A Thesis

entitled

Embodied Cognition: The Vicarious Presentation Effect

by

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There is an emphasis in education on teaching using digital media. Research suggests, however, that humans are participators and learning should reflect that. Since gestures have communicative functions, physical observation should lead to increased learning. The purpose of the current research is to determine if the principles of embodied cognition, meaning body-environment interactions that influence the way information is processed, extend to a vicarious experience of learning from an embodied source. Participants were randomly assigned to one condition (Letter-by-letter embodied, Non-letter-by-letter embodied, or Whole word non-embodied) in a between-participants design. First, participants watched words being written (letter-by-letter embodied condition), displayed letter-by-letter (letter-by-letter non-embodied condition), or displayed all at once (whole word non-embodied condition). Next, participants were given distracter tasks. Participants’ memory for the words was tested with free recall and word stem completion tasks. The dependent measure was the amount of words correctly recalled. It was hypothesized that those in the letter-by-letter embodied condition would remember more words on both dependent measures. Hypotheses were supported. Possible explanations for results are discussed.
I dedicate the completion of this work to Kelsie Lorraine Gleason. For the courage to continue through adversity, the strength to admit when I need help, and the permission to believe that dreams can happen, I thank one of the most driven people I have ever known. Because you will never have the opportunity to finish your dream, I dedicate mine to you. May you rest in peace, Bitty.
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Chapter One

Literature Review

Currently in education, there is an emphasis on instruction using a digital media lecture presentation. PowerPoint is the most notorious medium for educators at every level to disseminate information to groups of students quickly and economically. This passive method of instruction using text on slides is also used as the lecture presentation style in the majority of online courses. Evidence shows, however, that college students report lapses in attention and increased mind wandering during online lectures versus in-person lectures (Bligh, 2000). Humans are participators by nature and they are always involved in the activities in their environment. Therefore, learning must be more active than passive. In-person instruction may benefit because of research that suggests gestures have communicative and cognitive functions (De Nooijer et al., 2013). Thus, observation of physical movement tied to the presentation of words should lead to a variety of cognitive advantages, including increased memory. Accordingly, the current research aimed to determine if the principles of embodied cognition, meaning body-environment interactions that influence the way information is processed, extend to a vicarious experience of learning from a physical source of instruction. Would students have a better experience learning from a physical body moving through a classroom, or is the content presented digitally enough to induce adequate learning? In order to determine if the experience of a letter-by-letter embodied presentation affects memory, the current research examined the effect of lecture presentation of words on participants’ recall. It was hypothesized that participants would experience better recall when words were
presented in an embodied manner than when words appeared on a screen with no human presentation.

**A. Embodied Cognition**

“Embodied cognition pertains to the consequences on thought and emotion of living with our particular human sensory and motor systems” (Davis & Markman, 2012, p. 685). At the most basic level, embodied cognition is the effect of our body in time and space on our cognitive processes. Body-environment interactions constrain the way information can be processed, and the theory of embodied cognition is that action plays a role in what and how we learn. We use the body as a foundation of information or use the body as a part of the processing structure of cognition. The embodied experience is a source of conceptual organization of our thinking (Davis & Markman, 2012). Eelen, Dewitte, and Warlop (2013) argue that our bodily experience with the environment lies at the center of how humans think. For example, holding an object in the dominant hand while observing a consumer product decreases one’s liking for the observed product merely because interacting with the product seems unlikely given the current state of the dominant hand (Shen & Sengupta, 2012). Accordingly, thinking occurs in context with our interaction with the environment. Since humans think in the context of their relationship with the environment, learning should be heavily influenced by the level of embodiment a student experiences in an academic setting.

**B. Trends in Learning**

An independent news source estimated that, in 2013, almost 350 PowerPoint presentations were given every second (Parks, 2013). PowerPoint became the standard method of presenting information to groups, such that “Appearing at a meeting without
PowerPoint would be like showing up wearing no shoes” (Craig & Amernic, 2006, p. 147). While PowerPoint is infamously popular, there are some critics in education who believe the digital means of communicating turns normally intelligent people into people who are incapable of serious thought (Craig & Amernic, 2006). In a critical review, Tufte (2003) argues PowerPoint “induced stupidity, wasted time, and downgraded the quality of communication”. While it may be harsh, Tufte’s criticism of PowerPoint certainly translates into student performance when PowerPoint is the primary method of instruction.

