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Melodic Recall: Qualitative Insights on Singers' Strategies for Memorizing Scores of Simple Songs

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Abstract

In a choral setting, memorizing multiple choral scores and maintaining the stability of recall can be a challenge. This study investigates strategies for memorizing scores of simple songs. Music college students with extensive choral experience memorized three unfamiliar songs and recalled them after brief one minute practice. A mixed-methods research design facilitated the integration of multiple types of data, including performance accuracy, self-ratings of sight-singing strategies, and descriptive statistics of eye movements. Results, based on Mishra's (2005) theoretical model of memorization, indicated that students employed Holistic (singing the whole song) and Segmented (singing phrases) memorization approaches more frequently than Additive or Serial approaches. During memorization, students relied on the conceptual, visual, auditory, and kinesthetic components of memory. Good skills in sight-reading, chunking, and the use of structural cues played a key role in facilitating successful melodic recall. The pedagogical implications of the findings and directions for future research are discussed.

Keywords: choral practice, memorization approaches, melodic recall, eye movements, sight-singing

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In choral settings, singing without a score enhances the visual aspects of a performance, allowing for more effective communication with the audience and greater freedom of body movements (e.g., Davidson & Broughton, 2022; Kopiez et al., 2017; Williamon, 1999). Singing from memory is a common practice in certain choral traditions, such as barbershop, gospel, and show choirs, which frequently incorporate choral choreography (e.g., Stone, 2017). In contrast, church choirs, for example, may place a high value on sight-reading skills due to the volume and complexity of the music sung by the choristers in daily services.

In other musical contexts (e.g., instrumental music), the convention of performing from memory is a well-established practice (Boshoff & Odendaal, 2024; Fonte et al., 2022). Professional pianists, in a study by Fonte et al. (2022) reported that performing from memory has become a strong convention for standard repertoire, significantly influencing their decisions and leading many of them to prefer memorized performances. Furthermore, pianists highlighted several benefits of performing from memory, including a deeper understanding of the music, greater interpretive freedom, improved listening and communication skills, and the ability to mentally rehearse and refine the piece. When performing complex contemporary repertoire, however, pianists were motivated by a desire to achieve a "dramatic effect on stage" (Fonte et al., 2022, p. 12).

In Western classical music tradition, memorization became a convention in the 19th century, symbolizing skill and mastery, and has since shaped performance expectations in both classical and some popular music genres (Ginsborg, 2004; Mishra, 2016). However, memorization itself has not been integrated into the model that defines what virtuosity means to musicians (Ginsborg, 2018). Instead, it is often conceptualized as a tool for effective learning and achieving expressive, confident performances (Lisboa et al., 2015). Interestingly, musicians may prioritize different musical elements depending on whether they are performing from memory or rehearsing with a score (Ginsborg & Bennett, 2021). This distinction likely contributes to the enduring interest in the memorization process within music performance research (Snyder, 2000). Although the memorization strategies of instrumentalists have been studied extensively (for a review, see Mishra, 2010), research into the effectiveness of these techniques for vocal music remains an ongoing field of inquiry.

General Principles of Memorization

Music can be memorized without relying on a written score, a method commonly used in genres such as folk music and jazz, where musicians typically learn by ear, vocalizing melodies and internalizing rhythms through physical actions (e.g., Noice et al., 2008). Alternatively, musicians may use a written score to support memorization, a common practice in classical music. This score-based approach involves analytical and conceptual techniques, such as visualizing the notation, identifying structural and performance cues, and even studying the score away from the instrument. Fine et al. (2015) emphasized that during mental practice, the score serves as an orientation guide and a reference for interpretive choices.

Scholars have identified four interdependent types of memory—auditory, visual, conceptual, and kinesthetic—that collectively support music retention (e.g., Chaffin et al., 2016; Ginsborg, 2022), each of which has distinct pedagogical value (e.g., Ginsborg, 2004; Mishra, 2007). In addition, researchers have distinguished between spontaneous (or incidental) and deliberate ways of memorizing music. Spontaneous memorization occurs gradually through extended practice, whereas deliberate memorization involves intentional focus on structural and performance cues (e.g., Aiello, 2001; Ginsborg, 2004; Williamon & Valentine, 2002), which happened to be an essential method for classically trained musicians in the Western art tradition (Chaffin et al., 2016; Mishra, 2010). However, it has also been suggested that incidental versus deliberate memorization may vary depending on task demands, personal learning styles, and the type of repertoire; some instrumentalists reported using a deliberate approach to memorization, while others allow memorization to develop spontaneously, although this particular approach requires considerable time and effort (Fonte et al., 2022).

Memorization Approaches

Associative chaining and content-addressable memory systems for music, described by Chaffin et al. (2016), differ in how they facilitate the retrieval of musical information. Associative chaining operates through sequential linking, where each element cues the next, forming an interconnected chain that facilitates recall. Moreover, associative chaining was described as implicit and risky to rely exclusively on because it allows only a single starting point, usually the beginning. If memory fails and the chain breaks, the performer must start over (Chaffin et al., 2016). Content-addressable memory, on the other hand, allows retrieval based on the musical content itself rather than its sequential order. This form of memory is typically explicit, particularly linked to expertise, and supports a mental framework provided by structural and performance cues (Chaffin et al., 2023).

According to the theoretical model proposed by Mishra (2005), the memorization of a musical score consists of three stages: preview, practice, and overlearning. The practice stage is subdivided, and one of these subdivisions includes four processing strategies: Holistic, Segmented, Serial, and Additive. Mishra's concise definitions of these strategies were as follows: (a) a Holistic processing strategy is when the whole piece is repeatedly performed; (b) a Segmented strategy is when practicing an isolated portion of the piece; (c) an Additive strategy is when a new material is continually added to a learned fragment; and (d) a Serial strategy is when a short fragment is repeated multiple times (Mishra, 2005; 2011).

In a later experimental study, Mishra (2011) investigated the effectiveness of those four memorization strategies. The results showed that instrumentalists who used a Holistic strategy memorized the short piece faster than others who segmented the piece. The author attributed this success to the ability of musicians using the Holistic strategy to form a complete "mental picture" of the piece. However, when considering the time taken for complete memorization, there was no significant difference between the time used for the

Additive and the Holistic strategies. Although the additive strategy demonstrated greater efficiency compared to the Segmented or Serial strategies, it proved to be less efficient than the Holistic strategy.

A series of studies on the memorization strategies of professional singers has been conducted by Ginsborg (2002, 2004), with a particular focus on the relationship between the words and melodies of songs and their recall from memory. Ginsborg and Sloboda (2007) reported that for singers who deliberately memorized songs, words and melodies were remembered in association with each other, facilitating successive recall. The authors suggested that memorizing words and melody together is an effective strategy, but perhaps only for singers with high levels of expertise.

Many empirical studies have examined the memorization process, but most have focused on instrumentalists (e.g., Aiba & Matsui, 2016; Aiello, 2001; Boshoff & Odendaal, 2024; Chaffin & Imreh, 2002; Williamon & Valentine, 2002), leaving the strategies choral singers use to memorize vocal music largely unexplored. A key difference in memorizing vocal music lies in its performance style, which often occurs without instrumental support. This requires choral singers to rely exclusively on their music-reading skill.

Research Objectives

In educational settings, students are typically challenged by the volume of musical repertoire they must learn and perform by heart, often within a limited timeframe. The primary objective of this study was to identify strategies used by music students, particularly those with choral experience, for memorizing scores of simple songs. The research question guiding this inquiry was: What processing and memorization approaches contribute to successful melodic recall? The design and analysis of this study were shaped by Mishra's theoretical model of music memorization (2005). Mishra's concept of four processing strategies served as a framework for evaluating and interpreting the data and guided the exploration of the extent to which these different strategies benefit memory.

