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The Phonological Loop and Articulatory Suppression

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ABSTRACT

The researchers designed this study to demonstrate the role played by the phonological loop as defined by Baddeley's model of working memory (2000). The operation of the phonological loop can be disrupted by oral repetition of sounds while attempting to utilize working memory, a task known as articulatory suppression. The study utilized a between-group, experimental design to demonstrate the effectiveness of articulatory suppression for reducing accuracy of serial recall of a visually presented list of phonologically dissimilar letters.

Keywords: phonological loop, working memory, articulatory suppression

INTRODUCTION

Baddeley's Multimodal Working Memory Model

Working memory refers to a cognitive system through which information gathered from the perceptual organs and stored memories can be utilized to accomplish a variety of tasks. Baddeley and Hitch (1974) proposed a multimodal working memory model which has been the

prevailing theory of how working memory is constructed and functions since its proposal. This model proposes that working memory can be conceptualized as a system composed of several subsystems, each one responsible for manipulating a certain type of information, or coordinating the effort. Furthermore, the model posits that each subsystem can only handle a limited amount of information, and each acts independently of the other, barring the central executive.

The original model consisted of three distinct branches: the central executive, the visuospatial sketchpad, and the phonological loop. The central executive functions as the control center, determining how information stored in the slave systems combines and gets utilized. The visuospatial sketchpad stores visual and spatial information collected from external stimuli, while the phonological loop stores auditory and speech information gathered from the outside world. More recently, the episodic buffer has been added to the model by Baddeley (2000). The episodic buffer serves as a repository for retrieved episodic memory, whose content serves as an additional slave system subject to control by the central executive. The present study mainly concerns itself with the phonological loop.

The Phonological Loop

As stated above, the phonological loop primarily functions as a storage container for auditory and speech based information. Current research has identified two separate components which make up the phonological loop: the phonological store and the articulatory rehearsal process (Buchsbaum & D'Esposito, 2008). These two components act collectively to keep auditory information fresh and useable for cognitive tasks. The phonological store functions as a passive storage system for information kept viable in working memory through active repetition by the articulatory rehearsal process. Information stored in the phonological store appears to rapidly decay every two seconds unless the articulatory rehearsal process continues to refresh the

store. The phonological loop can store information either perceived as auditory information, or through the mental vocalization of written materials (Jones, Macken, & Nicholls, 2004).

Evidence for the conversion of written text into auditory information, and for the rehearsal function of acoustic information of the articulatory rehearsal process, in part come from the existence of the phonological similarity effect, which describes how people more accurately recall phonologically dissimilar words when compared to phonologically similar words. This effect has been confirmed by numerous studies, including Lobley, Baddeley, and Gathercole's (2005) finding that people recalled short sentences concluded with phonologically similar words less accurately than sentences ended with phonologically dissimilar words, Nimmo and Roodenry's (2005) finding that people recalled the letter order of three letter word and non-word lists (for example, CVC) less accurately if the lists contained phonologically similar items when compared to phonologically dissimilar items, and Lian, Karlsen, and Winsvold's (2001) finding that phonological similarity impaired the serial recall accuracy of both words and non-words when compared to phonologically dissimilar items. Another popular method used to research the phonological loop is called articulatory suppression.

Articulatory Suppression

Articulatory suppression refers to the repetition of verbal information (i.e. repeating a word such as "the", or a number such as "one") as a concurrent task to actively attempting to memorize a list of information (Alloway, Kerr, & Langheinrich, 2010). This concurrent task decreases accuracy of recall of phonologically stored information by disrupting the repetition of the information by the articulatory rehearsal process. Whereas the phonological similarity effect decreases accuracy because of the rehearsal of similarly sounding items overlapping and jumbling up the words, articulatory suppression overloads the rehearsal process, rendering

working memory unable to retain relevant phonological information. Numerous studies have been conducted proving the effectiveness of articulatory suppression, including a study by Larsen and Baddeley (2003) which showed that articulatory suppression more effectively reduced accuracy of recall of phonologically dissimilar words when compared to phonologically similar words (thereby displaying the confounding influence of the phonological similarity effect) and another study by Alloway, Kerr, and Langheinrich (2010) which showed that the accuracy of recall rate shows a negative correlation with complexity of articulatory suppression task.

