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Changing environments between encoding and recall may impair memory. This context-dependent memory (CDM) is presented in the literature as an artifact of little relevance outside the lab. Further, much of the previous research on this effect has poor internal validity. Thus the nature and function (i.e., preventing retroactive inhibition) of CDM outside the laboratory is unknown. The present study was conducted to determine whether CDM exists in the classroom, using verbal stimuli as learning material, in immediate and delayed recall conditions. In addition, the effectiveness of a mnemonic or imaginal, as opposed to a physical, reinstatement of context at reducing CDM was examined. Results indicate that context-dependent memory exists in the classroom for both immediate and delayed recall. Further, an imaginal reinstatement of context was found to eliminate this impairment at both immediate and delayed recall, but only for subjects who had high imagery ability, operationalized as scoring above the mean on a modified version of Bett's Questionnaire upon Mental Imagery. Though changed context reduces recall in actual learning situations, physical or imaginal context reinstatement may prove a valuable and compensatory retrieval strategy.

CONTEXT-DEPENDENT MEMORY
IN A COLLEGE CLASSROOM

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CHAPTER 1

INTRODUCTION

> A young gentleman who having learned to dance, and that to great perfection, there happened to stand an old trunk in the room where he learned. The idea of this (trunk) had so mixed itself with the turns and steps of all his dances, that though in that chamber he could dance excellently well, yet it was only while that trunk was there; nor could he perform well in any other place (credited to the 19th century British Associationist John Locke by Baddeley, 1976, p. 72).

Locke's tale attests to the importance of the environment in remembering. A change of context between encoding and recall may produce a memory hindrance, and this decrement is now referred to as context-dependent memory (CDM). A survey of the literature on CDM reveals several interesting themes. First, most of what is known about the effect exists as anecdotal evidence, such as the above passage credited to Locke, and writings of early functionalist psychologists such as Carr (1925) and McGeoch (1932). Second, much of the research supportive of CDM was not designed to examine the effect directly. Rather, CDM has been inferred from the results of studies examining related phenomenon, such as interference (McGeoch, 1942; Melton & Irwin, 1940) and encoding specificity (Tulving & Thomson, 1973), instead of being directly investigated. Finally, although CDM has generally been accepted as a real life phenomenon (i.e., hindering memory in actual learning situations such as the classroom), the experimental paradigms appear to treat it as an unstable, artifactual product of the psychological laboratory with results of questionable external validity.

One of the first references to CDM is Carr's bold proposal that "recall depends upon environmental conditions as...all experiences are revived in virtue of their direct or indirect association with some sensory stimulus" (1925, p. 250). To Carr, encoding involved not only association of material to that which was already in memory, but also involved incidental associations of the material to manifold aspects of the environment such as light, temperature, physical objects, and so forth. This has been referred to as a tagging phenomenon (Greenspoon & Ranyard, 1957), with physical aspects of the learning environment "tagging" material as it is learned. When the sensory stimuli "tags" are present at recall, the associated material may be more easily recalled. When the recall and encoding environments differ, these tags no longer act as retrieval cues, resulting in reduced recall. Similarly, McGeoch (1932) also stated that the associations made during encoding are "not only intrinsic to the material which is being learned, but also between parts of this material and the manifold features of the context or environment in which the learning is taking place" (p. 365).

Having formulated his theory, Carr (1925) hypothesized that "the speed and accuracy with which a given material can be recalled in a novel environment will be proportional to the similarity of those conditions to those that obtained when the material was learned" (p. 252). Thus, forgetting is attributable to being "unable to reinstate any given material because of a lack of associative connection with the present situation" (p. 256).

These ideas were formalized as tagging theory, which proposes that learners automatically and unconsciously associate physical aspects of the environment with input at encoding (Smith, 1979). Recall in a different environment negates the facilitatory effects of those encoded physical aspects as retrieval cues, resulting in reduced recall.

It is important to distinguish between internal and external context (McGeoch, 1932). Internal context refers to the learner's internal environment, such as mood (Bower, Monteiro, & Gilligan, 1978) or pharmacological (i.e., alcohol or marijuana intoxication, see Eich, 1980, for a review) states. When these internal environments are manipulated between encoding and recall, reduced recall is produced, and it can be argued that these effects stand on the same theoretical base as effects from external environmental manipulations (cf. Eich, 1980), which are the present author's focus. External context is defined as the physical aspects of the learning situation including objects, light, noise, temperature, and any other features that become sensory stimuli. This focus is referred to as context-dependent memory, while the former, based on internal contexts, is generally referred to as state-dependent memory.

One of the earliest experimental studies investigating CDM was conducted by Bilodeau and Schlosberg (1951). They exposed subjects to one word list in room A, a second list in either room A or B, and then had recall of both lists in room A. Subjects learning both lists in the same room had lower total recall than subjects learning each list in a different room. Retroactive inhibition (RI), that is, newly learned material hindering recall of previously learned material, is apparently reduced when the lists are tagged by the learning environments, allowing discrimination from each other at recall. Greenspoon and Ranyard (1957) replicated the results following the same procedure and making rooms A and B as physically dissimilar as possible.

