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METAMEMORY AND LEARNING ABILITY

by

William L. Cull

A Thesis Submitted to the Faculty of the Graduate School
of Loyola University Chicago in Partial Fulfillment
of the Requirements for the Degree of
Master of Arts

May

1992

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TABLE OF CONTENTS

ACKNOWLEDGMENTS.....	iii
LIST OF ILLUSTRATIONS.....	v
LIST OF TABLES.....	vi
Chapter	
I. INTRODUCTION.....	1
Monitoring.....	5
Control.....	12
Metamemory-Memory Relationship.....	15
The Present Study.....	19
II. EXPERIMENT 1.....	24
Method.....	24
Results and Discussion.....	26
III. EXPERIMENT 2.....	29
Introduction.....	29
Method.....	31
Results and Discussion.....	32
IV. EXPERIMENT 3.....	40
Introduction.....	40
Method.....	41
Results and Discussion.....	43
V. GENERAL DISCUSSION.....	49
General Metamemory.....	49
Metamemory and Learning Ability.....	56
REFERENCES.....	60

LIST OF ILLUSTRATIONS

Figure	Page
1. The Flow of Information From the Meta Level and the Object Level (adapted from Nelson & Narens, 1990).....	6
2. Mean Study Trials as a Function of Item Type and Testing (Experiment 2).....	35
3. Mean Proportion Recalled as a Function of Item Type and Testing (Experiment 2).....	37
4. Mean Study Trials as a Function of Item Type and Delay (Experiment 3).....	46

LIST OF TABLES

Table	Page
1. Mean Study Trials and Proportion Recalled (Exp. 1).....	27
2. Mean Study Trials and Proportion Recalled (Exp. 2).....	34
3. Mean Study Trials and Proportion Recalled (Exp. 3).....	44
4. Comparison of Results Across Experiments.....	52

CHAPTER I

INTRODUCTION

The study of metamemory, which generally refers to one's knowledge and awareness of memory (Flavell & Wellman, 1977; see also, Zechmeister & Nyberg, 1982), first developed in the early 1960s, and has continued unabated. In that early period, Hart (1965, 1966, 1967) conducted research on the feeling-of-knowing phenomenon, a frequently studied topic of metamemory. However, it was not until two influential publications in 1970 that the field of metamemory clearly began to evolve. The first was an annual review article written by Tulving and Madigan (1970) and the second was a chapter written by Flavell (1970).

In their 1970 review article, Tulving and Madigan discussed the division between researchers of verbal learning and researchers of memory. Despite having the common goal of understanding how people learn and remember, researchers of verbal learning and researchers of memory, according to Tulving and Madigan, tended to ask different questions, employed different methods, and used different terminology. Researchers of verbal learning investigated specific questions about learning through controlled experimentation with carefully paced conditions and multiple study trials; whereas, researchers of memory examined

questions concerning information-processing models by using some methods similar to and some methods different from verbal learning research (see also Keppel, 1968). Tulving and Madigan then proceeded to declare that the field of verbal learning and memory had made only minimal progress within the last century, and they forwarded the suggestion that if there was ever to be a genuine breakthrough in the psychological study of memory, "...it will, among other things, relate the knowledge stored in an individual's memory to his knowledge of that knowledge" (p.477).

Also in 1970, Flavell, a developmental psychologist, coined the term metacognition, meaning essentially cognition about cognition. Metamemory has been classified as a subcategory of metacognition (Brown, 1978), and has been defined as an individual's knowledge or cognition about anything pertaining to memory (Flavell, 1985). Adult metamemory research and developmental metamemory research have continued to beneficially influence one another. In particular, developmental metamemory researchers such as Flavell and Brown have influenced adult metamemory research theory and terminology.

Flavell (1979) later conceptualized two key components of metacognition: metacognitive knowledge and metacognitive experiences. Metacognitive knowledge refers to knowledge or beliefs about what factors act and interact to affect the course and outcome of cognition. He categorized this

knowledge into person knowledge, task knowledge, and strategy knowledge. With respect to metamemory, person knowledge encompasses everything a person knows about the memory of other people as well as what he/she knows about his/her own memory. Task knowledge refers to what a person knows about memory in relation to specific tasks, and strategy knowledge is all information pertaining to the effectiveness of various methods of learning. Flavell emphasized that most metacognitive knowledge involves interactions or combinations among two or three of these types of knowledge. For example, you might believe that you (unlike someone you know) should use a particular strategy (as opposed to a second strategy) for a certain task (as contrasted with a different task).

Flavell (1979) introduced the term "metacognitive experiences" to refer to occasions during cognitive processing when new insights about cognition arise (cf. Schneider & Pressley, 1989). An example may help clarify the concept. An individual learning a list of items may experience a momentary feeling that he or she is not going to remember a number of the items on a later test of memory. Although the individual may possess the metacognitive knowledge that people rarely remember all the items on a test, the sudden feeling, or metacognitive experience, that some items will not be remembered differs from metacognitive knowledge.

Brown (1978) also suggested that metacognition can be divided into two broad components: knowledge about cognition and regulation of cognition. Knowledge about cognition is synonymous with Flavell's (1979) metacognitive knowledge. Regulation of cognition, however, includes more than is defined in the term metacognitive experience. Metacognitive experiences are specific moments of insight, whereas regulation of control is thought to be integral to cognition in general. Regulation of control refers to the planning, monitoring, and checking of cognition (Brown & Palinscar, 1982). Brown suggests that knowledge about cognition and regulation of cognition recursively support one another, and that attempts to separate the two lead to oversimplification (Brown & Palinscar, 1982; see also, Cavanaugh & Perlmutter, 1982).

Nelson and Narens (1990) recently provided an overview of adult metamemory which focused on certain aspects of the regulation of memory. Memory processing generally is thought of in terms of the acquiring, retaining, and retrieving of information. Nelson and Narens (1990) refer to this as the object-level. They distinguish the object-level from a second level of memory processing, the meta-level, which they refer to as a dynamic model of the object-level. Less abstractly, the meta-level can be thought of as metacognitive knowledge pertaining to the acquiring, retaining, and retrieving of information.

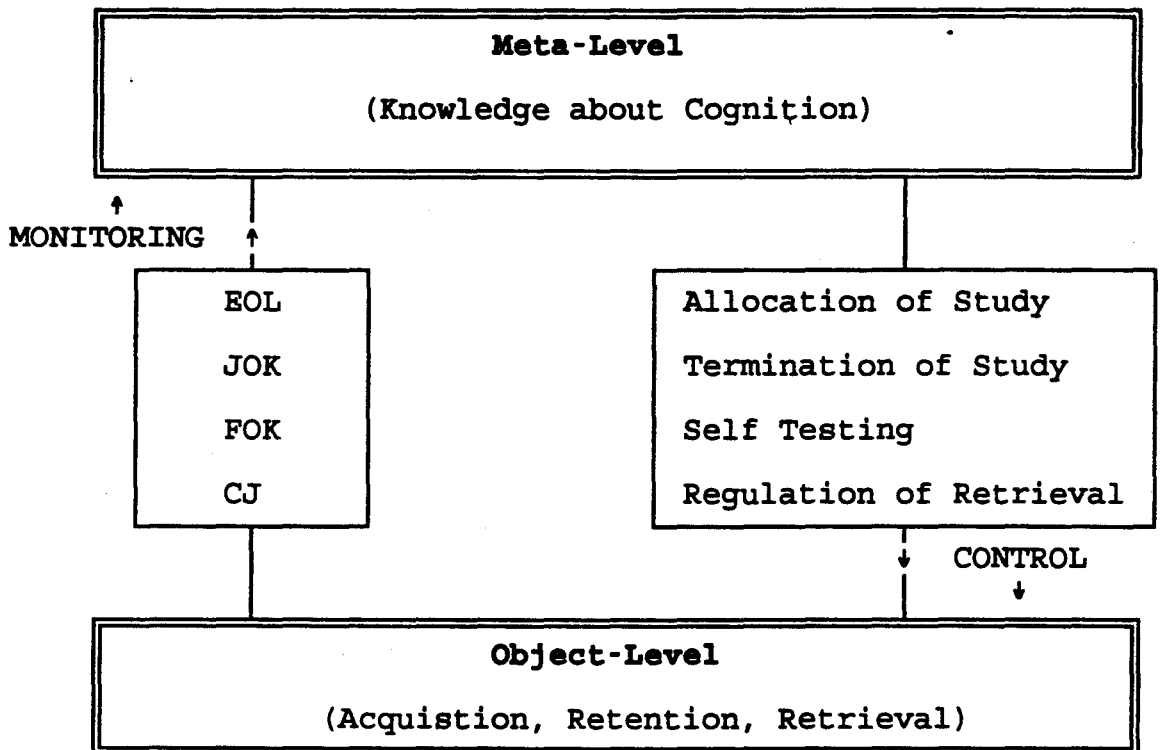
Nelson and Narens (1990) suggest that the object-level and the meta-level interact with each other through two processes: monitoring and control. Monitoring refers to an individual's ability to tap into the state of the object-level, and control refers to any attempt by an individual to influence the object-level. Figure 1 provides a way to organize the interaction of the meta-level with the object-level. Figure 1 is not intended to be a theory of metacognition, but rather is intended to aid conceptualization and understanding of adult metamemory research.