The aim of the present study was to reproduce the effect of articulatory suppression on serial recall of a written list of phonologically dissimilar letters. Phonologically dissimilar letters were used in order to avoid the confounding nature of the phonological similarity effect, in order to illustrate the most marked effect of articulatory suppression on serial recall. The experiment utilized two groups: a control group which performs no concurrent task while memorizing a list and an experimental group which performs the concurrent task of articulatory suppression while memorizing a list. The experimenter hypothesized that the percent accuracy of serial recall would be higher, on average, in the control group versus the experimental group.

METHOD

Participants

Thirty-four students from the McNeese State University undergraduate psychology subject pool participated in the study to earn bonus points or to fulfill course requirements.

Design

The study utilized a between-group, experimental design with the experimental group engaged in articulatory suppression after letter list presentation and the control group not

engaging in articulatory suppression following letter list presentation. The performance measure was generated by averaging the percent accuracy of recall across all 10 trials each participant underwent. The experimenter generated the percent accuracy of recall for each trial by dividing the number of correctly filled in blanks by 7. After generating 10 different measures for each partipant, the experimenter averaged these together to generate a single performance measure.

Materials

The experiment utilized a series of letter lists, all 7 letters long, randomly constructed from the letters F, K, L, M, R, X, and Q. These letters were adapted from Neath, Farley, and Surprenant (2003) because of their phonological dissimilarity which enabled the researcher to reduce any influence of the phonological similarity effect which could cause participant accuracy of recall to be lower. The experimenter presented one letter series per page so that the participant would not be distracted by other lists. The participants received an answer sheet for reporting back the lists which were numbered 1-10, with 7 blanks in each row.

Procedure

Participants received testing individually for only one of the two conditions (control and experimental). The experimenter randomly assigned each participant to one of the two groups, which each numbered seventeen individuals. In order to become acquainted with the procedure, participants in both groups viewed one practice list. In the control group, the experimenter showed participants a printed list for 5 seconds, instructed them to wait for 5 seconds, and then instructed them to report back, through writing as accurately as possible, the correct order of the letters on the answer sheet. Each participant repeated the procedure for 10 trials. In the experimental group, participants received instruction to repeatedly vocalize the numbers “1” and “2” at a rate of 2 numbers per second from the time of presentation of the list, to the time they

filled in the answer sheet. Again, each participant repeated the procedure for 10 trials. The experimenter closely monitored the rate of repetition of the numbers 1 and 2, and reminded the participants to continue repeating the numbers if they stopped, or to speed up or slow down as needed.

Each trial received scoring for accuracy. The experimenter counted the trial as correct if they contained the correct letters in the correct position. The experimenter then compared the average correct percent of recall for both the experimental and control groups.

RESULTS

Data from participants in the experimental group who concurrently performed articulatory suppression during the memorization process was much lower than the data collected from the control group. Despite the large difference in means, the standard deviations appear nearly identical. The experimenter performed a *t*-test between the control ($M = .76$, $SD = .13$) and experimental group ($M = .45$, $SD = .14$) which confirmed the presence of a significant difference, $t(32df) = -6.51$, $p < .01$.

DISCUSSION

As hypothesized the experiment yielded results which showed that the mean percent of accurate recall of the control group (0.76) differed significantly, and was higher than, the mean percent of accurate recall of the experimental group (0.45). The data appears to support Baddeley's model of working memory, by demonstrating that disruption of the phonological loop, through administration of articulatory suppression, results in less accurate working memory. Articulatory suppression overloaded the rehearsal capability of each participant's phonological loop, causing them much greater difficulty in memorizing and reporting back the letters than participants who did not engage in articulatory suppression.

Overall the experiment panned out without a hitch. One suggestion for future lines of research could focus on determining whether the loss of accuracy of recall scales with difficulty of articulatory suppression task. For example, it would be interesting to investigate whether participants viewing letter lists would have lower accuracy recall when required to verbalize three numbers instead of two, four numbers instead of three, and so on. Another possible future line of research could focus on how the letters were administered. Perhaps if the participants heard the letters spoken aloud rather than presented visually, the percent accuracy of recall under articulatory suppression conditions would give lower scores because the participant would not have the advantage of using their visuospatial sketchpad as it seems they would when the letters appear visually.

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