Representations (processing)
	5	Imagines sound of pitch and manipulates the auditory representation (making it louder or softer, or successfully navigating around that pitch to other pitches)
	4	Imagines sound of pitch before creation or specifically when skipping (pre-note)
	3	Imagines sound of pitch post-creation and compares with auditory feedback (post-note)
	2	Attempts to imagine the sound, but self-reports unsuccessful
	1	Does not attempt to create auditory representations (Does not think in pitches or sound)

Award	Possible	Audiation/Notational Audiation (processing)
	5	Employs/uses audiation with understanding (making outward sounds conform to inwardly audiated sounds while comprehending) For example: aiming to sing the “starting note”
	4	Employs/uses audiation without understanding (making outward sounds conform to inwardly audiated sounds without comprehension) For example: matching a specific staff location with one singular pitch
	3	Relies on assimilation of major tonality; attempts to match a specific staff location with one singular pitch, but self-reports unsuccessful
	2	Relies on assimilation of major tonality; guesses until it sounds right
	1	Does not attempt to employ/use audiation; guesses

Figure 2: Researcher-designed Sophistication of Strategy Use Level Index.

Research Site and Access for the Pilot and Main Study

There were three criteria for selecting the schools: chorus offered to eighth graders, familiarity with vocal sight-reading, and administrators’ and teachers’ willingness to participate in research. These were chosen so students would be capable of and familiar with performing the tasks required (Henry, 1999, 2008). Eighth graders represent early vocal sight-readers with a range of choral experience (Henry, 2004). By eighth grade, I anticipated many students would have participated in chorus for an average of 2 years, and therefore have experiences from which to draw. There is little research with eighth grade participants on vocal sight-reading (Lucas, 1994); most vocal sight-reading studies recruit high school or collegiate participants (Henry 2004, 2008; Killian & Henry, 2005; Scripp, 1995; Thompson, 2004).

A local music education professor who worked with student and cooperating teachers recommended that I contact several local choral directors, to whom I sent brief introductory emails (Appendix A). Several choral directors responded positively,

whereupon I sent a more detailed email containing the cooperating teacher's role and responsibilities during the intended pilot or main study. Two choral directors responded affirmatively, one for the pilot and one for the main study, and I met with the resident choral director and school administrators in a conference room at each respective school (pilot, Adams Middle School¹; main, Washington Middle School) to discuss purposes and procedures and gain the Principal's approval (Appendix B) (Miller, 1988; Younker, 2000). Because these two schools met all research criteria and the principals and choral directors gave permission, I selected these schools for the pilot and main study.

Participants and Participant Selection Procedures

At both schools and with the choral teacher present, I attended all sections of 8th grade chorus in person and explained the option of participating in the current study, because eighth graders have been considered by other scholars to be old enough to understand the task (Younker, 2000). I used the Student Recruiting Script (Appendix C) when speaking with students. In accordance with IRB stipulations, students took home and subsequently returned consent (Appendix D), assent (Appendix E), and participant questionnaire forms (Appendix F) to the resident choral teacher (Grutzmacher, 1985). The resident choral director held the submitted forms until I obtained them.

I employed purposeful sampling to find participants who met the research criteria, which included students who were in eighth grade, currently participating in school chorus, and familiar with and capable of the procedure and task of vocal sight-reading. Furthermore, I sought informants with varied music experience, who would provide rich

¹ Adams Middle School and Washington Middle School are pseudonyms. Student names are also all pseudonyms.

data and display a variety of behaviors and skills (Keller, 2008). Students (pilot, $n = 5$, and main study, $n = 14$) returned the consent, assent, and participant questionnaire forms, and, after consulting with the resident choral director to assure students' familiarity with the task, those students participated in the study (Deen, 2012; Keller, 2008). Purposeful sampling was not based upon sight-reading ability, due to the impossibility of quick and accurate screening for achievement levels.

Refining Procedures and Scripts

I completed a pilot study over the length of two months to refine equipment familiarity, procedures, and prompts. Participants ($n = 5$) were two boys and three girls, all 13 years old. While students generally accomplished the sight-reading tasks, the verbal data were more narrative-like, with too much defensive explanation and not enough verbalization of original thoughts. To better access initial stream of consciousness thoughts, I made minor alterations to the order of data collection, instructions, and prompts and practice examples for the main study. Each change was made to improve data validity by increasing student understanding.

For the pilot study, data collection happened in four discrete segments (a) sight-reading all six examples and answering a question regarding the seventh example; (b) consecutively performing a retrospective think-aloud for all six examples; (c) participating in video stimulated recall interviews for all six examples; (d) finally a closing interview question. Pilot participants had a difficult time remembering original details from each sight-reading exercise because of the extended time and other sight-reading performances in between initially sight-reading an exercise and then performing

a think-aloud on the same exercise. In order to decrease memory decay and improve recall detail, in the main study I interspersed the retrospective think-alouds amongst the sight-reading exercises. For example, a student (a) performed a sight-reading exercise, (b) promptly remembered his performance while thinking-aloud, and then (c) began the cycle of sight-reading exercise and think-aloud for the next exercise. The updated order of data collection included sight-reading and performing a think-aloud for each of six examples, answering a question regarding the seventh example, participating in video-stimulated recall interviews for all six examples, and finally a closing interview question. A comparison of the order changes can be seen in the following chart.

Order of Data Collection:	
Pilot:	Main Study:
1) Sight-read exercises #1 through #6	1) Sight-read exercise #1
2) Interview question for #7	2) Retrospective think-aloud for #1 without watching the video Repeat steps 1 and 2 for all 6 sight-reading examples
3) Watch video tape and perform retrospective think-aloud for all 6 examples	3) Interview question for #7
4) Watch video tape a second time and perform video-stimulated recall interviews	4) Watch video tape for the first time and perform video-stimulated recall interviews
5) Final interview question	5) Final interview question

During the pilot study participants watched a video of themselves sight-reading in order to complete both the think-aloud and video-stimulated recall interviews. Where the video was meant to be an aid-to-memory during the think-aloud, students were instead focused on evaluating their performance and, to a lesser extent, their appearance. To decrease the confounding factor of watching the video during the think-aloud segment, I

eliminated watching the video during the think-aloud and asked participants to purely rewind their thoughts to the beginning of the exercise and use the notation as a memory aid. Students were then free to remember their initial thoughts instead of adjudicating their performance and explaining their mistakes. Watching the video, then, was only utilized when performing the video-stimulated recall interviews.

Instructions during the pilot were too lengthy and inspired a conversation-like feel between the researcher and participant. This was possibly corrupting think-aloud data. Therefore, I condensed all directions and prompts to be more succinct and clear. To lessen the conversation-like atmosphere and decrease participants' desire to explain, I eliminated all variations of "tell me..." and replaced them with objective beginnings, such as "talk about..." or "go ahead"; I also turned the student's chair away from my chair, so the student was facing the wall and, ideally, not compelled to make the think-aloud a conversation.

During the pilot, students struggled to understand what a think-aloud would look and sound like; instead of producing stream-of-consciousness data (which are non-sequential, half-formed sentences, sans evaluation and defense), several participants added an evaluative element to their words (explaining, evaluating, and narrating their decisions and performance). To clarify the process, I replaced two student-answered pilot examples with two new examples, one researcher-modeled and one participant-completed (Appendix I). In general, students have most likely never encountered this type of think-aloud before; therefore, I needed to provide a model, using a similar, but not exact, prompt and example. The pilot examples included performing a math problem internally

and counting the number of windows in their house internally; these have little in common with the process of reading and reproducing symbols from paper. As to not bias participants' performance, examples could not demonstrate an exact sight-reading example. Instead, the practice examples needed to be as close to the process of sight-reading as possible. These criteria included reading or gaining information from text, not solely thinking or processing without text, and using symbols to solve a problem. It also needed to compel participants to use symbols on paper as an aide-mémoire, which is more akin to the think-aloud process of using notation to recall initial thoughts when sight-reading, instead of purely thinking about them.

Considering all of these stipulations, for the modeling example, I chose the process of assembling words from a list of random letters (Appendix J). Here, I modeled reading the example internally and producing the result externally (the list of words), which is akin to sight-reading. I then modeled rewinding my thoughts and producing stream-of-consciousness data, using the text on the paper to guide the order of my thoughts, and without explanation, evaluation, or narration. Participants then completed a practice example on their own, where they silently read a math word problem, produced the solution out loud, then rewound their thoughts and spoke their thoughts out loud. These exact instructions and procedures would later be used during the retrospective think-aloud segments.

Main Study

I collected data for the main study over the course of three months. I experienced significant delays to the data collection schedule because of student availability (limited

after-school options), failed student memory, prioritization of concerts, and vacation time (both Thanksgiving and Winter breaks).

Data collection procedures during pilot and main study. All data collection took place on the school's premises, inside a practice room adjacent to the chorus room. I administered all data collection measures. Students were dismissed from chorus, a study hall, or came after school, where data collection steps one through four took place successively on the same day, totaling approximately 30 minutes. The school choral director, accompanist, or substitute was nearby for all sessions.

To gather necessary information for the research questions, four procedural elements were included in the order described hereafter. The student and I entered an unoccupied practice room. I led them to a seat with a music stand and asked them to sit down. I read from the verbal instructions script, where we reviewed and I demonstrated the think-aloud procedure (Appendix K) (Henry, 1999). After the practice examples, I pointed toward the exercises sitting on the music stand, and said:

On the music stand in front of you, there are sight-reading exercises similar to ones you have sung in chorus. I will ask you to turn to a certain exercise, then give you the starting pitch on a pitch pipe. When you are ready, sing the exercise through in any way you choose. Any questions?
Please turn to number one. (Appendix K)

After the student turned to exercise one, I played the starting pitch and said, "Begin whenever you are ready." I purposely did not reference or limit preparation time; students were free to control preparation and start time. Secondly, I played only the starting pitch,

not the tonic triad or a harmonic progression, as to avoid harmonically priming participants' ears and obviate the demonstration of employing strategies. Finally, I did not instruct students to "choose any syllables" or that "if you make a mistake, try to continue" as these statements may have led a student to demonstrate atypical behaviors. The audio and video recorder began after the practice examples and before they began sight-reading.

For the first step, I administered levels one and two of the Leveled, Revised version of the Vocal Sight-Reading Inventory (six vocal sight-reading tasks) (Henry, 1999), alternating with retrospective think-alouds for each exercise. The Sight-Reading Inventory can be seen in Appendix H. Students completed all six examples, alternated with think-alouds. Examples were notated in treble clef but students chose to sing in any octave. There was one exercise per piece of paper, so students focused on only one example at a time.

Directly after each sight-reading exercise, students completed each think-aloud to minimize memory loss. To elicit the think-aloud, I said:

Now rewind your thoughts to the beginning of the exercise and remember your thoughts while you were sight-reading. Say all of your thoughts out loud as if you were thinking them in real time, starting from the moment you saw the exercise until you were finished. Don't explain what you did. Just act like you are alone in the room, talking to yourself. Say everything you remember thinking rather than what you think you must have thought. Use the sight-reading exercise to help you remember your thoughts. Do

you have any questions? Okay, go ahead. (Appendix K)

I allowed unlimited time to complete the think-aloud, because verbalizing thoughts often takes more time than experiencing the original thoughts (Ericsson & Simon, 1993). Based heavily on Ericsson and Simon's (1993) instructions and refined through pilot testing, I developed the protocol and prompts; the exact wording can be found in Appendix K.

Next, I conducted a short, structured interview. This was given just after the student mentally and/or physically prepared for the seventh exercise (akin to McPherson, 2005); after the student prepared, or just as they began singing, I covered up the exercise with a piece of paper and asked one structured interview question (Appendix L). The question was, "Just before I covered up the exercise, what were you thinking and doing?" The audio and video recorder continued running through the interview.