In a study examining potential issues with PowerPoint as a content delivery method, Amare (2006) split four classes of an undergraduate writing course into two classes instructed by PowerPoint and two classes instructed by a teacher at a podium using a chalkboard and handouts. Each section met 30 times and each instructor covered the same material and had no knowledge of the hypotheses. The students in the lecture sections performed nearly two times better, on average, on their post-tests than the students in the PowerPoint sections (Amare, 2006). The results indicate that PowerPoint lectures are perceived as more favorable, but students’ grades do not align with their reported preferences. While students usually report liking PowerPoint presentation better, the preference for the format does not translate to their performance in the course (Craig & Amernic, 2006). A myriad of research has shown that multimedia presentation format does not show any performance increase for students in courses using it; some even showing that students’ performance decreased when the instructor switched to PowerPoint from more traditional methods (Bartlett, Cheng & Strough, 2000; Szabo & Hastings, 2000).
Students may not be actively engaged in the material being presented due to the typical “read and copy” style of PowerPoint lectures. Students report “checking out” of the lecture and stop focusing attention on the instructor’s lesson in order to copy the material quickly (Craig & Amernic, 2006). Instructors attempt to keep students engaged by including pictures or other media on their lecture slides. However, when PowerPoint slides include information that is meant to be attention grabbing but ultimately not pertinent to the lecture, students perform worse on recall and recognition tasks than if there was no supplemental “attention grabbing” material (Giles & Baggett, 2009). Giles and Baggett (2009) found that when students were broken into groups instructed by black and white transparencies, color transparencies, or PowerPoint, students in the color transparencies condition performed the best and students in the PowerPoint condition performed the worst on a quiz of the material. The literature on PowerPoint use in classroom settings seems to suggest that PowerPoint lectures may not be the most effective method for teaching students. Our goal, however, is not to demonstrate the evils of using PowerPoint as a lecture medium, but rather to inform about the issues with engagement and absorption that may arise from the passive form of teaching and learning. These issues also transfer to the medium being used to lecture students in online classrooms.

Supporters of technology-mediated virtual learning environments believe they eliminate barriers to individualized education, provide flexibility, enhance the opportunity for feedback from instructors, and increase student retention over traditional classrooms (Kiser, 1999). Additionally, problems with traditional classrooms usually include poor attendance, disinterest, and inappropriate behavior in class. However,
learning effectiveness and engagement in material may be reduced by a virtual learning environment (Chou & Liu, 2005; Maki et al., 2000). In a study examining the difference in student performance between a classroom based psychology course and an online psychology course, students in the online course scored higher but reported lower satisfaction than those in the traditional classroom (Maki et al., 2000). Maki et al. (2000) inferred that this could have more to do with motivation than actual learning. In their experiments, the students who were taught in a traditional classroom performed worse on the final examination than the online students (Maki et al., 2000). Other than the issue of students not being randomly assigned to either online or traditional courses, Maki et al. (2000) also failed to mention the method of presentation for materials to the traditional classroom. Our current aim was to test whether human presentation would lead students to retain information better than information merely presented to them in a digital format. If Maki et al. (2000) presented the classroom materials as PowerPoint or note-pages, the lack of embodied experience for those students may be the reason they did not perform as well.

Students need to be aroused to the optimal level in order to actively learn in the classroom (Bligh, 2000). Accordingly, Bligh, 2000 suggests that audiotapes or purely text-based PowerPoint or verbal lectures would be ineffective because there is not a large enough increase in arousal from resting state. Unless professors maintain students’ attention and keep their minds from wandering, PowerPoint slides with static visual aids, regardless of if they are presented online or in a traditional classroom, may be an inappropriate lecturing method. Bligh (2000) showed that visual illustrations, unlike purely verbal lectures, have an arousing effect; a student’s heart rate increases 10bpm in
the 6 seconds after turning a projector off. This effect suggests that students need to experience some visual stimulation in order to actively learn. Similarly, humans also have a visual reflex to orient toward movement, so hand movements can draw a student’s attention toward the lecturer (Bligh, 2000). The orienting reflex toward someone writing information integrates well into the embodied cognition theory the current research seeks to examine.

C. Embodied Learning

While there has been an emphasis in the recent past on how “traditional” classrooms have become less popular in favor of a digital learning environment, that research has not concerned the benefits of physically being in class with an instructor. Embodied cognition as it relates to the learning environment has been studied in the form of gestures and imitation. De Nooijer et al. (2013) argue that gestures have communicative and cognitive functions. Therefore, observation of these gestures should lead to increased learning, specifically of words presented. Their research also finds support for the notion that imitation increases word learning. Hypothetically, gestures activate images in working memory and imitating those gestures during retrieval may facilitate recall of previously learned words. Through recall and fill-in-the-blank tasks, De Nooijer et al. (2013) found that the effect of imitation was present for object-manipulation verbs. Accordingly, De Nooijer and colleagues concluded that imitation of gestures during learning or immediate recall of a verb list can have an effect on the number of verbs correctly recalled on immediate and delayed memory tests.

Researchers argue that gestures help learners increase their comprehension and develop more elaborate memories (Chao et al., 2013). According to Chao and colleagues,
learners have more meaningful experiences when they apply physical movement and touch stimulus materials together during the learning process. In the referenced experiments, students, aged 19-29, either recited actions while physically performing them (kinetic condition) or while simulating the actions on the computer. The students who participated received an immediate cued recall task and a delayed free-recall test, which was given the following day. The students in the kinetic condition recalled significantly more, both in the immediate cued and delayed free recall tasks (Chao et al., 2013). Students have an easier time recalling information when their bodies are involved in the learning of that information. The relationship of a classroom of students to the instructor’s body movement has not yet been examined. If students experience better memory for kinetic movement and concept relationships, they may experience a vicarious presentation effect from viewing the movement of an instructor writing words on a board.

