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# THE TRANSITION FROM 3-D TO 2-D VISUAL STIMULI AND ITS EFFECT ON PAIRED-ASSOCIATE LEARNING

A Capstone Experience/Thesis Project

Presented in Partial Fulfillment of the Requirements for

the Degree Bachelor of Science with

Honors College Graduate Distinction at Western Kentucky University

Ву

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Western Kentucky University

2011

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#### **ABSTRACT**

A single experiment investigated the influence of varying dimensions of visual stimuli on the ability of academically gifted adolescents to recall paired-associations. Fifty-two participants were randomly assigned to one of four groups. Each group was asked to memorize the same set of 15 paired-word associations. The first group was presented with words only. The second group was presented with words and 2-dimensional (2-D) representations of each word. The third group was presented with words along with 3-dimensional (3-D) representations of the words. The fourth group was also presented words along with 3-D objects; however, this group was instructed to actively manipulate the objects. The recall accuracies of each group were measured directly after the presentation of the last word pair in the set. Large within-group variation prevented significant differences between the accuracy of the groups.

Keywords: paired-associate learning, gifted education, 2-D visual stimuli, 3-D visual stimuli

Dedicated to Verbally and Mathematically Precocious Youth

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#### FIELDS OF STUDY

Major Fields: Biology & Psychology

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#### CHAPTER 1

#### INTRODUCTION

There has been an increasing emphasis on investing government funding for the use of technology in educational settings in recent decades (Culp, Honey, & Mandinach, 2003). With the increase in technological tools in education (e.g. PowerPoint slides and online material) exposure to 2-dimensional (2-D) visual stimuli in the classroom has become far more prevalent, leaving less time for the incorporation of actual 3-dimensional (3-D) objects as an educational tool.

This transition in forms of visual stimuli can be especially prominent in the curriculum for academically gifted adolescents, who are often required to complete independent studies when they surpass the skill level of their fellow classmates.

Traditional forms of independent studies relied heavily upon assigned readings, which provide solely 2-D visuals. However, some curriculum developed for traditional forms of independent studies also allowed for students to work with models and other forms of 3-D visual stimuli.

In recent times online course materials have become popular replacements for traditional forms of independent study for all age ranges of gifted students. With online courses there is even less of an opportunity to include any form of interaction

with actual 3-D objects into the curriculum. Online Advanced Placement (AP)courses have become especially common, since they provide gifted students with the opportunity to earn college credit if they score well on end of the year placement exams. Online AP courses provide schools with a simple, affordable option for meeting the academic needs of students who attend schools that do not have the resources available to offer a wide array of AP courses, or in some cases, any AP courses. However, there has been minimal research investigating any aspect of online AP courses as a form of educational instruction and further research is required to properly outline the advantages and disadvantages of this type of online course (Shepard, 2008).

One such area that requires further research is the use of 2-D visual aides in online courses. Often instructors of online courses try to incorporate visual aides into their lessons, because visual stimuli have traditionally been used as a learning tool by teachers. However, there has been a lack of literature concerning the effects of visual stimuli on learning. Currently there is minimal literature in the area of comparison of the presentation of 2-D and 3-D stimuli in humans. The literature becomes even narrower when these visual stimuli are associated with applications in the field of education. Traditionally, the study of picture symbols as learning tools and other forms of visual stimuli has focused on individuals with severe intellectual disabilities (e.g. Welch & Pear, 1980; Han et al., 2007). In one such study, Gow & Ward (1984) found that the use of only photographs as stimuli was not as effective in generalization and maintenance stages of task development as the

use of actual objects or conventional teaching.

Like the task study performed by Gow & Ward (see above), some cognitive theories also indicate that imagery may be important in learning. The dual-coding theory developed by Paivio in 1969 indicates that elaboration in the form of verbal imagery greatly assists in recall, because it allows for another distinct memory code, in addition to a verbal memory code (Reed, 2007). Paivio, Smythe, & Yuille (1968) found this to be particularly true if both words in a paired word association had a high imagery potential (e.g. juggler, dress, letter). While the findings of Paivio and his colleagues indicates that visual imagery, whether created or given, is most likely to be helpful in assisting with memory recall, it is important to note that Paivio's theory relies upon an individual pupil creating a visual image. Thus, it has little relevance to the lesson plans designed for specific educational activities, since a teacher is unable to form a mental image for one of their pupils. In order to extend Paivio's theory into a more applicable theory, studies must begin to investigate whether stimuli similar to those presented in the classroom aids learning in the same manner as the formation of a visual image.