Monitoring

Monitoring, as defined by Nelson and Narens (1990), consists of the meta-level being informed by the object-level. Four measures have been used by researchers to investigate the monitoring of information. First, research has focused on ease of learning (EOL) judgments, wherein subjects are asked to rate how difficult a given item is to learn (e.g., Underwood, 1966). Second, researchers have asked subjects during or following study to judge whether they have learned a given item well enough to recall it on a later test; this has been termed both a judgment of knowing (JOK) (e.g., King, Zechmeister, & Shaughnessy, 1980) and a judgment of learning (JOL) (e.g., Leonesio & Nelson, 1990). Third, subjects have been asked to make feeling-of-knowing judgments (FOKs), which are predictions of whether a

Figure 1

The Flow of Information From the Meta Level
and the Object Level



currently nonrecallable item will be recalled on a subsequent retention test, such as a recognition test (e.g., Hart, 1965). Finally, researchers have examined subjects' confidence judgments (CJs), wherein subjects judge the probability that a given answer is correct (e.g., Lichtenstein, Fischhoff, & Phillips, 1977). Although considerable metamemory research has focused on FOK judgments and CJs, this research is only minimally related to the on-going study process, since both judgments are made following attempts to recall previously-studied items. Because the focus of the present study is on study time allocation, emphasis will be placed on research involving EOL judgments and JOKs, which ostensibly are pertinent to on-going study.

EOL judgments are usually made prior to study; the defining characteristic of an EOL judgment is that the subject is specifically assessing the difficulty to learn a particular item. It has been shown that subjects are rather adept at predicting which items are easy and which items are difficult to recall (Lippman & Kintz, 1968; Underwood, 1966). Underwood (1966) demonstrated that, in addition to being correlated with eventual recall, subjects' EOL judgments were substantially correlated with various item characteristics such as pronounceability and meaningfulness (cf. Zechmeister & Nyberg, 1982). Thus, it is plausible that EOL judgments are based primarily on item

characteristics.

In addition, at least for simple to-be-learned items, EOL judgments do not differ substantially when subjects are required to make immediate decisions and when subjects are allowed considerable time to decide (Zechmeister & Bennett, 1991). Thus, subjects appear to be able to process relevant information quickly when making EOL judgments.

Whereas an EOL judgment focuses on an item's perceived difficulty, a JOK focuses on the degree to which a given item is known or has been learned by the subject. In this latter case, subjects are asked to judge the likelihood of recalling a studied item either during or after study, but before a test of memory. Arbuckle and Cuddy (1969) were the first to demonstrate that subjects could make accurate JOKs. In their study, subjects learned lists of five paired-associate items. Each pair was studied for 3 s. After all the pairs had been presented, one of the five items was re-presented and subjects rated the likelihood that they would remember the pair. Subjects marked an "x" on a horizontal line containing five bars equally spaced and the phrases "very likely" and "very unlikely" printed on either side. As subjects' likelihood predictions increased so did their recall for all serial positions except the fifth, for which recall was consistently high for all ratings. Arbuckle and Cuddy concluded that "...Ss could reliably predict at time of presentation of an item whether they would recall it" (p.

130).

Researchers subsequently have identified a number of factors within the learning situation that allow subjects to make JOKs even more accurately. One factor is the presence of test trials. King et al. (1980) showed that accuracy of JOKs was considerably greater when subjects were given test trials during study than when subjects were not given test trials. Lovelace (1984) replicated this finding and further suggested that another factor, multiple study trials, enhances JOK accuracy. Prediction accuracy was shown to increase as the number of study trials increased, although the total study time remained the same. More recently, Nelson and Dunloskey (1991) demonstrated that JOKs made following a brief delay were substantially more accurate than JOKs made immediately after study.

In interpreting the basis of JOK accuracy, Arbuckle and Cuddy (1969) suggested that their subjects relied upon the perceived difficulty of the items. In other words, they felt that JOKs were actually EOL judgments. The possibility that JOKs are based on the same information as EOL judgments was investigated by Zechmeister, Christensen, and Rajkowski (1980), and Leonesio and Nelson (1990). Both studies revealed that the two types of judgments are moderately correlated, although subjects' JOKs are better predictors of recall than subjects' EOL judgments.

One possible explanation of the moderate correlation

between EOL judgments and JOKs is that EOL judgments are made prior to study and are based almost completely on item characteristics, whereas JOKs are made during or after study and use item characteristics as well as information provided from the on-going learning process. The results of Leonesio and Nelson's (1990) study support this position. JOKs were significantly more accurate than EOL judgments when items were learned to a criterion of four correct recalls, but were not significantly more accurate when items were learned to a criterion of one correct recall. Apparently, increased study leads to greater disparity between EOL judgments and JOKs.

The results of the studies by King et al. (1980), and Lovelace (1984) provide additional evidence that EOL judgments are primarily based on item characteristics and JOKs are based both on item characteristics and information from on-going study. In both studies, subjects studying without test trials were able to predict significantly above chance which items would be recalled; however, subjects studying with test trials predicted which items would be recalled substantially better. In both studies, moreover, subjects studying with test trials remembered which items were and which items were not recalled on the trial immediately preceding the prediction trial, and apparently used this information as a basis for their prediction. These results are consistent with those of Gardiner and Klee

(1976), who demonstrated that subjects can accurately recognize which items were recalled and which items were not recalled on a previous study trial. Shaughnessy (1981) interpreted the findings of King et al. (1980) as suggesting that in the absence of retrieval attempts prior to prediction, the most probable basis for JOK accuracy is perceived item difficulty.

A final study which has investigated the role of item characteristics in predictive accuracy was conducted by Cohen (1988). He examined the accuracy of subjects' JOKs for nonverbal items. Subjects were presented with a list of words or a list of subject-performed tasks (SPTs). An example of a SPT would be picking up a toothpick and breaking it. In one experiment, the items were presented either once or twice. Subjects recalled comparable amounts of words and SPTs, and recalled more twice-presented items than once-presented items. For both words and SPTs, subjects were able to predict that twice-presented items would be better recalled than once-presented items. Subjects were also able to predict reliably which words would and would not be recalled; however, they were completely incapable of predicting which SPTs would and would not be recalled. One interpretation of these results is that subjects can effectively monitor on-going study (once-presented or twice-presented items) regardless of the type of item, and subjects can effectively use item

characteristics of verbal items as a basis for their judgments, but subjects are incapable of deriving any meaningful predictive information from SPT item characteristics. Nevertheless, more research is needed to clearly delineate the processes underlying metacognitive judgments of SPTs, as well as those of verbal items.

Control

It seems probable that a learner's decisions within a learning situation depend on his/her ability to monitor the learning process. The decisions that a learner makes to influence the learning process have been defined as control processes. Some concrete examples of control are: allocating more study time, increasing effort during study, terminating study, self testing, choosing a specific memory search, and terminating the memory search (see Figure 1).

A limited amount of research has focused on the learner's decisions to control the acquiring, retaining, or retrieving of information. One reason for this is that control processes are dependent on metacognitive knowledge, as well as on the immediate monitoring of information. As a result, it is difficult to locate those factors accounting for differences in control. For example, a researcher might hypothesize that good learners increase effort during study of more difficult material, whereas poor learners do not. If this were found to be the case, it would be unclear if the differential effect was due to differences in control

(good learners are able to increase effort whereas poor learners can not), monitoring (good learners are better able to recognize difficult material), or overall meta-level knowledge (good learners know that difficult material requires more effort whereas poor learners do not). In this example it may be difficult to know exactly what is accounting for the increased effort on the part of the good learner; however, valuable information can still be gained from examining the entire control process. The discovery of overall metamemory relationships, between metamemory and learning ability in this example, could provide a starting point, which could be followed up with more analytic research.

