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The Effects of Rhythm Versus Visual Images on Working Memory Recall

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By

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Abstract

In the current study, the researcher aimed to examine the interaction between the independent variable of mnemonic modalities (visual images versus auditory rhythms) and working memory recall. Previous research indicates that information encodes better when presented with rhythm compared to a no-rhythm condition. This suggests that rhythm acts as a mnemonic, or a memory aid. However, across the numerous studies on rhythm and memory, rhythm's effectiveness on memory retention has not been compared to the effectiveness of more commonly used mnemonics, such as images. The researcher hypothesized that the auditory rhythm condition would produce better working memory recall compared to the visual images condition. Participants for this study included 11 undergraduate students at Western Oregon University. In Learning Condition A, participants learned ten words in Estonian and their associated English meaning, paired with images related to each word shown. In Learning Condition B, participants learned the same list, paired with a rhythm. After a short distraction, participants in both conditions were asked to recall the English meanings. The difference between the two conditions was significant, $t(10) = 3.184$, $p < .05$, supporting visuals as the better mnemonic device, leading the researcher to fail to reject the null. Future research should include more participants.

Keywords: rhythm, working memory, mnemonics

The Effects of Rhythm Versus Visual Images on Memory Recall

The positive effect of auditory rhythm on increasing recall in working memory has been supported through recent studies. Previous research indicates that information encodes better when presented rhythmically compared to no-rhythm conditions (Collier & Logan, 2000). The timing of when a piece of information occurs in a rhythm pattern creates a cue to recall that information (Collier & Logan, 2000). This suggests that rhythm acts as a mnemonic device, or a memory aid. Auditory learning in general also has an advantage in memory, using less cognitive load than when learning through visuals (Rummer, Schweppe, Fürstenberg, Seufert, & Brünken, 2010). In turn, learning auditorily may lead to a greater recall of information (Rummer et al., 2010). A possible explanation for this phenomenon is the Auditory Recency Effect. This effect suggests that when a person hears information, there is an echo effect through the phonological loop that holds the most recently spoken information in the person's mind for longer than visual information (Rummer et al., 2010). The modality effect is also a commonly studied and discussed effect in the realm of rhythm and memory. The modality effect describes the increase of information which can be held in memory when one piece of information is provided visually and the other auditorily (Rummer et al., 2010; Schüler, Scheiter, & van Genuchten, 2011; Wang, Allen, Fang, & Li, 2017). However, across the numerous studies on rhythm and memory, the effectiveness of rhythm on memory retention has not been compared to the effectiveness of more commonly used mnemonic devices, such as the use of visual images.

Silverman (2012) examined the effects of rhythmic melodies and nonrhythmic melodies on working memory. He hypothesized that adding a rhythm component would aid in working memory recall ability. To test this, Silverman presented six sung recordings of 9-digit sequences, with no number repeating within each sequence, then, after each list,

participants wrote the numbers in the order presented to the best of their ability. The results supported Silverman's hypothesis: recall ability was higher in rhythm conditions than in non-rhythm conditions This outcome indicates that rhythm, regardless of melody, may promote recall of information in working memory.

Hartley, Hurlstone, and Hitch (2016) analyzed the effects of rhythm on memory for spoken item sequences. They hypothesized that an increase in working memory recall would occur if rhythm was used. With the independent variable of rhythm predictability and the dependent variable of rhythm recall, the experimenters used a between-subjects design. In the first condition, participants were to memorize a list of predictably grouped items that were read aloud with simple temporal rhythms. The second condition consisted of an unpredictable pattern of items within the list, still read to a rhythm. The third condition also had an unpredictable list but was read without rhythm. The findings supported that rhythm is linked to better retention of lists. In the first two conditions, participants were able to accurately recall the rhythms, with little variance between conditions. It is in the third condition, the only non-rhythmic condition, that the researchers found a significant decrease in participant recall. These findings imply that memory recall is based on the timing of spoken items as they occur, or in other words, rhythm of speech.

Rummer et al. (2010) conducted cross-modal research with the two modes of images and auditory cues. The researchers discussed the modality effect: memory retention is increased when images are paired with auditory texts rather than visual texts. The modality effect claims that auditory texts and pictures can be processed at the same time. A related hypothesis, the visuo-spatial load hypothesis, suggests that the modality effect is accounted for by relieving the greater strain two visual inputs have on the visuo-spatial system (Moreno & Mayer, 1999). However, it is also suggested that both auditory and visual text are

processed by the same system: the phonological loop. This contradicts the visuo-spatial hypothesis by suggesting that auditory and visual text are not processed at the same time with two different systems, but by the same system, thus increasing cognitive load. Rummer and associates (2010) addressed this discrepancy between the two models and predicted that there would be an interaction between text modality (auditory or visual) and picture complexity. However, for shorter texts the auditory recency effect would occur, and modality would not be affected by image complexity.