While the importance of lyrics in the context of vocal music is acknowledged, the decision to prioritize the examination of melody was guided by several considerations. Focusing on a tonal melody allows for a more controlled investigation, avoiding the complexities introduced by lyrical content, as demonstrated in the study by Huovinen et al. (2021). Even when a melody is accurately performed, errors in reading and producing the text can significantly impact the overall quality of the performance. Furthermore, the focus on melody allows for comparability with previous studies, the majority of which have investigated the memorization approaches of instrumentalists (e.g., Mishra, 2010). In addition, melodic accuracy (which typically includes pitch, interval, and scale degree accuracy) is of great importance in higher musical education and serves as a fundamental aspect of music reading skills and performance evaluation (e.g., Fournier et al., 2019; Pomerleau-Turcotte et al., 2023).

Method

This study followed a mixed-methods approach proposed by Bazeley (2024), who underscores that the core feature of all mixed-methods research is the integration of heterogeneous components. This approach ensured that the study's components, such as the questionnaire, the accuracy of recall, memorization approaches, and eye movements were not viewed in isolation but as interconnected elements contributing to a unified understanding (see Bazeley, 2024). Integrating the eye-tracking method with both quantitative and qualitative methodologies allowed for a more flexible research process, utilizing a wider range of information for the analysis.

It is well-established that eye movements reveal how individuals process information (for reviews, see Perra et al., 2022; Sheridan et al., 2020; Sloboda & Parker, 1985). In the context of this study, the examination of eye movements supported understanding of the distribution of visual attention, gaze patterns, and strategies involved in the memorization of simple melodies. Eye-tracking was chosen as a method to assess learning processes by measuring fixation durations on various musical features, thereby providing objective data on how visual engagement within the score supports memorization (for a review, see Holmqvist et al., 2011; Rayner, 1998). A measure such as the total fixation durations was used to capture the spatial distribution of eye movement data and to track changes in visual attention throughout the practice sessions (e.g., Perra et al., 2022; Rosemann et al., 2016).

Participants

A total of 15 students from a higher education music institution in Sweden participated voluntarily in the study, comprising eight females and seven males, aged between 22 and 30 years ($M = 25$, $SD = 2.8$). The group consisted of nine students engaged in choral conducting, two students in music education, both within the Western classical music tradition, and four students enrolled in jazz program. All participants were proficient in singing, regularly practiced vocal music, and, according to their self-reports, had an average of 15 years ($SD = 5.8$) of formal music training and 13 years ($SD = 5.9$) of choral experience. None of the participants reported having absolute pitch. The sample was multilingual, and since the five English-speaking participants lacked proficiency in Swedish, the accuracy of melodic recall served as a criterion for analysis.

Materials

The stimulus set consisted of three lesser-known songs of Swedish folk tradition, charac-

[1] *Fixation* refers to the state when the eye remains still for a brief period, such as when it momentarily pauses on a word during reading. This stationary period, essential for visual processing, can last from a few tens of milliseconds up to several seconds (Holmqvist et al., 2011, pp. 21–22).

[2] *Total fixation duration* is the cumulative amount of time the eyes remain fixed on a specific area or object during a task, such as reading or viewing an image. This measurement sums the durations of all individual fixations on that target area, providing insights into how long a person engages with or processes specific information (for a review, see Holmqvist et al., 2011, pp. 386–389).

terized by predominantly stepwise melodic motion and non-repetitive phrases and Swedish text. The scores were written in treble clef, modified to ensure visual similarity in layout, with pitch range for all voice types (B3 to D5). The length of each stimulus was 16 bars (32, 36, and 38 notes long), which is comparable to that of Sloboda and Parker (1985). The songs were written in different keys (C minor, D major, and E minor) and had the same time signature (3/4). All songs were diatonic and featured a simplicity reflective of their folk origins (*see Appendix A*). The musical scores were written using the Sibelius music notation program (version 2022.12) and presented on two staves, with eight bars on each staff. When viewed from a distance of 68 centimeters, the stimuli subtended dimensions of 30° in width and 7° in height. Participants were not familiar with the songs prior to the experiment.

Apparatus

For data collection, I used the Tobii 4C (IS4 Large Peripheral, firmware version 2.27) remote binocular eye tracker (Core v.2.13.4) with a sampling frequency of 90 Hz. The remote eye tracker was placed below a computer screen and tracked the students' gaze. The visual stimuli (notated music) were displayed on a 27-inch computer screen with a resolution of 1920 x 1080 pixels (61.0 cm x 34.5 cm). The eye movements were recorded and analyzed by the Tobii Pro Lab 1.207 (x 64) software. Audio data were recorded using a ClearOne Unite 20 web camera (2.0).

Procedure

Prior to the experimental task, participants received detailed information about their rights, the study's methodology, and its objectives in accordance with the ethical guidelines of the Swedish Research Council (2017). Following this, participants provided informed consent by signing a consent form. They then completed a survey capturing relevant demographic information and details about their musical background, including both choral and instrumental experiences.

Students received instructions for the eye-tracking session and were reminded that during the recall phase when no stimulus was on the screen, they should keep their gaze fixed on the blank white background of the computer screen. The primary task consisted of memorizing three songs, with each song practiced for three 1-minute sessions, followed by recalling the melodic material from memory after each practice. The participants were instructed to focus on the melodies and were permitted to disregard the text, using freely chosen syllables such as "lah" for recall. The participants practiced each song three times, resulting in nine recall attempts in total.

To minimize head movements, participants were provided with a sturdy Tobii forehead rest, which was fixed to the table's edge but not attached to the participants' bodies. After calibration, the formal task instruction appeared on the computer screen, stating, "Your task is to memorize three folk songs." The three experimental songs were displayed on the screen in a randomized order.

Before each practice session, loudspeakers positioned on the table played the tonic triad to establish a sense of key. Participants had a total of 3 minutes to memorize each song. The recall from memory, when the stimulus was no longer visible on the computer screen, was self-paced, and the time for the memorized melody performance was not included in the practice time. After attempting to sing the song from memory, participants indicated their readiness for the next practice. The Tobii Pro Lab recorded the students' eye movements and audio throughout the practice sessions.

After completing the memorization task, participants rated eleven declarative statements (*see Appendix B*) to indicate the sight-singing strategies they used, choosing between "Yes" and "No" options. The questionnaire design was inspired by prior studies on sight-singing strategies (Bogunović & Vujović, 2012; Fournier et al., 2019). The declarative statements covered various reading and memorization strategies, such as thinking about scale steps and practicing challenging sections separately. Each data collection session lasted approximately 45–50 minutes.

Analysis

In previous research literature, both sight-singing and memorization have been referred to as "strategies." To distinguish between them, in this study, the term "strategies" will be used solely for sight-singing techniques, while "approaches" denotes four memorization strategies described in Mishras' memorization model.

Accuracy of the Recalls from Memory

I analyzed each of the 135 trials (3 songs × 3 memory recalls × 15 participants). The accuracy of relative pitch and rhythmic elements was subjectively assessed and quantified according to a criterion: "correct" or "incorrect." A sung note was considered an error if it was out of tune (deviating by a semitone or more as assessed by ear). Participants demonstrated proficiency in executing simple rhythmic configurations accurately, indicating no difficulty in this aspect. Consequently, the temporal aspect was excluded from the analysis. To quantify melodic accuracy in the recalls, the proportion of correctly sung notes to the total number of notes in each song was calculated (*see Appendix C*).

