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Context dependent memory for relaxing conditions

Kimberly Davies
Rowan University

CONTEXT DEPENDENT MEMORY FOR RELAXING CONDITIONS

by
Kimberly Davies

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ABSTRACT

Kimberly Davies
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Dr. Klanderman
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Although there are many studies on Context Dependent Memory (CDM), few studies have investigated CDM and relaxing environments. A recent British study by Cassaday, Bloomfield, and Hayward (2002) examined context dependent memory, relaxing conditions, and college student performance. The current study is a replication of the Cassaday, Bloomfield, and Hayward (2002) study. Participants in this experiment were 28 college students from a state university. The current study was a 2 x 2 between-subjects design with two independent variables: learning context and testing context. For all learning conditions participants completed a free recall task and a problem-solving task called the Tower of Hanoi. For all testing conditions participants completed a free recall task, a cued recall task, and a problem-solving task called the Tower of Hanoi. For the relaxing condition, the experimenter manipulated three aspects of the environment: odor, music, and instruction. The dependent variable for each task was the number of errors made. A 2 x 2 x 3 mixed (split plot) analysis of variance (ANOVA) was used to analysis the data. Context dependent memory was not found for any of the three tasks. However, participant performance was affected by task type.

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Chapter One: The Problem

Need

In the past three decades, total undergraduate enrollment in degree-granting postsecondary institutions has generally increased, and this trend is expected to continue throughout the next 10 years (National Center for Education Statistics [NCES], 2004). Moreover, the number of students enrolled both part time and full time, the number of students at 2- and 4-year institutions, and the number of male and female undergraduates are projected to reach a new high each year from 2004 to 2013.

As access to higher education has expanded, the importance of postsecondary schooling in determining life chances, occupational status, and wealth has increased. For example, males with a bachelor's degree or higher had earnings 19 percent higher than males with a high school degree in 1980 (NCES, 2004). However, by 2002 males that held a bachelors degree or higher were earning 65 percent more than their counterparts with less education. This earnings gap is even more dramatic for American women. Women with at least a bachelor's degree had earnings 34 percent higher than female high school completers in 1980, compared with earnings 71 percent higher in 2002 (NCES, 2004).

Consequently, Americans are spending an enormous amount of money on higher education. For the 2001-2002 school year, the average full-time student at a 4-year degree granting institution paid $16,287 in tuition and fees (NCES, 2002). In the same year, the average full-time student at a 2-year institution paid $10,010 in tuition and fees. American students are not the only ones contributing large amounts of money for

educational purposes. For the 1999-2000 school year, the average expenditure for a 4-year degree-granting institution was $25,256 per student (NCES, 2003). For the same year, the average expenditure for a 2-year institution was $ 8, 301 per student.

Clearly there are many negative consequences associated with low academic achievement. Students who do poorly in college may leave without obtaining a degree. These students are likely to earn much less in the course of a lifetime than their degree-earning peers. Furthermore, each student that leaves before degree completion costs the college or university thousands of dollars in unrealized tuition, fees, and alumni contributions.

Consequently, there is much interest in studying factors that may improve academic achievement. If such factors can be identified, then colleges and universities can take steps to improve student performance.

Purpose

Past research has examined how learning and testing environments affect academic performance. In general, these studies have found that students do best when the circumstances of learning and testing are the same. This phenomenon is called context dependent memory (CDM).

Although there are many studies on CDM, few studies have investigated CDM and relaxing environments. A recent British study by Cassaday, Bloomfield, and Hayward (2002) examined context dependent memory, relaxing conditions, and college student performance. The current study is a replication of the Cassaday, Bloomfield, and Hayward (2002) study.

Therefore, the primary purpose of the current study is to see if the results of Cassaday, Bloomfield, and Hayward's (2002) study can be replicated in the United States. If similar results are obtained, the hypotheses will be strengthened. If dissimilar results are obtained, this suggests that Cassaday, Bloomfield, and Hayward's (2002) study might not be valid. Either way, this study will add to the literature on context-dependent memory. Moreover, this study can have important implications for the field of education.

Hypotheses

Based on prior research, it is hypothesized that participants will perform better on cued and free recall tasks when taught and tested under relaxed conditions. That is, for the cued and free recall tasks, it is expected that reinstating a relaxing context will improve performance whereas reinstating a neutral context will not.

Also, the researcher predicts that participants will perform better on a problem-solving task in either of the congruent conditions than in either of the incongruent conditions. That is, for the problem-solving task, it is hypothesized that students who have been taught and tested in the same context will do better than students who are taught in one context and tested in another context.