Rummer et al. (2010) conducted two between-subjects experiments with an independent variable of text modality and a dependent variable of working memory load. Experiment 1 included simple single-color images paired with unrelated sentences. The participants listened to the sentences while viewing the image, and then recalled the sentence as correctly as possible. In the visual condition, the image was presented for the same amount of time that the auditory sentence was read to them. Experiment 2 tested recognition accuracy by displaying complex images and then text. In the second condition, the text sentence was displayed word-by-word instead of all at once. In the third condition, a sentence was read to the participant. The participant had to indicate whether the image was the same as the last and recall the content of the sentence. The participants in the first experiment were able to accurately recall the sentences that they were asked to memorize with no interference from the image in both conditions.

Rummer et al.'s (2010) experiment suggests that the auditory advantage is present regardless of the working memory load of the visuo-spatial system. These findings support the second half of the researchers' hypothesis, suggesting that the auditory recency effect occurred. The second experiment revealed that participants had decreased complex image recognition after a whole sentence was displayed with the image versus one word at a time

displayed with the image or listening to the sentence being read. This supports the researchers' first part of the hypothesis: the way that the text was presented (sentence, one word at a time, or auditorily) interacted with participants' ability to recall the complex pictures. When the sentence was displayed as a whole, the meaning of it interfered with image recall. The researchers suggest for future researchers to examine the effects of the working memory model using simple multimodal materials, and then using more complex materials.

Tierney and Kraus (2015) researched several different rhythmic skills, including rhythm memory/sequencing and beat-tapping. Prior research suggests that rhythm skills are associated with language skills (Strait, Hornickel, & Kraus, 2011; Wallentin, Nielsen, Friis-Olivarius, Vuust, C., & Vuust, P., 2010). Rhythm in speech determines word boundaries and linguistic stress in any given language. Verbal working memory in particular utilizes the skill of rhythm discrimination. Tierney and Kraus found a lack of understanding within existing research on how or if the different rhythm skills interact with one another. They wanted to investigate if there are multiple independent rhythm skills, or if all rhythm skills are linked together. Therefore, it was hypothesized that beat-tapping would represent a cluster of rhythm skills separate from memory with rhythm which represents another cluster of rhythm skills. With the independent variable of rhythm temporal intervals, they tested the effects on the dependent variable of participants' rhythm skills.

With 67 participants in a within-subjects design, Tierney and Kraus (2015) measured participants' ability to reproduce rhythm. In order to record data, a sensor was attached to the underside of a drum that participants used to beat out rhythm. For the first test, involving beat-tapping to a metronome, six trials of beats with a set interval rhythm between beats in each trial were presented. Participants were given time to synchronize their beats

before being measured for accuracy in rhythms. Tempo adaptation was tested similarly, with 55 trials of changing rhythms within and between each trial. To test memory and sequencing of rhythms, four trials were used with a recorded sequence of drumming that participants were asked to reproduce.

Tierney and Kraus (2015) found that those participants who could consistently synchronize their drum beats were also able to adapt to a changing rhythm the best, suggesting that these two skills are linked under beat-tapping. They also found that participants who could remember rhythms and reproduce them are better at drumming along to those rhythms, suggesting that these two skills are associated with the memory/sequencing rhythm skill set. Ultimately, their hypothesis was supported in that there was no relationship between beat-tapping and memory/sequencing tests, but skills that they predicted to cluster under beat-tapping or memory/sequencing did correlate. The patterns that rhythm creates and the perception of these patterns takes up less cognitive load. This aspect from the memory and sequence tests supports that rhythm impacts the cognitive processes of memorization, which supports the hypothesis of the current study. Tierney and Kraus (2015) suggest that future researchers should examine how language relies on rhythm using the two rhythm skills discovered.

Collier and Logan (2000) examined whether participants would be able to simulate auditory or visual rhythms at a more successful rate and if temporal differences changed recall ability. Previous research suggests that information retention is increased for auditory rhythm versus auditory non-rhythm when encoding information. The same is true with auditory rhythm versus visual rhythm. Auditory rhythms were also found to increase memory recall specifically when intervals were kept simple. However, controversy remains regarding whether rhythm and language are related and involve similar cognitive processes.

Collier and Logan hypothesized that participants would be able to simulate auditory rhythms more successfully than visual ones. To test the independent variable of rhythm modality, the experimenters used a within-subjects design for auditory and visual rhythms. Using seven intervals each, the visual rhythms were presented as light flashes and the auditory ones as beeps. Participants marked whether the rhythm sequence was the same or different throughout the 72 trials. In the next experiments, the researchers attempted to negate the auditory advantage by changing the structure of the auditory rhythms; however, the advantage was still present. The researchers' hypothesis was supported: participants did simulate auditory rhythms more accurately than visual rhythms. Collier and Logan's (2000) study indicates that our brains more successfully encode auditory rhythms than visual rhythms in working memory.