One of the earliest studies to investigate subjects' control of study time was conducted by Zacks (1969). She asked subjects to study lists of paired-associate items in one of two ways. Subjects studied under either the experimenter's control (2-s rate study/test) or under the subject's control of study and test trials (self-presentation). Subjects studying under their own control studied difficult pairs longer than less difficult pairs. There was no significant difference in overall recall between experimenter-paced study and subject-paced study.

Recent research has begun to focus more directly on the relationship of monitoring judgments and control. Nelson and Leonesio (1988) asked subjects to make EOL judgments

prior to a study trial during which subjects were allowed to study an item for as much time as they felt was necessary. Subjects were later given a cued-recall test. It was hypothesized that there would be an inverse relationship between EOL judgments and study time allocation. That is, items judged to be difficult to learn should be allocated more study time than items judged to be easy to learn. This was termed the "monitoring-affects-control hypothesis" (p. 678). It was further hypothesized that the extra study time given to more difficult pairs would result in complete compensation, whereby equal amounts of easy and hard items would be recalled. This was termed the "complete compensation hypothesis" (p. 678). The monitoring-affects-control hypothesis was in fact supported by their results, but the complete compensation hypothesis was not. Subjects did allocate more study to items judged to be more difficult to learn, but items judged to be more difficult were still recalled significantly less than items judged to be less difficult. Nelson and Leonesio (1988) were struck by subjects' inability to master every item even when study time was unlimited. Nelson and Narens (1990) later suggested, "Future research should determine whether the same or different results occur during multitrial acquisition, because people routinely learn information to mastery, and this needs to be reconciled with the Nelson and Leonesio findings" (p.8).

Mazzoni, Cornoldi, and Marchitelli (1990) investigated the relationship between JOKs and study time allocation. In one experiment, subjects were initially presented a noun pair for 2.5 s, 5 s, or 7.5 s, and then they were given 5 s to make a JOK. Following the JOK, subjects were allowed to restudy the pair for up to 15 s. When items were initially presented for 2.5 s or 5 s, items rated as most likely to be recalled were allocated less study time than items rated as least likely to be recalled; this is consistent with the relationship between EOL judgments and study time found by Nelson and Leonesio (1988). In contrast to these results, when the initial presentation was 7.5 s, items which received a rating of 3 (5-pt scale), meaning they were "uncertain about subsequent recall," were allocated the most study time; items judged least likely to be recalled or most likely to be recalled were allocated roughly the same amount of study time. More research is needed to examine the various factors influencing the control of study time.

Metamemory-Memory Relationship

One of the main motivations for research on metamemory has been the theoretical conviction that there are important relationships between knowing about memory and memory performance (Schneider & Pressley, 1989). Cavanaugh and Perlmutter (1982), however, reported that developmental research has yielded only moderate or low correlations between metamemory and memory performance. Developmental

research on the metamemory-memory relationship includes correlations between memory performance and a variety of metamemory indices such as knowledge of strategy effectiveness, strategy use, and predictive accuracy. Schneider and Pressley (1989) suggested that some indices of metamemory appear to exhibit correlations with memory performance more consistently than others. For example, spontaneous use of study strategies, such as rehearsal, tends to be more consistently correlated with memory performance than is predictive accuracy.

Nearly all adult metamemory studies investigating the memory-metamemory relationship have focused on showing a relationship between predictive accuracy and memory performance. For instance, in Lovelace's (1984) study subjects made JOKs for associative word pairs after one or multiple study presentations. For each condition, he correlated predictive accuracy with the total amount recalled. A significant correlation between predictive accuracy and learning ability failed to emerge in any of the conditions. Lovelace (1984) suggested that the experimenter's control over study trials may have precluded a relationship between memory performance and predictive accuracy. In other words, memory-metamemory relationships may be prevented if the memory prediction is not allowed to influence study. He suggested that a self-paced task would allow possible metamemory differences to influence memory

performance.

More recently, Kearney and Zechmeister (1989) directly investigated the relationship between learning ability and metamemory performance. Their procedure consisted of administering an initial learning task, having subjects make EOL judgments for a second list of items, and finally having them study and recall this second list of items. Good and poor learners were distinguished based on the initial learning task. Despite considerable differences in learning ability there were no apparent differences in the predictive accuracy of good and poor learners. Kearney and Zechmeister (1989) reasoned that perhaps differences between good and poor learners would emerge if subjects were given an initial attempt to learn the items. In the second and third experiments of their study, subjects studied the items (2 or 5 study trials) prior to making EOL judgments. Once again, subjects were able to make EOL judgments above chance, but a clear difference between good and poor learners' EOL accuracy failed to emerge.

Maki and Swett (1987) also found no correlation between predictive accuracy (JOKs) and number of narrative text idea units recalled. In contrast, Maki and Berry (1984) found that subjects who scored higher than the median performance on a multiple-choice memory test were more accurate at predicting future test performance for sections of written text than were subjects who scored below the median. Also,

Shaughnessy (1979) demonstrated that students who received higher scores on a classroom test made more accurate confidence judgments of whether a given test answer was correct.

In a recent developmental study by Dufresne and Kobasigawa (1989), the responsibility of monitoring and controlling the learning process was left up to the learner. Children (grades 1, 3, 5, and 7) were asked to study hard and easy items in a self-paced manner. Older children (grades 5 and 7) studied the hard items for more time than they did the easy items whereas younger children (grades 1 and 3) did not. Although it has been suggested that ability-related differences are not the same as age-related differences (Kurtz & Weinert, 1989), a design similar to Dufresne and Kobasigawa's may expose metamemory differences related to learning ability.

In summary, no adult studies investigating standard EOL judgments or JOKs have found a substantial relationship between predictive accuracy and learning ability. The one study conducted by Maki and Berry (1984) that did find a relationship between predictive accuracy and total amount recalled asked subjects to make a more complex prediction. Subjects were not asked to simply indicate how hard they felt an item was to learn or if they felt an item had been learned. Instead, subjects were asked to infer from a written paragraph whether they would be able to accurately

answer a multiple-choice test focusing on the given paragraph. This task may involve a more careful integration of the provided information than is required in standard predictive tasks. Perhaps differences between good and poor learners emerge not in the monitoring of information, but rather in the integration of that information with overall metacognitive knowledge, and in subsequent metacognitive decision making.

The Present Study

Adult metamemory research has focused primarily on subjects' ability to make predictions, such as how difficult an item is to learn (EOL judgment), or whether a given item has in fact been learned sufficiently well to be recalled on a later test (JOK). Research of this type has proven quite informative; however, as mentioned above, little is known about how these predictions relate to the learning process. Moreover, research focusing on metamemory predictions has yet to demonstrate clearly whether prediction accuracy is related to learning or memory abilities. The purpose of the present study was to examine general issues of metamemory while focusing on possible relationships between learning ability and metamemory. This was accomplished by investigating a control process, namely, the allocation of study time.

The general method used in the present series of experiments required the discrimination of good and poor

learners. This was done in each experiment using scores from an initial learning task performed prior to the main experimental task. Specifically, subjects first were given 5 min to study 20 paired associates, followed by a 3-min filler task, and a cued-recall test. The results of this cued-recall test served as the basis for distinguishing between good and poor learners following the experiment. After the initial task had been completed, subjects were asked to learn a second list of 36 word pairs, 18 difficult-to-learn and 18 easy-to-learn pairs (cf. Underwood, 1982). In each experiment subjects studied the pairs using a computer which was programmed to provide self-paced study.

The procedure for the critical task was as follows. Subjects were randomly presented each of the word pairs for 2 s (familiarization trial), then the word pairs were presented for 5 s in a new random order. After each 5-s presentation, the subject was asked whether he\she knew the word pair. If the response was "yes" the word pair was dropped from the list. If the response was "no" the word pair remained in the list for further study. Number of study presentations before a "yes" response was an important dependent variable. Following study, subjects were asked to perform a brief filler task and then were given a cued-recall test. Number of word pairs recalled was the second major dependent variable. This basic procedure allowed for the investigation of subjects' study time allocation as a

function of various experimental variables, while simultaneously allowing the examination of possible study/recall differences between good and poor learners.

Metamemory research has provided minimal information about a learner's control of the learning process. Subjects do tend to study more difficult material longer than less difficult material (Zacks, 1969), and subjects' EOL judgments (Nelson & Leonesio, 1988) and JOKs (Mazzoni et al., 1990) reflect this sensitivity to item difficulty. It is unclear, however, what impact this differential allocation has on eventual recall. Furthermore, research investigating study time allocation (Mazzoni et al., 1990; Nelson & Leonesio, 1988) has not allowed subjects to study a given item more than once. As suggested by Nelson and Narens (1990), research focusing on unlimited multi-trial learning is needed. Finally, research is needed on how subjects' control of learning processes is affected by factors, such as test opportunities, that have been shown to enhance metamemory predictions.