Lastly, I transferred the secure digital high capacity card (SDHC; made by SanDisk) from the video recorder to the computer and inserted another SDHC Card into the video recorder. I played back the participant's sight-reading and think-aloud video while administering the Video-Stimulated Recall Interviews. This segment lasted approximately ten minutes, during which I asked open-ended questions regarding four to six specific video clips, giving students an opportunity to describe their thoughts, actions, or think-aloud comments. Students were prompted to stop and remember and were not encouraged to provide narrative. Sample questions can be seen in Appendix M. The very last question was, "Imagine explaining how to sight-read this example to a friend. The goal is for your friend to be able to sight-read it alone; you are just guiding them to know

how to do it. How would you instruct them to accomplish it? Be as detailed as you can.”

Both the audio and video recorders were positioned to capture students’ comments and gestures.

Audio data were recorded on a voice-recording iPad application, entitled Voice Recorder made by Tapmedia. Video material was recorded on the video setting of a Canon SX700 HS, mounted on a standard tripod. Video recordings of sight-reading and think-alouds were shown to students on a QuickTime Player application on a 2009 Apple MacBook Pro computer.

Data Preparation

Sight-reading transcription. I transcribed all sight-reading task performances from audio recordings. When transcribing, I employed regular, solid note heads when participants used neutral syllables (La, Doo, Ooh) and the first letter of each solfege syllable (*Do*, *Re*) or letter (A, B) as a note head; however, I altered the syllable or letter with an accidental if necessary. If they began and then started over, I used a double bar line to signify the re-start. If they added extra pitches I sought to align bar lines, not by how many pitches were in the bar but how closely the contour matched the original notation, although this was not always clear. If they modulated during the exercise, I notated the performed pitches in the new key. If the pitches were quarter tones or smaller than half steps, I used arrows to indicate the direction of the pitch from the closest equal-tempered pitch.

Verbal data transcription. I transcribed all verbal data from interview questions, think-alouds, and video stimulated recall interviews onto Microsoft Word documents.

Arranging the page into two columns, I placed the sight-reading and retrospective think-aloud data in the left column and video-stimulated recall interview data in the right column. The data were organized in each column by rows per sight-reading question (1 through 6); thus reading each row from left to right meant seeing the sight-reading/think-aloud (left), and recall interviews (right) for one sight-reading exercise side-by-side. Finally, I imported all verbal data transcriptions into nVivo, a software program for analyzing qualitative verbal data (Welsh, 2002).

Sight-reading scoring. After transcribing all sight-reading data, I scored each exercise. For each sight-reading measure, there were 130 total points possible; the first exercise had 30 potential points and exercises two through six had 20 potential points. Initially, I intended to use Henry's weighted scoring system, as detailed above. For some of the participants, this scoring system would have been appropriate, because they generally stayed in the same tonality and key and negotiated the challenging sections moderately. For some, however, the scoring system was not appropriate because students did not stay in the same tonality and key and generally did not negotiate anything more than stepwise motion.

Instead of using Henry's scoring system of weighting targeted pitch skills, for each correctly sung pitch (regardless of syllable, letter name, or register sung) I awarded one point. I did not discount points for incorrect rhythms or losing the tempo and meter. If participants attempted pitches more than one time, I scored their final answer. If participants began in a different key than the exercise, or if they changed keys mid-exercise, I awarded points if the pitches were correct relative to the key context they

chose. For example, if they sang a notated pattern accurately (such as *Do, Re, Mi, Fa, So*) in their newly established key, I awarded points equal to the number of correct pitches sung in the pattern. If they sang the correct scale degree, yet in a different key than written or even with incorrect syllables, they received one point. I employed this scoring system primarily because the focus of this study was participants' cognitive strategies, not specifically on students' accuracy and reading skills.

A perfect score did not mean a perfect performance, only that their final answer for every pitch was correct; for example, Florence did not perform perfectly on her first attempt, but received a perfect score of 30 out of 30 after self-correcting several pitches. In Florence's case, the only mistake made was beginning a measure, singing the first interval incorrectly, stopping and correcting that interval and continuing to the end. Because I graded according to the final answer, she received a perfect score. For each exercise, I tallied the number of correctly performed pitches, then totaled the score for each of six exercises to arrive at a total score for each participant. After scoring all data, I entered the data into SPSS and calculated measures of central tendency.

Further data from vocal sight-reading. The focus of the study was strategies, not mere performance accuracy; therefore, to investigate other aspects of sight-reading performance, I analyzed data for elements other than pitch correctness. I evaluated the degree to which participants (a) retained the tonic and tonality throughout the exercise, (b) sang diatonic pitches in stepwise and skipping motion (contour), (c) matched their first pitch to the first given pitch (on the pitch pipe or researcher's voice), (d) performed cadential patterns (returning to last correct pitch), and (e) sang incorrect, but closely

related, patterns.

For example, I examined the accuracy of beginning and ending on the tonal center for each sight-reading exercise; I awarded one point, for a potential 6 points (one for each exercise), if the participant began and ended on the same tonal center pitch. Some participants changed keys in the middle of the exercise; if they began and ended on the tonal center relative to their established tonal context I awarded a point.

Assigning Strategy Use scores. In scoring, I considered each participant's sight-reading performance in association with his/her verbal data. For each category, I searched for comments they made regarding the subject as well as their overall performance. For example, when considering looking behavior for Amelia, she voiced that she looked ahead and saw a certain interval; I interpreted that as looking ahead and behind, and, because it interrupted the line of her performance (she paused), I awarded her 3 out of 5 points for the looking behavior category.

The pseudonyms in the current study are based on the sophistication of strategy scores; I ordered participants by their strategy use score and named them in alphabetic order and according to gender. Amelia (A = 1st) received the top ranking and was a female. The pattern continued down until Nelson (N = 14th), who received the bottom ranking and was male. If participants received the same strategy use score, the student with the better sight-reading score was given higher ranking.

Inter-rater reliability scores. I contacted a fellow music education doctoral student and a professor of choral music education to corroborate strategy use scores. The music education doctoral student also taught middle school chorus at a local school. The

professor taught choral music education at a mid-size university in the Mountain West region of the United States. I provided co-raters with audio recordings of sight-reading data, transcriptions of verbal data, a scoring sheet, and an instruction sheet. Via phone call, each co-rater and I discussed the process of rating strategy use scores and they had the opportunity to ask questions.

According to their speed and schedule, each co-rater listened to four participants' sight-reading data and read transcriptions of their verbal data. I instructed the co-raters to consider participants' sight-reading performance paired with participants' thoughts, decision-making processes, and explanations to give each participant a score in each category. Each co-rater returned a scoring sheet for each participant. Two co-raters independently scored 8 (4 each) of 14 total participants. The inter-rater reliability results are discussed in chapter 4.

Secondary coder. To establish trustworthiness in coding (especially think-aloud and video-stimulated recall interviews) and address potential researcher bias, a music education practitioner / doctoral student performed an external audit. This secondary coder provided objective and novel feedback on the first set of coding themes, by reviewing data and verifying coding (Patton, 2002).

I presented the secondary coder with videos and sight-reading and verbal transcriptions. To ensure consistent and accurate application of codes, I also supplied the secondary coder with coding guidelines, which explained each code and its appropriate usage. In the first iteration of coding, I coded for cognitive science and strategy themes. Together, the secondary coder and I simultaneously coded part of one participant's data,

to demonstrate the coding process and explain code definitions. Independently, the secondary coder then reviewed all sight-reading performance and verbal data from two participants, representing 14% of the data.

Overall, there were very few discrepancies in coding agreement. According to Armstrong, Gosling, Weinman, & Marteau (1997), agreement amongst coders in qualitative research will likely fall around basic themes, but vary according to labels and configurations. Accordingly, in the current study, the secondary coder and I agreed on most of the coding theme categories and their implementation by participants. The secondary coder suggested the need for an additional theme; we disagreed, because, according to my labeling, the phenomena were still present and recognized, but under another theme.

In the second iteration of coding, instead of coding for strategic elements according to cognitive science themes, I coded the data according to types and variations of strategies employed. In this iteration I more deeply looked at each strategy, its characteristics, components and context. This iteration did not involve considering the cognitive science categories (for example, looking behavior, long term memory), but rather dissected each strategy for its many cognitive and non-cognitive elements. While the secondary coder did not verify the second iteration of codes specifically, the coder had already confirmed the strategy codes from the first iteration. In many cases the codes overlapped but were relabeled.

Incorporation of Data

A distinctive feature of this study was the incorporation and comparison of participants' thought processes and actions, not separately, but as a unified whole. For example, when referring to a certain strategy, I cross-referenced participants' comments and performance, and noted similarities and discrepancies. This analysis technique is most similar to Thompson (2003), in which the researcher considered both sight-reading performance data and specific, event-driven comments in light of each other. On a very small scale, Thompson (2003) analyzed these data in comparison to each other, with one vocal sight-reading performance and one pre- and post-task interview per 11 participants. This analysis technique was also analogous to Scripp's (1995) study, in which the researcher combined sight-reading performance and interview data generally; however, the verbal and sight-reading performance data seemed to be analyzed separately, as two different types of data, not combined and analyzed as influencing each other. In the current study, I considered verbal data in the context of participants' sight-reading performance.

After I transcribed and scored the sight-reading performance exercises, I then hand-wrote verbal data from observations and interviews into the sight-reading diagram. I placed verbal data at the point in which participants voiced data, which was spoken initially while sight-reading, articulated during the think-aloud, or verbalized during the recall interview. I created a visual incorporation of all data streams by establishing a time-line of actual notes sung, verbal intentions, observed actions, vocalized thought-processes, and explained decisions.

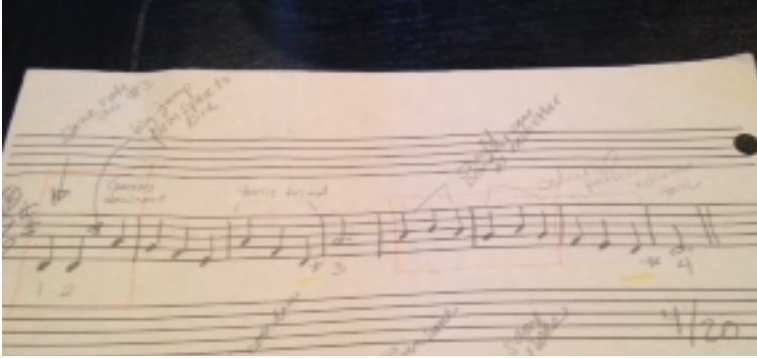


Figure 3. Time-line of combined data streams. Caty, exercise 4.

Data Analysis

I used the software analysis program nVivo (Welsh, 2002) to maintain and organize verbal data. After combining all sources of data into one document, I then divided student responses into events. An event was an instance within the sight-reading inventory, about which students made comments and described. For example, if a student discussed her initial thoughts regarding the octave skip in exercise 4 during the think-aloud, and then further explained her decision making during the video stimulated recall interviews, I labeled all the comments surrounding the octave skip as one event.

Similarly following the coding taxonomies of Scripp (1995), Vujović and Bogunović (2012), and Thompson (2003), I coded the events. I did not employ *a priori* codes, but utilized a specific lens (audiation and pertinent cognitive science literature regarding music reading) to inductively distill emerging codes and themes from the data. I coded only one occurrence of each action within each event. For example, if Beatrix talked about hearing the pitch before singing in the recall interviews, and then, in answering another interview question, made reference to the same action (hearing the pitch previous to singing), I only coded the action once in the visual/aural category for

that event. First, I completed a general coding of all the data, then grouped codes by themes. In this process, there emerged 3 knowledge domains (visual, aural, visual/aural) and 2 underlying systems (self-assessment and music vocabulary).

During data analysis, I treated the qualitatively gathered interview data as verbal data, not qualitative data. The verbal data were controlled and targeted, unlike open-ended qualitative data, and as such, I coded the verbal data within events in a quantifiable method. For example, I counted the number of times participants indicated visual strategies.

Scripp (1995) coded and scored verbal data for levels of articulation ("richness and specificity of description") and complexity ("level of relational coordination") (p. 113-114), whereas I coded strictly for strategy characteristics, without evaluating degrees of expression. Vujović and Bogunović (2012) similarly analyzed strategies in sight-reading by cognitive science themes, but did not include audiation. Thompson (2003) coded for cognitive science principles, according to researcher-labeled pitch perception metaphors (Builder, Chunker, Button-pusher, Tonal-thinker, etc.) (Thompson, 2003, 2004).