Motor fluency may be the link between kinetic memories and vicarious presentation effects. Longcamp, Anton, Roth, and Velay (2003) found that presentation of letters activates premotor areas in the brain that are involved in writing (Exner’s area), even though the individuals in their experiments were aware they would not be doing any writing. This activation of Exner’s area may give students the feeling of familiarity with a word, and therefore help them remember it in a recognition task. The feeling of familiarity is a concept referred to as motor fluency (Yang, Gallo, & Beilock, 2009). According to Yang, Gallo, and Beilock (2009), fluency of processing is the underlying mechanism in the formation of explicit memories. According to embodiment theory, encountering a stimulus causes the motor or sensory systems associated with the stimulus to be triggered automatically (Topolinski, 2012). Yang, Gallo, and Beilock (2009)
ultimately found that recognition memory judgments could be influenced by fluency information coming out of covert actions associated with the items to be remembered. The link between memory and motor fluency lends well to our research question of whether viewing an instructor as he or she writes a word on the board would induce better memory than merely viewing words that flash on a screen.

In order to understand if passive interactions have similar effects on learning as active interactions, research has explored feelings of familiarity. According to Yanchar, Spackman, and Faulconer (2013), embodied familiarization is framed in terms of the learner’s shift from self-conscious, uncoordinated, and unskilled action to increasing smooth, capable, and tactic action. Humans are active participators in their environments, even when those interactions are seemingly passive. A student reaches familiarity and fluency with a topic once they have encountered the material and actively processed it. Familiarization, like fluency, dictates what the student remembers of their learned material. Viewing a professor as he or she writes information creates a familiarity trace for that information, presumably leading to better recall of that information. Better recall for learned information does depend heavily on the level of attention given to that material such that given learning environments provide better opportunities for active learning and we should identify what those environments are.

Recently, related work on letter-by-letter embodied learning has been conducted using lessons of the Doppler effect. Fiorella and Mayer (in press) found that students benefit from watching the instructor draw diagrams (e.g., on a whiteboard) while listening to an oral explanation compared to simply viewing the same diagrams already drawn on the board while listening to the same explanation. Their preliminary findings
show that this effect may depend on the prior knowledge of the students, seeming to help students with the least prior-knowledge of the subject the most. The extent to which the instructor’s body or hand is visible throughout the lesson also impacts the quality of learning for students (Fiorella & Mayer, in press). For example, it may be important to show the instructor’s hand drawing the diagrams, rather than just having computer animated drawings, however it may not be necessary to show the instructor’s body through the lesson. Fiorella and Mayer are also exploring whether the instructor’s body movement, rather than just hand movement, may actually be distracting for students. These findings are important in showing that level of vicarious embodiment does have an effect on the students’ experience in the classroom.

D. Memory and Learning

In online lectures with traditional PowerPoint slides posted for study, college students report an inability to focus and the tendency to be thinking about information other than the lecture content (Bunce et al., 2011). Students who are involved in passive online learning, like students involved in classroom learning using the same techniques, may be experiencing a lack of ability to focus because their bodies are not involved in the learning of the material. Szpunar, McDermott, and Roediger (2008) found that students whose memory was tested at intervals on lists of words did better in the final memory test of the full list of words. Szpunar, McDermott, and Roediger (2008) concluded that only when combining online lectures with sporadic testing did students efficiently recall lecture content by way of decreased mind wandering, increased note taking, and facilitated learning (Szpunar, Kahn, & Schacter, 2013). Testing helps sustain students’ attention by engaging the students and discouraging task irrelevant activities. The act of
watching a person write lecture materials on the board may serve the same function to aid in decreasing mind wandering and increasing learning through active engagement. It is also important in the current experiment that the students are aware of the fact that their memory for the words will be tested in the end. Participants in memory experiments were more likely to hold words in mind as they study if they are aware they will be later tested on those words (Masson & McDaniel, 1981; Szpunar, McDermott, & Roediger, 2008).

Another particularly relevant contribution to the present discussion is the difference between the concepts of episodic and semantic memory. Episodic memory is knowledge held about one’s personal experiences and specific events situated in space and time (Tulving, 1972). The concept was introduced to explain the memory process humans use for word lists or for recalling something from a particular context at a particular time. Semantic memory is an organized collection of symbols, their meanings, referents, concepts, and relationships. Importantly, the semantic system allows one to retrieve information that was indirectly stored (Tulving, 1972). In other words, episodic memory is one’s store of explicit personal experiences, unlike semantic memory, which is the storage of one’s accumulation of associated knowledge. The current work explored the difference between the two types of memory stores by examining how a vicarious embodied presentation affects them differently. Because there is evidence that episodic memory differs as a function of degree of handedness,

**E. Hemispheric Differences**

Because there is evidence that episodic memory differs depending on level of access to the right hemisphere, handedness was included as an individual difference variable (Propper, Christman, & Phaneuf, 2005). Degree, not direction, of handedness is
defined as the preference to use the dominant hand over the non-dominant hand in writing and other daily activities (Prichard, Propper, & Christman, 2013). Handedness has been used as a predictor of cognitive performance. Previous findings show that inconsistent-handers have more interaction between their hemispheres, and therefore better retrieval of episodic memories typically stored in the right hemisphere (Propper, Christman, & Phaneuf, 2005). Propper et al. (2005) found no handedness difference in a word fragment completion task using the Tulving, Schacter, and Stark (1982) word list used in this study. We studied handedness differences as an individual difference variable in the current research and expected that there would be an interaction between handedness and presentation style for the episodic memory task.