These general metamemory issues were addressed in the present series of experiments. Specifically, half of the pairs on the critical list had been previously shown to be more difficult to learn than the other half (cf. Underwood, 1982). Consequently, the amount of study time allocated to hard and easy items as well as the number of hard and easy items eventually recalled could be easily tabulated. It was

expected that hard items would be studied more than easy items; of interest was whether this differential study time allocation would compensate for inherent item difficulty, allowing roughly equivalent recall between easy and hard items. In addition, factors known to enhance JOKs, such as test trials (Exp. 2) and delay (Exp. 3), were manipulated to see if they would enhance the allocation of study time and influence later recall.

The primary focus of the present study, however, was on the relationship of metamemory and learning ability. As was pointed out, adult metamemory research has provided meager evidence of a relationship between metamemory and learning ability. One reason that has been suggested for the lack of a relationship is that learning is often experimenter-controlled (Lovelace, 1984). In these situations, metamemory predictions can have little effect on study time allocation and, consequently, no indirect effect on recall. One solution is to allow subjects to regulate their own study (self-paced study). This was the approach taken in the present study.

A second reason that metamemory differences between good and poor learners may not have emerged is that metamemory research has focused primarily on predictive accuracy, which usually measures the ability to make relative judgments between the items. Perhaps both good and poor learners can make relative distinctions between which

items are more difficult or which items are better known (see Kearney & Zechmeister, 1989), but only better learners can effectively integrate these judgments with metamemory knowledge obtained during attempts to control learning. If this were the case, a relationship between learning ability and metamemory, which was absent for metamemory predictions, would emerge when control processes were investigated.

In the first experiment of the present study, possible differences between good and poor learners were investigated by examining the allocation of study time for hard and easy items, and the sufficiency of study as indicated by recall. Possible differences between good and poor learners were further investigated by examining the relative benefit on metamemory decisions of factors such as test trials (Exp. 2) and delay (Exp. 3). It was expected that good learners and poor learners would benefit differently. Thus, the present study provided a sensitive test of whether good and poor learners differ in their metamemory decision making.

CHAPTER II
EXPERIMENT 1

Method

Subjects

Forty-one introductory psychology students enrolled at Loyola University Chicago participated in the experiment. Each received course credit for participating.

Materials

Subjects were tested using an IBM-compatible computer. Two lists of paired associates were used. List 1 consisted of 20 word pairs of moderate difficulty according to Underwood's (1982) norms. The second list consisted of 18 pairs of high difficulty and 18 pairs of low difficulty. All words were five letters in length and each pair consisted of an uncommon word as the left-hand member and a fairly common word as the right-hand member. Sample pairs are: totem-wives, lares-black, and fugue-fifty.

Procedure

All subjects were given a stack of flash cards, each containing one of 20 associative word pairs that comprised List 1. They were given 5 min to study the word pairs and were informed that they would be given a cued-recall test following study and a brief delay. This provided a means to

discriminate good and poor associative learners as well as a warm-up to the main experimental task. A 3-min filler task (math problems) was given following study and before the cued-recall test.

Following the cued-recall test on List 1, each subject was introduced to the main task using a brief computer-presented sample list. List 2 learning did not begin until subjects reported understanding the task. Subjects studied the second list of associative word pairs using a procedure identical to that used for the sample list, except that new items were used. All word pairs were initially presented for 2 s, one item above the other. Thereafter, each pair was presented on the screen (one over the other) for 5 s, followed by a 3-s period in which only a prompt was on the screen which read, "Do you know the word pair? (Yes = terminate study, No = continue study)". If subjects responded "yes" by striking a specified computer key, the word pair was dropped from the study list. If subjects responded "no", the word pair was retained for further study. The next word pair was presented immediately following the subject's response. If a response was not made during the 3-s period the word pair was kept in the list for further study. The word pairs continued to be presented for study until each word pair had been dropped from the study list. Once again a 3-min filler task (math problems) was administered after study, and was followed by

a written cued-recall test.

Results and Discussion

Good and poor learners were distinguished on the basis of List 1 recall via a median split. Mean proportion recalled was .83 for good learners and .33 for poor learners. One subject was randomly dropped to attain an equal number ($n = 20$) of subjects in each group. A 2 (good vs. poor learner) \times 2 (easy vs. hard item) mixed design ANOVA was used to analyze number of study presentations allocated for List 2 as well as amount recalled. An alpha level of .05 was used for all tests.

Mean study trials and mean proportion recall for List 2 learning are summarized in Table 1. Subjects compensated for item difficulty by allocating significantly more study time to hard items than to easy items, $F(1,38) = 53.09$, $MSe = .16$. Also, poor learners studied for more study trials than good learners (see Table 1), although the difference was not significant, $F(1,38) = 3.03$, $MSe = 3.10$. Furthermore, there was no interaction between item difficulty and learning ability for amount of study, $F(1,38) < 1$, $MSe = .16$. Table 1 reveals that good and poor learners compensated similarly for item difficulty; both allocated more study presentations to hard items.

Easy items were recalled better than hard items, $F(1,38) = 43.49$, $MSe = 2.70$, and good learners recalled more than poor learners, $F(1,38) = 11.35$, $MSe = 45.37$. There was

Table 1

Mean Study Trials and Proportion Recalled (Exp. 1)

<u>Measure</u>	<u>Good Learner</u>		<u>Poor Learner</u>	
	<u>Easy Items</u>	<u>Hard Items</u>	<u>Easy Items</u>	<u>Hard Items</u>
<u>Study Trials</u>	2.55 (.78)	3.21 (1.2)	3.25 (1.3)	3.87 (1.6)
<u>Proportion Recalled</u>	.37 (.12)	.30 (.14)	.23 (.13)	.16 (.15)

no interaction between item difficulty and learning ability for items recalled, $F(1,38) < 1$, $MSe = 2.70$. Inspection of Table 1 reveals that neither good nor poor learners studied sufficiently; mean proportion recall ranged from .16 to .37.

The results of Experiment 1 are consistent with previous research (e.g., Leonesio & Nelson, 1988): Subjects studied the hard items more than the easy items, but the easy items were recalled better than the hard items even when multiple study trials were available. Although good and poor learners exhibited similar compensatory study strategies, neither group compensated sufficiently. Easy items were still recalled more than hard items, and even in the best condition, when good learners studied easy items, only about one-third of the word pairs were successfully recalled. When study time was unlimited, subjects terminated study prior to learning even half of the items.

CHAPTER III

EXPERIMENT 2

The results of the first experiment revealed that even though subjects compensated for item difficulty by studying hard items more than easy items, hard items were still recalled less than easy items, and overall recall was poor. More importantly, no significant study differences emerged between good and poor learners, despite markedly disparate learning ability as indicated by both initial and final recall. In the second experiment, the presence of test trials during study was manipulated to examine the effect of testing upon metamemory decision making. Previous research shows that test trials can improve JOKs (King et al., 1980). Thus, a relationship between testing (presence and absence) and decisions to terminate study was expected.

There are at least two plausible explanations for why test trials enhance predictive accuracy. The most parsimonious explanation is that test trials provide direct information concerning the state of the memory trace. In other words, performance on a test trial provides an indication of whether in fact an item has been learned. There is evidence that recall on a trial immediately preceding the prediction trial is used by subjects when

making JOKs in a multi-trial learning task (King et al., 1980; Lovelace, 1984). A second viable explanation is that learners are consistently overconfident when making metamemory predictions (e.g., Fischhoff, Slovic, & Lichtenstein, 1977) and test trials improve recall (e.g., Runquist, 1986), thus providing closer approximation to the inflated estimates. However, Shaughnessy and Zechmeister (1992) recently demonstrated that test trials improved predictive accuracy (JOKs) when the overall amount of recall was controlled. Therefore, the second explanation alone cannot account for the improvement in JOK predictive accuracy.

In the second experiment, test trials were provided during study via an anticipation procedure. This procedure was expected to improve recall indirectly by improving metamemory decision making. Moreover, possible relationships between metamemory and learning ability were further explored by examining the benefit of test trials. It was of interest whether test trials are differentially effective for subjects of different ability. That is, do good and poor learners benefit similarly from test trials? The second experiment addressed this question by examining possible differences in allocating study time between good and poor learners with or without test trials.

Method

Subjects

Sixty-four undergraduates from Loyola University Chicago participated in the second experiment. No subject had participated in the first experiment, and all subjects received course credit for their participation in the experiment.

