Is it more effective to study while sitting still or while participating in repetitive motion?

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Introduction

Studying is one of the many activities on which college students spend a lot of time. Study strategies include matching study and test environments, generating study guides and practice tests, elaborative rehearsal of information, and much more. Despite the large array of currently available study methods, students are always searching for new and more effective techniques. Is it possible that something as simple as repetitive motion, in the form of tossing a stress ball, could cause improvements in memory and reading comprehension? Or is it more effective for an individual to sit still and not get distracted by tossing a ball? The purpose of this study was to determine if repetitive motion during encoding, or the mental storage of information being studied, leads to memory gains and improved performance on cognitive tasks.

Eye tracking coupled with cognitive measurements (reading comprehension tests, verbal tests) has been demonstrated to be a good procedure for determining the attention allocated during encoding of visually presented information and the learning such attention produces (Hyona, 2010). In the current experiment, electrooculograms (EOGs) were performed to assess
the variation of eye movements and to record number of saccades to ensure that repetitive motion did not cause a major disruption in the subjects’ ability to read, study, and attend to visual information.

Some researchers believe that the body, in addition to the brain, is very important in higher level cognitive functioning such as listening to music, forming memories, and thinking (Seitz, 2000). Clinical evidence for the involvement of the motor system in cognitive functioning stems from Duchenne’s Muscular Dystrophy (DMD) patients. Young DMD patients may have developmental language delays and difficulty in school before muscular weakness is even observed, suggesting that neural connections exist between motor neurons and neurons associated with learning, development, and cognitive processing (Iannaccone, 2007).

Additionally, direct effects of muscle movement on task performance and emotion have been found in recent years. Men who participated in repeated muscle flexion typically had larger levels of fun-seeking motivation (approach system activation) and exhibited greater persistence on a difficult lab task than women (Haeffal, 2011). Despite the gender difference in this particular task, it appears that repetitive movement can affect certain types of cognition and higher level processing. This experiment was done to analyze the effects of repetitive motion on memory and reading comprehension, in particular.

Materials and Methods

Ten Wofford College students, 5 males and 5 females, from the age of 18-22 participated in this study. After providing consent, the students were tested in the Neuroscience lab of Wofford College for 30 minutes.
An EOG machine was utilized during the encoding phases of the study (list study and reading) to measure each subject’s saccadic eye movements and variability of eye movement. Electrodes were placed around the eyes as shown in Figure 1, after the subjects wiped their faces with an alcohol pad. Before testing could begin, the EOG equipment was calibrated as outlined in the Biopac EOG instructions.

![Figure 1. Proper placement of EOG electrodes.](image)

Subjects were given 90 seconds to memorize a list of 24 words presented on a computer screen. They were then asked to read two SAT reading comprehension passages on the computer. Four lines of approximately equal length were identified in each passage. The number of saccades was counted for each selected line. After reading each passage, subjects answered seven to eight questions pertaining to the passage. Subjects were instructed to read the passages carefully, since they were not allowed to refer back to the passages when answering the questions. Upon completion of the two reading comprehension passages and their respective test questions, subjects were told to recall the words from the list they had previously studied. The above procedure, from list study to list recall, was repeated a second time with new words and passages. The effects of repetitive movement were assessed at several points throughout the procedure. The repetitive movement consisted of subjects continuously tossing a stress ball while studying a list of words or reading a passage. The order of ball and no ball conditions was
randomized and is outlined in Table 1. After data was collected and properly organized, all statistical analyses were performed using SPSS software.

Table 1. Experimental condition (ball or no ball) for each subject during various tasks.

<table>
<thead>
<tr>
<th>Task</th>
<th>Ss 1-5 Condition (Order 1)</th>
<th>Ss 1-6 Condition (Order 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>List 1 study (1:30)</td>
<td>Toss ball</td>
<td>No ball</td>
</tr>
<tr>
<td><strong>Reading Comprehension 1</strong></td>
<td>Toss ball</td>
<td>No ball</td>
</tr>
<tr>
<td><strong>Reading Comprehension 2</strong></td>
<td>No ball</td>
<td>Toss ball</td>
</tr>
<tr>
<td>List 2 study (1:30)</td>
<td>No ball</td>
<td>Toss ball</td>
</tr>
<tr>
<td><strong>Reading Comprehension 3</strong></td>
<td>No ball</td>
<td>Toss ball</td>
</tr>
<tr>
<td><strong>Reading Comprehension 4</strong></td>
<td>Toss ball</td>
<td>No ball</td>
</tr>
</tbody>
</table>