F. Current Research

The current research examined if the principles of embodied cognition, meaning body-environment interactions that influence the way information is processed, extend to the vicarious experience of learning from an embodied source. In order to determine if the experience of a vicarious embodied presentation affects memory beyond a non-embodied presentation of words, in the current research, we examined the effect of lecture presentation of words on participants’ recall. On a global scale, embodied cognition research has real implications for the education system, especially in an age of digital content delivery. The application of the principles of embodied cognition to education and vicarious effects has not been examined. Therefore, embodied learning is an area worth further investigation.
Chapter Two

Method

A. Participants

Participants were 246 undergraduate students, (159 female) at the University Of Toledo, who received credit toward a course requirement for their participation. Six participants were excluded from the final analyses because they either did not follow instructions or did not finish the experiment in time. An additional two participants were excluded from analyses because they scored more than two standard deviations from the mean on the memory tasks. All analyses and demographic information reflects the remaining 238 participants. The median age was 19 ($M = 19.32, SD = 3.08$). The racial makeup of the sample was 73.2% White, 13.4% African American, 4.1% Hispanic, 2.8% Asian, 2.0% Middle Eastern, and 3.7% unknown or other race(s).

B. Materials and Procedure

Each timeslot lasted thirty minutes and there were one to four participants per timeslot. Participants were seated at a round table facing a Smart-Board screen and began by signing the informed consent. Oral instruction was given to participants telling them to remember the words that would be presented to them.

In the letter-by-letter embodied condition, the researcher handwrote, one by one, 30 words (taken from Tulving, Schacter, & Stark, 1982; see Appendix A) each 7-9 letters in length and of low to medium frequency. The same researcher wrote the list of words in every timeslot in order to maintain handwriting consistency. Each word was spelled out in the time span of 10 seconds on a white Smart-Board screen using black ink. Upon completion of each word, the researcher audibly stated the word to the participant group
in order to ensure they were aware of the word presented. Each word was then “erased” by continuing to a new blank page before presentation of the next word. Upon completion of the full word list, participants were reseated at individual computers running Media Lab software where they completed the remainder of the experiment.

In the letter-by-letter non-embodied condition, the same 30 words were presented in the same order as the first condition. In the letter-by-letter non-embodied condition, however, participants viewed the words on a Smart-Board running Media Lab software. Each word was presented in the same researcher’s handwriting and was similar in size and color to the letter-by-letter embodied condition. Each letter came up one by one to spell each word out in the 10-second time span. At the end of the 10 seconds per word, the word vanished from the screen. The researcher stood next to the Smart-Board for the duration of the experiment. Participants were then seated at individual computers running Media Lab software where they completed the remainder of the experiment.

In the whole word non-embodied condition, participants viewed the same 30 words presented in the first two conditions in the same order. The words came up on the screen all at once in a black, Arial font at 88pt size. Each word was presented for ten seconds and disappeared before the next word was automatically presented. Participants were asked to watch the screen and remember each word. This condition serves as a fully non-embodied control, as there was no human presentation, no anticipation as letters are presented, and the words were displayed in a computer font instead of the researcher’s handwriting. Participants were then seated at individual computers running Media Lab software where they completed the remainder of the experiment.

In the second portion of the experimental session, participants completed a set of
filler tasks before receiving the memory tasks. The first two filler tasks were completed on paper. The first task was an individual different task - the Edinburgh Handedness Inventory (Oldfield, 1971; see appendix B). The next filler task required participants to label both ends of a straight horizontal, positively, or negatively sloped line with dichotomous word pairs that are diametrically opposed (see Appendix C for full list of word pairs). The final filler task was conducted on computers running a Media lab program. Participants were asked to make judgments about ambiguous figures. These filler tasks are designed to determine the participant’s handedness and to see what judgments they make about social constructs depending on their reported handedness. All of the filler tasks combined took 8-10 minutes to complete. The filler tasks are not included in the primary analyses and the data will be used in later projects.

To test the memory of the participants for the word list, each participant completed a free-recall task followed by a word fragment completion task on computers running Media Lab software. The free-recall task measured participants’ episodic memory for the words they were presented. This explicit test of memory is scored as number correct out of 30 possible correct. The word fragment completion task measured participants’ semantic memory for the words presented. There were 60 fragments for each participant to complete; 30 of the word fragments corresponded to words not previously presented and 30 fragments corresponded to the previously presented words used in the experiment. The implicit word fragment completion task is scored as number of studied fragments completed minus the number of non-studied fragments completed. We measured memory with both tasks in order to determine if there is a difference within subjects in memory performance based on the type of memory task. It is important to test
the effects of vicarious embodiment, or human presentation, on both an explicit and implicit memory task because the types of memory are independent of one another (Tulving, 1972). By looking at both types of memory separately, we can compare the pattern of results for both tests to determine if the patterns are similar. After completing the memory tests, the participants completed a brief demographic questionnaire on the computer. Lastly, the participants were debriefed and awarded credit for their participation.
Chapter Three

Results

A. Preliminary Analyses

Participants were randomly assigned to one of the experimental conditions. The average number of participants per condition was 80. There were 159 females and 79 males. The mean age of participants was 19.32. After performing a median split on the handedness data, two handedness groups were formed, consistent-handers (N = 121) and inconsistent-handers (N = 117). Free recall memory test scores ranged from 0 to 27 (M = 8.88). The number of correctly recalled old words on the word stem completion task ranged from 0 to 27 (M = 14.58) and the number of correctly completed new words ranged from 0 to 13 (M = 2.44). Word stem completion scores were calculated as old fragments minus new fragments and the resulting total was used in all analyses.