For research question 2, I divided the participants into two groups based on the overall sight-reading indicator: those who scored in the highest 50% overall and those who scored in the lowest 50%. The point was not to group participants according to similarities in behaviors, but to investigate whether or not differences arose despite the similarities in behavior. I decided against using the highest and lowest quartiles, for example, because this would have highlighted differences between outliers; instead,

including the middle 50% (the second and third quartiles) in the analysis tempers these differences. Thus, when differences arise, they are more consequential. There are, however, only 14 participants' scores, with 7 participants per group, thus the differences may or may not be seen with a larger sample size.

Ideally, the questionnaire data, when compared with the verbal data and sight-reading scores, would have provided more insight into whether or not prior experience was a factor in participants' performance and scores. Students were to indicate on the questionnaire in what types of music activities they had participated and the length of study for each. Unfortunately, students interpreted the questions differently, and without the opportunity to clarify participant responses, the reports were inconsistent. Therefore, I did not employ the questionnaires in data synthesis and analysis. Prior experience may, indeed, be a factor, and this type of questionnaire data would enrich a follow-up study.

Trustworthiness

In the present study, methods triangulation via interviews, observations, verbal reports, and sight-reading performance was used to gain credibility and trustworthiness (Mathison, 1988; Patton, 1999; Trainor, 2013). Furthermore, two otherwise unaffiliated choral music educators corroborated strategy use sophistication scores verifying inter-rater reliability (Demorest & May, 1995). To establish trustworthiness in coding, a music education practitioner / doctoral candidate served as a secondary coder.

Summary

This study's design was an exploratory, collective case-study. I employed networking to find the research site, a middle school that offered eighth grade chorus, and

gained access to the site with choral teacher and administrator approval. The participants in the main study were fourteen eighth-grade choral singers. The pilot and main study data collection procedures included: a vocal sight-reading measure (Vocal Sight-Reading Inventory; Henry, 1999), structured interviews, retrospective think-alouds (Ericsson & Simon, 1993), video-stimulated recall interviews, and researcher observations. Trustworthiness was established through triangulation of data from interviews, observations, and verbal reports, inter-rater reliability in the sophistication of strategy use scores, and one auditor in coding. In the following chapter, I will present results from the sight-reading inventory, the strategy use sophistication level scores, and then follow with results organized according to research questions.

CHAPTER 4

RESULTS

In this chapter, I present the findings for each research question in aggregate across all 14 research participants. All streams of data (sight-reading performance, interviews, and observations) were merged to answer the research questions as detailed in chapter 3. First, I will present the results from the vocal sight-reading inventory and the sophistication of strategy use index. Second, I then present the findings from each research question.

Sight-Reading Measure: Vocal Sight-Reading Inventory

Participants ($N = 14$) each vocally sight-read the first six exercises from the Leveled and Revised version of Henry's (1999) Vocal Sight-Reading Inventory. The sight-reading scores ranged from 28 (21.5%) to 104 (80%) of 130 total points ($M = 61.86$, Median = 65, $SD = 21.87$). See Appendix N for scores listed by participant.

Overall, the tasks provided a challenge for most participants, and all participants (except Diana) sang through all exercises. Diana stopped halfway through two exercises. The tasks were difficult for some (Nelson and Louisa) and moderately difficult for other participants (Amelia, Beatrix). Henry (1999) designed the Inventory to increase in difficulty from 1 through 6; however, these participants demonstrated a slightly different pattern, where exercise 1 was the easiest, followed by exercises 3, 2, 6, 5, and 4.

Table 1. Average percent correct per difficulty ranking of sight-reading exercises.

Rank	Score (%)	Exercise #	Mean	Median	St. Deviation
1	70	1	20.86	22.50	8.09
2	54	3	10.71	12.00	4.65
3	45	2	8.93	8.00	5.20
4	40	6	8.00	8.50	3.40
5	37	5	7.36	6.50	4.27
6	30	4	6.00	3.50	6.14

Note: Percent correct and ranking are after standardization of scores of exercises. Ranking 1 was the easiest and 6 was the most difficult. Exercise 1 had 30 possible points, where other exercises had 20 possible points.

Sophistication of Strategy Use Index Scores

Participants' cumulative scores ranged from 6 to 20 ($M = 12.64$, Median = 12.5, $SD = 4.77$), with a possible 25 points (five points possible from five categories: looking behavior, chunking, long-term memory, auditory representations, and audiation/notational audiation). Table 2 shows participants' scores per category and cumulative score. If two participants earned the same Strategy Use score, the participant with a higher sight-reading score received the higher ranking.

Table 2. Strategy use sophistication level scores per participant per category.

Name	Looking Behavior	Chunking	Long-Term Memory	Auditory Representations	Audiation	Strategy Use Score
Amelia	3	4	4	5	4	20
Beatrix	4	3	5	4	3	19
Caty	4	4	3	4	3	18
Diana	3	3	4	4	3	17
Edwin	2	3	3	4	3	15
Florence	3	3	3	3	2	14
Georgia	2	3	3	3	3	14
Harriet	2	3	2	2	2	11
Ida	3	2	2	2	2	11
James	2	2	2	2	2	10
Kurt	2	2	2	1	1	8
Louisa	2	2	2	1	1	8
Margaret	1	1	2	1	1	6
Nelson	1	1	2	1	1	6

Overall, participants demonstrated the highest level of sophistication in the categories of long-term memory (Beatrix: 5) and auditory representations (Amelia: 5). Participants executed average sophistication level strategies in looking behavior and chunking, and the least sophisticated strategies in audiation. Individuals' Strategy Use scores across categories did not vary more than two points, suggesting the use of sophistication of strategies may develop concurrently.

Inter-rater reliability. To determine interrater reliability for strategy use scores, it was necessary to employ two external raters, three total. I used the Intraclass Correlation Coefficient (ICC), with two-way random and consistency, because there were three raters, I rated all 14 participants, and two independent raters adjudicated 4 participants each. There was a high degree of inter-rater reliability between the researcher and rater 1, the average measure ICC was .95 ($F(3,3) = 19, p = .019$). There was also a high degree of inter-rater reliability between the researcher and rater 2, the average

measure ICC was .88 ($F(3,3) = 8.133, p = .059$). A reliability coefficient between .75 and 1.00 can be considered acceptable (Cicchetti, 1994). Overall, coefficients of .95 and .88 established acceptable inter-rater reliability.

Research Question 1

What are the characteristics of strategies employed by middle school students during vocal sight-reading?

Students' strategies emerged in 3 knowledge domains, *visual* (notation orthography), *aural* (sound), and *visual/aural* (integration of notation orthography and sound), and 2 underlying systems, *self-awareness* and *music vocabulary*. The relationship between these categories is pictured in the following diagram, Figure 4. The visual, aural, and visual/aural knowledge domains are interrelated in a Venn-diagram manner. Eight hundred and thirty-two (55%) of the strategies employed within domains of knowledge were visual-only, 179 (12%) were aural-only, and 496 (33%) were visual/aural. Furthermore, strategies involving self-awareness and music vocabulary were underlying systems, lying beside the visual, aural, and visual/aural strategies, with 495 self-awareness strategies and 397 strategies involving music vocabulary. The strategies that fell in the 3 domains of knowledge and the underlying strategies were tallied separately. While several participants used strategies to address meter and tempo, I will not address rhythmic considerations.

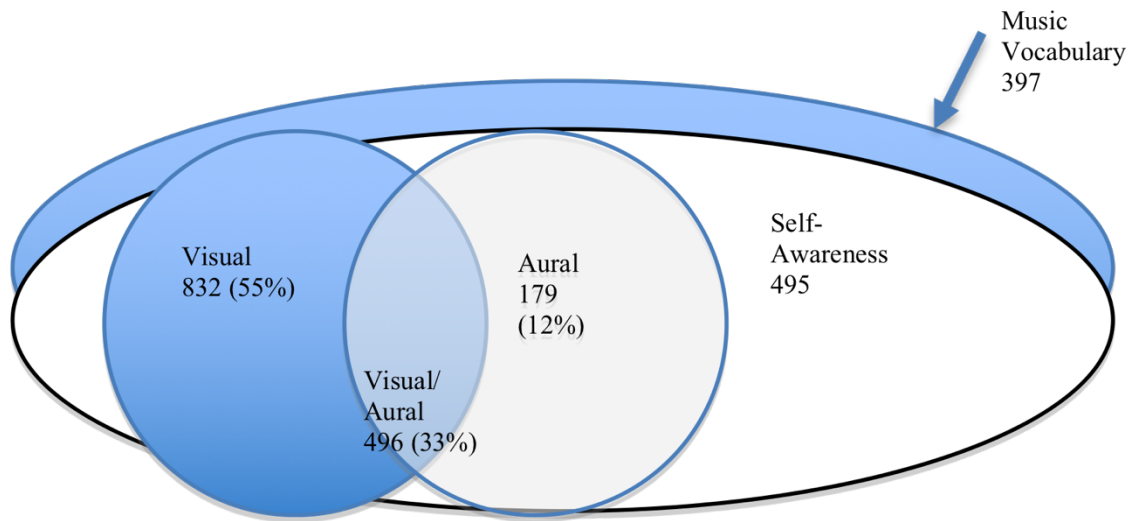


Figure 4. The relationship and frequency of strategies employed by participants.

Visual. Across all participants, students exhibited 832 (55%) instances of visual-only strategies, which is notation orthography information gained and analyzed visually. Notation orthography is the set of printed conventions of a language (in this case music notation) and the representation of the pitches/rhythms by written symbols. This included anything with reference to visual symbols, notes, patterns, spatial distances, and staff locations. These strategies included 6 different types.

First, students looked for direction and consistency in visual-spatial movement, such as all steps, all skips, and referent placement. For example, Diana said, “It’s just mostly going up by one note” (Exercise 1). There were 306 references to this type of strategy.

Second, students read in phrases and chunks; this included anticipating the end of the cadential pattern. For example, Beatrix chunked notes together when she explained, “then I went downwards back to *Do*” (Exercise 2). There were 89 examples of students

visually reading in chunks.

Third, students noticed changes in visual patterns or contrasted visual patterns. This happened with reference to both individual notes and entire patterns. For example, in explaining his thoughts while reading exercise 1, James detailed, “Same note, same note, one up, same note, another one up, same note, one up, same note, one up, down, down, down, down, up, skip” (Exercise 1). There were 194 references to this type of strategy.

Fourth, students read by analogy or familiarity, commenting they had seen something before or that it was similar to another something. For example, Georgia elucidated her strategy in singing a tonic triad when she commented, “I had this moment where I was like ‘oh, this is what we did in chorus.’ So, I’ll go back and sing it like we sang it in chorus” (Exercise 1). There were 40 examples of reading by analogy.

Fifth, students used the staff for visual cues, or, in other words, drew only visual meaning from the shapes and symbols, not musical (aural) meaning. For example, Margaret described visual cues in labeling notes when she described, “And this is *So*, it’s the same as this one, and it’s also if you count from the bottom, it’s *So*” (Exercise 1). There were 183 examples of using the staff for visual cues.

Aural. Across all participants, students employed 179 (12%) aural-only strategies. This category of strategies, as opposed to the visual/aural category, involved anything with regards to sound separate from a visual reference, such as relying on the aural distance of pitches. These strategies included two different types.

First, participants discussed matching their voice to the reference pitch (from

either the pitch pipe or the researcher's voice). For example, after hearing the pitch pipe sound a D, Caty explained her thought process, "I can't sing that high" (Exercise 3). There were 15 examples of this.

Second, students employed auditory representation creation. This occurred in many forms, such as: creating, remembering, comparing, listening to, and pivoting on and around auditory representations (and groups of auditory representations). For example, in trying to negotiate a sharp in exercise 5, Amelia employed an auditory representation, "I was trying to remember what a sharp sounded like. So I sang, like, regular *Re* and then *Re* with a sharp, I think, did I?" (Exercise 5). Participants also employed auditory representations to pivot to, from, and around other pitches; Beatrix demonstrated this when she explained, "I knew that it was a little more than the *Do-Mi* increment, so I tried to go, like, lower than that" (Exercise 6). There were 98 examples of employing auditory representations from the aural-only modality.