The studies mentioned above examined the effect of rhythm on memory, rhythm versus non-rhythm, rhythm in spoken sequences, the modality effect, rhythm skills, and auditory versus visual rhythms. However, researchers have yet to compare the effectiveness of rhythm to the effectiveness of other common mnemonic devices on the increase of recalled information. The use of visual images, a common mnemonic in memorization, has also been found to increase working memory recall over information with no images due to visual working memory (Liu & Jiang, 2005; Veksler et al., 2017). 10. The current study aimed to examine the interaction between the independent variable of mnemonic modalities (visual images versus auditory rhythms) and working memory recall. 11. The researcher hypothesized that participants in the auditory rhythm condition would have better working memory recall scores than those in the visual images condition.

Method

Participants

Participants for this study were undergraduate students at Western Oregon University (WOU) who volunteered using the WOU subject pool software system (SONA) after viewing a brief description of the study. Exclusionary criteria included all those who knew Estonian, had clinically diagnosed memory issues, or were not fluent English speakers. This study included 11 participants, 8 of which were female, with a mode age range of 18-24 years. The majority (54.5%) were Caucasian (36.4% Hispanic/Latino, 9.1% Black/African-American). Participants received credit towards psychology courses for their participation.

Materials

Informed consent forms provided information on the procedure, benefits and risks of participating, an explanation of how to acquire the results of the research, availability of counseling services, voluntary participation, and contact information for the researcher. Demographic questionnaires were printed, including questions of gender, age, and race. A list of ten simple Estonian words (see Appendix A) was compiled by the experimenter, along with the pictures used in Condition A (see Appendix B). An iPhone XR was used to voice record the researcher reading the list of words for both conditions and to play back the recording for the participants. A Lenovo laptop was used to play the YouTube video "Guy dresses up as dog's favorite toy ORIGINAL" as a distractor in both conditions. A Pilot ballpoint black pen was provided along with the printed list of Estonian words to test meaning recall. The experimenter created PowerPoint presentations on which to present the list of ten words (with and without pictures). A debriefing form was provided afterwards.

Procedure

The participants began by reading and signing an informed consent form. They then filled out the demographic questionnaire. In a between-subjects design, the participants were then randomly assigned to the Visual Learning Condition (Condition A) or Rhythm Learning Condition (Condition B) by drawing one of those two conditions out of a sandwich bag.

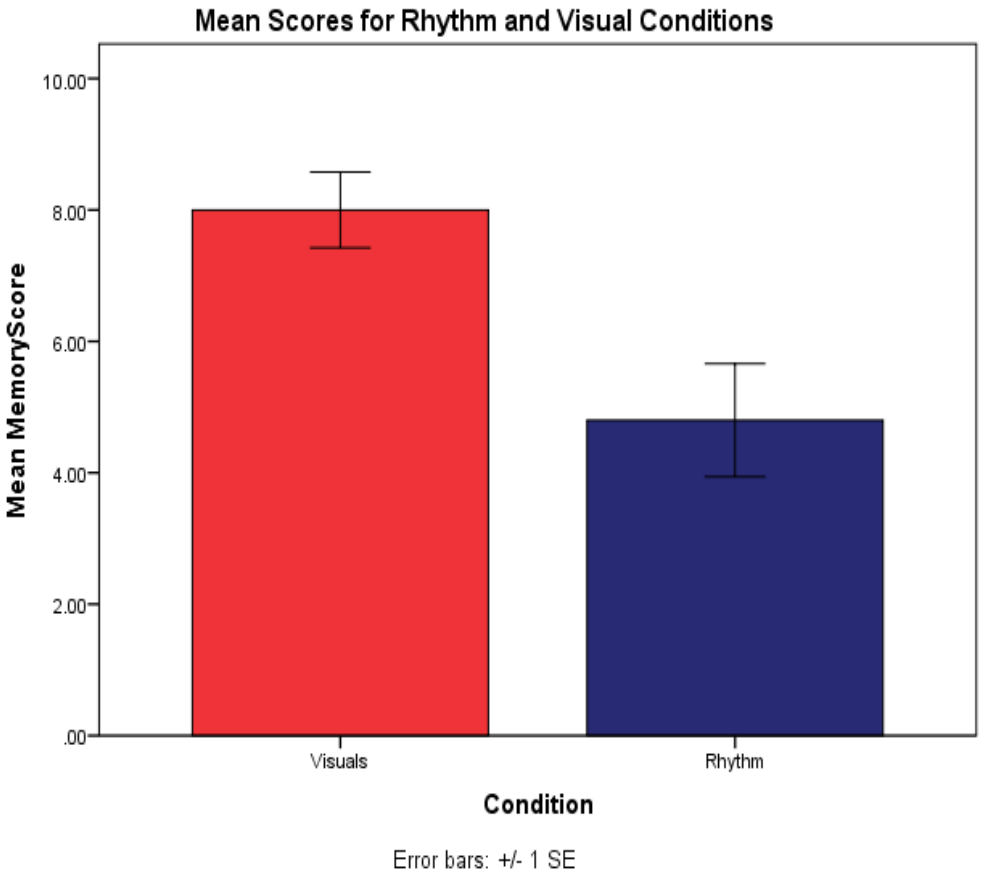
In Learning Condition A, participants learned ten words in Estonian and their associated English meaning (Appendix A), paired with images on a PowerPoint related to each word shown (Appendix B). The words and meanings were read to them in monotone without rhythm on a voice recording. Estonian was chosen because it is an uncommon language in the United States, it does not have many cognates with English, but still uses a similar alphabet. Participants then experienced a distraction in the form of watching the YouTube video: "Guy dresses up as dog's favorite toy ORIGINAL". The dependent variable was then assessed by giving the participant the list of words in Estonian and asking them to recall the English meaning.