Materials and Procedure

The materials and procedures were essentially the same as in Experiment 1. There were two notable changes, however. First, minor adjustments were made in the instructions given to subjects. Subjects were (a) told that they would have to remain for the entire experimental period, regardless of when the learning task was completed, and (b) it was stressed to subjects that they were being asked to attempt a very difficult task that would require their full attention. These adjustments were made to help prevent possible effects of low motivation. The second notable change from Experiment 1 was the inclusion of a second study condition, the "test" condition. In the test condition, following the familiarization trial, subjects were presented the second list of word pairs in a random order. Each presentation consisted of a 2.5-s period, during which the first word of the word pair was presented alone, followed by a 2.5-s period, during which both words of the pair were present. Thus, each presentation was 5 s

long, but divided into two 2.5-s periods. Following the study presentation, subjects were prompted as to whether they knew the word pair. The prompt was identical to that of Experiment 1, and was presented for a maximum of 3 s. If subjects responded "yes" during the prompt, the word pair was dropped from the list for further study. If subjects responded "no", the word pair remained in the list for further study. Immediately following a response, the next word pair was presented. As in Experiment 1, the word pairs continued to be presented until the subject responded "yes" for each word pair. Subjects were then given a 3-min distractor (math problems) followed by a written cued-recall test. Thus, there were two presentation conditions: test and no-test. The no-test condition was identical to Experiment 1 except for the instructional changes and differed from the test condition only in the method of presenting items for study.

Results and Discussion

The allocation of study during the second learning task, as well as the number of items recalled, were analyzed using a 2 (good vs. poor learner) X 2 (test vs. no-test study) X 2 (easy vs. hard item) mixed ANOVA design. Good and poor learners were distinguished on the basis of two median splits of List 1 recall. One median split was performed for the no-test condition, and one was performed for the test condition. Mean proportion recalled for good

learners in the no-test condition was .82, and was .73 in the test condition; whereas mean proportions for poor learners were .30 and .23, respectively. The difference between good learners, $t(30) = 1.66$, as well as the difference between poor learners, $t(30) = .74$, was not significant at the $p < .05$ level.

Mean study trials and mean proportion recall for List 2 learning are summarized in Table 2. Overall, hard items were allocated more study presentations than easy items, $F(1,60) = 128.36$, $MSe = .18$, and subjects in the test condition allocated more study presentations than subjects in the no-test condition, $F(1,60) = 7.13$, $MSe = 5.52$. Although poor learners allocated more study presentations than good learners, the difference was not significant, $F(1,60) = 2.53$, $MSe = 5.52$ (see Table 2). The three-way interaction of learning ability with item difficulty and testing was not significant, $F(1,60) = 2.45$, $MSe = .18$. Likewise, the two-way interactions of learning ability with item difficulty, $F(1,60) = 1.31$, $MSe = .18$, and learning ability with testing, $F(1,60) < 1$, $MSe = 5.52$, were not significant.

Testing did interact with item difficulty, $F(1,60) = 9.29$, $MSe = .18$. Figure 2 reveals that hard items were studied longer than easy items in both the test and no-test conditions; however, the magnitude of this difference was greater in the test condition. In other words, subjects

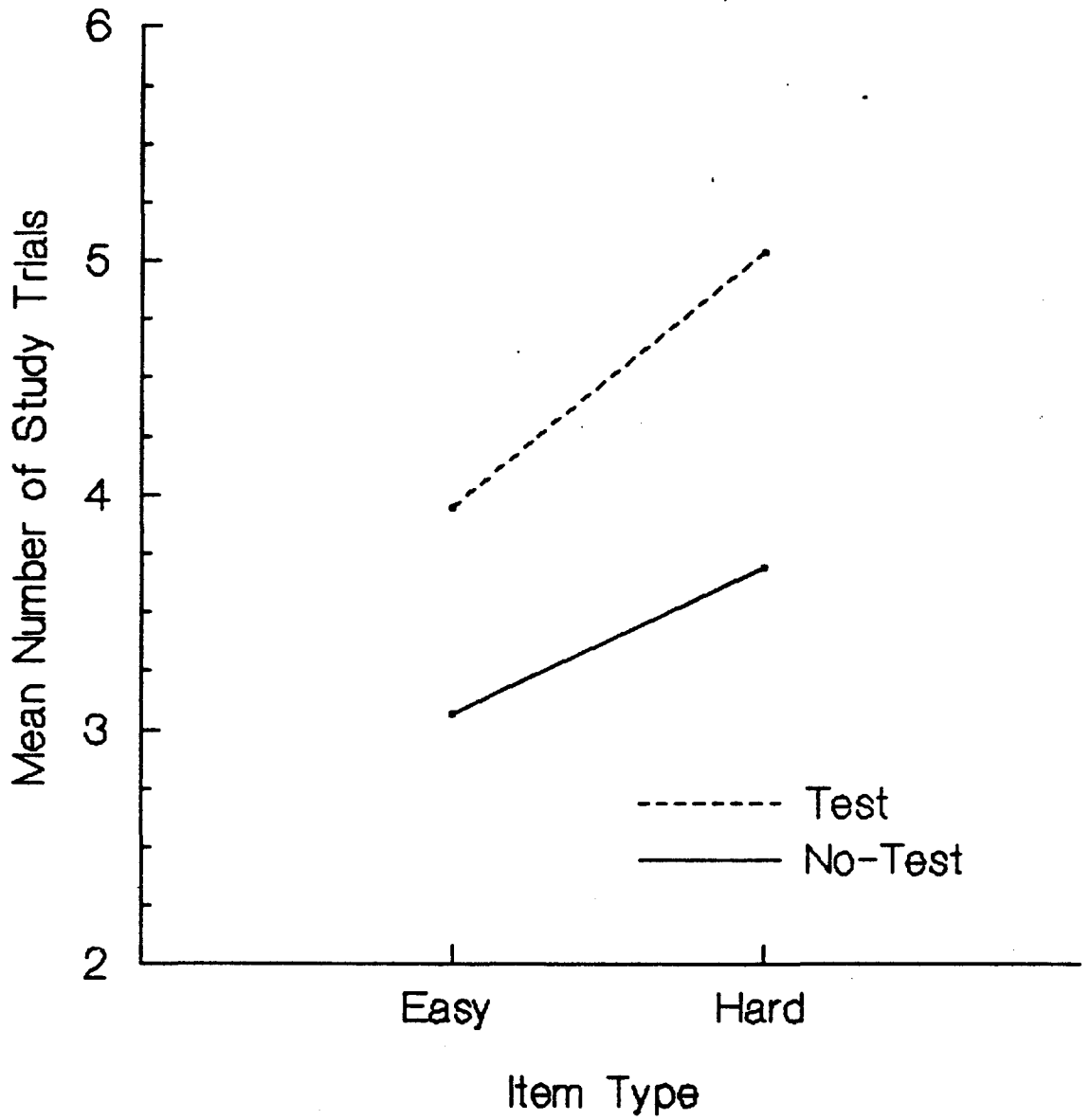
Table 2

Mean Study Trials and Proportion Recalled (Exp. 2)

Measure	<u>Good Learner</u>		<u>Poor Learner</u>	
	<u>Easy Items</u>	<u>Hard Items</u>	<u>Easy Items</u>	<u>Hard Items</u>
NO-TEST CONDITION				
Study Trials	2.82 (1.1)	3.48 (1.3)	3.31 (2.2)	3.89 (2.3)
Proportion Recalled	.72 (.30)	.59 (.33)	.46 (.25)	.28 (.20)
TEST CONDITION				
Study Trials	3.61 (.89)	4.50 (1.3)	4.28 (1.6)	5.57 (2.1)
Proportion Recalled	.85 (.17)	.80 (.21)	.58 (.30)	.46 (.28)