Visual/Aural. Encompassing all participants' strategies, there were 496 (33%) examples of visual/aural strategies. The criteria for this category were that strategies included pairing or integrating the visual (notation orthography) and aural (sound) modalities where each were dependent upon each other. These strategies consisted of three different types.

First, participants matched a pitch reference to a visual reference. This included hearing the pitch and then associating it with a visual reference, such as when Diana commented, "Well, you played it at the beginning of the piece, and it starts and ends on Do, so just, I had it in the back of my mind that that was Do" (Exercise 1). There were

only 15 examples of this.

Secondly, students matched a visual staff note placement with one discrete aural pitch. In this category were strategies such as matching (or attempting to match) a visual staff note reference to a singular pitch, matching syllables (gained visually/spatially) to a pitch, assessing visual/spatial/verbal distance of large intervals first before associating pitch, and considering previous and forthcoming notes to decipher or confirm the current note. For example, in determining a pitch, Florence described, “I just remembered the first note from over here, and I also knew that it was the first note over here, and I brought that knowledge out to there, and I knew that that was the same note” (Exercise 1). There were 144 examples within this category.

The third strategy in this category was *predicting*, using the integration of both aural and visual modalities. Examples in this category incorporated making inferences, approximating aural distances, predicting by looking forward, and anticipating future unknown pitches with auditory representations. For example, Florence explained, “I kind of had what it was in my head and then when it came out it was still skipping, so I decided to leave it and go on to the next” (Exercise 2). There were 61 examples of this.

Self-Awareness. Self-awareness strategies encompassed any comments regarding realizing a problem or implementing a repairing strategy. Underlying the aural, visual, and visual/aural strategies were 495 examples of employing self-awareness while sight-reading; there were self-awareness strategies that occurred within aural, visual, and visual/aural domains of knowledge.

In the first case, participants commented on and evaluated their self-production

accuracy. This was any self-report where they expressed listening to themselves or assessing their performance. This happened 127 times. For example, Florence explained:

Um, I was thinking, I didn't know like the note itself, I just knew that, I knew the first note just because we sing some *Do, Re, Mis* in class. I knew what that first note was and I knew what *So* was, and I knew what it looked like on, like, if I saw *So* I know that that's *So*. And I knew it was higher, so I just aimed higher, and when it came out I just kind of knew that it was the right note, and that it wasn't too low (Exercise 4).

When commenting on their self-production accuracy, participants rarely commented their performance “sounded right” (only 6 times), but more often identified a problem or miscue (58 times). When commenting on a problem or miscue, students described how they realized a problem or error, such as: an unknown or inaccurate label, a misalignment of expected syllables visually (a mismatch between known, expected, and ascertained syllables), a mismatch between aural expectations and visual note placement, a general and inexplicable discrepancy between aural expectations and aural production, failure to visually attend to symbols, and admittance of unfamiliarity with note or label. For example, Beatrix explained, “And then I couldn't really find my starting note” (Exercise 1).

After self-assessing and identifying a problem or miscue, students identified the need for a repair strategy 73 times and enacted a repair strategy 79 times. The repair strategies were: pausing briefly to think (and then continuing on); stopping and re-starting (re-singing a single note, pattern, or entire line); ignoring a note or symbol; continuing to

sing (purposefully singing incorrect note, slowing tempo slightly, pushing on knowingly after errors); and ceasing the exercise. For example, Amelia explained her repair strategy when she detailed, “I could tell like, I saw there were still 4 notes left, so I knew it couldn’t be *Mi*. And, I saw that it ended on *Do*, because it was the same note as here, so I knew it had to be *Fa* and not *Mi*. So *Fa* is like a note above *Mi*, so then I just sang *Fa* instead” (Exercise 4).

Furthermore, after performing a repair strategy, participants realized their repair strategy was unsuccessful, an inaccurate fix. For example, “I didn’t skip, didn’t fully register that there was a skip there before I got to the note, and then I kind of got all messed up and didn’t realize, and I knew that it was a skip. And then I tried to change that, but then it didn’t really work so I just started over so I could get the right note” (Exercise 6). This occurred 19 times.

The final manifestation of self-awareness was in participants’ understanding and assessment of their voice as an instrument. In this category, students were aware of their best range, and recognized when pitch requirements extended out of that range, placed performance in that range, and expressed discomfort outside of that range. For example, Georgia demonstrated knowing the capabilities of her voice when she explained, “Um, well, I can’t sing that low and I knew I couldn’t, so I was just like, what’s this note an octave higher?” (Exercise 3). There were 16 examples of this.

Musical Vocabulary. A second overlay, beside the aural, visual, and visual/aural categories, was musical vocabulary. This category refers to a participant’s understanding of, proficiency with, and ability to describe how to use the terms and content of music.

Furthermore, the instances in this category happened in the context of either visual, aural, or visual-aural domains of knowledge. This category does not mean labeling music terms, per se, but a very broad understanding of the components of music (aurally and visually) and how to employ, implement, and manipulate the components.

In this category, students recognized and verbally labeled musical symbols, such as scale, sharp, flat, dotted half note, rest, G clef, octave, and beat. For example, Nelson explained, “So it’s treble clef again. And it’s D sharp again, it looks like. And it starts off right above C so that’s B, and then it’s like a scale” (Exercise 3). This occurred 69 times.

A second example was when students applied solfege language or letter names to visual cues. This included rechecking labels, strategies for deciphering labels, and labeling from sight (labeling from the visual placement without deciphering). For example, Louisa detailed, “The first note being C also correlates to being *Do*, and the first few notes they don’t skip any spaces so it is just going up the octave. So it would be *Do*, *Do Re*, *Do Re Mi*, and then it repeats” (Exercise 2). There were 183 examples of this.

Students also exemplified this category when guessing the label, or predicting. For example, Kurt explained, “I’m not really sure what that note is, but, it’s probably *Do* because that’s what it usually starts on” (Exercise 1). Students demonstrated this 13 times.

Furthermore, participants displayed this strategy category when describing their strategies. Participants explained utilizing the staff for visual cues, how to use the staff, and how to implement matching visual to pitch. For example, Caty described, “So this note and this note are the same and this is a step up because there’s a space and then a

line, and this is a step up because it's a line and then a space" (Exercise 1). This occurred 132 times.

Overall, participants exhibited strategies in 3 domains of knowledge, visual, aural, visual/aural, and 2 underlying systems, self-awareness and music vocabulary (see Table 3). The self-awareness and music vocabulary underlying systems were overlaid on the visual, aural, and visual/aural domains of knowledge, as participants employed self-awareness and music vocabulary strategies while executing visual, aural, and visual/aural strategies.

Domains of Knowledge	
Visual	1 Looking for direction and consistency in movement
	2 Reading in chunks
	3 Noticing changes in visual patterns
	4 Reading by analogy
	5 Using the staff for visual cues
Aural	1 Matching first pitch to initial pitch source
	2 Employing auditory representations
Visual/Aural	1 Matching pitch reference to staff placement
	2 Matching visual staff placements to singular pitches
	3 Predicting
Underlying Systems	
Music Vocabulary	1 Recognizing and verbally labeling musical symbols
	2 Applying verbal labels to visual cues
	3 Guessing labels
	4 Describing using the staff
Self-Awareness	1 Awareness of self-production accuracy
	2 Awareness of problem or miscue
	3 Awareness of need to repair
	4 Implementation of repair strategy
	5 Voice as instrument

Figure 5. Summary of self-reported strategies employed during vocal sight-reading

Research Question 2

How does the strategy use of higher scoring sight-readers differ from those of lower scoring sight readers?

Participants who scored in the highest 50% of scores on the sight-reading inventory demonstrated employing a higher frequency of specific strategies in the visual, aural, visual/aural domains of knowledge, and self-awareness and music vocabulary underlying systems than those who performed in the lowest 50% of scores. The results

will be discussed from self-reported and researcher-observed data.

Self-reported. In the visual category, those in the highest 50% of sight-reading scores reported more frequently reading in chunks and reading by analogy. Both reading in chunks (highest 50%: 66 times; lowest 50%: 23 times) and reading by analogy (highest: 29; lowest: 11) occurred three times more often by those who performed in the highest 50% of sight reading scores.

Aurally, those with the highest 50% of sight-reading scores more frequently discussed matching their voices to the pitch source and employing auditory representations. Describing matching their voice to the pitch of the pitch source happened four times as often (highest: 12; lowest: 3) for those in the highest 50%. Also, those in the highest 50% reported creating and manipulating auditory representations twice as often (highest: 66; lowest: 32).

In the visual/aural category, those in the highest 50% of scorers reported both matching a pitch to a visual reference and matching visual staff placements to singular pitches. Those who were in the highest 50% discussed matching the initial pitch reference (from the pitch source) to a specific visual reference six times more often (highest: 13; lowest: 2) than those who were in the bottom half of scores. Matching a visual staff placement to a discrete pitch occurred twice as often by those in the highest 50% of scorers (highest: 96; lowest, 48).

For the music vocabulary underlying system, those who were in the highest 50% of scorers more often described how to negotiate the notation orthography (highest: 96; lowest, 36) (notation orthography is the set of printed conventions of a language);

however, the lowest 50% of scorers labeled more symbols and notes (with solfege or letters) (highest: 80; lowest: 185). This finding should be read with caution, because several of the highest scorers employed a neutral syllable when sight-reading, and those with higher sight-reading scores may have known more terms but did not verbalize them.

For self-awareness strategies, those in the highest 50% of scorers more often reported awareness of production, recognition of a problem or miscue, and identified the need for a repair strategy. Those who were in the highest 50% commented on being aware of their production almost three times more often (highest: 91; lowest: 36) than those in the lowest 50%. Recognizing a problem or miscue occurred more than eight times more often (highest: 52; lowest: 6) by those in the highest 50%. When commenting on problems or miscues, those in the highest 50% more often evaluated based on aural considerations (highest: 70; lowest: 10) than verbal/label considerations (highest: 10; lowest: 30). Furthermore, those in the highest 50% of scorers identified the need for a repair strategy two times more often (highest: 51; lowest: 22).

Overall, those who performed in the highest 50% of scorers *visually* read by chunking and analogy more often, aimed to *aurally* matched the first pitch and created/manipulated auditory representations more often, *visually/aurally* matched visual and aural references together more often, described negotiating notation orthography with *music vocabulary* more often, and were more often *aware* of their own production accuracy, errors, and need for repair strategies. See Table 4 below.

Table 3. Patterns among the highest and lowest 50% of scorers from self-reported verbal data

	Reading by chunk	Reading by analogy	Voice to pitch source	Auditory Representations	Matching visual placement to discrete pitch	Describe how to negotiate music	Awareness of production	Recognition of problem or miscue	Evaluated miscue on aural considerations	Need for repair
Highest 50%	66	29	12	66	96	96	91	52	70	51
Lowest 50%	23	11	3	32	48	36	36	6	10	22

Sight-reading performance and researcher observations. Those in the highest 50% of sight-reading scores were more often grounded in the tonality. First, these students more often matched their first sung pitch with the pitch source's pitch; for those in the top half, this occurred almost twice as many times (highest: 41; lowest: 25) as those in the bottom half of scores. Second, those who scored in the top 50% of sight-reading scores then retained the tonal center throughout the exercise more than three times more often (highest: 30; lowest: 7) than those in the bottom half of scores. Third, those who scored in the top half of sight-reading scores substituted incorrect, but harmonically relevant pitches, in cadential patterns and then returned to the correct last pitch more often (highest: 9; lowest: 5) than those who were in the bottom half. Fourth, when performing incorrect pitches, those who were in the highest 50% of scores achieved singing the correct contour with diatonic pitches and displaced by one scale degree (highest: 21; lowest: 6) more often than those in the lowest 50%. Finally, when singing incorrect pitches in large skips (fourths, fifths, and octaves), those who were in the highest 50% of scorers more often (highest: 8; lowest: 4) chose a diatonic and

harmonically related pitch than those who were in the bottom half.