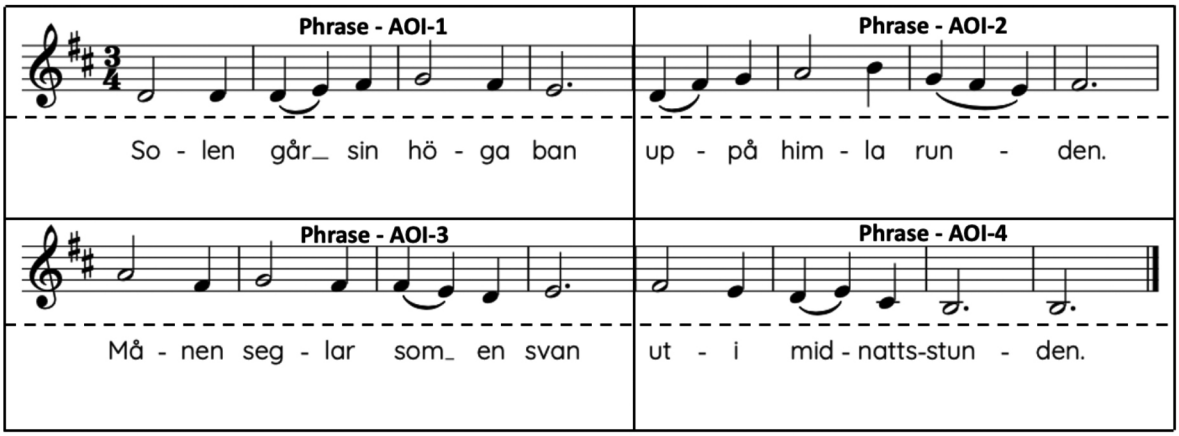
Eye Movements

Prior to data analysis, the accuracy of eye-tracking data collection was evaluated according to guidelines in Appendix D (Niehorster et al., 2020). Initial qualitative examination of the eye movement video recordings (Holmqvist et al., 2011, p. 87) showed that the participants divided each song into four phrases according to the melodic structure and treated each phrase as a separate unit for practice. Based on this observation, the four practice units (i.e., phrases), each consisting of four bars, were defined for further analysis. The Total Fixation Duration (TFD), which is a sum of all fixations within a specified Area

of Interest (see Figure 1), was computed for four melodic phrase-AOIs (as adapted from Holmqvist et al., 2011, pp. 386–89). TFD measurements allowed comparison of the time allocated to each melodic phrase.

Figure 1

An Example of a Song Divided into Four Areas of Interest (Phrase-AOIs)



Note. As can be seen in Figure 1, an Area of Interest (AOI) is a specific region designated within stimulus, to which eye-tracking measures are linked and analyzed. In the current study, each song was divided into four (1–4) phrase AOIs.

Processing and Memorization Approaches

To quantify the processing and memorization approaches, a deductive method with a predetermined categorization system was applied to the data set. Data analysis followed the principle that a phrase consisting of four bars was considered a single unit for practice. The numbers 1-4 were assigned to represent the four units to be visited. In this context, a "phrase visit" indicates that students practiced a particular phrase (4 bars) in its complete form.

For the purposes of this study, the following definitions were used as a basis for analysis: (a) Serial approach: Participants repeatedly sang the same phrase multiple times until the phrase was learned (e.g., 1-1-1); (b) Segmented approach: Participants performed a segment comprising two consecutive phrases (e.g., 2-3); (c) Additive approach: Participants processed larger segments of three phrases (e.g., 2-3-4); (d) Holistic approach: Participants sang through all four phrases in their proper order (e.g., 1-2-3-4). The Additive approach encompasses the expansion of memorized material by one phrase (regardless of whether it is in consecutive order or not), incorporating a new unit either before or after the previously practiced pair of phrases. This slightly modified interpretation of the Additive approach enhanced the flexibility of assessment. Detailed specification of the memorization approaches utilized in the current study is presented in *Appendix E*.

The organization of data into scarf plots was based on scanpaths (obtained from Tobii software) and video recordings. The scarf plots allowed for the assessment of the order and frequency of phrase visits, enabling the estimation of four memorization approaches. Additionally, they provided insights into changes affected by practice. In these scarf plots, multiple phrase visits were condensed into a single line, although specific timing values were not included. Each colored rectangle on the scarf plot corresponded to a unique phrase (*see Appendix F*). The primary goal was to analyze the order of phrases learned during each 60-second practice. The process of analyzing scarf plots can be associated with the "coding" guideline typically used in thematic interview analyses. A color-coding system was employed to quantify the processing and memorization approaches of musical students.

Questionnaire

Participants were asked to reflect on the strategies they employed during task completion. The responses provided information about the sight-reading strategies utilized in the practice sessions. The subsequent analysis focused on the frequency of positive ratings and outlined the similarities between students' strategies used (*see Appendix B*).

Results

Accuracy of Recall from Memory

The accuracy analyses revealed substantial variation in individual performance outcomes (*see Appendix C*). Some participants experienced occasional "blackouts," resulting in an inability to recall, despite demonstrating almost completely accurate performance just before attempting to perform from memory (similar to the study with pianists by Aiba & Matsui, 2016). In contrast, five participants (P1, P2, P3, P4, P7) achieved 100% accuracy at least once as early as in the second practice round, which only involved two minutes of practice. Two-thirds of the sample (10 students) could recall at least one song with 100% accuracy after the third practice.

However, two distinct groups emerged based on the range of scores. High-accuracy performers consistently demonstrated high levels of accuracy across the three practices. For example, P2 recalled the first song three times with accuracies of 81%, 100%, and 100%. The average accuracies for participants in this subgroup were as follows: P2 - 80%, P3 - 86%, and P13 - 93% (M = 86.3%, SD = 5.3). In contrast, the low-accuracy performers exhibited lower levels of accuracy. Participant P8 achieved 22%, 0% (due to "blackout"), and 53% accuracy across the three trials for the first song. On average, P8 demonstrated an accuracy of 28% across all three songs, while participants P10 and P14 achieved average accuracies of 40% and 48%, respectively (M = 38.7%, SD = 8.2).

Participants with an average accuracy level between 50% and 80% performed erratically, lacking consistency and exhibiting unpredictable "fluctuations" in accuracy (e.g., P5, P9). Consequently, the analysis focused on two subgroups: high-accuracy and low-accuracy

performers, each representing 20% of the sample. This targeted approach provided a more nuanced understanding of performance variability, highlighting the diversity within memorization approaches and supporting the description of approaches contributing to successful melodic recall.

According to the self-reported background information, the three high-accuracy performers had studied choral conducting and reported longer durations of music education (M = 15 years, SD = 5) and choral music experience (M = 17 years, SD = 6.08) compared to their counterparts. In contrast, the low-accuracy performers received an average of 11.33 years of music education (SD = 3.51) and 9.67 years of choral music experience (SD = 6.11), and two of the three students in the low-accuracy group had studied jazz.