Figure 2

Mean Study Trials as a Function of
Item Type and Testing



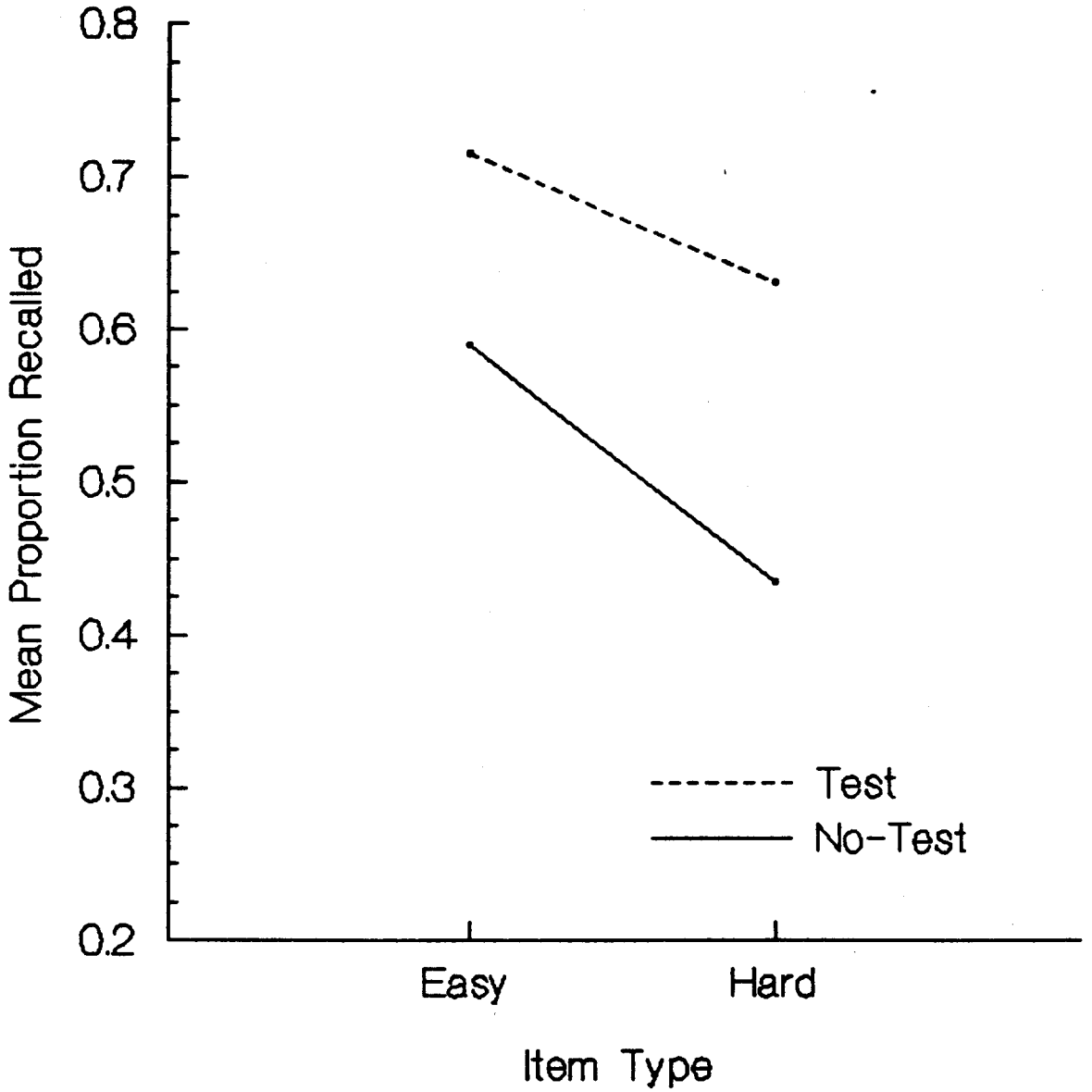
exhibited greater compensation for item difficulty when provided feedback through testing. Examination of each of the simple effects reveals that both main effects hold across each level of the other variable. Hard items were studied longer than easy items both with testing, $F(1,31) = 73.41$, $MSe = .23$, and without testing, $F(1,31) = 52.83$, $MSe = .12$, and items were studied longer with testing for both easy items, $F(1,62) = 5.20$, $MSe = 2.38$, and hard items, $F(1,62) = 8.44$, $MSe = 3.39$.

Easy items were recalled more than hard items, $F(1,60) = 60.34$, $MSe = 2.54$, subjects in the test condition recalled more than subjects in the no-test condition, $F(1,60) = 6.15$, $MSe = 41.15$, and good learners recalled more than poor learners, $F(1,60) = 21.9$, $MSe = 41.15$. The three-way interaction of item difficulty, testing, and learner was not significant, $F(1,60) < 1$, $MSe = 2.54$, and the two-way interaction of learner with testing was not significant, $F(1,60) < 1$, $MSe = 41.15$. The two-way interaction of learner with item difficulty also was not significant, although it approached significance, $F(1,60) = 3.15$, $MSe = 2.54$, $p = .081$. There was a greater difference between recall of hard and easy items for poor learners.

The interaction of testing with item difficulty was significant, $F(1,60) = 4.93$, $MSe = 2.54$. While the difference between hard and easy items was greater in the test condition for study trials, the reverse was true for

Figure 3

Mean Proportion Recalled as a Function of Item Type and Testing



recall (see Figure 3). Simple effects analyses revealed that easy items were recalled significantly more than hard items both with testing, $F(1,31) = 19.5$, $MSe = 2.00$, and without testing, $F(1,31) = 39.90$, $MSe = 3.17$. As seen in Figure 3, the difference was greater in the no-test condition. Additionally, recall was significantly higher in the test condition for hard items, $F(1,62) = 6.34$, $MSe = 29.80$, but recall was not significantly higher in the test condition for easy items, $F(1,62) = 2.82$, $MSe = 27.20$.

The results of Experiment 2 replicated and extended those of Experiment 1. The results of Experiment 2 further reveal that learners are sensitive to differences between hard and easy items and study accordingly. The presence of testing during study appeared to enhance metamemory decision making and to improve overall recall. This is strongly suggested by the complementary interactions between item difficulty and testing for study and recall. Learners compensated for item difficulty more in the test condition during study, and the difference between recall of hard and easy items was reduced in the test condition. It would appear that test trials aid learners' decisions regarding when to terminate study, just as they improve decisions about what will be remembered (i.e., JOKs).

No significant differences emerged in the way good and poor learners allocated study time. As in Experiment 1, poor learners tended to study slightly (but not

significantly) longer than good learners, yet good learners recalled significantly more. Most importantly, good and poor learners were influenced similarly by testing. Both good and poor learners compensated more for item difficulty if provided testing during study, and both recalled hard and easy items more equally if provided testing. These results replicate and extend the paradoxical relationship found in Experiment 1: Despite considerable differences in initial and final recall, good and poor learners appear equally sensitive to item difficulty and benefit equally from testing during study.

CHAPTER IV

EXPERIMENT 3

In Experiment 1, both good and poor learners were able to distinguish between hard and easy items, and used this information similarly when allocating study. Experiment 2 replicated this finding and further suggested that test trials during study enhance metamemory decision making and improve the sufficiency of study. Once again no differences in study were apparent between good and poor learners.

Nelson and Dunloskey (1991) recently demonstrated that a delay between study and JOKs significantly improves predictive accuracy. They suggested that JOKs made immediately following study are based on both short-term and long-term memory information, whereas JOKs made following a delay are based solely on long-term memory information and thus provide a more accurate indication of what will later be recalled. In Experiment 3, the effectiveness of a delay between study and the decision to terminate study was investigated.

It was expected that, when compared with immediate decision making, delayed decision making would enhance study and improve recall. As demonstrated for test trials in Experiment 2, it was expected that the presence of a delay

following study would enhance subjects' compensation for item difficulty during study, leading to improved recall. Thus, Experiment 3 was designed to further investigate the findings of Nelson and Dunloskey (1991), to provide convergent validity for the results of Experiment 2, and to provide another opportunity for possible differences between good and poor learners to emerge.

Method

Subjects

Eighty introductory psychology students enrolled at Loyola University Chicago participated in the experiment. Subjects received course credit in exchange for their participation. No subject from either of the first two experiments participated.

Materials and Procedure

The materials and procedure were nearly identical to that of the first two experiments. Upon arrival subjects were randomly assigned to one of two conditions: delay or no-delay. The anticipation procedure used in Experiment 2 was not used in either of these conditions. Once again the same word pairs and initial screening task as the previous two experiments were used. The no-delay condition was nearly identical to the no-test condition of Experiment 2. In order to provide a better control for the delay condition, two minor changes were made. First, when subjects were prompted as to whether they knew a given word

pair, the first word of the word pair remained on the screen. Second, subjects were given a maximum of 8 s as opposed to 3 s to decide whether they knew the word pair. As in the first two experiments, once subjects responded "yes" or "no" the next word pair was presented for study.

The only difference between the delay condition and the no-delay condition was the timing of the decision period. Unlike the previous experiments, subjects were not prompted as to whether they knew each pair until after studying all the pairs. That is, subjects were first presented each of the word pairs for 5 s and then, on a subsequent trial, were presented the first word of each pair along with the prompt, "Do you know the word pair? (Yes = terminate study, No = continue study)". The decision presentations were administered in the same order as the study presentations, and subjects had a maximum of 8 s in which to decide. Once a decision was made the next cue was presented and the subject then had 8 s to decide whether that pair had been learned. If a subject pressed the key marked "yes" the word pair was dropped from the study list. If a subject pressed the "no" key the word pair remained in the list for further study. Word pairs not dropped out were re-presented in a new random order; study presentations always preceded the decision presentations. This continued until all word pairs had been dropped out.