In addition to these RI paradigms, the literature on CDM commonly cites the proactive inhibition (PI) paradigm of Dallet and Wilcox (1968). In their study, subjects were exposed to consonant-vowel-consonant trigrams over numerous sessions, in an intentional learning task. Recall was tested after each two-trial session. Subjects had one session a day for either one, two, three, or four days. Half of the subjects in each of these conditions changed context between each list learning. Recall became worse across successive trials for all subjects, as would be predicted for PI, but was reported to be significantly less so for subjects who switched contexts. Dallet and Wilcox, like those using the RI paradigms, attribute their results to a tagging phenomenon, theorizing that this contextual tagging at encoding prevents the interference of material encoded later in different contexts.

The classic CDM study of Godden and Baddeley (1975) was the first to directly test tagging theory, as opposed to the indirect validation using the RI and PI research. Subjects exposed to word lists while either on dry land or underwater were tested for recall in either the original or opposite environment. Recall was reported to be significantly higher when environments matched.

Subsequently, Smith, Glenberg, and Bjork (1978) and Smith (1979) exposed subjects to word stimuli in one room, then had them recall in either the same or a different room. This simple paradigm demonstrated significant CDM, but more meaningfully, Experiment 3 of Smith (1979) included a third group of subjects who reversed the CDM decrement by writing down 10 things they could remember seeing in the original room, and then thinking of how the original context looked, sounded, smelled, and felt, prior to recall. Smith contended that rather than reinstating the context perceptually, a mnemonic reinstatement of the context may be sufficient to provide the tags needed to prevent CDM.

The label "mnemonic" refers to mental strategies used to help store and retrieve material. Most involve an elaboration of the to-be-learned material, which increases the number and/or quality of associations to the material and thus allows greater retention and easier access at recall (Baddeley, 1976). In the case of Smith (1979), the stimuli to be remembered are assumed to be elaboratively encoded automatically, via their association with the environmental context.

Elaborative encoding involves the use of visual memory, or imagination (Paivio, 1972). In a review of the literature relating imagery and memory processes, Paivio concludes that "imagery variables are among the most potent memory factors ever discovered" (p. 253). The improvement in memory reported by experimenters whose only manipulation is to instruct subjects to use imagery is consistent and reliable. Effects have been reported with free recall (Richardson, 1976), serial recall (Delin, 1969), and paired-associate learning (Bower, 1970), and with recognition memory using both absolute judgment (Morris & Reid, 1974) and forced-choice procedures (Bower, 1972). These and other studies (e.g., Paivio, 1975; Smith, Barresi, & Gross, 1971) have also reported that instruction to use imagery in these tasks improves immediate and delayed recall relative to groups not receiving these instructions. Mental imagery is generally considered to improve memory by making the stored material less vulnerable to forgetting (Richardson, 1969). Additionally, both Paivio (1972) and Bower (1972) report that the effect also exists whether the subjects engaged in incidental or intentional learning tasks. The mnemonic used in the present study involves imagery applied at retrieval rather than encoding to activate the tags or environmental associates of learned materials.

Thus Smith's (1979) Experiment 3 was modified to include an additional group that, before recalling in a different context, used an imagery-based exercise to provide tags from the encoding environment. This group was assessed for imagery ability on an established scale, in an attempt to isolate the exercise's effectiveness to individual imagery ability. Smith's 1979 study does not allow conclusions regarding the effect of imagery on CDM for two reasons. First, he told subjects that they would have greater recall by doing the mnemonic exercise, thus providing them encouragement and perhaps motivation not given to the other groups. The cuing of subjects to the researcher's expectations is a well-established confound (Christensen, 1988). Second, he did not instruct those subjects to use imagery in the mnemonic exercise. Though some subjects automatically use imagery strategies in memory tasks, both Bower (1970) and Richardson (1976) have demonstrated that subjects given imagery instructions for memory tasks recall significantly more than subjects not given such instructions.

The cited evidence and noted methodological flaws question the validity of the CDM results on three points. First, the RI and PI results only indirectly support the existence of CDM, and lack real life generalizability. For example, Dallet and Wilcox (1968), in their changed-context condition, had subjects stand with their heads inside an odd-shaped box containing flashing lights and psychedelic designs, which required dismissal of two subjects due to nausea. Godden and Baddeley (1975) had subjects wear scuba equipment while performing their task, receive their word lists through bone transducers (a type of underwater communication device) and record their answers on sealed formica boards. Meanwhile, the experimenters specified when the subjects were allowed and not allowed to breathe, so as to be heard over the sound of the scuba equipment. A second criticism is that disruption from changing contexts may account for the CDM. Strand (1970) concluded that having to change environments while the same-context group does not accounts for the lower recall of the changed-context groups. Her replication of Greenspoon and Ranyard's (1957) study controlled for disruption, and reported no recall differences between groups. A third problem is the greater anxiety and less habituation produced by the changed-context group in response to the new environment (Yerkes & Dodson, 1908) which could reduce recall. The lack of generalizability, unequal disruption, and differential anxiety levels weaken any conclusions drawn from the results of the cited studies.

The present author controlled for these alternative explanations for CDM by making the following methodological changes to Smith's (1979) paradigm. First, generalizability was augmented by using the more realistic learning situation of college students learning verbal material in a college classroom. Second, equal disruption was assured between groups by following Strand's (1970) procedure of requiring all subjects to briefly switch contexts between stimulus presentation and recall. Third, anxiety levels between groups were controlled by using environments equally familiar to all subjects. Finally, motivation was held constant between groups (Homans, 1965) by having all subjects do an imagery exercise before recall.