Background

Research on environmental context and memory dates back to studies conducted in the mid 1920's. Most notably, Carr (1925) examined the effects of environmental manipulations on maze running in rats. Since then, many studies have found that manipulation of environmental factors can affect memory performance. Early research studied the effects of environmental context on memory within interference reduction

paradigms. In an interference reduction paradigm, an interfering word list is learned in the same environment or a different environment than the target list. These studies found that interference was substantially lowered when participants learned the interfering and target lists in different environments (Smith, 1994).

Current research on contextual memory tends to focus on context dependent memory (CDM) rather than interference reduction. Context dependent memory refers to the finding that material is best remembered when the learning environment matches the testing environment. This phenomenon is also known as reinstatement effects. Researchers have theorized that context dependent memory occurs because contextual information is stored along with events in memory and can thereby cue memories for those events (S.M. Smith, 1994). That is, the learning context can act as a retrieval cue at testing and consequently enhance memory performance.

However, Eich (1995) proposes that context dependent memory effects may actually be due to mood dependent memory. His mood mediation hypothesis states that moods are associated with memories, and that these moods can be used as retrieval cues to enhance memory. Eich (1995) found that when information is encoded and retrieved in the same physical setting, memory performance suffers if the occurring psychological states differ. Moreover, he found that a change in environmental context does not adversely affect performance if the mood at encoding matches the mood at retrieval. More research is needed to determine if mood is a mediator in context dependent memory. The present study will explore the effects of reinstating a relaxing environment.

Definitions

Congruent Condition or Matched Condition. These terms refer to an experimental condition in which a participant is taught and tested in the same context. There are two congruent conditions in this experiment, the R-R condition (relaxing context at learning followed by relaxing context at testing) and the N-N condition (neutral context at learning followed by neutral context at testing).

Context. In this study, context refers to the environment in which a participant was taught or tested.

Context Dependent Memory (CDM) Context dependent memory occurs when material is best remembered if the circumstances of learning and retrieval are the same.

Cued Recall Task. This is a component of a memory task in which the participant is asked to recall items that were presented to him or her on an initial presentation list. The participant is given a hint, or a cue, about the items on the original list. In this study, participants are given a sheet of paper with category names.

Free Recall Task. In a free recall task, the participant is presented a list of to-be-remembered items. At the end of the presentation of the list, the participant is asked to recall the items (e.g., by writing down as many items from the list as possible). It is called a free recall task because the participant is free to recall the items in any order that he or she desires.

Incongruent condition or Mismatched Condition. These terms refer to an experimental condition in which a participant is taught in one context and tested in another context. There are two incongruent conditions in this study, the R-N condition

(Relaxing context at learning, Neutral context at testing) and the N-R condition (Neutral context at learning, Relaxing context at testing).

Problem-solving task. For this study, participants are given a problem-solving task called the Tower of Hanoi. The Tower of Hanoi is a puzzle that was invented by the French mathematician Edouard Lucas in 1883. It will be described in further detail in the methods section.

Reinstatement Effects. See Context Dependent Memory (CDM).

Assumptions

For the purposes of this study, the researcher has made several assumptions about the current sample. First, it is assumed that all participants will complete the experimental tasks to the best of their ability. Each experimental session is relatively short and only moderately challenging; therefore, there is no reason to believe that participants will not do their best. A second assumption is that all participants possess the necessary cognitive abilities to perform the experimental tasks. The experimental tasks are age appropriate; therefore, it is assumed that students attending a university will be able to complete them.

Limitations

This study has two important limitations. First, our sample size was small, which may limit the generalizability of the findings. Second, the participants are not randomly assigned to experimental conditions. Instead, participants will sign up for the days and times in which they are available to participate in the study.

Summary

In conclusion, this study will replicate a previous study conducted in England by Cassaday, Bloomfield, and Hayward (2002). It will examine context dependent memory, relaxing conditions, and college student performance.

A detailed review of the literature will be provided in the next chapter. Following this chapter will be a description of the methods including participants, measures, and procedures. Next, the results of the current study will be discussed. Then, the findings will be discussed, along with limitations and implications of the study. Finally, recommendations for future research will be discussed.

Chapter Two: Literature Review

This chapter describes literature relevant to the research purposes of this thesis. It is organized into five main sections: (1) context dependent memory in the laboratory and the classroom, (2) guiding principles of context dependent memory, (3) the mood mediation hypothesis of context dependent memory, (4) reinstatement of relaxing conditions, (5) summary of the research on context dependent memory.