Those who were in the lowest 50% of sight-reading scores more often performed non-diatonic pitches or incorrectly associated the visual/spatial changes with aural changes. First, those who performed in the lowest 50% more often sang arpeggiated motion when the notation indicated stepwise motion (highest: 13; lowest: 34) than those in the highest 50%. Secondly, when performing incorrect pitches, those who were in the lowest 50% of scores achieved singing the correct contour but with non-diatonic pitches (highest: 18; lowest: 66) or did not achieve the contour, but sang in the incorrect or opposite direction (highest: 5; lowest: 30) more often than those in the highest 50%. Finally, participants in the lowest 50% of scorers also made aural substitutions in miscue patterns more often (highest: 0; lowest: 20) than those in the highest 50% of scorers.

Table 4. Patterns among the highest and lowest 50% of scorers from sight-reading performance and researcher observations.

	Match first sung pitch with reference	Retain tonal center	Correct cadential substitutions	Correct contour displaced by one scale degree	Relevant skip substitutions	Arpeggiate when stepwise motion	Correct contour but non-diatonic	Opposite direction of contour	Aural substitutions in miscue patterns
Highest 50%	41	30	9	21	8	13	18	5	0
Lowest 50%	25	7	5	6	4	34	66	30	20

Overall, those who scored in the top 50% on the sight-reading indicator displayed similar patterns in their strategy use. These students more often: read in visual chunks, created and manipulated auditory representations, paired singular pitches with discrete staff placement locations, were more self-aware of their production and commission of errors, and aurally grounded in the tonality. Conversely, those who performed in the lowest 50% also exhibited similar patterns. These students more often lacked a tonal anchor and awareness of their production.

Research Question 3:

Does the use of more sophisticated strategies influence sight-reading scores?

All participants employed strategies to some degree, yet all participants did not score equally well on the sight-reading measure. Participants employed strategies ranging from less-sophisticated to more-sophisticated. These sophistication levels were derived from empirical studies in cognitive science literature. I assigned strategy use scores according to participants' general and overall use of a strategy, derived from considering

both their self-reported and sight-reading performance data. For example, within the Looking Behavior category, if, over the course of all six exercises, a student described both looking ahead and looking behind their current place while sight-reading and it did not interrupt their performance tempo, then they received a “4” on the looking behavior category.

As detailed in chapter 3, I performed a correlation analysis on the sight-reading scores and strategy use scores for each participant. There was a positive and strong correlation ($r = .84, p < .00$) between strategy use sophistication scores and vocal sight-reading scores. As the strategy use sophistication scores rose, sight-reading achievement also increased. Figure 5 below displays a scatter plot of the correlation between strategy use sophistication scores and strategy use scores.

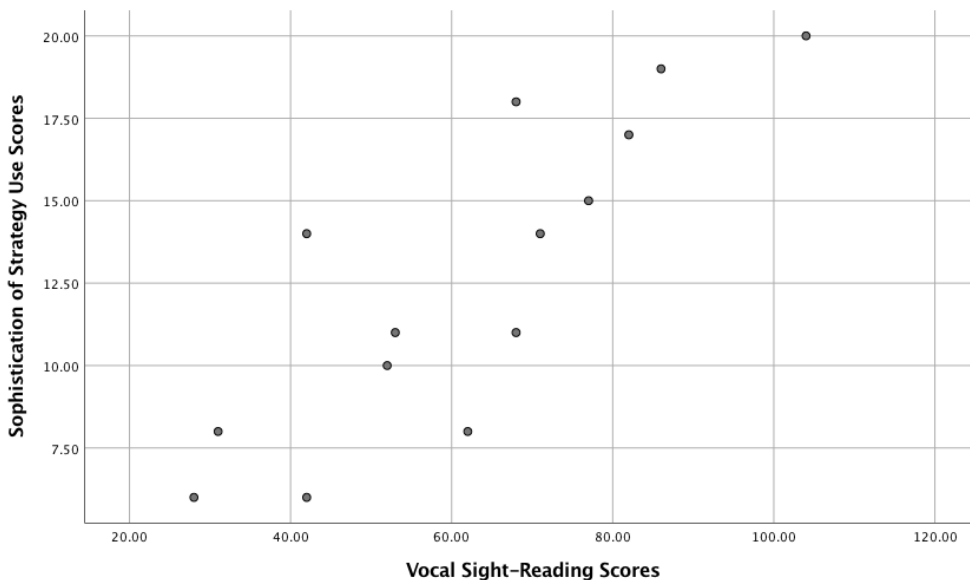


Figure 6. Scatter plot of sight-reading scores in relation to strategy use scores.

Participants all utilized some strategies while sight-reading; however, the frequency of strategy use was not a determinant in strategy use sophistication scores. The

differences between strategies employed at each sophistication level were not quantitative but qualitative in nature. In other words, more sophisticated strategies were not determined by the frequency of strategies employed, but defined by the quality and type of understanding used. For example, for strategies in the looking behavior category, the most sophisticated strategies included reporting looking ahead to phrase and pattern boundaries, while the least sophisticated strategies encompassed reporting looking at one note at a time.

CHAPTER 5**DISCUSSION**

The purpose of this study was to elucidate the strategies that might or might not be employed by eighth grade choral students during vocal sight-reading. The following three research questions guided data collection and analysis:

1. What are the characteristics of strategies employed by middle school choral students during vocal sight-reading?
2. How does the strategy use of higher scoring sight readers differ from those of lower scoring sight readers?
3. Does the use of more sophisticated strategies influence sight-reading scores?

The data from this study led to three major findings:

1. Students employed strategies in three domains of knowledge, visual-only (most frequent), aural-only (least frequent), and visual-aural, and two underlying systems, self-awareness and music vocabulary.
2. Those who scored the highest 50% on the sight-reading indicator employed these strategies more frequently than those who scored in the lowest 50%
 - read in visual chunks and by analogy;
 - created and manipulated auditory representations;
 - paired singular pitches with discrete staff placement locations;

- employed self-awareness in production and commission of errors;
 - remained aurally grounded in the tonality.
3. There was a positive and strong correlation ($r = .84, p < .00$) between students' sophistication of strategy use scores and vocal sight-reading scores.

Five Categories of Strategies

Reliance on visual, less on aural. In sum across all participants, there was a strong reliance on visual strategies (55%) and little reliance on aural strategies (12%). In the currently available literature regarding sight-reading, no researchers studying strategy use have labeled strategies by the type of modality employed.

These participants might have engaged in strategies that fall into the first step Lehmann and McArthur (2002) suggested, scanning the notation orthography. Lehmann and McArthur (2002) described that in the first step of reading music, the performer scans the notation orthography and automatically encodes typical musical attributes, and the attributes are seen as chunks and matched with information in long-term memory storage. While the participants in the current study heavily employed visual strategies, many participants did not self-report engaging in strategies in the second step of encoding, which is transferring the material from visual to auditory form. Additionally, many did not recognize visual patterns in the first place and, therefore, were unable to link visual stimuli with formerly sung patterns. In other words, they may be using visual strategies to interpret visual material, but struggle to digest the pitch aspect, demonstrated

by their lack of aural references or strategies. Participants might be getting stuck post-visual interpretation and pre-aural association.

Findings from McPherson's (1994, 2005) studies suggested students in their early years of instrumental study may develop visual skills within music (playing rehearsed music and sight-reading) faster than aural skills (playing from memory and ear, and improvising). Students in the current study may be demonstrating more proficiency with visual skills, by having strategies that involve the visual modality. More research is necessary to determine if there is a connection between visual and aural skills and visual and aural strategy use.

Character of some strategies matched those of expert readers. In the five types of categories employed, participants demonstrated strategies that involved looking behavior, chunking, long-term memory, auditory representations, audiation and notational audiation. In looking behavior, participants in the current study demonstrated looking forwards, backwards, and around structural markers. This is consistent with research on expert sight readers who organized looking ahead around phrase boundaries or structural markers (Sloboda, 1977, 1984; Waters et al., 1997). In chunking, participants in the current study grouped notes into melodic, harmonic, and cadential patterns. This is akin to strategies employed by expert readers, who chunked musical material when reading (Fine et al., 2006; Gilman & Underwood, 2003; Goolsby, 1994b). In long-term memory, participants remembered sequences of pitches in chordal form, which is similar to subjects in Salis' (1980) study who significantly more often remembered visual stimuli in chordal form than non-musicians. In auditory

representations, participants created and employed auditory representations to negotiate the notation. This is not unlike expert readers, who utilized musical imagery in sight-reading (Brodsky et al., 2003). In audiation, participants in the current study purposefully aimed to remember the starting pitch. In notational audiation, participants paired a pitch with a staff location, which is akin to participants in Vujović and Bogunović (2012) who stated, “I focus on stable tones” (p. 1108). Participants in the current study employed strategies that experts utilize, and this suggests these participants are on the developmental path towards proficient sight-reading skills.

Underlying musical cognitive processes. Within the aural-only, visual-aural, self-awareness and musical vocabulary categories, participants in this study created, manipulated, and employed auditory representations while vocally sight-reading to varying degrees. This study, in part, addresses Lehmann, Sloboda and Woody’s (2007) argument that the underlying musical cognitive process of creating mental representations of music is the central skill required in becoming an expert musician. The more sophisticated the strategy use, the higher the sight-reading scores, and creating and manipulating auditory representations was one aspect of sophisticated strategies. Participants in Edgington’s (2005), Vujović and Bogunović’s (2012), Thompson’s (2003, 2004), and Scripp’s (1995) studies reported employing auditory representations as a strategy during sight-reading.

Difference Between Strategies of High and Low Scorers

Self-awareness. Participants in the top 50% of scorers displayed self-awareness strategies, such as self-reporting the recognition of singing incorrect pitches, more often than those who scored in the bottom half of scores. This is similar to longitudinal findings from Deen (2012) and Scripp (1995) who found students' awareness levels grew in tandem with sight-reading ability. Scripp found meta-cognition skills correlated with sight-reading ability. Lacking the ability to employ self-awareness strategies may indicate students do not recognize the correct answer or are not listening to their own musical production.

Maintain grounding in the tonality. Participants in the top 50% of scorers more frequently implemented aural-only and visual-aural strategies. These strategies included creating and manipulating auditory representations and employing musical auditory expectancy, such as remembering a formerly sung pitch or pivoting around an auditory representation to achieve a new pitch. Musical auditory expectancy is the expectation of hearing an aural representation and a strategy often utilized by expert adult sight-readers in music cognition literature (Brodsky et al., 2003, 2008; Kalakoski, 2007). As they most often reported expectancy for the starting note, participants may have experienced stronger musical auditory expectancy for the tonal center than for other tonal functions.

These findings echo those that of Yankeelov (2016), who, when studying the auditory representation formation of classical and non-classical undergraduate musicians, found the strongest auditory image elicited from notation to emerge first is tonal center auditory representation. Indeed, Colwell (1969) argued "the ability to hear the presence

or absence of a tonal center is essential for understanding of all music” (p.112).

Corroborating this belief, Gordon (2007) theorized the six hierarchical stages of audiation begin with first, momentary retention (which is a fleeting auditory representation), and second, “imitating and audiating tonal and rhythmic patterns and *recognizing and identifying a tonal center* and macrobeats” (italics added, p. 20).

Positive and Strong Correlation Between Strategy Use and Sight-Reading Scores

Strategies matched those of sophistication levels. Not only did participants in the current study employ strategies used by expert readers, participants in the current study also utilized a range of sophistication level of strategies. Vujović and Bogunović (2012) divided participants’ cognitive strategies into three levels according to musical structure, ranging from the first level of focusing on singular pitches to the highest level of creating mental representations. Participants in the current study exhibited the same range of sophistication of strategies, from focusing/labeling/recognizing one pitch at a time to creating mental representations of musical material based on higher order relationships.

Participants’ strategies also echoed the sophistication levels recorded and labeled by Thompson (2003, 2004). These pitch internalization (hearing a pitch in one’s mind) strategies included the Follower, the Button-pusher, the Contour-singer, the Tonal-thinker, the Builder, the Pitcher and the Chunker. Participants in the current study demonstrated many of these strategies, primarily the Follower (relying on an outside pitch source), the Tonal-thinker (utilizing audiation of the tonic and tonality to make educated guesses), and the Builder (thinking intervallically).