Context-dependent memory has been produced when the environmental changes between encoding and recall have been unusual (e.g., Godden & Baddeley, 1975). CDM, however, also exists in more realistic learning situations such as a classroom. Discovering the nature and function of CDM, and its mediators, may provide a means to overcome it, revealing practical applications to students involved in classroom learning.

From the aforementioned theories and research findings, the following hypotheses were derived:

1. Subjects recalling in the original learning context and subjects performing the mnemonic exercise prior to recalling in a different context would have higher recall of stimulus words than subjects recalling in a different context.
2. Subjects' high relative to low imagery ability would only effect recall of those engaging in the mnemonic exercise.
3. High imagers would have higher recall in the mnemonic exercise condition than low imagers.

A research question was also posed: will physically or mnemonically reinstated contexts differentially effect immediate and delayed recall?

CHAPTER 2

METHOD

Subjects

The subjects were 38 male and 75 female volunteers obtained from introduction to psychology and introduction to teaching courses at Emporia State University, ranging in age from 18-48 with a mean of 21.2. Subjects received extra credit for their participation.

Design

The present study had a 3 [Context: same room (SR), different room (DR), or different room with imagery exercise (DE)] X 2 [Imagery: high imagers (HI) or low imagers (LO)] x 2 [Session: immediate and delayed] mixed factorial quasi-experimental design. The between-subjects independent variables were Context and Imagery, while the within-subjects independent variable was Session.

Materials

A subject consent form, which all subjects were required to read and sign, appears in appendix A. It was typed on white, 8 1/2" by 11" paper, and includes biographical questions on the bottom half of the form.

A modified version of Bett's (1909) Questionnaire Upon Mental Imagery (QMI) was used to assess individual imagery ability (see appendix B). This version is Sheehan's (1967) 35 item subset of Bett's 150 item QMI, reported by Richarson (1969) to correlate satisfactorily (>.90) with the original. This self-report measure evaluates the evoked imagery of five items in seven sense modes (visual, auditory, cutaneous, kinesthetic, gustatory, olfactory, and organic) on a seven point scale from 1 to 7, yielding scores from 35-245, a low score being indicative of high imagery. Juhasz (1972) reports an odd-even reliability of .95 for the QMI (N = 67), and test-retest reliabilities of .72-.75 (N = 147) have been reported after a two week interval (Westcott & Rosenstock, 1976).

Sheehan's (1967) version has undergone three modifications. The first was suggested by Ashton and White (1980), who reported that scores for women on the QMI were artifactually increased by response set factors as women were more likely than men to fall into a pattern when rating items in each mode, rather than rating each independently. Following Ashton and White's recommendation, the items on the QMI were randomly ordered, unlike the original version, which groups items by sense modality. Second, item format was standardized by stating the mode to be evaluated at the first of each item, as Ashton and White demonstrated that the original format sometimes led to different item interpretations by subjects. Third, the test instructions were slightly changed to clarify to the subjects that the purpose of the QMI is to rate the test items for imageability, and not to assess the subjects' imagery ability. Paivio, Yuille, and Madigan (1968) found that imagery measures tend to have low variability, with scores clustered around the high imagery end of the scale, and that variability increases when subjects are unaware that they are rating themselves. A pilot test of this modified QMI on 45 volunteers from an experimental psychology course offers some support these changes, as men ($N = 16$) averaged 109.86 ($SD = 27.32$) and women ($N = 29$) averaged 103.81 ($SD = 16.95$) on this modified version, which was revealed by *t*-test to be an insignificant difference.

Stimuli were randomly arranged words (see appendix C) presented with a standard audio cassette recorder. Several researchers (e.g., Marks, 1972; Paivio, 1971) have demonstrated that recall of concrete words is greater for subjects high relative to low in imagery ability. Thus the stimulus words were nouns selected from the Paivio et al. (1968) normative values of concreteness and meaningfulness for nouns. Words chosen for the learning task fell at least .4 standard deviations above the mean in meaningfulness (meaningful) and .4 standard deviations below the mean in concreteness (abstract). These constraints generated a pool of 32 words, of which 20 were randomly selected and randomly ordered.

Lastly, two imagery vividness exercises were prepared. The exercises are similiar in most respects. Each gives specific instructions to use imagery in recalling a scene, the vividness of which is rated along several continuums. Following this, the subject is instructed to list several things they can imagine seeing in this scene, similiar to the procedure used by Smith (1979). Lastly, the subject is told to use imagery in answering a few questions about the scene. The primary difference between the two exercises is that in the first (see appendix D), the environment of focus is the context of learning (the classroom), whereas in the second (see appendix E), the focus is on an environment irrelevant to the learning situation yet familiar to the subjects (certain areas of the campus).

Procedure

Subjects were tested by a 24-year-old white, male experimenter. Subjects began the procedure in their usual classroom, at the regular class time, tested as a group. Subjects received a packet containing the consent form, QMI, either the first (for DE subjects) or second (for SR and DR subjects) imagery vividness exercise and a white, lined 8 1/2" by 11" sheet of paper. After reading and signing the consent form and answering the biographical questions included on the form, subjects were asked to write the last four digits of their student identification number on this form. Subjects were then told to turn the page, and then listened to the instructions for the QMI, after which the experimenter answered any questions. Subjects were then told to complete the QMI, close their packets when they finished, and to wait quietly for the next instruction. When the entire group finished, subjects were told that "later in the study" they would be tested on the word list about to be presented, and that the words would be presented only once at a fairly slow rate. The subjects were also instructed not to talk with one another from the time the words were presented until they were tested on the words. The word list was then presented via tape recorder, at a rate of one word every three seconds. After stimulus presentation, all subjects left the room and were led on a two minute walk through the hallways of Visser Hall.