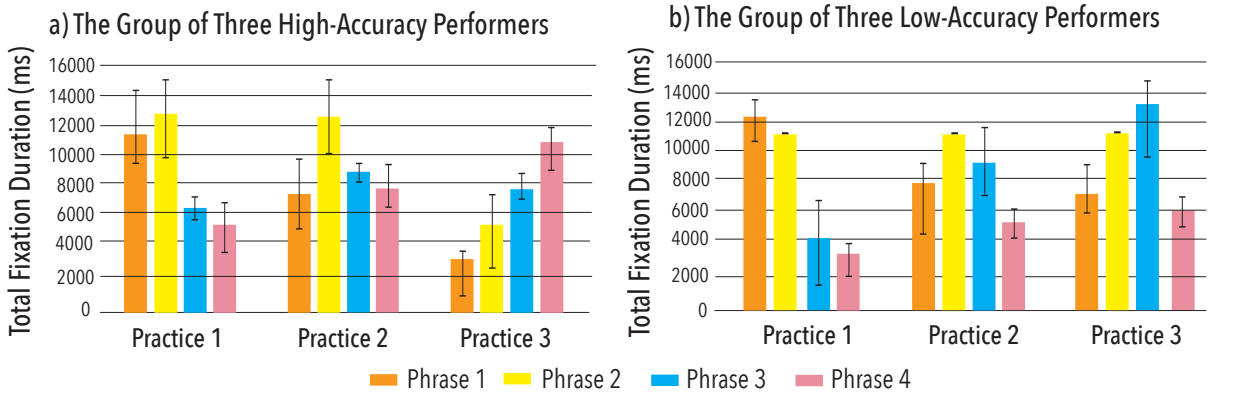
Eye Movements

A comparison of the processing time between both subgroups helped identify differences in the time distribution allocated to each AOI-phrase during the memorization task. The Total Fixation Duration (TFD) not only revealed disparities between individuals and subgroups, but also provided insights into the underlying dynamics of the observed variations across practice (see *Appendix G*).

When comparing the average Total Fixation Duration exhibited by high-accuracy performers during the first and last practices, a decrease of approximately 8 seconds was observed for each of the first two phrases (see Figure 2a). The opposite effect was seen for the third and fourth phrases. The TFD increased in the last practice by approximately 1 second for the third phrase and 5 seconds for the fourth. This suggests that the learning process was generally linear, with students memorizing phrases in the natural order of the music—starting from the first phrase and gradually placing more focused attention on the fourth phrase towards the end of the practice.

Figure 2

Mean Total Fixation Duration Across Practice Sessions Between Two Subgroups

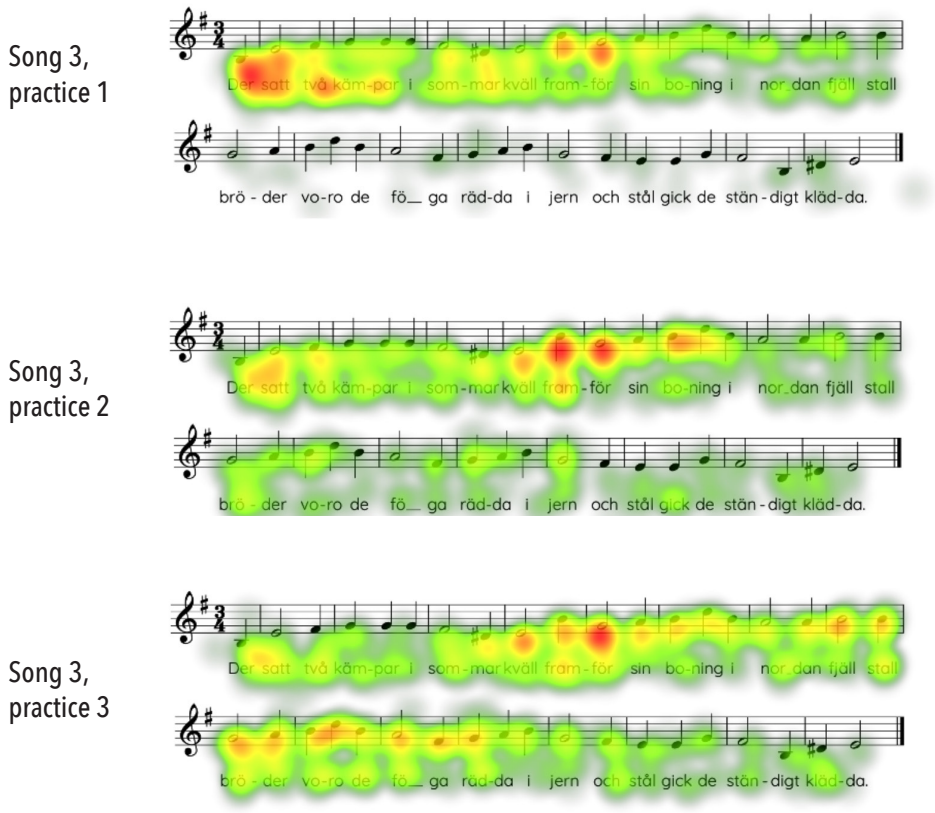


Note. Figure 2 illustrates the average Total Fixation Duration (ms), calculated as the mean across the four music phrases within each of the three songs for every practice session. The data is presented for two subgroups of performers: (a) high-accuracy performers and (b) low-accuracy performers. The error bars represent the standard error of the mean (SE), reflecting the variability in the mean Total Fixation Duration for each subgroup.

In contrast, the average Total Fixation Duration (TFD) for low-accuracy performers (Figure 2b) indicated that their allocation of visual attention was influenced by the musical features itself and the ability to process them. For example, the time spent on phrase two during the final practice session was nearly the same as in the initial session, suggesting ongoing difficulties in processing this phrase. The cumulative heatmaps were a valuable tool for examining the types of elements on which singers fixated their gaze. The warmer colors on the heatmaps in Figure 3 denote the musical features where low-accuracy performers primarily fixated. The melodic intervals as wide as a third and a fourth received higher values of fixation duration, which indicated difficulty in extracting musical information from a stimulus. Interestingly, during the first practice, low-accuracy performers spent more time focusing primarily on the beginning of the song, with minimal attention paid to phrases 3 and 4. At the final practice, however, their visual attention had shifted, still with many fixations (shown with warm colors - red) by the beginning of the second phrase.

Figure 3

Cumulative Heatmaps of Visual Attention Derived from Eye-Tracking Data



Note. Figure 3 is an example of cumulative heatmaps based on eye-tracking data collected from three low-accuracy performers during three one-minute practice sessions for Song No. 3. The heatmaps visually represent variations in fixation duration, with red areas indicating regions of highest fixation and cooler colors (green) representing areas with less fixation. Regions outside the heatmap were not fixated upon. These heatmaps illustrate the spatial distribution of eye movements and highlight changes in visual attention throughout the practice sessions.

