

## **Influence of strategy on memorization efficiency**

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**ABSTRACT:** The purpose of this study was to investigate experimentally the effectiveness of four memorization strategies: Holistic, Segmented, Serial, and Additive. Forty university wind players memorized a 16-bar exercise using a randomly assigned strategy. Effectiveness was based on how quickly notated music could be encoded (efficiency) and on the number of errors committed made during a delayed performance (stability). The Holistic strategy was significantly more efficient than the Segmented and Serial strategies. No difference was found between the strategies on the stability measure. Practising a short, technically simple piece from beginning to end (Holistic strategy) allowed musicians to memorize more efficiently than segmenting the piece.

**KEYWORDS:** Memorization strategies, musical performance, efficiency, stability

Memorizing music requires a great deal of time, even for the professional musician (e.g. Chaffin, Imreh, & Crawford, 2002). For instance, Williamon and Valentine (2000) found that pianists required nearly fourteen hours to memorize the Bach Prelude and Fugue in D minor, BWV 851, and even the Polonaise in G minor, BWV Anhang 119, an easier and shorter piece, required an average of three and a half hours to memorize. However, musicians vary widely in the time required to memorize as evidenced by large reported standard deviations for memorization time (see Mishra, 2008, for a review). In the Williamon and Valentine study, the standard deviation reported for the Bach Prelude and Fugue was more than five hours indicating that some pianists required fewer than ten hours to memorize the piece while others required nearly twenty.

For nearly a century, researchers have been interested in discovering ways to expedite the memorization process. Early twentieth-century researchers investigated the relative

efficiency of two memorization strategies: Holistic (Whole) and Segmented (Part). When using the Holistic strategy, a musician repeatedly practised the entire piece from beginning to end. A musician using the Segmented strategy focused practice on isolated sections of the piece, subsequently adding the segments together. The results were mixed. Brown (1928), Clapp (1924), and Eberly (1921) found the Holistic strategy was most efficient, but O'Brien (1943) found the Segmented strategy to be more efficient. Rubin-Rabson (1940) found the strategies equivalent.

A major complication in this line of research is the lack of consistency in what constitutes "part" and "whole." A segment could be described as a two- or four-bar fragment (Brown, 1928; O'Brien, 1943; Rubin-Rabson, 1940), which may or may not be musically meaningful, while the "whole" might consist of only eight bars (Rubin-Rabson, 1940) rather than an entire piece. More recent researchers have been primarily concerned with observing musicians learning a piece of music in a naturalistic environment where the definition of a segment is fluid, often guided by the formal structure of the piece. Williamon and Valentine (2002) found that expert musicians systematically used the formal structure of the piece to guide practice and that the length of the segments increased with long-term practice. Segment size also appears related to task difficulty with more challenging sections divided into smaller segments (Chaffin & Imreh, 1997; Miklaszewski, 1989; Nielsen, 1999). Additionally, alternating between intensive sectional work (Segmented) and run-throughs (Holistic) is frequently reported with expert musicians during the long-term process of preparing a piece for performance (Chaffin & Imreh, 2000; Hallam, 1997; Miklaszewski, 1989; Miklaszewski, 1995; Williamon, 1999).

While the Holistic and Segmented strategies have been the focus of research, other approaches to memorizing have been identified. Observing musicians memorizing in a naturalistic setting, Mishra (2002) identified four strategies used by musicians when memorizing a short piece of music: Holistic, Segmented, Serial, and Additive. Musicians using the Serial strategy began practice at the beginning of a piece, but stopped when an error occurred, returning to the beginning for another attempt. This strategy was distinct from the Holistic strategy in which musicians nearly always played to the end of the piece with only minor regressions when errors or memory lapses occurred. Other musicians in the Mishra study used an Additive strategy, initially memorizing one segment, but then systematically increasing the length until the segment encompassed the entire piece. This strategy differed from the Segmented strategy in that musicians did not focus on discrete segments in isolation prior to linking them into a unit, but continued to reinforce all previously learned material. While the Serial and Additive strategies may appear, superficially, to be variations on the Holistic and Segmented strategies respectively, there were disparate outcomes for the various strategies. In the Mishra study, musicians using the Holistic and Additive strategies were more efficient memorizers (requiring between 8 and 17 minutes to memorize the piece) while those using the Segmented and Serial strategies were much slower (requiring between 66 and 100 minutes to memorize the same piece).