They then returned to either the same or a different room, based on predetermined random assignment by group. The different room was Visser Hall's atrium , as it was assumed to be non-anxiety producing (see Smith, 1979), but still different from the learning context (Greenspoon & Ranyard, 1957). Subjects were then instructed to turn to the imagery vividness exercise in their packets, read the instructions for themselves, complete the form, and close their packets when they were finished. When finished, subjects were told that they had three minutes to write down as many of the stimulus words from the word list that they could recall, including words "you're not sure about," on the blank sheet of paper given in their packet. Finally, after one week's delay, subjects were brought in their same groups to their recall environment and given a packet containing the imagery vividness exercise originally used by their group and a white, lined 8 1/2" by 11" sheet of paper. Subjects wrote the last four digits of their student identification number on this packet (for matching purposes), then completed this imagery vividness exercise and recall session in a manner identical to the first session. Once all data had been gathered, subjects were debriefed, thanked, and dismissed.

Scoring

Subjects whose scores were above the overall mean on the QMI (105.46, SD = 25.20) were classified as low imagers (N = 59) and those with scores below the mean were high imagers (N = 54). For immediate and delayed recall, each word exactly given was scored at 1 point. The sum of the points was the score, giving a range of 0-20 points per subject per recall session.

CHAPTER 3

RESULTS

The present study examined the influence of context on memory in the college classroom, and the efficacy of a mnemonic reinstatement of context at reducing the effect, for both immediate and delayed recall conditions. Recall in the present study was the number of words from a list of 20 remembered. Additionally, the influence of individual imagery ability on the mnemonic exercise's effectiveness was studied. From a review of the literature on these topics, it was hypothesized that: 1) subjects recalling in the original learning context (SR) and subjects performing the mnemonic exercise prior to recalling in a different context (DE) would have higher recall of stimulus words than subjects recalling in a different context (DR), 2) subjects' high (HI) relative to low (LO) imagery ability would only effect recall of those engaging in the mnemonic exercise, and 3) high imagers would have higher recall in the mnemonic exercise condition than low imagers. A research question was also posed: will physically or mnemonically reinstated contexts differentially effect immediate and delayed recall?

To test these hypotheses, the recall data were analyzed with a 3 (Context: SR, DR, or DE) X 2 (Imagery: HI or LO) X 2 (Session: immediate and delayed) repeated measures analysis of variance, using Context and Imagery as the between-subjects and Session as the within-subjects independent variables, with the dependent variable being number of stimulus words recalled. Only 102 of the original 113 subjects completed both immediate and delayed Sessions, so only their data could be used in this analysis. The results of the ANOVA appear in Table 1, while means and standard deviations for all cells appear in Table 2.

Main Effects

The main effect of Context was a statistically significant between-subjects effect, $F(2, 96) = 4.88$, $p < .01$. A Fisher's Least Significant Difference (LSD) test for post-hoc comparisons revealed significantly higher recall for SR ($M = 4.04$) and DE ($M = 4.23$) than DR ($M = 2.62$) groups, while the first two groups did not differ. The main effect of Imagery was also statistically significant as a between-subjects effect, $F(1, 96) = 8.64$, $p < .01$, with HI subjects ($M = 4.42$) recalling significantly more words than LO subjects ($M = 3.08$). Session was statistically significant as a within-subjects main effect, $F(1, 96) = 249.77$, $p < .0001$.

Table 1

Context X Imagery X Session

Repeated Measures Analysis of Variance

for Word Recall

Source	DF	MS	F
Between-Subjects Effects			
Context	2	34.44	4.88*
Imagery	1	61.03	8.64*
Context X Imagery	2	9.75	1.38
Error	96	7.06	
Within-Subjects Effects			
Session	1	249.77	171.59**
Context X Session	2	9.58	6.58*
Imagery X Session	1	3.21	2.20
Context X Imagery X Session	2	9.20	6.32*
Error	96	1.46	

*$p < .01$

**$p < .0001$

Table 2

Table of Means and Standard Deviations

Word Recall

	Immediate	Delayed	Total
Same Room			
High	5.65 (2.54)	3.27 (2.34)	4.63 (2.45)
Low	4.74 (2.56)	2.33 (1.80)	3.59 (2.20)
Total	5.16 (2.56)	2.72 (2.06)	4.04 (2.33)
Different Room			
High	3.38 (2.22)	2.27 (1.90)	2.87 (2.07)
Low	3.37 (2.24)	1.50 (1.54)	2.46 (1.90)
Total	3.38 (2.20)	1.79 (1.70)	2.62 (1.96)
Different w/Exercise			
High	7.19 (2.27)	3.00 (1.75)	5.15 (2.01)
Low	4.12 (1.96)	2.12 (1.58)	3.12 (1.77)
Total	5.82 (2.62)	2.59 (1.71)	4.23 (2.17)
Overall	4.88 (2.65)	2.41 (1.86)	3.70 (2.27)

Overall, subjects recalled more words in the immediate (M = 4.88) relative to the delayed (M = 2.41) Session.