Influence of sophistication of strategy on vocal sight-reading scores. The sophistication level of the participants' strategy use correlated with their sight-reading scores. This finding is akin to Thompson's (2004), where the researcher found that the three most effective types of strategies were Harmonic Thinking (94% correct), "Other" combination of strategies not combined by Thompson (91% correct), and Tonal-Thinker (86% correct). It is not clear if participants in the current study employed harmonic strategies; however, participants did utilize tonal thinking, which was relying on the tonic and tonality and making tonally-based educated guesses.

Most of the research findings regarding the sophistication of strategies while sight-reading originated in studies from cognitive science researchers. For example, more effective sight-reading included harmonically-based chunking (Goolsby, 1994b; Salis, 1980) and utilizing musical auditory expectancy (Schön & Besson, 2005; Yumoto et al., 2005a). Interestingly, participants in the current study demonstrated many unsophisticated strategies, such as the lack of chunking and the lack of musical auditory expectancy, which may be developmentally appropriate.

Implications and Future Research

The results in this exploratory, collective case-study, might have implications for choral music educators and music cognition researchers. Due to the small sample size, ideas should not be extended to middle school choral singers comprehensively. There are, however, implications that educators and researchers might consider.

For choral music educators. Results from the current study have implications in designing and implementing sight-reading curricula, especially with regards to content

and pedagogy. The primary implication is that teachers might scaffold instruction in employing more sophisticated strategies and avoiding less sophisticated strategies to accomplish a sight-reading task. Results of the current study suggest that students might find it beneficial to implement these strategies while vocally sight-reading:

- reading in visual chunks and by analogy;
- creating and manipulating auditory representations;
- pairing singular pitches with discrete staff placement locations;
- increasing self-awareness of production and commission of errors;
- remaining aurally grounded in the tonality.

In order to scaffold reading in visual chunks, for example, teachers could have students physically chunk sight-reading material before singing to emphasize types of chunks (harmonic, cadential). To develop students' ability to create and manipulate auditory representations when sight-reading, teachers could ask students to audiate all of the pitches except the dominant pitch; thus demonstrating students' ability to internally hear other pitches. In a similar vein and to encourage pairing singular pitches with discrete staff placement locations, teachers could create a human staff, where each person sang only one pitch, and the teacher played melodies on the staff (where each person sang only their prescribed pitch). Teachers could ask students to listen to themselves sing, thus scaffolding how to be self-aware. Finally, in order to demonstrate remaining aurally grounded in the tonality, teachers could constantly ask students to sing the tonic or tonic triad throughout an exercise, thus reminding the student to constantly audiate the tonic and tonic triad while sight-reading.

In terms of curricular content, results suggest strengthening underlying musical cognitive processes may be beneficial for improving strategy intentionality and implementation. For example, increasing students' tonal assimilation and building students' aural vocabulary seem to be integral parts of underlying aural cognitive processes and processing, necessary for creating and manipulating auditory representations and maintaining a tonality. Furthermore, in order to employ musical auditory expectancy, students must experience expectancy, therefore the expectation must be generated or built from familiarity. Students may need more major tonal and syntax assimilation in order to establish something to expect. If musical auditory expectancy develops first around the tonic, activities and training could emphasize tonal center audiation and notational audiation. The teacher could implement this aurally by singing a melody, pausing at random or predictable places, and asking students to find the tonal center. Another method of aural implementation could be splitting the choir in half, having one half sing the melody and the other half audiate and/or sing the tonal center. One suggestion in notationally audiating the tonal center would be asking students to sing only the tonic pitches (while audiating the other pitches) written in a sight-reading example or repertoire section.

Another aspect of designing and implementing curricular content is arranging and emphasizing musical components according to higher order relationships, specifically chunking. Results from the current study suggest better sight-readers group notes into patterns, such as triads or patterns (scalar, cadential), and draw patterns from memory (instead of figuring out note-by-note). Empirical studies from music cognition literature

also suggest musicians read notation by organizing incoming information into hierarchies (Lehmann et al., 2007; Waters et al., 1997). When designing curricula, avoid teaching students to read individual notes, but to group notes according to harmonic function or high frequency use, effectively teaching students to see and hear notation and think in musical patterns, small and large. When creating sight-reading exercises, group pitches by harmonic function (for example, *Do, Mi, So*, and *La, Fa, Do*) instead of focusing exclusively on stepwise patterns. When sight-reading, ask students to decipher whole chunks instead of separate notes, such as *So, Mi, Do*, and *Re, Ti, Do*, by prompting students to collectively sing whole measures (or groups of measures) instead of note-by-note. A third suggestion is having students memorize and recall notated patterns, as a reading teacher would have students memorize and recall words by sight. This could be done with note cards, where one pattern was printed on each card, and students recall and sing patterns as whole units.

Furthermore, when initially teaching students to read music, these findings, especially regarding chunking, suggest students might benefit from being introduced to aural and visual patterns from the beginning. Where middle school teachers usually begin with stepwise motion, instead begin music reading instruction with whole chunks. For example, instead of focusing on letter names first, it may be beneficial to start by having students read one whole measure of pitches at a time (perhaps covering the measure before they sing, to ensure absorption of the whole chunk). Thus, students might be habitually thinking in and reading patterns, instead of note-by-note.

A final element of curricular planning and pedagogy would be to increase

students' meta-cognition surrounding vocal production and commission of errors.

Teachers could require students evaluate teacher and other student sight-reading, thus students could become more attuned to the accuracy of another's production. Teachers could also ask students to frequently rate themselves on their sight-reading production.

Future research for music educators. This study has implications for current educators, but extended research is necessary to confirm results with other populations. Research could be extended in several ways: First, replication studies would be beneficial with different middle schools; because these data were collected at one school, results may be due to other factors, such as the choral director's teaching style or methods. A larger sample size, also, would illuminate if self-selection prevented other populations from participating.

Furthermore, a longitudinal study would be beneficial, investigating how strategy use is related to sight-reading over time. Results from the current study suggest strategy use sophistication levels and sight-reading achievement are correlated for eighth grade vocal sight-readers. Regarding mental strategies for many musical skills, McPherson (2005) found that "those children who applied musically appropriate mental strategies very early in their learning were more likely to succeed in comparison with their peers" (p. 31-32). This relationship has yet to be researched with vocal sight-readers and longitudinally. If strategy use and sight-reading achievement levels are indeed correlated over time, then students would benefit from beginning to learn sight-reading strategies as soon as they begin reading music notation, which for most students is late elementary school.

For music cognition researchers. Whereas the findings from the current study may be directly applicable to choral music educators, they may also be applicable to music cognition researchers. These results directly suggest students are capable of chunking and creating/manipulating auditory representations while sight-reading. It is not clear, however, from a cognitive science viewpoint, the range and strength of these skills. Secondly, these results indirectly imply musical auditory expectancy in developing sight-readers may be modulated by tonal function or tone semantics. This may be of interest as part of ongoing research in music reading acquisition.

For music cognition researchers, extending and confirming these findings with a psychological or neuroscientific basis would be beneficial. Currently, we are without an overarching theoretical or empirically researched model for music reading acquisition. This study's results could be extended by investigating chunking, creating/manipulating auditory representations, and musical auditory expectancy elicited from notation in developing sight-readers, and if these areas are or are not modulated by tonal function. Skill in these areas also may or may not be mediated by sophistication of strategy use. For example, modern brain scanning techniques, such using fMRI and measuring ERPs (event-related brain potentials), could be used in comparative studies investigating the effects of tonal function on musical auditory expectancy in developing sight-readers. Also, are these effects mediated by the quality of the tune (an actual melody instead of a generic tonal pattern), the proximity to a singer's comfortable vocal range, or familiarity with a specific tonality (major, minor, dorian)? Schön and Besson (2005) found that the further a mismatched tone was from the tonal context, the stronger the brain responded

with ERPs; further research in this vein might uncover whether or not this might be simultaneously modulated by tonal function.

Furthering the question of whether auditory representation formation elicited from notation is more difficult for singers than instrumentalists, an extended study could investigate differences in strategy use between instrumentalists, singers, and singer/instrumentalists. Does instrumental study aid in strategy use development in reading notation? In what ways does instrumental study help or hinder strategy use? Using latency data in an auditory representation formation task, do response times differ for singers, instrumentalists, and singer/instrumentalists?

Closing

The purpose of this study was to further the research dialogue in the relationship between strategy use and accelerated learning in vocal sight-reading. Specifically, the goal was to better understand the strategies that might or might not be employed by eighth grade choral students during vocal sight-reading. These data suggest that participants employed a range of strategies, from effective to ineffective, and that the sophistication level of strategy use was positively correlated with vocal sight-reading scores.

In the opening narrative, Nora's strategy for sight-reading was to imitate the piano or the teacher's voice. With more strategies at her disposal, perhaps Nora could have sight-read a small portion of the sight-reading exercise. There are students like Nora in many middle school choirs who might benefit from learning strategies to become independent sight-readers. Directors might empower their choirs with a more solid

foundation in underlying musical cognitive processes and strategies with which to negotiate sight-reading notation. Students might, instead of being trapped like Nora, accelerate their own learning and experience the joy and thrill of independent musicianship.

APPENDICES

APPENDIX A: School Recruiting Email

May 1, 2015

Dear Choral Director,

My name is Sarah Houghton, and I am currently a Doctoral student at Boston University, studying Music Education. I will be conducting this research between August and December 2015. I am contacting you because you teach eighth grade chorus and incorporate sight-reading into the choral curriculum. The purpose of this letter is to explain the study and request your help in implementing this study at your school.

The purpose of this research study is to investigate the thought-processes of eighth grade choral students when sight-reading music. The results of this study will help me, other educators, and other researchers better understand enabling or impeding strategies used by middle school singers when sight-reading.

If you volunteer to help implement this study, you will be asked to:

1. obtain permission from your school for me to conduct this study. I have an authorization form for the Principal.
2. allow me to meet with your 8th grade choral classes for approximately ten minutes each to introduce myself, explain the study, answer any questions, and ask for their consideration to participate. It is expected that a minimum of fifteen eighth grade students will participate.
3. collect any consent, assent, or questionnaire forms as they are returned by students, and hold them until I can obtain them from you.
4. secure the use of an empty, quiet classroom, rehearsal space, or practice room where I can meet with students. If possible, the room should be visible to passersby. I would bring all needed equipment.
5. allow students to be dismissed from chorus rehearsal or help arrange for students to meet with me at another time. Each student would meet with me for approximately twenty-five minutes. We can spread the meeting times over several days.
6. be on site while I am meeting with students, in case of unforeseen circumstances.

In order for students to participate, parents must sign a consent form, students must sign an assent form, and the Principal must also sign an authorization form.

Students choosing to participate in this study will, individually: 1) fill out the assent form and questionnaire (age, gender, grade level, and types of former music experience); 2) sign up for a time to meet with me (approximately 25 minutes); 3) meet in the chorus, rehearsal, or practice room at the designated time; 4) vocally sight-read six examples; 5)

answer some questions about sight-reading; and 6) make comments about sight-reading while watching a video recording of themselves sight-reading. Students' participation is entirely voluntary and they can withdraw at anytime. There are no foreseen risks or discomforts in participating in this study.

When the results of this research study are published or presented, no identifiable information will be used. Your name, students' names, the choirs' names, this school, and district will never be linked to any data.

Please contact me with any questions or concerns at sh@bu.edu or 603-233-8916. If you are willing to participate, please contact me. I look forward to hearing from you.

Thank you,

Sarah Houghton

APPENDIX B: In-School Research Authorization Form

Dear Principal LAST NAME,

Students at your school have the opportunity to participate in a research study conducted by Sarah Houghton (Boston University Doctoral student) and Dr. James Imhoff (BU faculty advisor), because this school offers chorus to eighth grade and sight-reading is a familiar part of the choral curriculum. The purpose of this form is to provide you with information about students at this school taking part in a research study.

Purpose of the Study:

The purpose of this research study is to investigate the thought-processes of eighth grade choral students when vocally sight-reading music notation. The results of this study will help me, other educators, and other researchers better understand enabling or impeding strategies used by middle school singers when sight-reading, and potentially lead to the development of better sight-reading curricula. The choral teacher has consented to participating in this study.