Bruer (1997) suggests that educators often overlook the possible potential for research in the realm of cognitive psychology to provide practical applications. One particular area of debate in education that could benefit from cognitive studies is the importance of using 3-D visual stimuli as a part of "hands-on" learning. "Hands-on" learning, which involves students manipulating objects as part of an educational activity, is considered to be a highly effective instructional tool by many

educators. However, a detailed review of haptic ("active touch") literature that may be relevant to education, conducted by Minogue & Jones (2006), indicated that haptic research has not been able to translate to practical applications for education. Minogue and Jones (2006) also highlight that very little research has been conducted on the haptic abilities of adolescents. Considering adolescence is the most common age group to be exposed to online courses, it is important to begin to investigate the impact of haptically manipulating 3-D objects on learning capacity in this age group.

Since funding for gifted programming is continually in jeopardy, it is especially important to understand which forms of visual stimuli are the most effective educational tools. The memorization and cued recall of paired-word associations is a straight forward task that resembles testing circumstances that gifted students may encounter in school settings. Therefore, this study aims to begin to investigate the relative value of 2-D versus 3-D visual stimuli in the development of gifted programming by measuring the effect of varying forms of visual stimuli on paired-associate learning.

#### CHAPTER 2

#### METHOD

#### *Apparatus*

An Apple iMac computer presented the word pairs, as well as the images for the 2-D condition from a 100 cm viewing distance. The order of the word pairs was randomly selected by the computer from a standard set of 15 paired word associations (see Table 1) used for all four experimental conditions.

#### Experimental Stimuli

Objects were used to create 2-D and 3-D representations for each word displayed in the set of paired word associations presented. The 2-D representations were presented in only one condition, while the 3-D representations were presented in two conditions. There were 30 words total (all nouns) and therefore 30 objects. All of the objects were approximately the same size and could be easily grasped in the palm of an individual's hand. The objects were also as texturally similar to the actual objects they symbolized as their miniature stature would allow (i.e. the object representing the dolphin had a leathery feel, similar to the texture of an actual dolphin and so forth).

In order to maintain consistency across all conditions a Canon Rebel XT was

used to take pictures of the objects used as the 3-D visual stimuli. The photographs of these objects were programmed to be displayed directly under the words they represented on the computer screen during the condition that used 2-D visual stimuli. During the conditions that used 3-D visual stimuli, the actual objects were placed on an elevated platform to ensure that both 2-D and 3-D visual stimuli were presented in the same location relative to the paired-word associations being presented above the stimuli.

#### **Participants**

Fifty two participants took part in this study (28 female, 24 male). The mean age of participants was 14.8, with a range of 13-17 years old. Participants were randomly assigned to one of the four conditions. Thus, there were 13 participants per condition.

The participants were recruited from adolescents attending a residential summer camp for academically gifted students offered through the Center for Gifted Studies at Western Kentucky University. In order to qualify to attend this summer camp students had to be identified as gifted via eligibility for a talent search (e.g. Duke Talent Identification Program), as well as earning qualifying ACT or SAT scores. For a brief description of the academic and social structure of this specific camp, one can refer to the first two paragraphs of the participants section of Rinn (2006).

In accordance with the 1964 Declaration of Helsinki, all participants gave their informed assent before participating in the experiment. Since participants were all minors, informed consent was also given by the participant's parent or legal guardian. The methods and procedure used in this experiment were reviewed and approved by an institutional ethics committee at Western Kentucky University (Human Subjects Review Board Approval, document HSRB 20-257).

#### Procedure

Consent forms signed by the participants' parent or guardian were collected upon arrival at the summer camp. Participants also signed an assent form.

Participants were tested individually throughout the duration of the three week program. Upon arrival at the testing site participants were randomly assigned to the four experimental groups. Each group was instructed that they would be presented with 15 paired word associations and to memorize them to the best of their ability. Each pair was presented on the screen for a period of 20 seconds as in the procedure used to present the paired-word association task used by Lockhart (1969). Also in agreement with the procedure used by Lockhart (1969), participants "were instructed that either word of the pair might be given (to) them as the cue for recalling the other member" of the pair.