B. Primary Analysis

The independent variables of interest were condition, sex, and handedness. The dependent variables of interest were performance scores on the word stem completion (semantic) task and the free recall (episodic) task. See Table 5 for a complete table of means and standard deviations. In order to determine if there was an interaction between condition, handedness, and gender on our two dependent variables (episodic and semantic memory tasks), we conducted two 3(Condition: letter-by-letter embodied, letter-by-letter non-embodied, and whole word non-embodied) X 2(Sex: male versus female) X 2(Handedness: consistent versus inconsistent) factorial ANOVAs.

There was a significant main effect of condition on the number of words correctly reported in a word-stem completion task, $F(2, 237) = 13.57, p < .001, \eta^2_p = .107$. There
was also a significant main effect of condition on correctly recalled words in a free recall task, $F(2, 237) = 3.62, p = .028, \eta^2_p = .031$. The strength of the relationship between presentation style and performance in the word-stem completion task, as assessed by partial $\eta^2$, was large, $\eta^2_p = .107$. The strength of the relationship between presentation style and performance on the explicit recall task, as assessed by partial $\eta^2$, was small, $\eta^2_p = .031$. The memory tasks were strongly positively correlated, $r(238) = .62, p < .001$.

Post hoc comparisons using the Tukey HSD test indicated that the mean score on the word-stem completion task for the letter-by-letter embodied condition was significantly different than the letter-by-letter non-embodied condition, $t(158) = 4.66, p < .001, d = .74$, and the whole word non-embodied condition, $t(154) = 3.53, p < .001, d = .56$, but the latter two conditions did not significantly differ from each other, $t(158) = -.95, p = .34, d = .15$. Post hoc comparisons on the explicit free recall task indicated that the mean score for the letter-by-letter embodied condition was significantly different than for the letter-by-letter non-embodied condition, $t(158) = 3.02, p < .01, d = .48$. The whole word non-embodied condition significantly differed from the letter-by-letter non-embodied condition, $t(158) = -2.18, p < .05, d = .34$, and did not significantly differ from the letter-by-letter embodied, $t(154) = .64, p = .52, d = .10$. See Table 1 for means and standard deviations. These results suggest that the manner of presentation of words influences one’s implicit and explicit memory for those words. Specifically, those who were shown the words by an embodied source performed significantly better on the implicit memory task than those who saw the words in a step-wise handwritten format and those who were shown the words all at once for 10 seconds in a computer font. In the explicit memory task, there was no difference for the number of words recalled for the
letter-by-letter embodied condition or the whole word non-embodied condition, but both groups outperformed the letter-by-letter non-embodied condition, the embodied condition significantly and the whole word non-embodied condition moderately. See Figures 1 and 2 for graphs depicting mean differences by condition and task.

C. Secondary Analyses

Our 3(Condition: letter-by-letter embodied, letter-by-letter non-embodied, and whole word non-embodied) X 2(Sex: male versus female) X 2(Handedness: consistent versus inconsistent) ANOVA on word stem completion scores revealed a main effect of sex, $F(1, 237) = 12.06, p < .001, \eta^2_p = .05$. There was no significant main effect of handedness, $F(2, 237) = 2.02, p = .157, \eta^2_p = .009$. See Table 3 for means and standard deviations. The ANOVA on word stem completion scores revealed no significant interaction for condition by sex by handedness, $F(2, 237) = .993, p = .372, \eta^2_p = .009$.

The 3(Condition: letter-by-letter embodied, letter-by-letter non-embodied, and whole word non-embodied) X 2(Sex: male versus female) X 2(Handedness: consistent versus inconsistent) ANOVA on free recall scores also revealed a main effect of sex, $F(1, 237) = 7.44, p < .05, \eta^2_p = .03$. There was no significant main effect of handedness, $F(2, 237) = .004, p = .949, \eta^2_p = .000$. The ANOVA on free recall scores also revealed no significant interaction for condition by sex by handedness, $F(2, 237) = .863, p = .372, \eta^2_p = .008$. See Table 4 for summary of main effect and interactions.