Context Dependent Memory in the Laboratory and the Classroom

Researchers have found that the environment may play an important role in memory retrieval. Specifically, many researchers have found memory for material to be better when the circumstances of learning and retrieval are the same. This phenomenon is known as context dependent memory. Researchers have theorized that context dependent memory occurs because contextual information is stored along with events in memory and can thereby cue memories for those events (S.M. Smith, 1994). That is, the learning context can act as a retrieval cue at testing and consequently enhance memory performance.

Context Dependent Memory in the Laboratory

Most studies have been conducted in a laboratory setting and have looked at context dependent memory for free recall or recognition tasks. Free recall is a basic paradigm used to study human memory. In a free recall task, a subject is presented a list of to be remembered items, one at a time. For example, an experimenter might read a list of 20 words aloud, presenting a new word to the subject every 4 seconds. At the end of the presentation of the list, the subject is asked to recall the items (e.g., by writing down

as many items from the list as possible). It is called a free recall task because the subject is free to recall the items in any order that he or she desires, (Smith and Vela, 2001). The recognition task is a variation of the recall memory task. For this task, the subject is not required to explicitly state the items; instead, they must simply identify which items (from a larger group of items) were on the original list, (Smith and Vela, 2001).

Many of the laboratory studies utilizing the recall task have found evidence of context dependent memory (Godden and Baddeley, 1975; Jensen, Harris, & Anderson, 1971; Smith, 1985a, 1985b, 1986; Smith, Glenberg, & Bjork, 1978). Most recently, two experiments by Parker, Gellatly, & Waterman (1999) investigated context dependent memory for implicit and explicit tasks. The explicit memory task for both experiments was a free recall task. For the first experiment, participants studied a list of 48 words in a college classroom or on a balcony overlooking a busy courtyard of an academic building. Participants were then tested in the same environment in which they had learned the words or in the other environment.

For the second experiment, participants studied a list of 40 words in a teaching laboratory or in a classroom. The teaching laboratory was large, brightly lit, and contained various equipment. In contrast, the classroom was small, dimly lit, and contained only tables and chairs. Once again, participants were either tested in the same environment in which they had learned the words or in the other environment. For both experiments, Parker, Gellatly, & Waterman (1999) found evidence for context dependent memory effects on the free recall task.

However, some researchers studying recall and context dependent memory have failed to find reinstatement effects (Eich, 1985; Fernandez & Glenberg, 1985).

Furthermore, although some studies on recognition and context dependent memory have found reinstatement effects (Canas & Nelson, 1986; Geiselman & Bjork, 1980), many studies have not (Godden and Baddeley, 1980; Jacoby, 1983).

In summary, the laboratory studies of context dependent memory demonstrate that although context reinstatement has been found to aid memory in many studies, reported failures to find context dependent memory are also numerous. In particular, evidence for context dependent memory is generally found with recall, but not with recognition testing.

Context Dependent Memory in the Classroom

In addition to laboratory studies, a number of studies on context dependent memory have been conducted in classroom settings. These studies are typically composed of college students taking a psychology class from the researcher. The researcher teaches the students in the normally assigned classroom setting and then tests half of the participants in that setting and half of the participants in another setting, usually another classroom. In general, these studies have found that students do not score lower on exams as a result of being tested outside their regular classroom. (Abernethy, 1940; Farnsworth, 1934; Saufley, Otaka, & Bavaresco, 1986).

Smith (1988) has proposed that context dependent memory effects are not found in classroom studies because students study the material outside their regular classroom; therefore, any classroom context is different from the students' predominant learning context. In other words, these researchers have controlled the context in which students first learn the material, but they have not accounted for studying that students do outside of the classroom.

An exception to this pattern is a study by Mellgren (1984), who did control students' study place, having some students spend study time in the regular classroom and others spend study time in another classroom. In this study, evidence for context dependent memory was found; the participants who studied and were tested in the same room did significantly better on the test than participants who studied and were tested in different rooms. The results of Mellgren's (1984) study suggest that context dependent memory effects may be obtained in classroom studies if both learning and studying contexts are controlled.

In summary, context dependent memory has been studied in laboratory and classroom settings. In laboratory settings, context dependent memory is most often found with recall testing, but not with recognition testing. However, some studies using recall tasks have also failed to find evidence for context dependent memory. Moreover, when context dependent memory has been studied in the classroom context reinstatement effects have generally not been found. These mixed findings have prompted researchers to investigate factors that may impede context dependent memory.

Guiding Principles of Context Dependent Memory

In a recent review of the literature, Smith and Vela (2001) established two guiding principles to describe and explain the effects of context dependent memory on human performance. These basic principles also help to explain why researchers have sometimes failed to find evidence for context dependent memory. The first guiding principle states that, "the effect of environmental manipulation decreases as the use of nonenvironmental cues, at learning or at test, increases" (Smith and Vela, 2001, p.205). The overshadowing hypothesis is a good example of this guiding principle.