The first group was presented with words only and no visual stimuli. The second group was presented with words and 2-D representations (photographs) of each word. The third group was presented with words along with 3-D

representations. The fourth group was also presented words along with 3-D objects; however, this group was instructed to actively manipulate the objects with their hands.

The recall accuracy for each participant was measured directly after the presentation of the last word pair in the set. To measure recall accuracy a single word was presented on the computer screen and the participants were cued to respond with the word it had been previously paired. The experimenter recorded both the cue word and the participant's verbal response on a data sheet. This procedure was repeated for each of the paired word associations previously presented. Therefore, there were 15 cue words and 15 verbal responses made by each participant. Due to the known influence of the serial position effect on recall accuracy in similar tasks, the order of the cue words was randomly selected for each participant. Whether the first or second word in each pair was presented as the cue word was also randomly determined by the computer.

#### **CHAPTER 3**

#### **RESULTS**

The number of incorrect responses was calculated for each participant. This data was then used for statistical analysis. A one-way between-subjects analysis of variance (ANOVA) was conducted on the number of incorrect responses given by the four groups of participants. No significant differences existed between the four experimental groups (F(3, 48) = 0.366, p = 0.778, partial eta squared = 0.022). The mean number of incorrect responses for each of the four groups can be found in Figure 1.

There was a large within-group variation in the recall accuracy for each of the four conditions. The standard deviation values for each condition and the overall standard deviation across all participants are reported in Table 2. For the range of the incorrect responses in each group, see Figure 2.

#### **CHAPTER 4**

#### DISCUSSION

Contrary to finding a variation in the influence of varying forms of visual stimuli on retention and recall of paired associates in gifted children, this study demonstrated the existence of profound individual differences. The standard deviations for each condition reflect this variability (see Table 2). Figure 2 also indicates the large variability by depicting the range of numbers of incorrect responses for each group. These large within-group variations prevented significant differences between the accuracy of the groups.

The foundation for paired associate tasks was laid by Mary Calkins in the late 1800s (Calkins, 1894; Calkins, 1896a). Calkins originally included detailed notes on subjective observations as part of her methods. However, since no meaningful conclusions could be drawn from these notes, they were never reported (Calkins, 1896b). In the preceding years researchers modeling the paired associate task developed by Calkins have dropped subjective observations entirely from their methodology. The results of this study indicate that it may be important to reintroduce detailed observations into the methodology for paired associate tasks,

particularly experiments designed to have applications for an educational setting. In the current study, behavioral observations provide the greatest insight into the possible reasons for the high within-group variability that was obtained.

Behavioral observations made by the primary investigator during the course of this study support the distinction of independent learning styles among gifted children by noting varying degrees of comfort with the stimuli presented. For instance, some participants in the fourth condition were eager to haptically manipulate the items, while others had to be reminded that they needed to actively manipulate the objects in front of them. Another observation is that some students in the second, third, and fourth conditions focused their attention more on the words, while others focused their attention upon the visual stimuli. However, the majority of participants alternated their attention between the visual stimuli and the words being presented.

Divided attention seemed to be most common among participants in the fourth condition, which involved haptic manipulation of the objects. This was also the condition in which individual learning preferences and diverse personalities became apparent. This may have been a contributing factor to the fourth condition having the highest variability in the range of incorrect responses (see Figure 2). The condition with the lowest number of incorrect responses was also the condition that provided the least potential for divided attention. This was the first condition, which presented words only (refer to Figure 1). However, learning style preferences were still visible in the behavior of participants in this group. Some

participants in this group found 20 seconds to be a long period to concentrate on memorizing a single word pair and struggled to remain on task. While previous studies have found that brain activity is altered when attention is divided during a memory task, resulting in decreased recall accuracy (e.g., Iidaka, Anderson, Kapur, Cabeza, & Craik, 2000), it is important to note that the aforementioned factors are based on subjective observations. More research must be conducted in this area to provide quantifiable data so that stronger conclusions can be made about the general consistency of response accuracy across the four conditions.