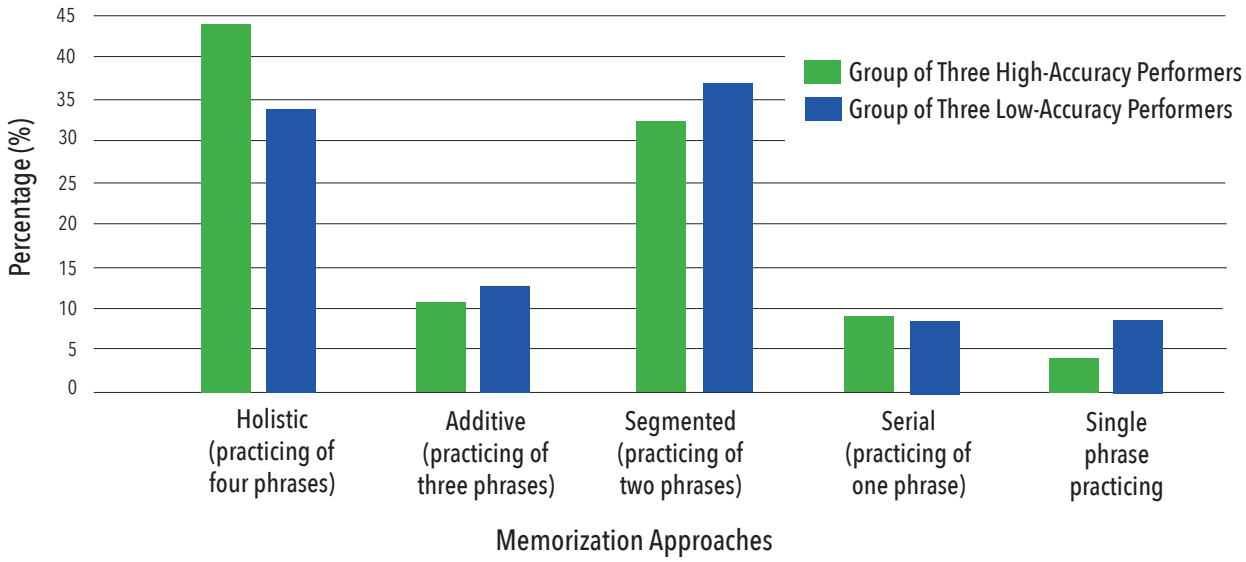
Processing and Memorization Approaches

The high-accuracy performers made a greater number of phrase visits, totaling 453 visits (visits on average P2 – 64, P3 – 46, P13 – 41) due to their faster practice tempo. In contrast, performers with lower accuracy completed only 190 phrase visits (visits on average P8 – 21, P10 – 21, P14 – 21) attributable to their slower processing speed. Additionally, during single 60-second trials, the high-accuracy group visited phrases with a frequency ranging from 9 to 27 times (M = 18, SD = 9), whereas their counterparts visited phrases between 4 and 10 times (M = 7, SD = 3).

The analysis of memorization approaches revealed that students from both subgroups predominantly utilized Holistic and Segmented approaches (see Figure 4). The high-accuracy performers often employed the Holistic approach, while the low-performing group relied slightly more on a Segmented approach. In comparison to the Holistic (44% vs. 34%) and Segmented (32% vs. 37%) approaches, the application of the Additive (11% vs. 13%) and Serial (9% vs. 8%) approaches was relatively sporadic in use by both subgroups. During the analysis, an extra category labeled "single phrase" emerged, which involved practicing a single phrase before the allocated time expired. However, the performances did not offer clear evidence that students relied exclusively on one specific approach throughout their learning. Instead, it appeared that they utilized a variety of approaches interchangeably, adapting memorization to the limited time condition and aiming for the most effective outcomes.

Figure 4

Relative Proportions of Different Memorization Approaches



Note. The Figure 4 displays the relative proportions of four memorization approaches used by high-accuracy and low-accuracy performers during practice sessions. The memorization approaches are arranged on the horizontal (x) axis, ranging from practicing all four phrases together (Holistic) to practicing each phrase separately (Serial). The last two bars on the right represent a category that emerged during analysis, labeled "Single phrase practice," which is not considered a memorization approach. The percentages of memorization approaches employed by each subgroup during practice for recall were calculated relative to the total number of phrases sung by each subgroup (high-accuracy performers = 453; low-accuracy performers = 190).

Interestingly, the students exhibited different tendencies in terms of how they initiated the practice sessions. Specifically, the low-accuracy performers chose to restart each new practice attempt from the beginning (i.e., bar 1) in 92.6% of the cases (in 25 out of 27 trials). In contrast, the high-accuracy performers opted to restart the practice from the beginning in only 55.6% of the cases. This discrepancy indicates that the low-accuracy performers relied more heavily on the initial section of the song, suggesting that they used associative chaining compared to the high-accuracy performers who had developed an ability to target specific parts of the score utilizing the musical content.

An additional illustration of the differences in the processing approaches between the two subgroups was derived from the grand mean of average phrase repetition frequency across all songs. This result highlights the ability of high-accuracy performers to remember the initial segments of the melodies (phrases 1–2) while deliberately focusing on the repetition of less mastered material (phrases 3–4), providing the opportunity to learn. The grand means (M) and standard deviations (SD) for each phrase were as follows: Phrase 1, M = 9.56, SD = 1.03; Phrase 2, M = 11.11, SD = 1.73; Phrase 3, M = 14.11, SD = 1.50; and Phrase 4, M = 15.56, SD = 0.96. The opposite tendency was observed among low-accuracy performers (*see Appendix H*). Perhaps because of their learning style, they did not allow enough repetitions to memorize the last phrase. Consequently, the number of repetitions decreased considerably by the final phrase—dropping by more than half. The grand means (M) and standard deviations (*SD*) for each phrase were as follows: Phrase 1, M = 7.34, SD = 0.47; Phrase 2, M = 6.45, SD = 0.31; Phrase 3, M = 4.55, SD = 0.96; and Phrase 4, M = 2.89, SD = 0.68.

Questionnaire

When comparing the two subgroups, only four of the eleven sight-reading strategies were equally rated: (a) grouping notes together to create melodic motives, (b) comparing with a previously sung note, and (c) practicing challenging sections separately. None of the students reported (d) singing other notes to fill a leap.

During the three 60-second practice periods, students exhibited a spectrum of problem-solving techniques. The students were able to adjust their practice pace, accelerating performance in easy or familiar sections of songs and decelerating when confronted with new or challenging segments. Additionally, they employed a range of kinesthetic approaches, such as counting the pulse through foot stomping, finger tapping on a table or their lap, and occasionally using conducting gestures. Interestingly, during recalls, when confronted with forgotten parts, students exhibited remarkable improvisational skills by humming melodies while maintaining tempo through body movements and later resuming singing from a remembered point further ahead. The self-monitoring technique during practice time, which involved briefly sidetracking the gaze from music notation or even closing the eyes for 1-2 seconds, was widely used. These diverse observations underscore that music students employ problem-solving and self-monitoring techniques (e.g., Lehmann & Kopiez,

2016; Parkes, 2022), wherein they support and evaluate their own memorization of musical material.

Discussion

The objective of this descriptive study was to identify the score memorization strategies that contributed to successful melodic recall. Results indicate that music students employed four distinct memorization approaches while learning simple melodies, adapting these strategies interchangeably. Both subgroups preferred the Holistic and Segmented approaches over the Additive and Serial approaches, with high-accuracy performers particularly relying on the Holistic approach. The following section highlights other factors behind successful melodic recall.

Accuracy

The results demonstrated that high-accuracy performers were fluent in music reading, which may be explained by their developed audiation skills (e.g., Gordon, 1977). In the context of learning, students used musical phrases as structural cues, serving in memorizing task (e.g., Aiello, 2001; Williamon & Valentine, 2002). Moreover, high-accuracy performers exhibited an accelerated processing speed, likely attributable to their advanced chunking abilities or a more extensive internalized vocabulary of melodic elements cultivated through practice (e.g., Ericsson et al., 1993; Gordon, 1977; Pozenatto, 2020). Students' recall accuracy may also be attributed to their active working memory capacity and the automatization of certain skills, which assisted in the retention process (e.g., Pomerleau-Turcotte et al., 2023; Pozenatto, 2020; Shiffrin & Schneider, 1977).

In contrast, low-accuracy performers were less successful despite having the same amount of practice time, suggesting possible gaps in their music reading skills. Since learning by listening to recordings or live demonstrations from a coach was not an option, students with weaker sight-reading skills faced greater challenges, possibly due to a reliance on the jazz tradition of learning by ear (for more on memorization techniques among jazz musicians, see Noice et al., 2008). Thus, true learning could not occur without the ability to sing through the piece and comprehend the pitches and their relationships. Without learning, remembering was also impossible.

Self-reported demographic information showed that high-accuracy performers had more years of music education and greater experience with choral music than their counterparts. Previous research also identified years of choral experience as a significant variable influencing individual performance (e.g., Demorest & May, 1995). This may support the conclusion that a more extensive choral experience was a factor that benefited high-accuracy performers in their mastery of reading and memorizing.