Given the main effect of sex, the univariate main effects were examined. Significant univariate main effects for sex were obtained for the word stem completion task, $F(1, 237) = 12.06, p < .001, \eta^2_p = .05$, and the free recall task $F(1, 237) = 7.44, p < .05, \eta^2_p = .03$. To determine where the sex differences occur, an independent-samples t-
test was conducted to compare performance on both memory tasks depending on sex. There was a significant difference in the scores on the word stem completion task for females ($M = 12.77, SD = 4.72$) and males ($M = 10.86, SD = 5.08$); $t (236) = -2.87, p = .004, d = .29$. There was also a significant difference in the scores on the free recall test for females ($M = 9.33, SD = 4.04$) and males ($M = 7.99, SD = 3.19$); $t (236) = -2.58, p = .011, d = .37$. Our Results suggest that sex has an effect on memory for words.
Chapter Four

Discussion

The purpose of this study was to examine the relationship between embodied cognition in a vicarious learning situation and memory for words. Participants engaged in a learning session of words and were instructed using letter-by-letter embodied, letter-by-letter non-embodied, or “customary” media presentation format. To measure the effects of presentation style, each group completed an episodic as well as semantic memory test.

We anticipated a main effect of condition. Participants who were in the letter-by-letter embodied presentation condition were predicted to remember more words in both memory tasks than the letter-by-letter non-embodied and whole word non-embodied groups because gestures help form more elaborative memories (Chao et al., 2013). We found that in both tests of memory, our manipulation of presentation style affected how many words participants remembered. Those in the letter-by-letter embodied condition outperformed students in both conditions featuring no embodied source of presentation. The group who saw the words in the researcher’s handwriting, in a step-wise format, performed the worst on both memory tasks. The results of the non-embodied condition may indicate that having time to anticipate words as the letters come up one by one may be more detrimental than seeing material presented all at once. The students in the condition most resembling a traditional PowerPoint lecture performed better than those in this non-embodied condition, but our results clearly indicate that students benefit from having an instructor physically modeling the information to be learned. Therefore, if our results were to extend to a full lecture, the traditional multimedia lecture format for both
classrooms and online courses may not be as effective in teaching students as in-person lectures.

Our results, in reference to presentation style, are particularly exciting for two important reasons. First, we found more robust human presentation and vicarious embodiment effects in the word stem completion scores. As Tulving (1972) suggests, a word stem completion task measures semantic memory, a more implicit form of memory storage and retrieval. In a real classroom situation, most of what is absorbed by students is semantic. Students may not remember the date and time and where they were when they learned a certain piece of information, but they do have semantic associations that include that knowledge. Since our results were more robust for the semantic test of memory than for the episodic test of memory, we can postulate that this paradigm does have real implications for education. Second, we found that the embodiment effects observed overcome extended study time. Craik and Tulving (1975), among many others, suggest that extended study time increases depth of processing and subsequently improves retention of words in memory. Participants in the traditional whole word non-embodied condition got a full 10 seconds of study time whereas the other two conditions had between 3 and 5 seconds of study time depending on if they correctly guessed the completed word as it was being spelled out. Participants in the letter-by-letter embodied condition performed best on both memory tasks, even though the whole word non-embodied condition had nearly twice as long to study each word.

We expected that there would be an interaction between handedness and presentation style based on previous findings that inconsistent-handers have better access to their right hemispheres, and therefore better retrieval of episodic memories (Propper,
Christman, & Phaneuf, 2005). We used both episodic and semantic forms of memory tests in order to determine if embodiment would impact how consistent- and inconsistent-handers performed. Propper et al. (2005) previously found no handedness difference in a word fragment completion task using the same word list. We did not find a main effect of handedness nor any interaction between handedness, condition, and gender on how many words participants remembered. This was true for both memory tasks. It could be that inconsistent-handers already benefit from increased interhemispheric interaction and the embodiment effects do not add to that benefit. This might also explain why the consistent-handers did not perform significantly different on the episodic memory task. It may be that embodiment effects improve consistent-handers’ retrieval to the level where inconsistent-handers already perform.

Our finding with respect to sex is not necessarily surprising. Women excel on tasks where the information to be remembered is verbal in nature, as is the case with our task (Herlitz & Rehnman, 2008). Women may have an advantage on episodic memory tasks because of their superior verbal-production abilities. Other tasks involving visuospatial memory tested with an episodic memory task show an advantage for males over females (Lewin, Wolgers, & Herlitz, 2001). We did not seek to explain how men and women might differ in their individual level of response to embodiment. Future research using materials that are not verbal in nature may reveal that the sex effects are due to the type of materials used, not susceptibility of individuals to embodiment effects.

A. Limitations and Future Directions

Notable limitations in this study include homogeneity of the sample, the noise of the lab environment, the sex and expectations of the experimenter, and the ease or
simplicity of the presented content compared to a classic lecture. First, the sample used was comprised of college students enrolled in psychology courses. While these students provide an excellent college sample, we cannot postulate that the results would transfer to students in other levels of education such as elementary or high school students. Second, the noise of the lab may have contributed to the learning environment differently for each group. The lab environment was tightly controlled, but groups of students participating at once ranged from one to four. This could not be controlled due to sign-up rates. In addition, although the computer was precisely timed to display the letters in the letter-by-letter non-embodied condition for 10 seconds, the computer would sometimes delay for a few milliseconds longer than anticipated in the middle of a word. This extra time, however, would presumably have given those conditions longer study time and yielded better memory for those specific words. We did not find that to be the case. When taken out of the larger data set, there was no difference for that condition. Third, the sex of the experimenter may be partially responsible for the increased word recall in women. Because the experimenter was a woman, the congruency between experimenter sex and participant sex may have influenced recall. The experimenter was also aware of the hypotheses of the experiment. Lastly, the materials used to investigate this theory were simple. It could be argued that the 30 words were easier to remember than a full lecture. However, we used these materials because of their simplicity in order to examine if the framework applied to even the most basic learning situation.