The primary purpose of the present study was to investigate experimentally the efficiency of four memorization strategies: Holistic, Segmented, Serial, and Additive. Based on Mishra's (2002) observational study, it was predicted that the Holistic and Additive strategies would result in faster memorization and the Segmented and Serial strategies would result in slower memorization. However, musicians develop an image of their memorization

skills, formally or informally, based not only on how quickly a piece can be memorized, but on how stable the memory is during a subsequent performance.

Most research on musical memorization has explored the initial encoding of the material to be memorized, but stability of the memory trace over time has been investigated in a few studies. Koh (2002, Experiment 2) asked pianists to learn short melodies using a holistic approach where the melody was presented five times and the pianists attempted to recall the material on the keyboard after each presentation. A three-minute retention interval followed the fifth trial after which memory for the melody was assessed again. Koh found a significant difference in accuracy between the fifth and sixth trials indicating that some material was lost from memory during the retention interval. In a similar study, Zielinska and Miklaszewski (1992) presented both tonal and modal melodies aurally to musicians who sang as much as they could remember of each melody immediately after each of the ten trials. After a retention interval of ten minutes, participants sang both the tonal and modal melodies. Recall accuracy did not diminish for the tonal melody, but accuracy for the modal melody fell significantly.

To date, studies of long-term musical memory have not included memorization strategy as a variable, so the possible effects of strategy on stability of recall following memorization have not been explored. In the present study stability was measured, but no prediction could be made on the basis of the existing literature as to whether, and if so how, it would be affected by strategy use.

## METHOD

### Participants

Participants were 40 instrumental music education majors enrolled in a music education methods class at a large university in the southern United States. All participants were music majors and had successfully passed the university entrance audition on their primary instrument. Participants were in their third or fourth year of university and within one year of graduation. The participants' primary instrument was either a brass (57.5%,  $n = 23$ ) or woodwind (42.5%,  $n = 17$ ) instrument. The mean age of the participants was 21.68 ( $SD = 1.45$ ). Twenty-three were male (57.5%) and seventeen were female (42.5%). The participants were randomly assigned to one of four treatment groups: Holistic, Segmented, Serial, or Additive.

### Materials

Each participant was asked to memorize a 16-bar musical exercise from the Watkins-Farnum Performance Scale (WFPS) (1962). The WFPS is a standardized performance measure. It consists of 14 graded exercises for wind and brass instruments presenting progressively increasing demands on players. Each exercise is published in the most appropriate key to the instrument, so they are of equivalent difficulty; for example, the same exercise appears in F major for saxophone and A flat major for trombone and tuba. Exercise 10 was chosen as it was difficult enough to elicit some performance errors, but easy enough for music majors to memorize in one sitting. It consists of four 4-bar phrases and has relatively simple rhythms

with some syncopations and dotted figures. Participants sight-read it easily, with few errors, indicating that it was well within their technical abilities.

Performances were recorded using a Sony MZ-M100 Minidisk and a Sony ECM-MS957 stereo microphone.

**Procedure**

Participants were randomly assigned to one of four treatment groups: Holistic ( $n = 10$ ), Segmented ( $n = 10$ ), Serial ( $n = 10$ ), or Additive ( $n = 10$ ). The treatment groups varied in the amount and sequencing of material presented for memorization at any one time (see Table 1).