Interactions

The following interactions were significant: Context X Session, $F(2, 96) = 6.58$, $p < .01$; and Context X Imagery X Session, $F(2, 96) = 9.20$, $p < .01$. Fishers LSD was performed on each of these interactions and the results appear in Tables 3 and 4, respectively. For the Context X Session interaction, Fisher's revealed that in the immediate recall Session, DE (M = 5.82) subjects recalled significantly more stimulus words than SR (M = 5.16) subjects, who recalled significantly more than DR (M = 3.38) subjects. In the delayed Session, SR (M = 2.72) and DE (M = 2.59) subjects recalled significantly more than the DR (M = 1.79) group, while not significantly differing from each other. This data is graphically presented in Figure 1. For the Context X Imagery X Session interaction, Fisher's revealed that HI subjects in each Context had significantly higher recall than their LO counterparts, with SR, DR, and DE subjects of high imagery ability recalling more than SR, DR, and DE subjects of low imagery ability, in both recall Sessions. Only in the DR group at immediate recall were no recall differences revealed for Imagery ability.

Table 3

Fisher's Test of Least Significant Difference

Word Recall

For Context X Session Interaction

Immediate Session		
DE	SR	DR
5.82	5.16	3.38

Delayed Session		
SR	DE	DR
<u>2.72</u>	<u>2.59</u>	1.79

Legend:

SR = Same Room

DR = Different Room

DE = Different Room with Imagery Exercise

Underlined means are not significantly different

Table 4

Fisher's Test of Least Significant Difference

Word Recall

For Context X Imagery X Session Interaction

Immediate Session

DE-HI	SR-HI	SR-LO	DE-LO	DR-HI	DR-LO
7.19	5.65	4.74	4.12	3.38	3.37

Delayed Session

SR-HI	DE-HI	SR-LO	DR-HI	DE-LO	DR-LO
3.27	3.00	2.33	2.27	2.12	1.50

Legend:

SR = Same Room

DR = Different Room

DE = Different Room with Imagery Exercise

HI = High Imagery Ability

LO = Low Imagery Ability

Underlined means are not significantly different

Also, SR and DE subjects had higher recall than the DR subjects across both Sessions, but only for HI imagers. For LO imagers, DE subjects did not differ from DR subjects. This data is graphically presented in Figure 2.

Additional Tests

A *t*-test on male and female QMI scores was performed as a validation of one modification made to the QMI used in this study (see Chapter 2, pp. 13-14). As suggested by Ashton and White (1980), the items on the QMI were randomly ordered (unlike the original version, which grouped items by sense modality), to prevent response set factors from artifactually increasing scores for women. All subjects who took the QMI were used in this analysis, a total of 38 men (M = 109.29, SD = 25.42) and 75 women (M = 103.52, SD = 25.04). The *t*-test [$t(111) = 1.03$] revealed that men and women did not differ. The modification had its intended effect.

Finally, a repeated measures ANOVA from SAS was run on the data with the inclusion of gender as a variable, for a 3 (Context: SR, DR, or DE) X 2 (Imagery: HI or LO) X 2 (Gender: male or female) X 2 (Session: immediate or delayed) mixed-factorial design. Gender differences are often reported to exist in memory studies (Baddeley,