Overshadowing is said to occur when participants are deeply processing material and making conceptual associations between items, resulting in little or no encoding of the environmental context (Glenberg, 1997; Glenberg et. al., 1998; Matzel, Schachtman, & Miller, 1985; Smith and Vela, 2001). That is, at the time of encoding, contextual information is overshadowed by conceptual information. Because the contextual information is never encoded in memory, it does not act as a retrieval cue at testing and context dependent memory does not occur.

The outshining hypothesis is another good example of the first guiding principle. The outshining hypothesis is said to occur when participants use noncontextual retrieval cues, such as inter-item associations, during testing instead of contextual retrieval cues (Eich, 1980; Geiselman and Bjork, 1980; Smith et al., 1978; Nixon & Kanak, 1985). That is, even if participants have encoded contextual information during learning, they may not use this information as a retrieval cue during testing. Both the overshadowing and the outshining hypotheses predict that the use of noncontextual cues can diminish the effect that contextual cues have on memory.

The second guiding principle proposed by Smith and Vela (2001) states that, "the effect of changing the environment from study to test decreases to the extent that subjects are encouraged at test to mentally reinstate the context that was present during learning" (p. 205). This principle is supported by several studies, which have found that internal manipulation of contextual information can improve memory performance (Fisher, Geiseman, Mackinnon, & Holland, 1984; Krafka & Penrod, 1985; Smith, 1979, 1984). That is, these studies have found that subjects can imagine a previously experienced environmental context and use the internally generated image as a memory cue even if

that environmental context is not physically present. Mental reinstatement of contextual information may explain why some researchers have failed to find context dependent memory effects; subjects tested in a new context might sometimes generate their own context cues internally (Smith and Vela, 2001). This seems especially likely for studies that have instructed participants to pay close attention to their surroundings during learning (e.g. Nixon and Kanak, 1981). When participants are instructed to attend to their learning environments, it seems likely that they may mentally reinstate these contexts when tested in a new environment.

The two guiding principles suggested by Smith and Vela (2001) are basic statements that help describe and explain trends in the context dependent memory literature. Most importantly, these principles offer explanations as to why context dependent memory effects are not always found by researchers. However, Smith and Vela (2001) did not include the mood mediation hypothesis in their review of context dependent memory.

Mood Mediation Hypothesis

The mood mediation hypothesis proposes that context dependent memory effects may actually be due to mood dependent memory (Eich, 1995). The hypothesis states that moods are associated with memories, and that these moods can be used as retrieval cues to enhance memory. Moreover, different environments produce different moods, and the environmental changes that affect moods the most should be most likely to result in context dependent memory. In support of his hypothesis, Eich (1995) found that when information is encoded and retrieved in the same physical setting, memory performance suffers if the occurring psychological states differ. Moreover, he found that a change in

environmental context does not adversely affect performance if the mood at encoding matches the mood at retrieval. Based on these results, Eich (1995) proposed that studies that appear on the surface to demonstrate context dependent memory my actually reveal the presence of mood dependent memory.

Although other researchers have not specifically investigated the mood mediation hypothesis as proposed by Eich (1995), some researchers have made similar observations concerning mood and context dependent memory effects. Several studies have investigated context dependent memory effects by manipulating odor, background music, or both (Aggleton & Waskett, 1999; Balch & Lewis, 1996; Cassaday, Bloomfield, & Hayward, 2002; Eich, 1978; Parker & Gellatly, 1997; Parker, Ngu, & Cassaday, 2001; Pointer, Adelaide, & Bond, 1998). Many of these researchers have commented on the ability of odors and music to alter the mood of individuals. Thus suggesting that the environmental manipulations may have affected the mood of their participants, which in turn may have lead to context dependent memory findings.

For example, Balch & Lewis (1996) studied context dependent memory and music tempo. They found that subjects performed better on a free recall task if they heard music played at the same tempo at retrieval as at encoding (Balch & Lewis, 1996). Although Balch and Lewis (1996) attributed this finding to context dependent memory they speculated that alterations in tempo might influence the arousal dimension of mood.

Similarly, Parker, Ngu, and Cassaday (2001) found that reintroduction of the same odor (lemon or lavender) improved performance four weeks later in both free recall and recognition of a word list. Parker, Ngu, and Cassaday (2001) also attributed these effects to context dependent memory, although they noted that lavender is often thought

to have a calming effect on individuals. Therefore, one may interpret their results as denoting mood dependent memory rather than context dependent memory.

Clearly, many researchers have manipulated environmental contexts in ways that may influence the mood of their participants. Therefore, it seems likely that context dependent effects may be mediated by alterations in affect or mood as Eich (1995) has proposed.