Results

From the behavioral data, there was no effect of experimental condition (ball toss vs. no ball toss) on number of words recalled, F (1,8)=0.006, p=0.943, meaning that repetitive motion did not lead to a change in the amount of words that can be remembered and recalled (See Figure 2). There was a significant interaction between order and passage, F (1,8)=5.556, p=0.046, meaning that if the ball is not thrown until the second reading comprehension passage, then the subject is likely to miss more questions related to that passage (See Figure 3). This would suggest that it may be necessary for repetitive motion to be initiated at the commencement of reading or learning tasks for it to have observable effects. A significant interaction was also observed between experimental condition, passage number, and order, F (1,8)=9.093, p=0.017, which seems to further support that repetitive motion should be initiated at the commencement of reading to have an effect. The data also suggests that repetitive motion may have negative
effects on reading comprehension if not initiated at the beginning of a study session (See Figure 4).

**Figure 2.** Average number of words recalled after study phases that involved tossing a ball or sitting still.

**Figure 3.** Average number of incorrect answers on a reading comprehension test based upon order and passage number. Red= Order 1 (Subjects 1-5); Blue= Order 2 (Subjects 6-10); See Table 1 for the order in which subjects tossed the ball. Passage 1= With Ball; Passage 2= No ball.
Figure 4. Average number of incorrect answers on a reading comprehension test based upon the experimental condition and passage number. Red= Order 1 (Subjects 1-5); Blue= Order 2 (Subjects 6-10); See Table 1 for the order in which the subjects tossed the ball.

From the physiological data, there was no main effect of experimental condition on horizontal standard deviation, $F(1,8)=1.089$, $p=0.327$, or vertical standard deviation $F(1,8)=0.836$, $p=0.387$, meaning that there was not a large amount of variability in eye movement between experimental conditions while studying the word lists (See Figures 5 and 6). When analyzing the saccades recorded during reading, no significant interaction between experimental condition and passage and line was found, $F(3,21)=0.941$, $p=0.438$, which also means that the variability in eye movements between conditions, passages, and lines was low (See Figures 7 and 8). The standard deviation and saccades data indicate that the addition of repetitive motion did not disrupt normal reading/study eye muscle movements. There was no main effect of order from the physiological data.
Figure 5. Average horizontal standard deviation during a list study task for ball toss and no ball conditions.

Figure 6. Average vertical standard deviation during a list study task for ball toss and no ball conditions.
Conclusion

The lack of main effect of repetitive motion on the number of words recalled suggests that repetitive motion does not improve memory. This was a surprising finding because it was hypothesized that the repetitive motion of tossing a ball coupled with word rehearsal would
increase list memory as the repetitive motion would provide a physical match to the mental processes of rehearsal and encoding. It is possible that the memory task was too easy for such an effect to occur. Perhaps a subject needs to be involved in a much longer, more involved memory task for a movement variable to have a significant impact.

Prior to experimentation, it was thought that the reading comprehension task would serve as a distraction for the list recall task and that few, if any, significant findings would be observed. However, it was found that the order in which the ball was tossed during the reading comprehension tasks was important. Because subjects who did not toss the ball until their second reading comprehension passage produced more incorrect answers at test for that second passage, it is possible that the time of movement initiation has effects on comprehension. The data seem to suggest that the repetitive motion must be instituted at the beginning of a study task rather than during the middle of it. It could be that subjects who did not toss the ball until their second passage may have become accustomed to reading while sitting still and were then distracted when they had to read while tossing a ball. The remaining subjects, who tossed the ball during the first passage, may have become accustomed to tossing the ball at the same time they became accustomed to reading the passage on the computer screen, and therefore, were not as distracted by the ball. Significant interactions may have occurred for the reading comprehension task rather than the memory task because the reading comprehension task is longer and involves deeper processing of information to understand and answer questions on the passage.

In the future, it would be beneficial to perform this experiment with a more complex memory task to determine if deeper processing of information is, in fact, needed to demonstrate effects of repetitive motion. Also, it may be interesting to test types of repetitive motion that are
more commonly associated with studying, such as pencil tapping, pacing, and leg bouncing, to see if repetitive motion of which we are normally not consciously aware can produce memory and reading comprehension improvements.

References