It is because of these limitations that we have further avenues to explore using this paradigm. Additional research on elementary school or high school aged children may provide the opportunity to apply our findings to education as a whole. It would also be
beneficial to see this paradigm at work in a more realistic setting, away from the artificial nature of the lab. Future projects are currently planned in order to study the vicarious presentation effect on memory for richer lecture material. Future projects may also include an online condition in order to generalize results to the growing number of students who are taking distance-learning courses. In the future, the experimenter should be blind to the hypotheses as to eliminate expectancy effects.

We are also interested in how note-taking style plays a role in the embodied learning environment. Recently, Mueller and Oppenheimer (2014) showed with three studies using college students that laptop note taking results in shallower processing. Students who took notes on laptops, rather than using pen and paper, performed worse on conceptual questions. Because students who take notes with laptops copy what they hear or read verbatim, they do not benefit from processing and reframing the concepts like pen and paper note takers do (Mueller & Oppenheimer, 2014). Future lines in our research should examine how note-taking methods are influenced by learning from an embodied source versus a multimedia format.

B. Conclusions and Implications

These findings bolster the argument that the use of multimedia lectures like PowerPoint presentations in classroom settings may be detrimental to students’ learning. PowerPoint is the standard for use in groups where dissemination of knowledge is the goal, so convincing educators to reduce their use may be difficult. PowerPoint offers convenient instruction, which college administrators appreciate when designing distance-learning courses that are cost effective. Students also report “enjoying” multimedia lectures more than traditional lectures. However, the results of our study suggest that, if
our goal is the education of our students, not merely entertainment, we may need to at least limit the use of PowerPoint-type teaching methods. The current findings are not only exciting because they push embodiment research into a new realm involving vicarious effects, they also give us insight into a the growing problem of student engagement and retention in education.
Table 1

*Descriptive Statistics for Dependent Variables (by Condition)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Word Stem Completion Task</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Letter-by-letter embodied</td>
<td>14.20</td>
<td>4.34</td>
</tr>
<tr>
<td>Letter-by-letter non-embodied Embodied</td>
<td>10.80</td>
<td>4.79</td>
</tr>
<tr>
<td>Whole word non-embodied</td>
<td>11.53</td>
<td>4.99</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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<td>4.71</td>
</tr>
<tr>
<td><strong>Explicit Free Recall Task</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Letter-by-letter embodied</td>
<td>9.60</td>
<td>3.84</td>
</tr>
<tr>
<td>Letter-by-letter non-embodied Embodied</td>
<td>7.90</td>
<td>3.26</td>
</tr>
<tr>
<td>Whole word non-embodied</td>
<td>9.19</td>
<td>4.17</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8.90</td>
<td>3.76</td>
</tr>
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Table 2

**Descriptive Statistics for Dependent Variables (by Sex)**

<table>
<thead>
<tr>
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</tr>
</thead>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Word Stem Completion Task</strong></td>
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<td></td>
</tr>
<tr>
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</tr>
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<td>Females</td>
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<td>4.72</td>
</tr>
<tr>
<td>Total</td>
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<td>4.90</td>
</tr>
<tr>
<td><strong>Explicit Free Recall Task</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>7.99</td>
<td>3.19</td>
</tr>
<tr>
<td>Females</td>
<td>9.33</td>
<td>4.04</td>
</tr>
<tr>
<td>Total</td>
<td>8.66</td>
<td>3.62</td>
</tr>
</tbody>
</table>
Table 3

*Descriptive Statistics for Dependent Variables (by Handedness)*

<table>
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<tr>
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<th>$SD$</th>
</tr>
</thead>
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<tr>
<td><strong>Word Stem Completion Task</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consistent Handed</td>
<td>12.00</td>
<td>4.51</td>
</tr>
<tr>
<td>Inconsistent Handed</td>
<td>12.28</td>
<td>5.31</td>
</tr>
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<td>Total</td>
<td>12.14</td>
<td>4.91</td>
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<tr>
<td><strong>Explicit Free Recall Task</strong></td>
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<td></td>
</tr>
<tr>
<td>Consistent Handed</td>
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<td>3.83</td>
</tr>
<tr>
<td>Inconsistent Handed</td>
<td>8.68</td>
<td>3.82</td>
</tr>
<tr>
<td>Total</td>
<td>8.85</td>
<td>3.83</td>
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</tbody>
</table>
Table 4