In general, knowledge of musical theory and analysis (e.g., Aiello, 2001; Halpern & Bartlett, 2010) and music reading skills gained through deliberate practice (e.g., Ericsson et al., 1993) facilitate faster encoding and retrieval, thus improve recall accuracy. The three re-

calls from memory, which served as checkpoints for the participants, could also be seen as integral components of the learning process. This perspective aligns with Mishra's (2005) concept of overlearning, or, alternatively, as a form of practice in performing from memory. Such practice allows students to identify areas for improvement—a goal distinct from merely learning to sing the song (for more on self-directed learning strategies, see Parkes, 2022).

Eye Movements

As mentioned in the previous sections, eye-tracking provides objective data on where musicians focus their visual attention on a score, the duration of their gaze, and the sequence of their fixations (for a review, see Holmqvist et al., 2011). This information was helpful for understanding the processes of learning and memorization. For example, by analyzing fixation duration metrics, it was possible to uncover patterns in students' cognitive processing and observe changes in their visual attention over time, providing insight into how their focus evolved during practice sessions.

The increased fixation duration observed in the eye-tracking data for the second phrase suggests challenges in processing bars with melodic intervals, such as major and minor thirds and fourths, both ascending and descending. Such increased fixations were likely due to processing difficulties, as visual gaze is associated with cognitive effort (e.g., Goolsby, 1994; Madell & Hébert, 2008; Sheridan et al., 2020), similar to text reading, where gaze duration increases with word or sentence complexity (e.g., Just & Carpenter, 1980).

Another factor that may have affected eye movements was a system break that immediately followed the second phrase unite. The system break may have initiated long saccades from the right to the left margin, resulting in a comprehension setback. Studies of text reading (e.g., Rayner et al., 1982) suggest that the acquisition of useful information is more efficient to the right of fixation. Consequently, disruptions in the reading comprehension, coupled with challenging melodic intervals, affected processing time (e.g., Sheridan et al., 2020), as evidenced by the increased total fixation duration for the second and third phrases for low-accuracy performers. The cumulative heatmaps provided valuable insights into the students' learning processes (see Duchowski et al., 2012), showing how their visual attention evolved over time in response to the musical features of the score. This suggests that low-accuracy performers, while actively working to improve their fluency with specific intervals, became hindered by those complexities and were ultimately unable to succeed fully in the memorization task.

Memorization Approaches

Awareness of compositional structure and the use of structural cues allowed the students in this study to effectively guide their memorization process (e.g., Halpern & Bower, 1982; Sloboda, 1977; Williamon & Valentine, 2002). Despite engaging in numerous holis-

tic run-throughs suggestive of associative chaining learning, the high-accuracy performers addressed challenging segments separately, consistent with the concept of content-addressable memory (Chaffin et al., 2016). By combining associative chaining and content-addressable learning, the high-accuracy performers demonstrated the benefits of using different approaches. In contrast, the low-accuracy performers tended to restart each practice trial from the beginning. This behavior suggests a heavy reliance on associative chaining memory, which may be less efficient (Chaffin et al., 2016).

Furthermore, high-accuracy performers tended to focus more on practicing the endings of the songs. This observation aligns with the theoretical assumptions that memory retention is generally stronger at the beginning of a musical piece (see Chaffin & Imreh, 2002; Finney & Palmer, 2003). Intuitively applying this concept, high-accuracy performers devoted extra time to sections that required additional reinforcement for memorization. Moreover, the practice frequency of high-accuracy performers likely strengthened their encoding and retrieval processes, often linked to auditory memory (e.g., Pozenatto, 2020). Through repeated singing and listening to these melodies, the performers strengthened their auditory memory—a crucial component of working memory that underpins the accurate reproduction of music (for more on auditory memory, see Ginsborg, 2022).

Based on all these observations, the Holistic approach, favored by high-accuracy performers may be considered effective for memorizing short and technically simple melodies written in a conventional musical style, particularly when the time allotted for the task is limited. Furthermore, the results of this study highlight the dynamic nature of the memorization process, showing that experienced musicians can consciously select from a range of memorization approaches and adapt them to different stages of learning, as also discussed by Mishra (2011) and Chaffin et al. (2016). This flexibility allows skilled musicians to align their strategies with the specific demands of each learning stage. Consistent with previous research, memory strategies appear to vary based on a performer's skill level (e.g., Aiello & Williamon, 2002), with more experienced musicians able to employ particular techniques that optimize retention and recall.

The question remains as to how effective these memorization approaches will be in a real-time choral setting, where each voice part has its own melodic signature—an area that could be explored in future scientific studies. Notably, the three high-accuracy performers were male choral conducting students who sang bass and tenor in their school choir. Their advanced sight-reading and memorization skills likely stemmed from their choral training, which involved the ability to navigate complex harmonies, among others. Unlike soprano lines, bass and tenor vocal lines often contain fewer traditional melodic passages. Memorizing the melodies of simple songs may differ from memorizing choral parts because each vocal line has unique characteristics in four-part harmony. Future research could explore how singers of all vocal parts memorize choral scores together and examine the relationship between text and melody during memorization, as focusing on melody alone provides only a partial view.

Questionnaire Responses and Observations

Responses to the declarative statements identified the sight-reading strategies students used during the memorization task (e.g., Pomerleau-Turcotte et al., 2023), with certain strategies used more regularly (e.g., relating to scale degrees, grouping notes to create melodic motives) than others (e.g., singing other notes to fill a leap) (e.g., Fournier et al., 2019). The ability to chunk (group notes), use audio cues (previously sung material), and practice challenging sections separately were supportive memorization strategies for singers in both subgroups. In general, participants adopted strategies that suited their own needs and task requirements, as also reported in studies by Hallam (1997) and Ginsborg and Sloboda (2007).

Furthermore, several supportive techniques that enhance learning processes and establish a framework for recall accuracy have been observed. These techniques, including (a) repeating the tonic for tonal stability, (b) incorporating body movements for pulse and rhythm steadiness, and (c) self-monitoring through brief memory checks, could be viewed as signs of utilizing visual, auditory, conceptual, and kinesthetic memories, as described in works by Ginsborg (2022), Killian and Henry (2005), and Parkes (2022).

Methodological Consideration

Bazeley's (2024) concept of integrating both qualitative and quantitative approaches provided a more comprehensive view of the memorization processes. The quantitative data was analyzed using qualitative research tools, shedding light on the cognitive mechanisms that guided music students during the memorization task. The utilization of eye-tracking technology allowed for an objective examination of participants' visual processing of music notation. Future studies may involve the use of wearable eye-tracking glasses and traditional printed music sheets as opposed to digital formats to better reflect real-world scenarios.

The limitations become evident when considering statistical support. Statistical analysis necessitates a larger collection of empirical data; therefore, the findings of this study with a small sample size cannot be generalized to the wider population or provide conclusive results. A further limitation is the lack of clarity regarding the prior memorization experience of participants, the level of rigorous sight-singing training they have undergone, and the regularity with which they have sung from memory in their previous choirs. This study did not examine the correlation between past training and current memorization skills. It would be beneficial for future research to include such data, as well as pre-test memorization skills, and control for absolute pitch ability.

Suggestions for Implementation and Future Research Directions

In terms of the memorization process, it would be beneficial for singers to consciously adopt Mishra's (2005) four different approaches to memorization and use them systematically, regularly applying the Holistic approach that is effective for memorizing simple songs.

To foster effective learning and strengthen robust memorization skills, conductors can systematically enhance individual singers' deliberate memorization and sight-singing abilities by integrating structural and performance cues into choral training. Singers may wish to consider actively utilizing four components of memory (visual, conceptual, auditory, and kinesthetic) to enhance memorization, as suggested by previous studies (e.g., Chaffin et al., 2016; Hallam, 1997).