If you authorize this study can be conducted at this school, the choral director will be asked to:

1. obtain permission from the principal for me to conduct this study.
2. allow me to meet with the eighth grade choral classes for approximately ten minutes each to introduce myself, explain the study, answer any questions, and ask for their consideration to participate. It is expected that a minimum of fifteen eighth grade students will participate.
3. collect any consent, assent, or questionnaire forms as they are returned by students, and hold them until I can obtain them.
4. secure the use of an empty, quiet classroom, rehearsal space, or practice room where I can meet with students. If possible, the room should be visible to passersby. I would bring all needed equipment.
5. allow students to be dismissed from chorus rehearsal or help arrange for students to meet with me at another time. Each student would meet with me for approximately twenty-five minutes. We can spread the meeting times over several days.
6. be on site while I am meeting with students, in case of unforeseen circumstances.

Explanation of Procedures With Students:

It is expected that students' participation will be approximately twenty-five minutes, in one sitting. Students who participate in this study will, individually, complete a questionnaire form, vocally sight-read several music examples, and answer questions about sight-reading. The questionnaire form will consist of age, gender, grade level, and types of former music experience. To sight-read, students will be given pieces of paper with six sight-reading examples, whereupon they will sing the examples out loud.

Students will then be asked to answer questions about sight-reading, and make comments about sight-reading while watching a video recording of themselves sight-reading. The interviews and vocal sight-reading will be audio and video recorded. This study will take place at SCHOOL NAME, where students will either be dismissed from chorus class or sign up for another time to meet with me.

Audio/Video Recordings:

As part of this study, participants will be audio and video recorded. I will assign participants a unique identification number and label the recordings with this number; participants' names will not be associated with any of their recordings. The purpose of video recording is to capture facial expressions, gestures, and movements, which will further demonstrate and explain different thought-processes. After labeling the recordings with a unique identification number, I will store these recordings in a locked cabinet. The key to the code connecting participants' names to their unique identification number will be kept in a password-protected computer file, accessible only by me. The video recordings will be stored until the completion of data analysis and dissemination with a maximum time frame of seven years and then will be destroyed.

Confidentiality:

The records of this study will be kept confidential. Participants will be identified by a unique identification number. When the results of this research study are published or presented, no identifiable information will be used. Audio recordings may be shared when the results are presented to students, teachers, or at professional conferences, but all identifying data will be removed. Your name, students' names, the choirs' names, this school, and district will never be linked to any data.

Members of the research team and the Boston University Institutional Review Board (IRB) may access the data for purposes such as quality control or safety. Information from this study and study records may be reviewed and photocopied by the institution and by regulators responsible for research oversight such as the Office of Human Research Protections, and the Boston University Institutional Review Board. The IRB reviews and monitors research studies to protect the rights and welfare of research subjects.

Potential Risks and Discomforts:

There are no known risks or discomforts associated with students' participation in this study. It is possible that students may feel self-conscious about watching themselves sight-reading in a video recording. Students will not be pressured into participation and may withdraw from participation at anytime without consequence to their relationship with the researcher or their teacher, or their chorus grade.

Potential Benefits to Participants and Society:

Students may or may not benefit from taking part in this study. Possible benefits may include practice in sight-reading as an individual and engaging in the process of self-

reflection regarding sight-reading strategies.

Researchers, choral directors, and music teachers may benefit in the future from the information that is learned in this study by better understanding the enabling or impeding strategies used by middle school singers when sight-reading. This may lead to an expanded understanding of the sight-reading acquisition process, and the potential for designing more effective sight-reading curricula. There are no costs to students for taking part in this research study.

Voluntary Participation and Withdrawal:

Participation in this study is voluntary. Parents and students may decline from participation or withdraw from the study at any time. Participation in this study will not affect their chorus grade.

Questions and Contact Information:

If you have any questions or concerns regarding students’ participation in this study, please contact me, Sarah Houghton, at sh@bu.edu or 603-233-8916, or my supervisor, Dr. Jim Imhoff at jfimhoff@msn.com. If you have questions about students’ rights in this research study, or want to speak with someone at BU, you may contact the Boston University IRB directly at 617-358-6115 or irb@bu.edu.

Principal’s Name

Consent: (Please check)

Yes, this research can be conducted at this school No, we decline participation

Principal’s Signature

Date

APPENDIX C: Student Recruiting Script

“Hello students. My name is Sarah Houghton, and I am a Doctoral student at Boston University, in Boston, MA, studying Music Education. I’m talking with you today to introduce myself and invite you to consider participating in a research study. This research study is part of my graduate school program. For this study, I’m interested in the thought-processes of eighth grade choral students when sight-reading music. I am asking you to participate because you are an eighth grader, enrolled in chorus at your school, and have vocally sight-read music before.

“If you choose to participate, you would meet with me for approximately twenty-five minutes in the chorus room or another quiet room at your school. You would sight-read six music examples, which means looking at the music and singing it out loud, just like you would regularly do in a chorus rehearsal. Then I would ask you some questions about sight-reading. Finally, you would make comments about sight-reading while watching a video recording of yourself sight-reading. You can ask questions at any point in the study.

“If you participate in this study, I will not tell anyone or share your name or other information about you. You do not have to take part in this research study. You may decline from participation or withdraw from the study at any time. Participation in this study will not affect your chorus grade. I will destroy the video recordings at the end of the study. I would like to share the audio recordings and results in presentations and publications. If so, I will change all the names so no one will know it was you in this study. Do you have any questions?

“If you are considering participating, please take home the forms that your teacher will give you. Please discuss the study with your parents, and have your parents email or call me if you or they have any questions. If, after talking to your parents, you still want to participate, then your parents need to sign the consent form, you need to sign the assent form, and you need to fill out the questionnaire. Bring the three signed forms back to school, hand them to TEACHER NAME, and we will find a time for you to meet with me. Thank you for listening to my explanation today. Does anyone have any questions?”

APPENDIX D: Parental Informed Consent Form

Protocol Title: Eighth Grade Middle School Choral Students' Strategy Use In Vocal Sight-Reading
Principal Investigator: Student: Sarah Houghton; Advisor: Dr. James Imhoff
Description of Subject Population: Eighth grade, middle school choral students
Version Date: Draft 1 – 5/1/15

Dear Parents of an Eighth Grade Choral Student,

Your child has the opportunity to participate in a research study conducted by Sarah Houghton (Boston University Doctoral student) and Dr. James Imhoff (BU faculty advisor), because your child is an eighth grader, enrolled in chorus, and has vocally sight-read music before. The purpose of this form is to provide you with information about your child taking part in a research study. Please ask any questions you have. If you decide your child may take part in this study, I will ask you to sign this form.

Purpose of the Study:

The purpose of this research study is to investigate the thought-processes of eighth grade choral students when vocally sight-reading music notation. The results of this study will help me, other educators, and other researchers better understand enabling or impeding strategies used by middle school singers when sight-reading, and potentially lead to the development of better sight-reading curricula. The school administration and choral director have approved this study.

Explanation of Procedures:

It is expected that students' participation will be approximately twenty-five minutes, in one sitting. Students who participate in this study will, individually, complete a questionnaire form, vocally sight-read several music examples, and answer questions about sight-reading. The questionnaire form will consist of age, gender, grade level, and types of former music experience. To sight-read, students will be given pieces of paper with six sight-reading examples, whereupon they will sing the examples out loud. Students will then be asked to answer questions about sight-reading, and make comments about sight-reading while watching a video recording of themselves sight-reading. The interviews and vocal sight-reading will be audio and video recorded. This study will take place at SCHOOL NAME, where students will either be dismissed from chorus class or sign up for another time to meet with me.

Audio/Video Recordings:

As part of this study, participants will be audio and video recorded. I will assign your child a unique identification number and label the recordings with this number; your

child's name will not be associated with any of their recordings. The purpose of video recording is to capture facial expressions, gestures, and movements, which will further demonstrate and explain different thought-processes. After labeling the recordings with a unique identification number, I will store these recordings in a locked cabinet. The key to the code connecting your child's name to their unique identification number will be kept in a password-protected computer file, accessible only by me. The video recordings will be stored until the completion of data analysis and dissemination with a maximum time frame of seven years and then will be destroyed.

Confidentiality:

The records of this study will be kept confidential. Participants will be identified by a unique identification number. When the results of this research study are published or presented, no identifiable information will be used. Audio recordings may be shared when the results are presented to students, teachers, or at professional conferences, but all identifying data will be removed.

Members of the research team and the Boston University Institutional Review Board (IRB) may access the data for purposes such as quality control or safety. Information from this study and study records may be reviewed and photocopied by the institution and by regulators responsible for research oversight such as the Office of Human Research Protections, and the Boston University Institutional Review Board. The IRB reviews and monitors research studies to protect the rights and welfare of research subjects.

Potential Risks and Discomforts:

There are no known risks or discomforts associated with your child's participation in this study. It is possible that your child may feel self-conscious about watching themselves sight-reading in a video recording. Students will not be pressured into participation and may withdraw from participation at anytime without consequence to their relationship with the researcher or their teacher, or their chorus grade.

Potential Benefits to Participants and Society:

Your child may or may not benefit from taking part in this study. Possible benefits may include practice in sight-reading as an individual and engaging in the process of self-reflection regarding sight-reading strategies.

Researchers, choral directors, and music teachers may benefit in the future from the information that is learned in this study by better understanding the enabling or impeding strategies used by middle school singers when sight-reading. This may lead to an expanded understanding of the sight-reading acquisition process, and the potential for designing more effective sight-reading curricula. There are no costs to your child for taking part in this research study.

Voluntary Participation and Withdrawal:

Participation in this study is voluntary. You, or your child, may decline from participation

or withdraw from the study at any time. Participation in this study will not affect their chorus grade. If you, or your child, decide to withdraw, your child's information will be kept confidential and destroyed.

Questions and Contact Information:

If you have any questions or concerns regarding your child's participation in this study, please contact me, Sarah Houghton, at sh@bu.edu or 603-233-8916, or my supervisor, Dr. Jim Imhoff at jfimhoff@msn.com. If you have questions about your child's rights in this research study, or want to speak with someone at BU, you may contact the Boston University IRB directly at 617-358-6115 or irb@bu.edu.

Student's Name

Parental Consent: (Please check)

Yes, my child can participate No, we decline participation

Parent or Guardian's Signature

Date

APPENDIX E: Student Assent Form

Protocol Title: Eighth Grade Middle School Choral Students' Strategy Use In Vocal Sight-Reading
Principal Investigator: Advisor: Dr. Jim Imhoff, Student: Sarah Houghton
Description of Subject Population: Eighth grade, middle school choral students
Version Date: Draft 1 – 5/1/15

Dear Eighth Grade Choral Student,

You are invited to participate in a research study I am conducting at your school. I am a Doctoral student at Boston University, in Boston, MA, and this research study is part of my degree program. The purpose of this form is to provide you with information about taking part in a research study. Please ask any questions you have. If you decide to take part in this study, I will ask you to sign this form.

Purpose of the Study:

The purpose of a research study is to gather information that will help researchers learn more about something. In this study, I am researching the thought-processes of eighth grade choral students when sight-reading music notation. I am asking you to participate because you are an eighth grader, enrolled in chorus at your school, and have vocally sight-read music before.

Explanation of Procedures:

If you decide to participate in this study, I will ask you to:

1. fill out an assent (an agreement) form and questionnaire.
2. sign up for a time to meet with me during school (approximately 25 minutes).
3. meet in the chorus, rehearsal, or practice room at the designated time.
4. vocally sight-read several examples (look at the music notation and sing it out loud).
5. answer some questions about sight-reading.
6. make comments about sight-reading while watching a video recording of yourself sight-reading.

Audio/Video Recordings:

As part of this study, participants will be audio and video recorded. I will assign you a unique identification number and label the recordings with this number; your name will not be associated with any of their recordings. The purpose of video recording is to capture facial expressions, gestures, and movements, which will further demonstrate and explain different thought-processes. After labeling the recordings with a unique identification number, I will store these recordings in a locked cabinet. The key to the code connecting your name to your unique identification number will be kept in a password-protected computer file, accessible only by me. The video recordings will be stored until the completion of data analysis and dissemination with a maximum time

frame of seven years and then will be destroyed.