Results and Discussion

As before, two main dependent variables, number of study presentations allocated and number of words recalled on the second cued-recall test, were analyzed. A 2 (good vs. poor learner) X 2 (delay vs. no-delay) X 2 (easy vs. hard item) mixed ANOVA design was used to analyze each dependent variable. Again, good and poor learners were distinguished on the basis of the first cued-recall test. Separate median splits were performed for both conditions; subjects in the top half were defined as good learners and subjects in the bottom half were defined as poor learners. Mean proportions were .74 (good learner) and .34 (poor learner) in the delay condition, and .73 (good learner) and .29 (poor learner) in the no-delay condition. The differences between good learners, $t(38) = .28$, and between poor learners, $t(38) = 1.24$, were not significant at $p < .05$.

Mean study trials and mean proportion recall for List 2 learning are summarized in Table 3. Analysis of the number of study presentations allocated revealed a significant main effect for item difficulty, $F(1,76) = 143.13$, $MSe = .22$, but no significant main effects for delay, $F(1,76) < 1$, $MSe = 4.05$, or learner, $F(1,76) = 3.9$, $MSe = 4.05$, $p = .052$. Similar to Experiment 1 and Experiment 2, hard items were studied longer than easy items, and poor learners studied longer than good learners, although this latter difference

Table 3

Mean Study Trials and Proportion Recalled (Exp. 3)

Measure	<u>Good Learner</u>		<u>Poor Learner</u>	
	<u>Easy Items</u>	<u>Hard Items</u>	<u>Easy Items</u>	<u>Hard Items</u>
NO-DELAY CONDITION				
Study Trials	3.10 (1.3)	3.69 (1.8)	3.35 (1.4)	4.09 (1.6)
Proportion Recalled	.74 (.22)	.61 (.30)	.39 (.26)	.26 (.22)
DELAY CONDITION				
Study Trials	2.75 (.97)	3.65 (1.4)	3.47 (1.2)	4.80 (1.8)
Proportion Recalled	.88 (.12)	.80 (.16)	.60 (.20)	.43 (.18)

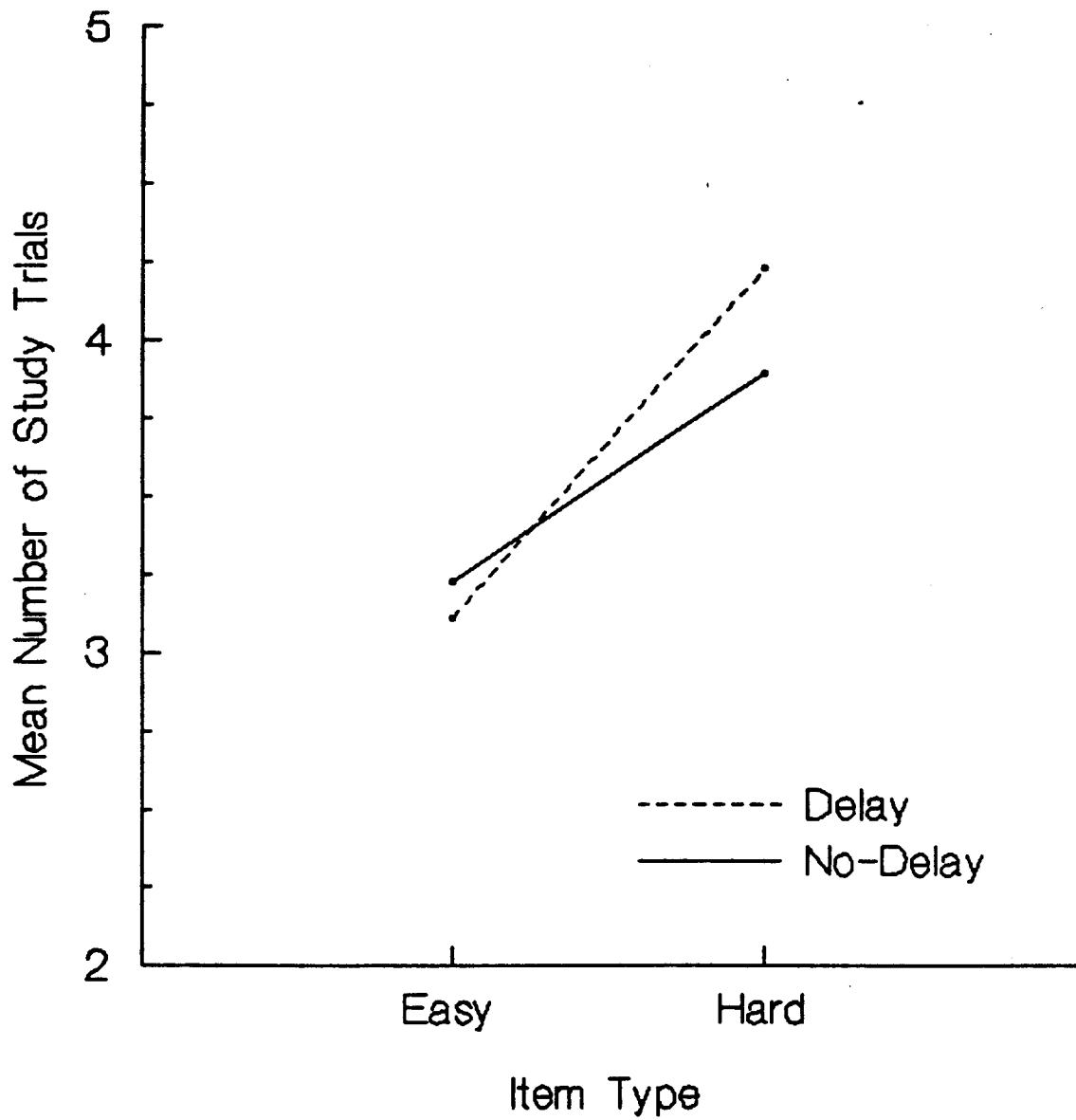
was not significant (see Table 3). The three way interaction of item difficulty, delay, and learner was not significant, $F(1,76) < 1$, $MSe = .22$. Also, the two-way interactions of learner and delay, $F(1,76) < 1$, $MSe = 4.05$, as well as learner and item difficulty, $F(1,76) = 3.65$, $MSe = .22$, $p = .06$, were not significant, although the interaction of learner and item difficulty approached significance. The difference between easy and hard items was greater for poor learners. The interaction of item difficulty and delay was significant, $F(1,76) = 9.07$, $MSe = .22$. Simple effect analyses revealed that hard items were studied significantly more than easy items for both the delay condition, $F(1,39) = 91.63$, $MSe = .27$, and the no-delay condition, $F(1,39) = 47.6$, $MSe = .19$, with the difference being greater in the delay condition (see Figure 4).

Examination of the number of items recalled on the second cued-recall test revealed that easy items were recalled significantly more than hard items, $F(1,76) = 80.00$, $MSe = 2.95$, good learners recalled significantly more than poor learners, $F(1,76) = 54.97$, $MSe = 26.5$, and subjects in the delay condition recalled significantly more than subjects in the no-delay condition, $F(1,76) = 14.8$, $MSe = 26.5$. There was no interaction between learner, item difficulty, and delay $F(1,76) = 2.9$, $MSe = 2.95$, $p = .093$.

There were also no significant interactions between

Figure 4

Mean Study Trials as a Function
of Item Type and Delay



learner and delay, $F(1,76) < 1$, $MSe = 26.5$, learner and item difficulty, $F(1,76) = 3.22$, $MSe = 2.95$, $p = .077$, and delay and item difficulty, $F(1,76) < 1$, $MSe = 2.95$. Although none of these interactions was significant at the $p < .05$ level, the two-way interaction of learner and item difficulty, as well as the three-way interaction of learner, item difficulty and delay did approach significance. The disparity between the number of easy and hard items recalled tended to be less for good learners, and this difference was accentuated in the delay condition.

The results of Experiment 3 are generally consistent with those of Experiment 1 and Experiment 2. A delay between study and decision led to significantly greater compensation for item difficulty during study, as well as better recall. Interestingly, subjects in the delay condition did not study items significantly longer; yet, subjects in the delay condition recalled significantly more items. Although this finding appears to be inconsistent with the results of Experiment 2, it must be remembered that actual study time was not equivalent for the test (2.5-s test/2.5-s study) and no-test conditions (5-s study) of Experiment 2. The only notable inconsistency between Experiment 2 and Experiment 3 was the presence of a recall interaction between testing and item difficulty in Experiment 2, and the absence of a recall interaction between delay and item difficulty in Experiment 3.