Moreover, the incorporation of metacognitive techniques, such as evaluation, planning, concentration, and self-monitoring, can foster singers' understanding of their own learning processes and prepare them for self-directed learning (e.g., Hallam, 2001; Parkes, 2022). Educators can further develop instructions based on individual student's cognitive abilities, learning styles, and prior musical training, enabling singers to develop their music reading and memorizing skills to function independently as musicians (e.g., Demorest, 1998; Demorest & May, 1995; Henry, 2008). However, future research into effective memorization approaches in choral settings—particularly those that benefit both individual proficiency and collective dynamics within choral ensembles—would be a valuable area of investigation (e.g., Ginsborg, 2022).

Based on this discussion, several recommendations could be made for future research in the field of choral music education. One suggestion is to conduct an additional study on memorization with a larger number of participants, focusing specifically on pedagogical interventions. Additionally, a longitudinal study could be conducted to investigate the effects of the mentioned approaches and strategies on choral singers' memorization abilities over time. This would provide valuable information on the sustained effectiveness of recalling choral music in ensemble situation for performances over an extended period. Examining memorization strategies for songs, particularly by investigating the role of text—which may either complicate memorization or serve as a valuable reference point—could provide insights into the interrelationship between a song's text and melody. Additionally, in choral settings where different voices may articulate distinct text lines and sing varying melodic patterns, exploring this dynamic could yield meaningful results.

In summary, the results demonstrate the effectiveness of both holistic and segmented memorization strategies for recalling simple melodies. Furthermore, the research highlights that specific competencies—such as knowledge of music theory, analytical skills, sight-singing abilities, the use of structural cues, and adaptability in selecting the most effective strategy for each situation—can significantly enhance successful memorization within a limited time frame. These findings provide encouragement for choral teachers, who can regularly incorporate memorization exercises to strengthen individual proficiencies, thereby enhancing overall performance quality and fostering deeper musical engagement of singers. Additionally, these insights may broaden the scope of research on the development of musical memory in the context of choral singing.

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Declaration of Conflicting Interests

The author confirms that there are no conflicts of interest to disclose.

Supplemental Materials

The online supplementary materials are available at http://doi.org/10.6084/m9.figshare.25846438

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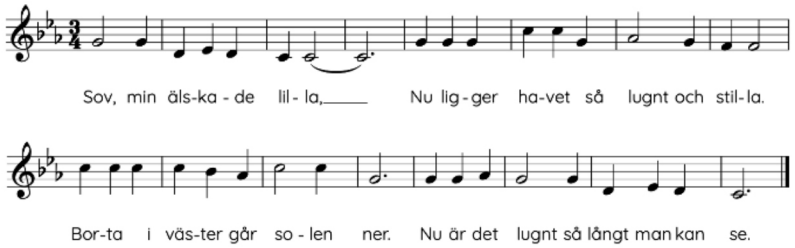
Appendices

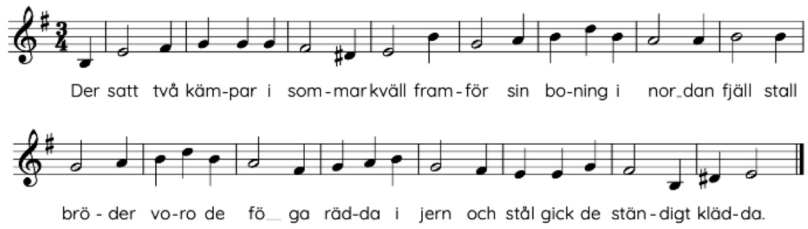
Appendix A

Musical Material Used in the Memorization Task

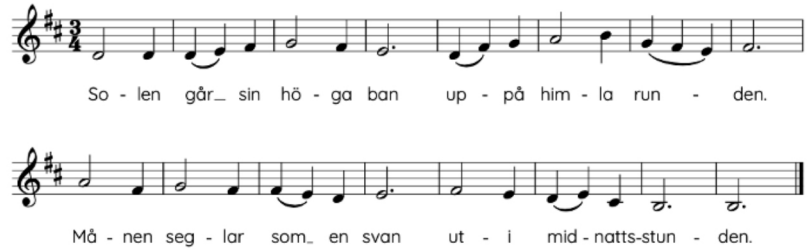
Song 1



Song 2



Song 3



Appendix B

Table

Questionnaire on Sight-Singing Strategies and Summary of Responses

The number of positive responses to statements that begin with "When I sung the songs I …"	All participants ($N = 15$)	The high-accuracy performers ($N = 3$)	The low-accuracy performers ($N = 3$)
1 I related to scale degrees.	13	3	2
2 I related to intervals.	12	2	3
3 I compared with a previously sung note.	13	3*	3*
4 I have sung other notes to fill a leap.	4	0*	0*
5 I grouped notes to create chords or arpeggios.	9	2	0
6 I looked for repetitions and sequences.	13	2	3
7 I looked for common melodic patterns.	9	1	3
8 I looked for scale patterns.	10	2	1
9 I grouped notes to create melodic motives.	13	3*	3*
10 I determined the meter and the key before singing	12	1	3
11 I practiced challenging sections separately	15	3*	3*

Note. Ratings of declarative statements on sight-singing strategies utilized by music students during practice. The numbers in the table represent the ratings of the "Yes" responses. * = strategies marked with an asterisk (*) received equal ratings from participants in both subgroups.

Appendix C

Table

The Accuracy (in %) of the recall from memory after each practice

	Song 1			Song 2			Song 3		
	Practice			Practice			Practice		
Participants	1	2	3	1	2	3	1	2	3
P1	50	100	100	41	56	66	47	47	100
P2	81	100	100	91	100	100	71	74	92
P3	94	100	94	97	100	75	63	95	100
P4	50	92	83	53	100	100	61	55	66
P5	0	78	97	5	68	50	42	29	68
P6	47	94	86	53	97	100	47	76	79
P7	75	100	100	94	100	100	32	29	34
P8	22	0	53	28	59	63	24	47	63
P9	50	64	86	41	84	66	45	24	55
P10	6	28	67	25	31	25	24	24	24
P11	50	92	100	0	66	88	5	45	76
P12	0	44	81	19	88	100	39	68	100
P13	75	53	100	53	94	100	50	95	100
P14	0	50	42	25	53	75	37	53	95
P15	47	81	100	25	84	72	39	66	71

Note. The analyses of recall accuracy, reported as percentages (%), were conducted for fifteen participants (P1–P15). Some participants experienced occasional "blackouts," which resulted in an inability to recall, despite demonstrating almost completely accurate performance just before attempting to perform from memory. These blackouts are indicated as "0" in the accuracy matrix.

Appendix D

Report on Eye-Tracking Data Collection Accuracy

The eye-tracking data collection began with a 5-points calibration routine, followed by a 4-points validation of the calibration, all conducted in a room with consistent lighting conditions. After the data collection, to ensure the quality of the analyzed eye-movement data, several key metrics were computed for whole sample (Niehorster et al., 2020). These metrics include accuracy indicating the closeness of gaze points to targets participants are asked to fixate (M = 0.60 deg., SD = 0.29), *precision*, demonstrating the consistency of measurements (M = 0.08 deg., SD = 0.02), and the *proportion of data loss* (M = 8.8 %, SD = 4.5).