In Learning Condition B, participants learned the same list of ten words in Estonian with their associated English meanings, paired with a rhythm tapped out in the voice recording by the YouTube video "120 BPM (Beats Per Minute) Metronome Click Track" to create a consistent-interval rhythm for the words and meanings to be read. They then followed the same procedure as Learning Condition A for the distraction and recall. At the end, all participants were given a debriefing form stating the purpose of the study and variables that were being tested. Each participant was granted class credit through SONA. Confidentiality was ensured through immediate filing of participant information into a manila envelope kept by the researcher, with no names or identifiable information included.

Results

The participants who were shown the visual images had higher memory recall of the English meanings from the word list (M = 8, SD = 1.41), than those who listened to the English meanings at a rhythm (M = 4.8, SD = 1.92). The mean difference was significant, $t(10) = 3.184$, $p < .05$, $r^2 = .24$. See figure 1 for the graphed results.

Figure 1. Mean Scores for Rhythm and Visual Conditions



Discussion

How the mind encodes and recalls information is an ongoing field of study. As researchers discover additional ways the brain successfully encodes information, it is important to compare the effectiveness of these strategies to each other. This is done to find the most effective methods for learning. This study aimed to compare the effectiveness of

two mnemonic devices: visual images and auditory rhythm. The data for the current study indicate that visual images are a more effective mnemonic for working memory recall than rhythm. Although a significant difference was found between the two conditions, the leading condition was contrary to the hypothesis, as the participants in the visual image condition had a higher mean score than those in the rhythm condition, indicating that rhythm is not as effective as the more commonly used mnemonic of visual images. Before this study, the effectiveness of rhythm as a mnemonic and visual images as a mnemonic have been studied separately, but never compared. This is the first study to suggest that rhythm as a mnemonic device, although better at encoding information than non-rhythm, is not as effective at memory recall as visual images. These findings are still important in learning research, however, suggesting that rhythm should not be given equal weight in the memorization process, and more focus should remain on using visual images to encode information into memory.

Some limitations were present in this study, which should be addressed in future research. Even though a significant difference was found, the sample size of 11 was too small to have strong generalizability. As small sample sizes are more affected by outliers than large ones, future researchers should replicate this study with more participants for results that are more representative of the population. Further, the regression analysis found that only 24% of the variability is explained by the mean for the visual condition. This low number indicates that there is much variability for the scores in that condition and a type I error may have occurred.

Additionally, a design flaw may have influenced the outcome. The modality effect was present in Condition A, as these participants learned the words' meanings through both auditory and visual systems (visual images and the auditory English meaning). Visual and

auditory information is processed by different modalities in the brain (Rummer et al., 2010). Condition B did not have this advantage, as they only learned the meaning of the words through one modality: the auditory system. This could be a reason why the visual condition had significantly higher scores than the rhythm condition. Future researchers should take the modality effect into consideration when designing the various conditions to examine.

Appendix A

Words in Estonian (pronunciation in parentheses) with associated English terms:

- Tere (Tare-a)/Hello
- Ema (eh-ma)/Mother
- Laud (Low-d)/Table
- Puu (poo)/Tree
- Poiss (Poy-s-s)/Boy
- Lind (L-in)/Bird
- Küünal (Koo-nal)/Candle
- Toit (Toy)/Food
- Koolis (K-O-lys)/School
- Raamat (Rah-mat)/Book

Appendix B

Hello:

Mother:

Table:

Tree:

Boy:

Bird:

Candle:

Food:

School:

Book:

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