Reinstatement of Relaxing Conditions

A recent study by Cassaday, Bloomfield, and Hayward (2001) examined context dependent memory and relaxed conditions. Based on prior context dependent memory research and the mood mediation hypothesis, Cassaday, Bloomfield, and Hayward (2001) hypothesized that a relaxed learning environment would provide particularly effective retrieval cues. To test this hypothesis, the researchers used multiple contextual cues combined to create relaxing versus neutral contexts at separate learning and memory stages of the experiment.

The participants were given a list of words to memorize and a problem-solving task under either relaxing or neutral conditions. The next day they were tested on the material under the same or different (relaxing versus neutral) conditions. Cassaday, Bloomfield, and Hayward (2001) found that, for the recall tasks, reinstating the relaxing context provided more effective reminders than those that were produced by reinstating the neutral context. That is, context dependent memory was seen when the relaxing condition was reinstated, but not when the neutral condition was reinstated. For the problem solving tasks, they found that fewer errors were made in either of the matching conditions (i.e., when relaxing and neutral conditions were reinstated) than in either of

the mismatching conditions (i.e., when participants learned and were tested in different environments). Cassaday, Bloomfield, and Hayward (2002) concluded that reinstating a context can aid memory and a relaxing environment can provide particularly effective retrieval cues.

Summary of the Literature Review

Many researchers have found memory for material to be better when the circumstances of learning and retrieval are the same. Thus, the presence of cues that were around at encoding can serve as effective reminders. In laboratory settings, evidence for context dependent memory is generally found with recall, but not with recognition testing. Moreover, when context dependent memory has been studied in the classroom context reinstatement effects have generally not been found.

These mixed findings have prompted researchers to investigate factors that may impede context dependent memory. In general, the factors that prevent context dependent memory fall under two guiding principles proposed by Smith and Vela (2001). The first guiding principle states that, "the effect of environmental manipulation decreases as the use of nonenvironmental cues, at learning or at test, increases" (Smith and Vela, 2001, p.205). The second guiding principle proposed by Smith and Vela (2001) states that, "the effect of changing the environment from study to test decreases to the extent that subjects are encouraged at test to mentally reinstate the context that was present during learning" (p. 205).

However, the mood mediation hypothesis, which proposes that context dependent memory effects may actually be due to mood dependent memory, is not included in the two guiding principles of context dependent memory (Eich, 1995). However, it is

important to consider this hypothesis as many studies have manipulated environmental contexts in ways that may influence the mood of their participants. The current study is a replication of the Cassaday, Bloomfield, and Hayward (2002) study; it will examine context dependent memory, relaxing mood, and college student performance.

Chapter Three: Method

Sample

Participants in this experiment were 28 college students (23 female, 20 male) from a state university in New Jersey. The self-reported ethnic background of the sample was 83.3% Caucasian, 6.7% Asian, 5% African-American, and 5% mixed ethnicity/other.

The study was advertised on a research board that is located in the school's psychology building. It was one among several experiments that students could participate in to fulfill a class requirement. Thus, the majority of participants were psychology students who took part in the experiment to fulfill a class requirement. However, in addition to receiving class credit, research participants were entered in a drawing for a chance to win a $30 gift certificate to the store of their choice. Therefore, several participants were college students who took part in the study solely for the chance to win a gift certificate.

Design

Like the Cassaday, Bloomfield, and Hayward (2002) study, the current study was a 2 x 2 between-subjects design with two independent variables: learning context and testing context. This design yielded four experimental conditions: relaxing at learning followed by relaxing at testing (R-R); neutral at learning followed by neutral at testing (N-N); relaxing at learning followed by neutral at testing (R-N); and neutral at learning followed by relaxing at testing (N-R).

Materials

A list of 20 words was used for the free recall and cued recall tasks. This list consisted of five categories each containing four nouns taken from among the 56 categories used by Battig and Montague's taxonomy norms (1969). The words on the list ranged from three to six letters in length, with an average word length of five letters. To avoid possible floor effects in recall, the words included under each category were chosen from the top eight examples of that category. A stopwatch was also used for the free recall and cued recall tasks to time participants as they memorized the word list.

For the problem-solving task, the Tower of Hanoi puzzle was used. For this task, participants are given a tower of four disks, initially stacked in increasing size on the first of three pegs. The objective is to transfer the entire tower to the last peg, moving only one disk at a time and never a larger one onto a smaller.