Both the subjective observations and objective data from this study have implications for gifted students utilizing technology based educational tools, specifically those used in online courses. This research suggests that there is no detriment in having 2-D visual stimuli as visual aids in comparison with 3-D visual aids in an educational setting. It must be noted that this research only utilized a single task involving the memorization of paired associates. This study also did not take into consideration 3-D visual stimuli generated by a computer. The topic of computer generated 3-D visual stimuli and kinetic 2-D stimuli as educational tools have sparked the interest of researchers in recent years. Studies in these areas have focused on very specific skills, such as learning organic reactions in chemistry (Aldahmash & Abraham, 2009) and instructing doctors in surgical methods (Jurgaitis et al., 2008). While, studies of 3-D generated and kinetic stimuli seem to yield promising results, this form of technology is not currently prevalent in educational settings. The research in this area has also been very task specific.

Therefore, the focus of the literature should shift to filling the gap in our understanding of more accessible visual and haptic stimuli before studies continue to explore the educational applications of more complicated forms of stimuli.

This study begins to lay a foundation for literature on practical applications of visual and haptic manipulation of stimuli as part of the gifted education curriculum. One limitation of this study was that even though all of the participants were identified as academically gifted, each participant's level of verbal giftedness may have varied. In the future, a more precise measurement of verbal skill could be obtained from participants prior to completing a paired associate task to account more precisely for this measure. The same participants could also be exposed to all four conditions in order to investigate if there truly is an individual preference for different types of stimuli. The main difficulty with a within-subjects design would be designing four separate, yet equivalent, sets of word pairs. Future studies could also utilize different methods of measuring the memory of a set of paired words: multiple choice is one example of a varying form of measurement that is commonly used in schools. In the future, the study of visual stimuli and haptic manipulation of objects can be expanded to include broader investigations that will hopefully lead to practical applications for gifted education.

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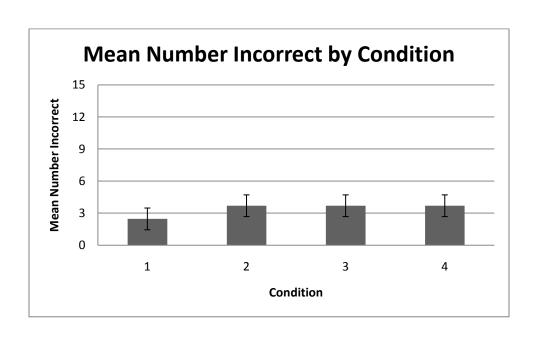


Figure 1. Mean Number Incorrect by Condition.

A graphical representation of the mean number of incorrect responses for each of the four experimental conditions (Condition 1: 2.46, Condition 2: 3.69, Condition 3: 3.69, Condition 4: 3.69; Standard Error: 1.017).

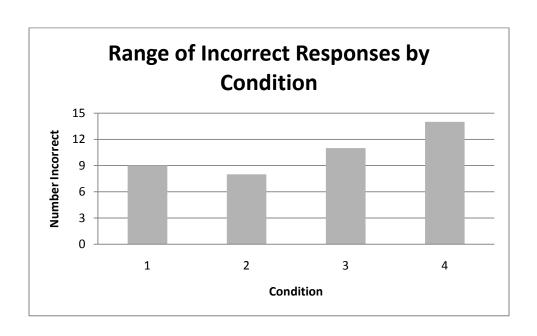


Figure 2. Range of Incorrect Responses by Condition.

A graphical representation of the range of incorrect responses for each condition (Condition 1: 9, Condition 2: 8, Condition 3: 11, Condition 4: 14). Each condition had at least one participant obtain a perfect score on the recall accuracy test.

**Table 1.** List of Paired Word Associations

	_	
1.	airplane	cup
2.	alligator	mask
3.	baby	lemon
4.	bow	horse
5.	apple	hairbrush
6.	flashlight	elephant
7.	baseball	mirror
8.	flower	truck
9.	banana	sunglasses
10.	football	grapes
11.	candle	dolphin
12.	bear	shovel
13.	beetle	sponge
14.	bowl	crown
15.	paintbrush	whale

 Table 2. Standard Deviations for Each Condition and the Overall Standard Deviation

Condition	Standard Deviation
1	3.045
2	3.011
3	3.614
4	4.733
Overall	3.598