Strategy	Notation Presented		
	Start- ing point	Ending point	Total bars presented
<b>Holistic</b>	Bar 1	Bar 16	16 bars
	Bar 1	Bar 16	16 bars
	Bar 1	Bar 16	16 bars
	Bar 1	Bar 16	16 bars
	Bar 1	Bar 16	16 bars
	Bar 1	Bar 16	16 bars
	Bar 1	Bar 16	16 bars
	Bar 1	Bar 16	16 bars
	Bar 1	Bar 16	16 bars
	Bar 1	Bar 16	16 bars
<i>Memory Test</i>			
<b>Segmented</b>	Bar 1	Bar 2	2 bars
	Bar 3	Bar 4	2 bars
	Bar 5	Bar 6	2 bars
	Bar 7	Bar 8	2 bars
	Bar 9	Bar 10	2 bars
	Bar 11	Bar 12	2 bars
	Bar 13	Bar 14	2 bars
	Bar 15	Bar 16	2 bars
<i>Memory Test</i>			
<b>Serial</b>	Bar 1	Error	16 bars
	<i>Memory Test after error free performance</i>		
<b>Additive</b>	Bar 1	Bar 2	2 bars
	Bar 1	Bar 4	4 bars
	Bar 1	Bar 6	6 bars
	Bar 1	Bar 8	8 bars
	Bar 1	Bar 10	10 bars
	Bar 1	Bar 12	12 bars
	Bar 1	Bar 14	14 bars
	Bar 1	Bar 16	16 bars
<i>Memory Test</i>			

**Table 1.** Overview of memorization strategies reflecting the amount and sequencing of material presented with number of trials prior to memory test.

Participants in the Holistic treatment group were shown all 16 bars of the piece and instructed to play through the entire exercise from bar 1 to bar 16 while attempting to memorize the piece. If a mistake was made or a memory lapse occurred, the participant was asked to continue playing until the end of the exercise even if he or she needed to refer to the notation. Every tenth trial, the notation was removed and the participant was asked to test his or her memory for the piece to decide whether the piece was memorized or if more practice was needed. If the participant required more practice time, the notation was again presented.

For the Segmented treatment group, the exercise was divided into eight 2-bar segments. The participant was presented with each 2-bar segment in isolation beginning with bars 1 and 2. The participant was instructed to perform the presented material until the bars were memorized and could be performed without error. When the participant indicated that the two presented bars were memorized, the bars were replaced with notation for the next two bars (bars 3 and 4). When all eight segments had been presented, the notation was removed and the participant was asked to test his or her memory for the piece to decide whether it was memorized or if more practice was needed. If more practice was needed, two bar segments were presented again, starting with bars 1 and 2.

Notation for the entire piece was presented to participants in the Serial treatment group, but they were instructed to stop when a mistake was made or a memory lapse occurred. The participants were allowed to practise the bar in which the error occurred and then returned to the beginning of the piece for another attempt. Following each error-free performance, the notation was removed and the participant was asked to test his or her memory for the piece to decide whether the piece was memorized or if more practice was needed. If the participants required more time, the notation was again provided and the treatment continued.

Participants in the Additive treatment group were presented with the piece in segments increasing in length. Initially, the participant was presented with bars 1 and 2. The participant was instructed to perform the presented material until the bars were memorized and could be performed without error. When the participant indicated that the two presented bars were memorized, the notation for the next two bars was added. When all eight segments had been added (i.e. notation for the entire piece presented), the notation was removed and the participant was asked to test his or her memory for the piece to decide whether the piece was memorized or if more practice was needed. If more practice was needed, the sequence was repeated starting with the first two bars and proceeding until the participant was presented with all 16 bars of the piece.

Musical material was presented on a computer screen and participants controlled their own progress within the restrictions of the treatment. Presentation via computer was necessary to control for the possibility that participants would deviate from the experimentally defined strategy (e.g. looking ahead when memorizing using the Segmented or Additive strategies). While this presentation method was somewhat artificial, the participants appeared to adapt to the presentation method and seemed to have no problem with the task or reading from the computer screen. Each time new material was presented, participants heard four metronome clicks at  $\downarrow = 63$  and were instructed to practise at this tempo. Memorization sessions were recorded so the researcher could check that the participants had followed the treatment procedures.

When the participant indicated that the piece was memorized, the experimenter checked memorization accuracy. Memorization was deemed complete when the participant played one error-free performance of the piece for the experimenter. If the participant made an error during the performance, the participant was given the choice of another attempt at performing the piece from memory or returning to the treatment for additional memorization practice. Approximately half of the participants (53%,  $n = 21$ ) were unable to perform the piece from memory for the experimenter at first. Thirteen elected to return to the treatment and continue practising.

Once the exercise was memorized, participants performed a five-minute distractor task unrelated to the memorization experiment, but designed to discourage participants from rehearsing the memorized exercise during the retention interval. This task required participants to process short fragments of notation visually. A target fragment was presented for two seconds and participants were asked to recognize which of two lures were most similar to the target fragment. The task was timed and did not involve performing on an instrument.