For the relaxing condition, an oil diffuser containing 0.2 ml of essential lavender oil and 5 ml of cold water was allowed to diffuse around the room for five minutes. In addition, an except of Mozart from the Royal Philharmonic Collection of Sonatas in A minor (K.310 and K.331), C major (K.545), and A major (K.331) was played throughout the duration of the relaxing condition.

Procedure

Participants signed up for the experiment dates and times that fit their schedules. That is, participants were not randomly assigned to conditions. The date that they chose to complete the experiment determined which treatment condition they were in.

For the relaxing condition, the experimenter manipulated three aspects of the environment. First, the odor of the room was manipulated by allowing an oil diffuser with lavender oil diffuse around the room for 5 minutes. Second, the Mozart sonatas described in the previous section were played on a small stereo system. Finally, the experimenter manipulated her speech in such a way that she was more conversational and reassuring in the relaxing condition versus the neutral condition. That is, the experimenter gave participants in the relaxing condition additional reassurances in the task instructions. For the category lists she said, "20% of people score less than 50% on this task, so don't worry if you can't remember them all". For the Tower of Hanoi task she said, "Don't worry if you find it hard at first, as most people take practice, needing about 14 moves, but you will soon get the hang of it. Again just do your best."

Except for the above-mentioned manipulations, the neutral condition was identical to the relaxing condition. That is, the room, furnishings, and time of day were kept constant. In both conditions, the participants completed the word recall task first. Participants were given 1 minute to study the list of 20 words. In order to give the impression that the experiment was complete and so reduce the likelihood of further rehearsal, a memory test was given immediately after the 1-minute exposure. Participants were given 2 minutes to write down all the words, in any order, that they

could remember from the study session. They were given a single sheet of paper with the numbers 1-20 printed on the left hand side.

Next, participants in both conditions completed the Tower of Hanoi puzzle. The same instructions were given to both groups, "Move the four disks from pole A to pole C, moving only one disk at a time, never placing a larger disk on top of a smaller one." As previously described, participants in the relaxing condition received additional assurances. In both conditions, participants were instructed to keep working until they were able to complete the puzzle in the minimum number of moves. This was done during the learning phase so that all participants could reach the same level and gain a sense of competence.

Participants returned 24 hours later to complete the second session of the experiment. They returned to their selected experimental condition, which was either congruent (N-N, R-R) or incongruent (N-R, R-N). Both groups received the same instructions that were given at the learning phase. Participants in the relaxing condition also received the same relaxing instructions that were used in the learning phase.

First, participants completed a free recall test of the original word list, as used in the immediate recall test. Next, participants completed a cued recall test of the same word list. Participants were given a sheet of paper with the category labels and the numbers 1-4 written underneath them. Once again, the participant had 2 minutes to write down as many of the words as they could remember.

Finally, the participants were asked to solve the same Tower of Hanoi puzzle. On completing the study, participants were entered in a drawing to win a $30 gift certificate. The experimenter then drew a participant name from a box and this person won a $30 gift certificate to a retail store.

Statistical Analyses

The dependent variable for each task was the number of errors made, i.e., the number of wrong or blank answers given in the free recall and cued recall task and, for the Tower of Hanoi, the number of moves above the optimal seven needed to solve the task at testing. This was done to allow statistical comparison of performance across the tasks. A 2 x 2 x 3 mixed (split plot) analysis of variance (ANOVA) was used to analysis the data. The between-subjects factors were the learning context and the testing context; the within-subjects factor was the recall tests.

Interactions between learning and testing arise because the effect of the (relaxed versus neutral) testing context depends on the (relaxed versus neutral) learning context. Thus it is the significance or otherwise of the interaction that tests for the presence or absence of CDM.

Hypotheses

Because this study is a replication of the Cassaday, Bloomfield, and Hayward (2002) study the researcher hypothesizes that she will obtain identical results. That is, for the recall tasks, the researcher predicts that context dependent memory will be seen when the relaxing condition is reinstated, but not when the neutral condition is reinstated. For

the problem solving tasks, the researcher hypothesizes that fewer errors will be made in either of the matching conditions (i.e., when relaxing and neutral conditions are reinstated) than in either of the mismatching conditions (i.e., when participants learn and are tested in different environments).

Summary

Twenty-eight college students participated in this study. The current study was a 2 x 2 between-subjects design with two independent variables: learning context and testing context. This design yielded four experimental conditions: relaxing at learning followed by relaxing at testing (R-R); neutral at learning followed by neutral at testing (N-N); relaxing at learning followed by neutral at testing (R-N); and neutral at learning followed by relaxing at testing (N-R).