Appendix E

Table

Specification of the Memorization Approaches Utilized in the Current Study

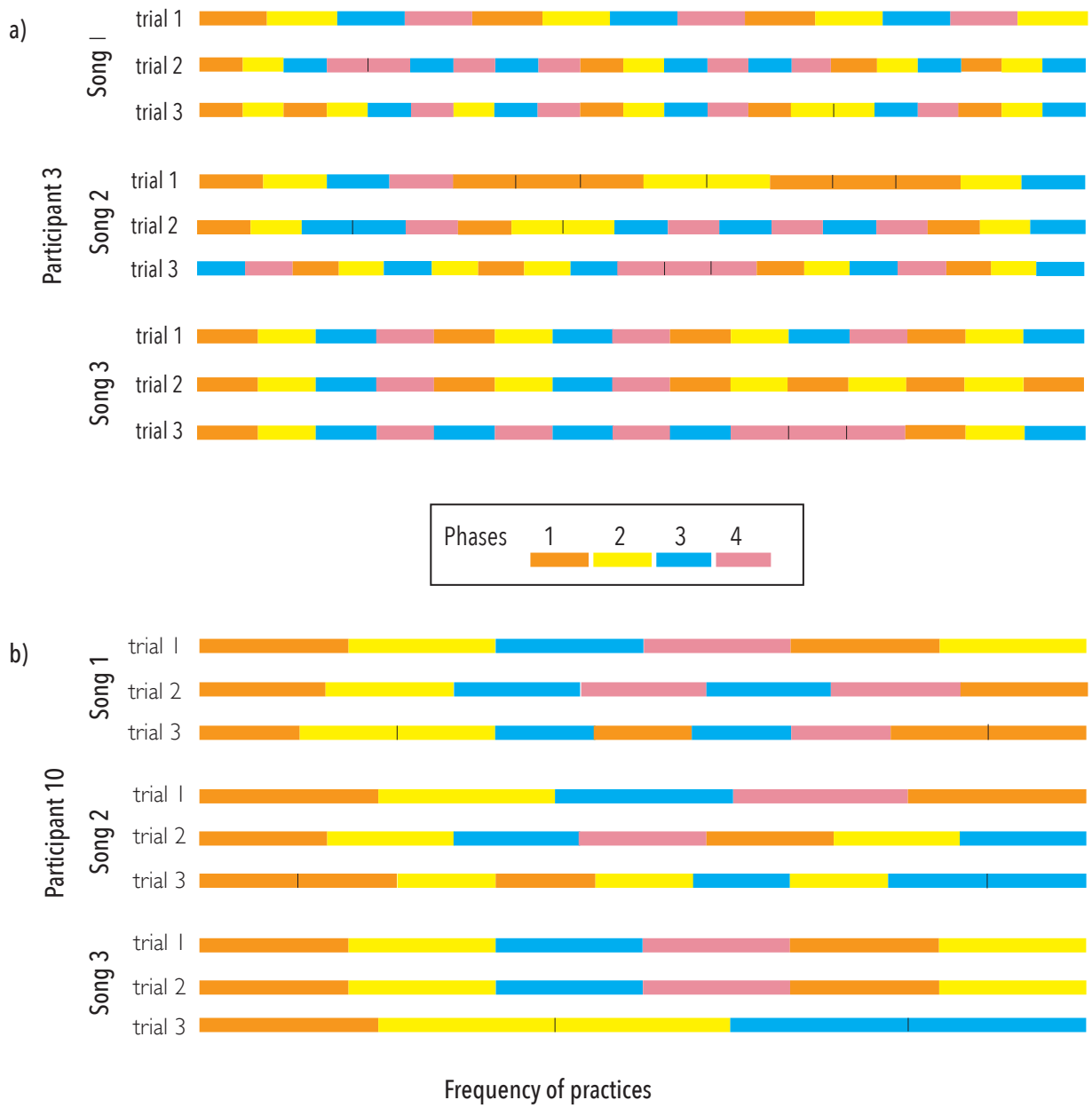
Approach	Progression in the sequence		Total amount of phrases in one practice sequence (bars)
	Starting point	Ending point	
Holistic	Phase 1	Phrase 4	4 phrases (16 bars)
Additive	Phase 1	Phrase 3	3 phrases (12 bars)
	Phase 2	Phrase 4	3 phrases (12 bars)
Segmented	Phase 1	Phrase 2	2 phrases (8 bars)
	Phase 2	Phrase 3	2 phrases (8 bars)
	Phase 3	Phrase 4	2 phrases (8 bars)
Serial	Phase 1	Phrase 1	1 phrase (4 bars)
	Phase 2	Phrase 2	1 phrase (4 bars)
	Phase 3	Phrase 3	1 phrase (4 bars)
	Phase 4	Phrase 4	1 phrase (4 bars)

Note. This overview of memorization approaches indicates the quantity and sequence of phrases practiced before the memory test.

Appendix F

Figure

Frequency of Practices Illustrated in Scarf Plots



Note. This scarf plots illustrate the differences of practice frequencies between two participants: (a) Participant 3, who achieved the highest accuracy rate (M = 93%), and (b) Participant 10, who had the lowest accuracy rate (M = 28%). The scarf plots show the order and frequency of practice for each song over three 60-second trials. For example, Participant 3 visited the four phrase units in Song 1 (Trial 1) thirteen times, while Participant 10 made only six visits. Each musical phrase is represented by a colored rectangle, and the sequence of repetitions is condensed into a single line to preserve order. The scarf plots display the number of repetitions without the explicit time spent on each phrase.

Appendix G

Table

Average Total Fixation Duration (ms) for the First vs. Last Practice Sessions

		First practice			Last practice		
	N	*Mean*	*SE*	*SD*	*Mean*	*SE*	*SD*
High-accuracy performers							
Phrase 1	9	11694	2812	8436	3184	644	1931
Phrase 2	9	12377	1039	3117	4998	441	1322
Phrase 3	9	6235	1793	5380	7741	1683	5048
Phrase 4	9	5005	1473	4419	10453	1723	5169
Low-accuracy performers							
Phrase 1	9	12182	2331	6993	7392	1525	4576
Phrase 2	9	10954	1528	4585	11051	2250	6750
Phrase 3	9	3982	1242	3723	12119	2021	6062
Phrase 4	9	2909	1330	3990	6028	1107	3320

Note. This table presents the average total fixation duration, including standard deviation and standard error, for four phrases across the first and last practice sessions.

Appendix H

Table

The Number of Times on Average Each Single Phrase was Sung Across all Songs

	Song 1	Song 2	Song 3	Grand mean (SD)
	M (SD)	M (SD)	M (SD)	
		High-accuracy performers		
Phrase 1	8.67 (2.05)	11.00 (2.83)	9.00 (3.74)	9.56 (1.03)
Phrase 2	12.33 (1.70)	12.33 (1.25)	8.67 (3.30)	11.11 (1.73)
Phrase 3	14.00 (2.83)	16.00 (2.45)	12.33 (1.25)	14.11 (1.50)
Phrase 4	15.67 (5.19)	16.67 (3.81)	14.33 (4.71)	15.56 (0.96)
		Low-accuracy performers		
Phrase 1	6.67 (1.24)	7.67 (0.94)	7.67 (2.05)	7.34 (0.47)
Phrase 2	6.00 (2.16)	6.67 (1.70)	6.67 (1.70)	6.45 (0.31)
Phrase 3	4.67 (2.05)	5.67 (3.30)	3.33 (2.05)	4.55 (0.96)
Phrase 4	3.66 (1.25)	3.00 (1.63)	2.00 (0.82)	2.89 (0.68)

Note. This table provides an additional illustration of the learning patterns of the two subgroups. The increase in the number of phrase repetitions toward the fourth phrase for the high-accuracy performers highlights their ability to remember the initial segments of the melodies (e.g., phrases 1–2) while deliberately shifting focus to less retained material (e.g., phrases 3–4). The opposite tendency appeared in the learning patterns of low-accuracy performers.