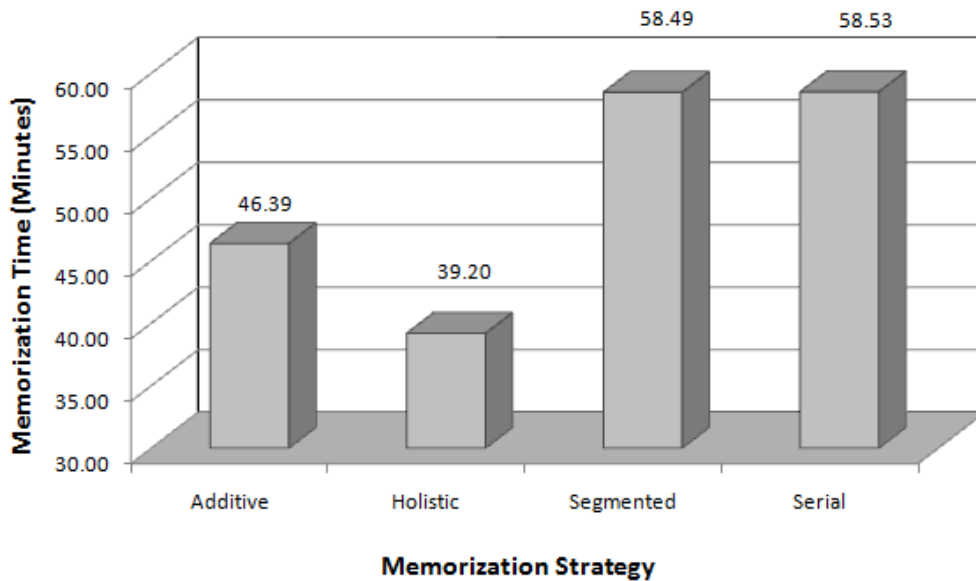
Following the five-minute retention interval, participants were asked to perform as much of the piece they had memorized as possible. They were encouraged to continue playing and skip material that could not be immediately recalled. Finally, the participants were asked whether the strategy utilized during the memorization process was similar to the memorization strategy the participant generally used to memorize music.

## RESULTS

All practice sessions were recorded. Data from one participant (Segmented treatment group) was lost due to a recording error and three participants (one in the Segmented treatment group and two in the Serial treatment group) did not finish memorizing the music. The participants who elected to stop the memorization process had all practised in excess of 60 minutes at the time the study was discontinued. Memorization times for these participants were not included in the data set, resulting in a total of 36 participants (Holistic  $n = 10$ ; Segmented  $n = 8$ ; Serial  $n = 8$ ; Additive  $n = 10$ .)

Total time to memorize the piece was determined based on the recordings. Memorization time was measured from the point at which the participants first saw any portion of the notated music (which coincided with metronome clicks clearly audible on the recordings) until the participants indicated the piece was memorized (an aural click was coded into the computer program to indicate when the participant announced that the piece was memorized.) The memorized performance for the experimenter was also timed and included in the total practice time. If participants were initially unsuccessful in performing the piece from memory for the experimenter, the unsuccessful attempts were also included as part of total memorization time.

Analysis of variance showed that there was a significant difference in memorization time between the strategies ( $F [3, 36] = 2.80, p = 0.05$ ). Post hoc analyses revealed the Holistic strategy produced significantly faster memorization times ( $M = 39.20$  minutes;  $SD = 17.84$ ) than either the Segmented ( $M = 58.49$  minutes,  $SD = 17.84$ ) or Serial strategies ( $M = 58.53$  minutes,  $SD = 19.36$ ), but not significantly faster memorization times than the Additive strategy ( $M = 46.39$  minutes,  $SD = 15.46$ ) (see Figure 1).



**Figure 2.** Mean memorization time and standard error by strategy.

There was no significant difference attributable to strategy between the number of errors made in the performance from memory following the retention interval ( $F [3, 33] = 0.51, p = 0.68$ ): Holistic ( $M = 3.00, SD = 2.35$ ); Segmented ( $M = 2.75, SD = 3.81$ ); Serial ( $M = 5.14, SD = 7.43$ ); Additive ( $M = 3.10, SD = 2.73$ ).