ANOVA on Free Recall and Word Stem Completion Scores Table

<table>
<thead>
<tr>
<th>Effect</th>
<th>DV</th>
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<th>$F$</th>
<th>$\eta^2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>Word Stem</td>
<td>1</td>
<td>12.06</td>
<td>.051</td>
<td>.000**</td>
</tr>
<tr>
<td></td>
<td>Free Recall</td>
<td>1</td>
<td>7.44</td>
<td>.032</td>
<td>.007*</td>
</tr>
<tr>
<td>Condition</td>
<td>Word Stem</td>
<td>2</td>
<td>13.57</td>
<td>.107</td>
<td>.000**</td>
</tr>
<tr>
<td></td>
<td>Free Recall</td>
<td>2</td>
<td>3.62</td>
<td>.031</td>
<td>.028*</td>
</tr>
<tr>
<td>Handedness</td>
<td>Word Stem</td>
<td>1</td>
<td>2.02</td>
<td>.009</td>
<td>.157</td>
</tr>
<tr>
<td></td>
<td>Free Recall</td>
<td>1</td>
<td>.004</td>
<td>.000</td>
<td>.949</td>
</tr>
<tr>
<td>Sex*Condition</td>
<td>Word Stem</td>
<td>2</td>
<td>.665</td>
<td>.006</td>
<td>.515</td>
</tr>
<tr>
<td></td>
<td>Free Recall</td>
<td>2</td>
<td>.533</td>
<td>.005</td>
<td>.587</td>
</tr>
<tr>
<td>Sex*Handedness</td>
<td>Word Stem</td>
<td>1</td>
<td>.522</td>
<td>.002</td>
<td>.471</td>
</tr>
<tr>
<td></td>
<td>Free Recall</td>
<td>1</td>
<td>.000</td>
<td>.000</td>
<td>.990</td>
</tr>
<tr>
<td>Condition*Handedness</td>
<td>Word Stem</td>
<td>2</td>
<td>.246</td>
<td>.002</td>
<td>.782</td>
</tr>
<tr>
<td></td>
<td>Free Recall</td>
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<td>.614</td>
<td>.005</td>
<td>.542</td>
</tr>
<tr>
<td>Sex<em>Condition</em>Handedness</td>
<td>Word Stem</td>
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<td>.993</td>
<td>.009</td>
<td>.372</td>
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<tr>
<td></td>
<td>Free Recall</td>
<td>2</td>
<td>.863</td>
<td>.008</td>
<td>.423</td>
</tr>
</tbody>
</table>

* Significant at the $p<.05$ level.
** Significant at the $p<.001$ level.
Table 5

*Descriptive Statistics for Dependent Variables (by Independent Variables)*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Letter-by-letter Embodied</th>
<th>Letter-by-letter Non-Embodied</th>
<th>Whole Word Non-Embodied</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Sex</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>SD</td>
<td>SD</td>
</tr>
</tbody>
</table>

**Word Stem Completion Task**

<table>
<thead>
<tr>
<th></th>
<th>Consistent Handed</th>
<th>Inconsistent Handed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>SD</td>
</tr>
<tr>
<td>Consistent Handed</td>
<td>12.71</td>
<td>15.00</td>
</tr>
<tr>
<td></td>
<td>4.26</td>
<td>4.58</td>
</tr>
<tr>
<td>Inconsistent Handed</td>
<td>13.85</td>
<td>14.48</td>
</tr>
<tr>
<td></td>
<td>3.13</td>
<td>4.69</td>
</tr>
</tbody>
</table>

**Explicit Free Recall Task**

<table>
<thead>
<tr>
<th></th>
<th>Consistent Handed</th>
<th>Inconsistent Handed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>SD</td>
</tr>
<tr>
<td>Consistent Handed</td>
<td>8.76</td>
<td>9.44</td>
</tr>
<tr>
<td></td>
<td>2.68</td>
<td>4.12</td>
</tr>
<tr>
<td>Inconsistent Handed</td>
<td>8.54</td>
<td>11.14</td>
</tr>
<tr>
<td></td>
<td>2.50</td>
<td>4.62</td>
</tr>
</tbody>
</table>
Figure 1. Word Stem Completion Performance by Condition
Figure 2. Explicit Recall Performance by Condition
References


Appendix A

Experimental Word List – Tulving, Schacter, & Stark (1982)

APPROVAL
UNIVERSE
ALMANAC
CREVICE
BLADDER
INKWELL
BAZOOKA
FLANNEL
BUREAU
FLAMINGO
CHIPMUNK
TEQUILA
YOGURT
CUPCAKE
MEMBRANE
APRICOT
COBBLER
ANTENNA
OCTOPUS
MARTINI
HORIZON
PIGMENT
ANYBODY
AVOCADO
BACHELOR
INSOMNIA
COPYCAT
COCONUT
CLIMATE
MYSTERY
### Handedness Inventory

Please indicate your preference in the use of hands for each of the following activities or objects by placing a check in the appropriate column.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Always Left</th>
<th>Usually Left</th>
<th>No Preference</th>
<th>Usually Right</th>
<th>Always Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spoon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Jars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toothbrush</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Throwing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comb Hair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scissors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knife</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Striking a match</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Is your mother left-handed?  
Is your father left-handed?  
Do you have any brothers or sisters who are left-handed?  
Are you male or female? M F
Appendix C

List of Dichotomous Word Pairs

Good – evil
Peace – war
Life – death
Rich – poor
Day – night
Right – wrong
Sacred – profane
Us – them
Happy – sad
Health – illness
Sane – crazy
Beautiful – ugly