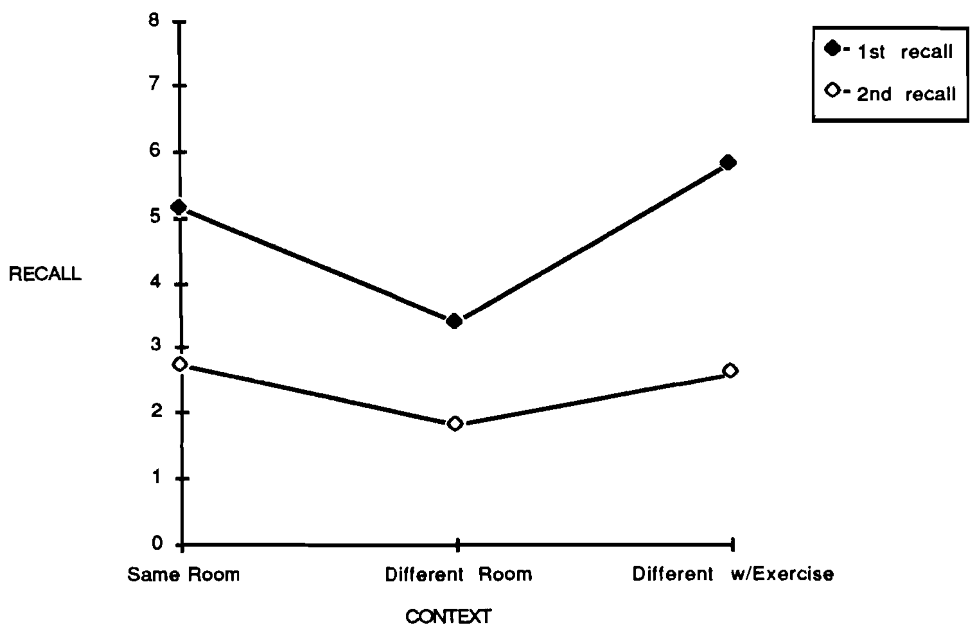

Figure 1. Context X Session Interaction

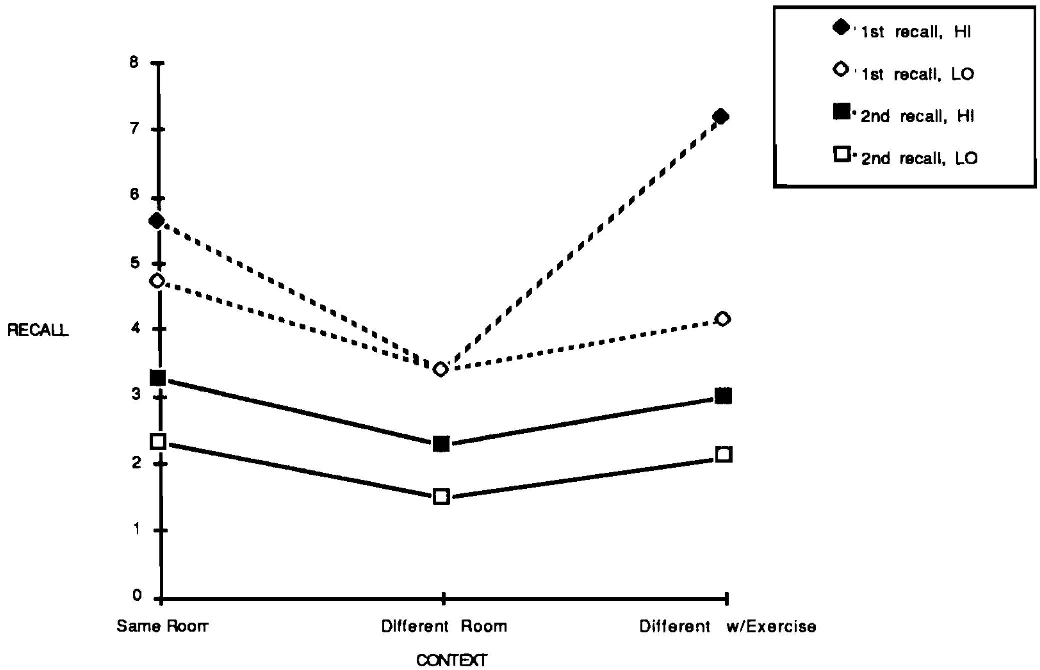

Figure 2. Context X Imagery X Session Interaction

1976), but previous CDM research reports no investigation of these differences. The results of the described four-way ANOVA found gender to have no significant effect.

CHAPTER 4

DISCUSSION

In an attempt to explore the nature of context-dependent memory (Carr, 1925; McGeoch, 1932; Smith 1979), the present study investigated the phenomenon with particular regard for ecological validity, control of certain methodological flaws, and determining the efficacy of physical and imaginal context reinstatement on CDM reduction across immediate and delayed recall.

Hypothesis 1

The hypothesis that subjects recalling in the original learning context (SR) and subjects performing the mnemonic exercise prior to recalling in a different context (DE) would have higher recall of stimulus words than subjects recalling in a different context (DR) was supported. Subjects recalling in an environment different from their learning context had significantly reduced recall, unless performing a mnemonic exercise prior to recall. Those subjects who imaginally reinstated the original context performed as well at both immediate and delayed recall as those in the SR group.

Context-dependent memory is a real-life effect (i.e., existing in the classroom under these conditions) hindering recall both immediately and after one week as well. Performing at recall a mnemonic exercise designed to imaginally reinstatement the encoding context seems to be an effective way of reducing or eliminating CDM.

In supporting this hypothesis, tagging theory has also been supported. Physical aspects of the learning environment "tag" material at encoding, and when the sensory stimuli "tags" are present at recall, the associated material may be more readily retrieved. The function of the tags is unclear, but perhaps they prevent proactive and retroactive inhibition from continually hindering memory via an automatic association of learned stimuli with its accompanying environment. The better discrimination of information in memory improves recall.

Hypothesis 2

The hypothesis that subjects' high (HI) relative to low (LO) imagery ability would only effect recall of those engaging in the mnemonic exercise was not supported. With only one exception (for DR subjects in the immediate Session), the HI subjects in each Context group had higher immediate and delayed recall than the LO subjects.

Context-dependent memory has often been reported as being "overridden" by other memory effects in studies (c.f. Smith, 1988). According to Smith's "outshining" hypothesis, environmental cues on CDM (whether physical or imaginal) may be outshone or concealed by other effects such as the presence of a stronger cue or the use of memory strategies, analogous to the way a celestial body is easily seen at night while being imperceptible in the presence of the sun. For this reason, the present study attempted to control one of these potential "outshiners," individual imagery ability (see Bower, 1972; Paivio, 1971, 1972), by using abstract instead of concrete words as stimuli. Despite this precaution, imagery ability was demonstrated to have an influence on memory not only at retrieval, as seen from the performance of the DE group, but at encoding as well, as seen from the Imagery main effect (see Paivio, 1971, for a theoretical analysis of imagery effects at encoding).

Hypothesis 3

The hypothesis that high imagers would have higher recall in the mnemonic exercise condition than low imagers was supported. The imagery exercise was useful in eliminating CDM in both immediate and delayed recall conditions, but only for subjects with high imagery ability. For LO DE subjects, this retrieval strategy appears to be ineffective, as those subjects did no better than the DR subjects in the immediate and delayed recall Sessions.

Subjects not capable of forming vivid mental images might consider employing non-imagery based mnemonics. For example, Baddeley (1982) reports on several verbal mnemonics which people of low imagery ability may find of use, at least as an encoding strategy. But whether such mnemonics can find application at retrieval to reduce CDM is unclear. Tulving and Thompson's (1973) encoding specificity principle, similar to tagging theory, proposes that a word functions best as a retrieval cue if present at encoding. A person of low imagery ability, restricted to verbal mnemonics, might use knowledge of this principle at encoding to improve later recall.