Six participants indicated a match between the memorization strategy randomly assigned for use in the study and the strategy they generally used to memorize music. Five of these participants were assigned to the Additive treatment group and one was assigned to the Holistic treatment group. This result was not surprising as most participants, regardless of treatment group, reported favouring the Additive strategy ( $n = 22, 59.46\%$ ). Fewer participants reported using the Segmented ( $n = 5, 13.51\%$ ) or Holistic ( $n = 4, 10.81\%$ ) strategies and only one participant ( $2.70\%$ ) reported using the Serial strategy. Five participants were uncertain of their preferred memorization strategy ( $13.51\%$ )<sup>1</sup>.

A Mann-Whitney U test was carried out to determine whether participants who reported using the memorization strategy to which they were randomly assigned benefited from the match either in memorization efficiency or in stability. Participants whose preferred memorization strategy matched the randomly assigned strategy did not memorize significantly faster than the other participants ( $U = 63.00, p = .45$ ). Additionally, no significant difference was found between the numbers of errors made during the delayed performance by participants whose memorization strategy matched and did not match the randomly assigned strategy ( $U = 72.5, p = 1.00$ ).

<sup>1</sup> It is not uncommon for musicians to report having no systematic memorization approach. Mishra (2007) found that 22% of musicians did not use a systematic memorization strategy and Shockley (1980) reported that 44% of college musicians reported no systematic memorization strategy. It is likely that these musicians have a system of which they are unaware or are unsystematic in their memorization practice

## DISCUSSION

The purpose of this study was to investigate experimentally the effectiveness of four memorization strategies: Holistic, Segmented, Serial, and Additive. Each strategy was used successfully to memorize a notated piece of music, but this study investigated whether one or more strategies was more effective, based on how efficiently the musical material could be encoded and the stability of the memory trace.

### *Memorization efficiency*

Musicians using a Holistic strategy, where the short exercise was performed repeatedly from the beginning to the end, memorized more efficiently than musicians using both the Segmented Strategy, where small segments of the exercise were isolated for practice, and the Serial Strategy, which involved returning to the beginning of the exercise following an error or a memory slip. The results may reflect the ability of musicians using the Holistic strategy to form a complete mental picture of the piece, understanding the exercise as a whole. In contrast, those using Segmented or Serial strategies may have focused their attention on discrete fragments, ignoring large parts of the piece. Segmenting the piece, especially when the segments were very short (e.g. only two bars) and did not highlight its formal structure, impeded the development of a mental representation and therefore the musician's understanding of the piece. Musicians using a Serial strategy may have focused on errors and memory slips rather than on understanding the piece as a whole and it is possible that those using this strategy did not even attempt to understand why the error occurred or to place the problematic section into the context of the piece. In the Holistic strategy, the musician noted errors, but these errors were not allowed to impede progress towards the end of the piece. Mishra (2002) observed that, in a naturalistic environment, musicians using a Holistic strategy might stop and regress slightly at the point of an error, but seemed to perform through the error to the end of the piece. The Additive strategy also entails stopping prior to the end of the piece, but involves adding new material to that previously memorized, creating a new "whole" – a new understanding of the piece. New material is not practised in isolation, as it is when using a Segmented strategy, but is connected to previously learned material.

In addition to disrupting understanding, kinaesthetic flow may also be impeded when using the Segmented or Serial strategy. Stopping a pattern of movement, particularly at an arbitrary point, disrupts the automatization of the movement that is required, ultimately, for performance. In Mishra's (2002) study, musicians using the Segmented strategy spent a great deal of time practising the transitions between segments.

Every attempt was made to control the memorization strategy used by the participants experimentally; however, it should be noted that it is possible that participants using the Segmented strategy may have been using a cognitive strategy to make transitions from one segment to the next, and those using the Holistic strategy may have nevertheless thought of the piece in sections. Practice sessions were recorded so as to be able to check, as far as possible, that the participants had used their assigned strategy. There was no obvious evidence from the performances that the participants had used a strategy other than the one assigned.