Confidentiality:

I will not tell anyone or share your name or other information about you if you join this study. I would like to use the audio recordings and study results in presentations and publications in the future. If so, your name will never be connected with any information.

Benefits:

You may or may not benefit from taking part in this study. Possible benefits may include practice in sight-reading as an individual and engaging in the process of self-reflection regarding sight-reading strategies.

Researchers, choral directors, and music teachers may benefit in the future from the information that is learned in this study by better understanding the strategies used by middle school singers when sight-reading.

Potential Risks and Discomforts:

There are no known risks or discomforts associated with your participation in this study. It is possible that you may feel self-conscious about watching yourself sight-reading in a video recording. You will not be pressured into participation and may withdraw from participation at anytime without consequence to your relationship with the me or your teacher, or your chorus grade.

Taking Part in This Research Study and Withdrawal:

You do not have to take part in this research study. You may decline from participation or withdraw from the study at any time. Participation in this study will not affect your chorus grade.

Questions and Contact Information:

If you have any questions or concerns, please contact me, Sarah Houghton, at sh@bu.edu or 603-233-8916, or my supervisor, Dr. Jim Imhoff at jfimhoff@msn.com. If you want to speak with someone at BU, you may contact the Boston University IRB directly at 617-358-6115.

I will give you a copy of this paper if you want.

Student's Name

Student Assent: (Please check)

Yes, I want to participate No, I decline participation

Student's Signature

Date

APPENDIX F: Participant Questionnaire Form

Please fill out this form only if you have agreed to participate in the study, and return this form, along with the Parental Consent and Student Assent forms, to your choral director.

1) Name: _____

2) Age: (please circle) 11 12 13 14 15 16

3) Grade: (please circle) 6 7 8 9

4) Sex: (please circle) Male Female

5) Have you ever participated in any music activities, lessons, or ensembles (either inside or outside of school)? If so, please describe what kinds and the numbers of years you participated in each.

Kind of activity, lessons, or ensemble:

Number of years participated:

APPENDIX G: Permission to Use Vocal Sight-Reading Inventory



Sarah Houghton <sh@bu.edu>

Questions regarding use of the "Vocal Sight-Reading Inventory"

Henry, Michele L. <Michele_Henry@baylor.edu>
To: Sarah Houghton <sh@bu.edu>

Thu, Jan 16, 2014 at 4:02 PM

Sarah,

Thanks for being in touch. I'm pleased to know about your interest in vocal sight-reading strategies and specifically in the VSRI.

You are more than welcome to use or adapt the VSRI to suit your needs. While there is great intentionality in the construct of the melodic content, it's really the principles and the scoring system that make it what it is. If you need something more official, just let me know.

Your plans sound very interesting, and I would love to know what you find out. I might refer you to an article that Jan Killian and I did on practice and performance behaviors for vocal sight-reading (JRME, 2005). This might be along the line of what you are investigating, in terms of what people do/are thinking during the process. We didn't do any interviewing, just observation. I'm always personally interested in hearing singer articulate what they know and how they go about the music reading process.

Best Wishes!

Michele

--

Michele L. Henry, Ph.D.
Associate Professor of Choral Music Education
Baylor University
One Bear Place
Box 97408
Waco, TX 76798

APPENDIX H: Michele Henry's Vocal Sight Reading Inventory, Revised/Leveled version

Level 1 (#s 1 – 3)

1)

Two staves of music in G major (one sharp) and 4/4 time. The first staff contains 12 measures of quarter notes: G4, A4, B4, C5, D5, E5, D5, C5, B4, A4, G4, F4. The second staff starts with a fermata over the first measure, followed by 11 measures of quarter notes: G4, A4, B4, C5, D5, E5, D5, C5, B4, A4, G4, F4. The piece ends with a double bar line.

2)

One staff of music in G major (one sharp) and 3/4 time. The melody consists of 12 measures: G4, A4, B4, C5, D5, E5, D5, C5, B4, A4, G4, F4. The piece ends with a double bar line.

#3)

One staff of music in G major (one sharp) and 3/4 time. The melody consists of 12 measures: G4, A4, B4, C5, D5, E5, D5, C5, B4, A4, G4, F4. The piece ends with a double bar line.

Level 2 (#s 4 – 6)

4)

One staff of music in G major (one sharp) and 3/4 time. The melody consists of 12 measures: G4, A4, B4, C5, D5, E5, D5, C5, B4, A4, G4, F4. The piece ends with a double bar line.

5)

One staff of music in G major (one sharp) and 3/4 time. The melody consists of 12 measures: G4, A4, B4, C5, D5, E5, D5, C5, B4, A4, G4, F4. The piece ends with a double bar line.

6)

One staff of music in G major (one sharp) and 3/4 time. The melody consists of 12 measures: G4, A4, B4, C5, D5, E5, D5, C5, B4, A4, G4, F4. The piece ends with a double bar line.

Level 3 (#s 7 – 9) (Students will not see or sing examples 8 or 9)

7) Students will not sing this example, they will only prepare to sing this example.

One staff of music in G major (one sharp) and 3/4 time. The melody consists of 12 measures: G4, A4, B4, C5, D5, E5, D5, C5, B4, A4, G4, F4. The piece ends with a double bar line.

APPENDIX I: Retrospective Think-Aloud Instructions and Practice Examples

“Thank you for helping out today. Your participation is voluntary, and you can stop at any time. This will take approximately twenty-five minutes. Please let me know if you have any questions at any time. Would you like to continue?”

“I’m interested in learning about your thought processes as you sight-read music. Some of this will be easy for you and some might be a little more challenging. But, it doesn’t matter how well you do sight-reading; what matters most is your thought processes. As we proceed, I’ll be writing down some notes so that I can remember some thoughts. To begin, we’ll start with some practice examples. I will demonstrate the first example.”

The researcher reads the example and answers out loud:

“Consider these letters F, A, E, R, G, and T. From these letters, create as many words as you can and state them out loud.” Pauses.

“Fear...great...get...rag...fat...rear...tag...rat.”

The researcher models the retrospective think-aloud:

“Now I’m going to rewind my thoughts to the beginning of the example and speak the thoughts out loud that I can remember thinking, as if I were thinking them in real time. I’ll start from first seeing the example and go through answering the question. I’m going to talk like no one else is in the room and I’m just voicing what I remember thinking out loud. Like this:

(Researcher points to relevant spots in the prompt, while demonstrating)

Pointing through (as if internally reading) ‘Consider these letters F, A, E, R.’ Speaking out loud: “oh, this is one of those combine-the-letters problems. I’ve done these before...” Pointing through: ‘G, and T. From these letters, create as many words.’ Out loud: “there aren’t many letters to work with.” Pointing through: ‘as you can and state them out loud’ ... Speaking out loud: “F, A, E, R, that looks like fear, oh, change the E and the A, FEAR. F, A, E, R, G, T, grrreat, GREAT. Let’s see, greaf, no, graaat, no, gt, oh GET. Um, R? Raaag, RAG. What about F... Faaa, oh... t, FAT. A, E, R, that looks like aero, but no o, aerg, aerf, aert, no. Backwards? R, E, A... r. REAR. That’s using a letter twice...wait, was that okay? She didn’t *say* anything about it...T’s over here... Taaag, TAG. Rrrrrraat, RAT.

“So, I rewound my thoughts back to the beginning of the exercise. I remembered back to what I was thinking the first time through and said all of my thoughts out loud as if I were thinking them in real time. I didn’t plan to say anything or explain what I did. I just said everything I was thinking when I initially solved the example and I used the question prompt to help me remember my thoughts. Do you have any questions?

“Here’s a practice example for you. You’ll read this practice example out loud, solve it, and state the answer out loud. Then you’ll rewind back to the beginning and then say out loud all the thoughts you can remember when you read and solved the question, just like I did. Any questions? Here’s the example:

Subject reads out loud from paper prompt, “A classroom of 12 students travel to an orchard. Half of the students are girls. Four of the boys pick pumpkins, while the rest of the boys pick apples. Half of the girls pick apples and the other half pick pumpkins. How many students in the class pick apples?” The student states an answer out loud.

The researcher says, “Now think back and remember your thoughts while you were solving the question. Say all of your thoughts out loud as if you were thinking them in real time, starting from the moment you saw the example until you were finished. Don’t explain what you did. Just act like you are alone in the room, talking to yourself. Say everything you remember thinking rather than what you think you must have thought. Use the question prompt to help you remember your thoughts. Do you have any questions? Okay, go ahead.”

Researcher starts the audio and video recording.

APPENDIX J: Main Study Practice Example Prompts

Practice example 1:

“Consider these letters: F, A, E, R, G, and T. From these letters, create as many words as you can and state them out loud.”

Practice example 2:

“A classroom of 12 students travels to an orchard. Half of the students are girls. Four of the boys pick pumpkins, while the rest of the boys pick apples. Half of the girls pick apples and the other half pick pumpkins. How many students in the class pick apples?”

APPENDIX K: Sight-Reading and Retrospective Think-Aloud Protocol Script

The researcher continues immediately after the student finishes the second practice example, saying, “On the music stand in front of you, there are sight-reading exercises similar to ones you have sung in chorus. I will ask you to turn to a certain exercise, then give you the starting pitch on the piano. When you are ready, sing the exercise through in any way you choose. Any questions? Please turn to number one.”

Student turns to exercise. Researcher plays starting pitch and says, “Begin whenever you are ready.”

After the student finishes sight-reading exercise one, the researcher says, “Now rewind your thoughts to the beginning of the exercise and remember your thoughts while you were sight-reading. Say all of your thoughts out loud as if you were thinking them in real time, starting from the moment you saw the exercise until you were finished. Don’t explain what you did. Just act like you are alone in the room, talking to yourself. Say everything you remember thinking rather than what you think you must have thought. Use the sight-reading exercise to help you remember your thoughts. Do you have any questions? Okay, go ahead.”

When the student is finished the retrospective think-aloud for exercise one, the researcher will say, "Please turn to exercise two." Student turns to exercise. Researcher plays starting pitch and says, "Begin whenever you are ready."

After the student finishes sight-reading exercise two, the researcher says, "We'll now repeat the same process as with exercise one. Remember to just act like you are alone in the room. Say everything you remember thinking rather than what you think you must have thought. Use the sight-reading exercise to help you remember your thoughts. Go ahead."

Researcher repeats the sight-reading and retrospective think-aloud process for the remaining four examples.

APPENDIX L: Interview Question and Script

Just before or just as the participant begins to sight-read the seventh example, the researcher will cover up the sight-reading example with a blank piece of paper and say, “Just before I covered up the sight-reading example, what were you thinking and doing?”

APPENDIX M: Video Stimulated Recall Interview Protocol and Questions

Researcher takes memory card from the video camera, places it in the computer, and accesses the video segment.

“Now you will watch several clips of yourself sight-reading and thinking out loud. I will stop the video occasionally and ask you some questions. Any questions?”

Sample questions regarding initial sight-reading exercises (if the student didn't already address this during the retroactive think-aloud):

- 1) “What were you thinking about?”
- 2) “Tell me what you were thinking here.”
- 3) “What was your thought process here?”

Sample questions regarding retroactive think-aloud responses:

- 1) “What did you mean by ...”
- 2) “Can you further explain ...”

When finished showing the video clips, the researcher asks a final question, “Imagine explaining how to sight-read exercise number one to a friend. The goal is for your friend to be able to sight-read it alone; you are just guiding them to know how to do it. How would you instruct them to accomplish it? Be as detailed as you can.”

“Thank you again for your help today!”

APPENDIX N: Sight-Reading Scores

Sight-Reading Scores per Participant, in Descending Order

Name	Vocal Sight-Reading Score
Amelia	104
Beatrix	86
Diana	82
Edwin	77
Florence	71
Caty	68
Harriet	68
Kurt	62
Ida	53
James	52
Georgia	42
Margaret	42
Louisa	31
Nelson	28

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