Research Question

Will physically or mnemonically reinstated contexts differentially effect immediate and delayed recall? For both immediate and delayed recall, SR and DE relative to DR subjects recalled significantly more. Clearly, CDM exists at immediate recall and across time as well. Additionally, mnemonic reinstatement of context, as evidenced by performance of DE subjects, proved as effective at eliminating CDM as physical reinstatement, even after a week's delay. Students involved in classroom learning must be aware that these effects exist whether recall occurs immediately or after a delay, but that imaginal reinstatement of context may eliminate the effect, particularly for high imagers.

Conclusion

While previous studies have demonstrated CDM under bizarre circumstances (e.g., Godden & Baddeley, 1975) and indirectly supported tagging theory (e.g., Dallet & Wilcox, 1968), this study demonstrates that CDM exists under realistic classroom conditions, while directly supporting tagging theory. In addition, an imaginally-based mnemonic exercise has proven effective in reducing CDM across both immediate and delayed recall conditions for high imagers. This knowledge may have practical application, as instructors and students realize that a change in classroom between learning and recall may hinder performance, and as students in such a situation realize that context may be effectively reinstated imaginally, as a recall strategy at test time. Instructors should refrain from testing their students in other than the original lecture room, and students may wish to study in the test environment or provide their own context clues from their study environment at test time, such as a "lucky" shirt, flavor of chewing gum, and/or other sensory stimuli.

As demonstrated by the Imagery main effect, imagery ability is difficult to control, suggesting that effects investigated in previous memory studies may have been "outshone" or unknowingly reduced, to some degree, by imagery ability. This individual difference, unchecked, may increase within-subject variability and thereby conceal effects of interest. Because of this, cognitive researchers must develop paradigms which control for imagery ability.

Imagery ability is a powerful influence at both encoding and retrieval (Paivio, 1971; Bower, 1972). Practical application of this knowledge may be realized through improved learning materials, such as the creation of highly concrete or imaginally vivid materials for fairly abstract subjects (i.e. mathematics, or spelling for beginners), and improved instructional techniques, such as the utilization of imaginally vivid examples, and the systematic teaching of mnemonic strategies to students.

Recommendations for Future Research

As word lists are seldom the content of our learning, future research may investigate CDM with more realistic material, such as prose or pictures. Also, researchers may wish to investigate the effect with other samples, such as children in the elementary classroom, and in other learning situations, such as motor skill refinement (as seen in dancing or athletics). Researchers may also wish to explore the development of mnemonics for people of low imagery ability, with application at both encoding and retrieval. Clearly, the need has been seen for cognitive researchers to develop paradigms which control for imagery ability, as a protection from their "outshining" effects.

Context-dependent memory is a real effect, but the present study suggests that a mnemonic intervention can attenuate the effect. A continuing problem, the extent to which CDM hinders us in everyday life remains relatively uninvestigated.

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Appendix A

Informed Consent Letter

Please read the following statements. If you agree with them, please sign your name at the bottom.

I agree to participate in a study being conducted by Jim Persinger. The purpose of this study is to investigate learning styles in the college classroom, and will take about 25 minutes of time over two different days. I understand that I may stop participating in this study at any time and for any reason, without penalty. I also realize that my confidentiality will be respected and neither my name nor any identifying data will be used in any report of this research.

Signed ______________________________

In addition, please go ahead and provide the following information:

1) Age ______

2) Gender (circle): M F

3) Last four digits of your student id # __________

4) Classification (circle): Fr So Jr Sr Grad

Appendix B

Modified Bett's QMI

[Note: The actual QMI used was printed in an elite font, single-spaced, and was given somewhat smaller margins, making it three pages in length.]

Purpose:

The purpose of this questionnaire is to rate the vividness of the mental images formed from the test items. Your ratings will be combined with other's ratings to provide data determining normal responses to the items, and will be of use to researchers in future studies.

Instructions:

The test contains 35 items. You are to read an item carefully and then assess the vividness of the mental image that is formed, using the following rating scale:

1 - Perfectly clear and as vivid as the actual experience.

2 - Very clear and comparable in vividness to the actual experience.

3 - Moderately clear and vivid.

4 - Not clear or vivid, but recognizable.

5 - Vague and dim.

6 - So vague and dim as to be hardly discernible.

7 - No image present at all, you only "knowing" that you are thinking of the object.

If your image is "vague and dim" you give it a rating of 5. Record your answer in the brackets provided after each item. Before you turn to the items on the next page, familiarize yourself with the different categories on the rating scale, and pick one when judging the vividness of each image. A copy of the rating scale will be printed on each page. Please do not turn to the next page until you have completed the items on the page you are doing, and do not turn back to check on other items you have done. Complete each page before moving on to the next page. Judge each item separately, and not based on how you have judged previous items.

An example of an item on the test would be one which asked you to consider your mental image of a red apple. If your visual image was moderately clear and vivid you would check the rating scale and mark '3' in the brackets as follows:

Item	Rating
5. Seeing, a red apple	[3]

Now turn to the next page when you have understood these instructions, and begin the test.