For all learning conditions participants completed a free recall task and a problem solving task called the Tower of Hanoi. For all testing conditions participants completed a free recall task, a cued recall task, and a problem-solving task called the Tower of Hanoi. For the relaxing condition, the experimenter manipulated three aspects of the environment: odor, music, and instruction. Except for these manipulations, the neutral condition was identical to the relaxing condition. That is, the room, furnishings, and time of day were kept constant.

The dependent variable for each task was the number of errors made. A 2 x 2 x 3 mixed (split plot) analysis of variance (ANOVA) was used to analysis the data. It is the significance or otherwise of the interaction that tests for the presence or absence of CDM.

Chapter Four: Results

As mentioned in the previous chapter, the dependent variable for each task was the number of errors made. For the free recall and cued recall tasks the number of errors made was the number of wrong or blank answers given for each task. For the Tower of Hanoi puzzle the number of errors was equal to the number of moves above the optimal seven needed to solve the puzzle at testing. The number of errors was used as the dependent variable for each task so that performance across tasks could be compared.

The data were entered into a 2 x 2 x 3 mixed (split plot) analysis of variance (ANOVA). The between-subjects factors were learning context and testing context. The within-subjects factor was the recall tests. The ANOVA revealed that there was no significant main effect of learning context, $F(1, 24) = .001$, $p > .05$. It also revealed that there was no significant main effect of testing context, $F(1, 24) = .249$, $p > .05$.

However, the ANOVA did reveal a significant main effect of Task $F(2, 48) = 25.803$; $p < 0.01$. As expected, participants made fewer errors on the cued recall task than on the recall task (see Table 1). Participants made the fewest errors of all while completing the Tower of Hanoi puzzle.

Table 1. Mean number of errors and standard deviations across three tasks.

Task	Mean number of errors	Standard deviation
Free Recall	6.00	3.47
Cued Recall	4.89	3.17
Tower of Hanoi	2.00	1.69

Also, there was no interaction between learning context and task, $F(2, 48) = .342$; $p > .05$. Likewise, the ANOVA revealed there was not an interaction between testing context and task, $F(2, 48) = .049$, $p > .05$.

Finally, the ANOVA revealed that there was no interaction between learning context and testing context, $F(1, 24) = 1.79$, $p > .05$. It is the significance or otherwise of the interaction between learning context and testing context that tests for the presence or absence of context dependent memory. Therefore, this suggests that context dependent memory did not occur.

Chapter Five: Discussion

Because the present study is a replication of the Cassaday, Bloomfield, and Hayward (2002) study the researcher hypothesized that the results from this study would be identical. However, the results of the present study do not support either of the researcher's main hypotheses. That is, context dependent memory was not found for the recall tasks when the relaxing condition was reinstated. In fact, participants in all four experimental conditions recalled about the same number of words.

Moreover, context dependent memory was not seen for the problem-solving task. Statistically, participants in the matching conditions (i.e., when relaxing and neutral conditions are reinstated) and mismatching conditions (i.e., when participants learn and are tested in different environments) made the same number of errors. However, the present study did find significant differences in student performance between the three different tasks.

However, the main hypotheses concerning context dependent memory were not supported by the present study. This study had some important limitations that must be taken into account when considering these findings. First, the present study had a very small sample size of only 28 participants. With this sample size each experimental condition only had 7 participants. Therefore, it is very likely that context dependent memory effects were not found because the present study lacked statistical power.

Also, individual differences between the experimental groups may have affected the outcome of this study. The researcher was unable to randomly assign participants to the four experimental conditions. Participants were grouped according to which day and

time they signed up for. Therefore, it is possible that the groups were not equal, in terms of ability to memorize, at the start of the experiment. Perhaps participants in the mismatching conditions were better at memorizing words than participants in the matching conditions. If this were the case, they could have done just as well as participants in the matching groups even though they did not have the benefit of contextual reinstatement.

Also, the stimuli used to manipulate the environment in the relaxation conditions may not have had the intended affect on participants. The present study used lavender oil and Mozart piano sonatas to create a relaxed environment, as these were the stimuli used in the original study by Cassaday, Bloomfield, and Hayward (2001). Cassaday, Bloomfield, and Hayward (2001) found there was some support in the literature to suggest that lavender generally produces a relaxing effect. However, more research has to be done to determine this. Moreover, there is no research to suggest that the Mozart piano sonatas produce a relaxing effect.

Therefore, it is possible that the stimuli in this experiment failed to produce a state of relaxation for study participants. According to Eich (1995), context dependent memory effects are actually due to mood dependent memory. Moods are associated with memories, and it is these moods that are used as retrieval cues to enhance memory. If the relaxing condition failed to make participants feel relaxed this would account for the results.