For the purposes of control, the exercise used for this study was very short and technically simple for the participants. Thus, the results of this study do not necessarily apply to the memorization of longer, more technically challenging pieces of music. Also, it may be inferred incorrectly that the Holistic and Segmented strategies are mutually exclusive: a musician either memorizes using a Holistic Strategy or memorizes using a Segmented strategy. Yet, while expert musicians often report segmenting a piece (a less efficient memorization strategy), observational data suggest that actually they alternate strategies to achieve optimal results (Chaffin & Imreh, 2000; Chaffin, Imreh, & Crawford, 2002; Hallam 1997; Miklaszewski, 1989; Miklaszewski, 1995; Williamon 1999). Chaffin and Imreh (2000) provide evidence from changes in segment length over the course of practice that “work” and “runs” develop differently, indicating two distinct types of practice. Also, experts appear to partition a piece for practice; starting with smaller sections for more difficult sections and lengthening them as technical aspects become easier (Chaffin & Imreh, 2000; Miklaszewski, 1989; Nielsen, 1999). For a more technically challenging piece, isolating sections may be necessary to overcome technical concerns, but the play-throughs mediate the isolation, allowing the musician to form an understanding of the piece as a whole. Further, expert musicians also segment meaningfully, often choosing segments based on the formal structure of the piece. A rigid segmentation of the piece for memorization (size of section and number of repetitions) is inefficient and boring, leading to mindless and passive rehearsal, neither of which is conducive to efficient memorization. Additional research is needed to determine whether alternating Holistic and Segmented strategies leads to optimal efficiency when memorizing longer, more technically challenging pieces.

The large standard deviations in memorizing times for all strategies, ranging between 15.46 minutes for the Additive strategy and 19.36 minutes for the Serial strategy, indicate a wide variability in the time needed to memorize the same piece of music using each of the strategies. This variability suggests that other factors may influence memorization efficiency. When piece and strategy are held constant, the characteristics and/or experiences of the musician may influence the amount of time required to memorize notated music.

Little is known about the use of these four memorization strategies among musicians. The frequency of use especially of the Serial strategy has not been investigated empirically. Regrettably, this strategy may be in common use, especially among younger, less experienced performers. Teachers of younger students should note when a student is using a Serial strategy and encourage the student to continue playing to the end of the piece or large section, regressing only a couple of notes or measures before continuing rather than returning to the beginning for another attempt. Teachers should also discourage the mindless repetition of musically meaningless segments. Younger students may attempt to drive the music into memory by sheer force of repetition. This strategy is exceedingly inefficient. Students should be encouraged to understand the piece as a whole, segmenting when technical difficulties arise, but always interspersing segmented with holistic practice.

### *Stability of recall following memorization*

No significant differences were found between the numbers of errors made after a five-minute retention interval attributable to use of memorization strategy. This measure was included since a strategy may be efficient but unstable in that memorization time is shorter

but more errors are made. At this time, no evidence exists to question the stability of any of the memorization strategies, but the higher average and standard deviation for errors made by musicians using the Serial strategy suggests that future research is necessary to determine whether use of this strategy could result in more errors in performance. The five-minute retention interval used in the present study to test long-term memory, although considered long enough in the psychological literature, is much shorter than that used when actually memorizing music for a performance. Other researchers have explored the long-term recall of performers (e.g. Ginsborg & Chaffin, 2009; Ginsborg & Chaffin, 2011) involving memories for musical works that have been stored but also re-encoded over an extended period: months and years. It is possible that the effects on the stability (or otherwise) of memory of one or more of the strategies tested in the present study would only become evident in a more naturalistic musical situation.

### CONCLUSION

The results of this experimental study confirm the results of an earlier observational study (Mishra, 2002). Memorization efficiency was affected by the strategy employed. Practising a piece from beginning to end (Holistic strategy) allowed musicians to memorize a short, technically simple piece of music faster than segmenting it. The important element of Holistic practice is playing until the end of the piece even if memory or technique is disrupted temporarily. The Serial strategy involves returning to the beginning when an error or memory slip interferes with practice, rather than pushing through to the end. This is the least efficient strategy and questions remain as to the stability of the memory obtained through this approach. Most musicians reported using an Additive strategy and while this strategy was more efficient than either the Segmented or Serial strategy, it was less efficient than the Holistic strategy.

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