Item	Rating
1) Seeing, a relative or friend walking toward you.	[ ]
2) Feeling, the prick of a pin.	[ ]
3) The feeling in your body, reaching up to a high shelf.	[ ]
4) Tasting, your favorite soup.	[ ]
5) Smelling, roast beef.	[ ]
6) The sensation of, hunger.	[ ]
7) Smelling, an ill-ventilated room.	[ ]
8) Feeling, sand.	[ ]
9) The sensation of being full, as from a very big meal.	[ ]
10) Tasting, oranges.	[ ]
11) Hearing, the sound of escaping steam.	[ ]
12) The feeling in your body, kicking something out of the way.	[ ]
13) Seeing, the sun rising above the horizon into a hazy sky.	[ ]
14) Hearing, the honk of an automobile.	[ ]
15) Feeling, fur.	[ ]
16) The feeling in your body, running upstairs.	[ ]

17) Hearing, the mewing of a cat. [ ]

18) Seeing, the front of a shop to which you often go. [ ]

19) The feeling in your body, springing across a gutter. [ ]

20) Hearing, the whistle of a locomotive. [ ]

21) Tasting, jelly. [ ]

22) Smelling, new leather. [ ]

23) Seeing, a lake in the country. [ ]

24) Tasting, salt. [ ]

25) The sensation of, drowsiness. [ ]

26) Feeling, the warmth of a tepid bath. [ ]

27) Smelling, fresh paint. [ ]

28) The sensation of, a sore throat. [ ]

29) Tasting, granulated (white) sugar. [ ]

30) Hearing, the clapping of hands in applause. [ ]

31) Seeing the exact contours of face, head, shoulders and body of a relative or friend. [ ]

32) Feeling, linen. [ ]

33) The sensation of, fatigue. [ ]

34) The feeling in your body, drawing
a circle on paper. [ ]

35) Smelling, cooking cabbage. [ ]

Appendix C

Nouns Low in Concreteness, High in Meaningfulness for Stimulus Word List

1. Bravery
2. Research
3. Direction
4. Panic
5. Blessing
6. Freedom
7. Heaven
8. Expression
9. Joy
10. Reflection
11. Life
12. Justice
13. Truce
14. Soul
15. Charm
16. Evidence
17. Law
18. Affection
19. Grief
20. Health

Appendix D

Imagery Vividness Exercise - 1

[Note: The actual exercise used was printed in an elite font, single-spaced, and given somewhat smaller margins, making it one page in length.]

For this exercise, I would like you to imagine that you have traveled back in time, back to your classroom where this study began. Then, carefully read each of the following descriptions of that scene. As you read each description, go to the accompanying rating scale and put an X at the point corresponding to how strongly you can imagine each sensation happening to you, from "perfectly vivid" to "no image at all".

For example, if the description reads "seeing the chalkboard in the room," you would imagine how that would look while in the classroom. If you can imagine that sensation pretty clearly, you would mark the scale as follows:

8) Seeing the chalkboard in the room.

perfectly vivid <-X--------------> no image at all

Now, imagine that you are in your classroom. Rate how strongly you can imagine each of the following:

1) Seeing the color of the floor or carpet.

no image at all <----------------> perfectly vivid

2) Hearing the sound of papers shuffling.

perfectly vivid <----------------> no image at all

3) Seeing the experimenter talking to you in that room.

no image at all <----------------> perfectly vivid

4) The sound of the experimenter's voice on the tape recorder.

perfectly vivid <----------------> no image at all

Briefly, write down four things that you can imagine seeing in your classroom during the experiment:

A) C)

B) D)

From your mental pictures of your classroom, answer the following questions:

1. How many windows are in the room? ____________

2. What color are the walls painted? ____________

3. How many desks are in the room? ____________

Appendix E

Imagery Vividness Exercise - 2

[Note: The actual exercise used was printed in an elite font, single-spaced, and given somewhat smaller margins, making it one page in length.]

For this exercise, I would like you to imagine that you are taking a walk around campus and experiencing the following activities. Then, carefully read each of the following questions. After reading each question, rate the vividness of your mental imagery by putting an X at the point on the rating scale corresponding to how vividly you can imagine the scene, from "perfectly vivid" to "no image at all."

For example, if you can vividly imagine seeing the bridge over Wooster Lake, you would mark the scale as follows:

8) How well do you see the bridge over Wooster Lake?

perfectly vivid <-x--------------> no image at all

Now, imagine that you are taking a walk around campus and experiencing the following activities. Rate how vividly you can imagine each of the following:

1) How well do you see Visser Hall as you approach it?

no image at all <----------------> perfectly vivid

2) How well do you smell the buttery popcorn in the Memorial Union?

perfectly vivid <----------------> no image at all

3) How well do you hear the steam whistle blowing?

no image at all <----------------> perfectly vivid

4) How well do you see a good friend standing in the entrance of Plumb Hall?

perfectly vivid <----------------> no image at all

Briefly, write down four things that you can imagine seeing on this walk around campus:

A) C)

B) D)

From your mental pictures of these campus areas, answer the following questions:

1. How many cash registers are at the front of the bookstore? ____________

2. How many pillars are in front of Plumb Hall? ____________

3. How high is the ceiling of the bookstore? ____________

I, Jim Persinger, hereby submit this thesis to Emporia State University as partial fulfillments of the requirements for an advanced degree. I agree that the Library of the University may make it available for use in accordance with its regulations governing materials of this type. I further agree that quoting, photocopying, or other reproduction of this document is allowed for private study, scholarship (including teaching) and research purposes of a nonprofit nature. No copying which involves potential financial gain will be allowed without written permission of the author.

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May 14, 1990

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