However, there are other factors that may account for the findings of this study. In a recent review of the literature, Smith and Vela (2001) established two guiding principles to describe and explain the effects of context dependent memory on human

performance. These basic principles may help to explain why the current study failed to find evidence for context dependent memory. The first guiding principle states that, "the effect of environmental manipulation decreases as the use of nonenvironmental cues, at learning or at test, increases" (Smith and Vela, 2001, p.205).

The overshadowing hypothesis is an example of this guiding principle. Overshadowing is said to occur when participants are deeply processing material and making conceptual associations between items, resulting in little or no encoding of the environmental context (Glenberg, 1997; Glenberg et. al., 1998; Matzel, Schachtman, & Miller, 1985; Smith and Vela, 2001). That is, at the time of encoding, contextual information is overshadowed by conceptual information. Because the contextual information is never encoded in memory, it does not act as a retrieval cue at testing and context dependent memory does not occur.

Overshadowing could explain why the current study did not find evidence for context dependent memory. During the learning period, participants could have been making conceptual associations between words on the list. This seems very likely as the words that participants had to remember were grouped into categories. Therefore, participants could have been focusing so much on grouping the words to be memorized into categories that they did not pay any attention to the environmental context. Thus, it is possible that the contextual information was never encoded in memory and, therefore, did not affect participant performance.

The outshining hypothesis is another example of the first guiding principle. The outshining hypothesis is said to occur when participants use noncontextual retrieval cues, such as inter-item associations, during testing instead of contextual retrieval cues (Eich,

1980; Geiselman and Bjork, 1980; Smith et al., 1978; Nixon & Kanak, 1985). That is, even if participants have encoded contextual information during learning, they may not use this information as a retrieval cue during testing.

Outshining could also explain why the current study did not find evidence for context dependent memory. That is, participants could have been aware of contextual cues but used other cues that were present during learning and testing to aid in retrieval. Watkins and Watkins (1975) have found that the less overloaded a cue is (i.e. the fewer items associated with a cue) the more likely it is to be used. For this experiment the contextual cues were associated with all the words on the list to be remembered. However, each category heading was only associated with four words on the list. Therefore, according to Watkins and Watkins (1975) the category headings are better cues than the contextual cues. So, participants could have encoded contextual cues in memory but not use them. Participants could have used better cues that were present during learning and testing, such as the category headings.

The second guiding principle proposed by Smith and Vela (2001) states that, "the effect of changing the environment from study to test decreases to the extent that subjects are encouraged at test to mentally reinstate the context that was present during learning" (p. 205). This principle is supported by several studies, which have found that internal manipulation of contextual information can improve memory performance (Fisher, Geiseman, Mackinnon, & Holland, 1984; Krafka & Penrod, 1985; Smith, 1979, 1984). That is, these studies have found that subjects can imagine a previously experienced environmental context and use the internally generated image as a memory cue even if that environmental context is not physically present.

Mental reinstatement of the learning context may be another reason why the hypotheses of this study were not supported. During testing participants in the mismatching conditions could have thought back to the original testing environment, creating an image of it in their mind. This could have helped them to do just as well as participants in the matching conditions. Thus, context dependent memory would not be observed because participants in all of the experimental conditions would have the original learning environment reinstated. Participants in the matching conditions would have a physical reinstatement of the learning environment at testing and participants in the mismatching conditions would have a mental reinstatement of the learning environment.

Finally, there are factors that are not related to Smith and Vela's (2001) guiding principles that may account for the results of this study. For example, one explanation may be that individuals vary as to how susceptible they are to manipulations of context. A study by Smith (1985a) found that field-dependent participants had more context dependent memories than field-independent participants. Field dependence is a personality trait that refers to how much individuals rely on contextual influences while making perceptual judgments. Field-dependent individuals are more affected by perceptual contexts than field-independent individuals. Therefore, it is possible that context dependent memory was not found because there were differences between experimental groups in terms of field dependence.

The current study is important because it adds to the literature on context dependent memory. The findings suggest that odor and music are not always effective in producing context dependent memory. There are several possible explanations as to why

context dependent memory was not found with these stimuli. However, small sample size is the most likely reason that context dependent memory was not found. Also, it is possible that the stimuli in this experiment failed to produce a state of relaxation for study participants. According to Eich (1995), context dependent memory effects are actually due to mood dependent memory. Thus, if the relaxing condition failed to make participants feel relaxed this would account for the results.

Further research is needed to determine if context dependent effects are mediated by alterations in affect or mood. In particular, researchers should determine which mood states are most conducive to context dependent memory. In order to effectively study the mood mediation hypothesis future studies should: (1) have a large sample size, (2) randomly assign participants to experimental conditions, (3) and conduct preliminary research to ensure that stimuli evoke the mood state that is being studied.

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