Nonetheless, in both experiments, type of study interacted with item difficulty for study, and in both experiments recall was substantially greater for the test and delay conditions as compared with the no-test and no-delay conditions.

CHAPTER V
GENERAL DISCUSSION

The combined results of the three experiments provide important information about adult metamemory. These results will be interpreted first in relation to general metamemory issues, and second, in relation to possible interactions of metamemory abilities and learning abilities.

General Metamemory

Adult metamemory research generally has focused on examining the learner's sensitivity to information influencing the learning process. For example, studies using EOL judgments have examined subjects' sensitivity to item difficulty (e.g., Kearney & Zechmeister, 1989), and studies using JOKs have examined subjects' sensitivity to what has been learned (e.g., King et al., 1980). More recently, metamemory researchers have begun to focus on how this sensitivity to learning-relevant information relates to subjects' control of the learning process (Nelson & Narens, 1990). This shift in focus has led metamemory researchers to consider the sufficiency of the learner's control. In examining subjects' control of study time, for instance, researchers have emphasized the amount recalled in a self-paced learning situation (e.g., Leonesio & Nelson, 1988); if

subjects are given unlimited study time and do not attain nearly perfect recall, it is considered a metamemory failure. The results of the present study, also, can be interpreted in regard to the subjects' sufficiency of study, as well as to subject's sensitivity to item difficulty.

In Experiment 1, subjects allocated significantly more study trials to hard items than to easy items. This finding is consistent with previous research demonstrating that subjects are sensitive to item difficulty when making metamemory decisions in a self-paced learning task (Zacks, 1969). Hard items, nevertheless, were still recalled less than easy items despite subjects' compensation during study. This finding, also, is consistent with previous research suggesting that subjects do not compensate sufficiently for item difficulty (Nelson & Leonesio, 1988). Perhaps, the most striking finding in Experiment 1, however, was the surprisingly low level of recall given that subjects had unlimited opportunities to study the material. As a whole, the results of Experiment 1 evoke a mixed impression of subjects' metamemory abilities. Subjects' sensitivity to item difficulty reflects efficient monitoring of information; however, subjects' failure to study items sufficiently, despite being allowed unlimited study opportunities, demonstrates unsuccessful controlling of the learning process.

The results of Experiment 2 and Experiment 3 suggest

that a lack of motivation may account somewhat for the low level of recall in Experiment 1. The procedures used in the control condition of Experiment 2 were identical to the procedures used in Experiment 1 except for the changes made to increase motivation. Although the obtained pattern of results was nearly identical to that of Experiment 1 (see Table 4), the overall level of recall was much higher in the control condition of Experiment 2. The same pattern of results, including the raised level of recall, also emerged for the control condition of Experiment 3. Thus, the findings of Experiment 1 would appear to be stable, despite overall recall being somewhat diminished by motivational factors. It should be noted, however, that recall in the control conditions of Experiment 2 and Experiment 3 was still far from perfect; mean proportion recall ranged from .74 to .26 across both experiments.

Of greatest importance to our understanding of metamemory in general, is the relative influence of the test manipulation, as well as that of the delay manipulation. Previous research has demonstrated that the presence of test trials during study significantly improves JOK predictive accuracy (King et al., 1980; Lovelace, 1984). In Experiment 2, subjects who were given test opportunities during study compensated significantly more for item difficulty than subjects who were not given test trials. That is, subjects in the test condition studied hard items longer than easy

Table 4

Comparison of Results Across Experiments

<u>Experiment</u>	<u>Study</u>		<u>Recall</u>	
	<u>Mean Diff.</u>	<u>R²</u>	<u>Mean Diff.</u>	<u>R²</u>
Exp. 1				
Item Difficulty	.36*	.058	.07*	.048
Type of Learner	.34	.067	.14*	.209
Item by Learner	.04	---	.00	---
Exp. 2				
Item Difficulty	.62*	.030	.16*	.064
Type of Learner	.45	---	.29*	.208
Item by Learner	.06	---	.06	---
Exp. 3				
Item Difficulty	.69*	.047	.13*	.044
Type of Learner	.32	---	.35*	.323
Item by Learner	.15	---	.00	---

* Indicates difference was significant ($p < .05$)

--- Indicates there was no systematic variation

items to a greater extent than did subjects in the no-test condition. Moreover, subjects in the test condition recalled significantly more items than did subjects in the no-test condition. Apparently, the presence of test trials increased subjects' sensitivity to item difficulty and improved the sufficiency of their study.

It has also been demonstrated that a delay between study and prediction improves subjects' JOK accuracy (Nelson & Dunloskey, 1991). In Experiment 3, subjects in the delay condition compensated for item difficulty significantly more than did subjects in the no-delay condition. It was also found that subjects in the delay condition recalled significantly more items than did subjects in the no-delay condition. It appears as if a delay between study and decision increased subjects' sensitivity to item difficulty and enhanced the sufficiency of their study, as was demonstrated for test trials.

On the surface, it seems as if test opportunities, as well as delayed decision making, assist one's metamemory abilities and consequently improve recall. Although this may be the case, these findings must be examined further prior to making such a conclusion. It seems plausible that increased sensitivity to item difficulty should improve recall, and Experiment 2 provides evidence to support this claim. The presence of test opportunities significantly interacted with item difficulty; subjects in the test

condition studied hard items more than easy items to a greater extent than did subjects in the no-test condition. A complementary interaction between testing and item difficulty was also found for recall: The recall difference between hard and easy items was less in the test condition than in the no-test condition. These results would seem to converge in support of the intuitive assumption that improving metamemory performance results in improved memory performance.

In Experiment 3, subjects in the delay condition compensated significantly more for item difficulty than did subjects in the no-delay condition. Surprisingly, however, a complementary interaction between delay and item difficulty was not found for recall; the recall difference between hard and easy items was the same for subjects in the delay and no-delay condition. The fact that recall was substantially improved in the delay condition, despite there being no evident benefit of differential study, raises the question: What is accounting for higher recall in the delay condition?

As mentioned in the introduction to Experiment 2, prior research has demonstrated that attempts to retrieve a given item directly facilitate retrieval of that item (Runquist, 1986). Subjects in the test condition of Experiment 2 most probably benefitted similarly from retrieval opportunities, although it is impossible to tease this effect out since the

number of study trials was significantly greater for subjects in the test condition. Nelson and Dunloskey (1991) suggested that subjects in their study may have attempted to retrieve the second half of a paired-associate item when asked to make a delayed JOK. Similarly, subjects in the delay condition of Experiment 3 may have attempted to retrieve the second half of each paired-associate item when making their decision to terminate or continue study. Furthermore, the number of study trials was not significantly greater for subjects in the delay condition of Experiment 3, as compared with subjects in the no-delay condition. (There was also no significant study interaction between learning ability and delay.) Thus, if subjects did not study longer in the delay condition, and there is no evidence of a benefit due to increased compensation, then it is likely that subjects attempted retrieval during delayed decision making which, in turn, facilitated recall. Clearly, more analytical research is needed on the processes involved in delayed metamemory decisions.

In summary, the results of the present series of experiments can be interpreted in terms of subjects' sensitivity to item difficulty and their sufficiency of study. Both testing and delay enhanced metamemory decision making and improved recall. It remains unresolved, however, whether greater compensation for item difficulty is directly related to higher recall. It is interesting that factors

such as testing and delay may improve recall both by enhancing metamemory decision making and by directly improving the quality of study. This finding has implications for planning effective learning in general.

Metamemory and Learning Ability

Previous metamemory research had suggested that there were no substantial correlations between learning ability and the ability to make metamemory predictions when the learning task used simple verbal items (e.g., Kearney & Zechmeister, 1989). It was reasoned that perhaps good and poor learners are similar in their ability to monitor which items are harder to recall or which items have been learned, but differ in their ability to integrate those judgments with past knowledge and thus make appropriate decisions during learning.

In the present study, the control of study time allocation by good and poor learners was investigated. It was hypothesized that good learners study more effectively than poor learners. Experiment 1, however, failed to show any differences in study allocation between good and poor learners. Both good and poor learners studied hard items more than easy items and recalled more easy items than hard items. This finding was replicated in the control conditions of Experiment 2 and 3 (see Table 4). These results were obtained despite sizable differences in initial recall between good and poor learners as demonstrated on the

pretest.

In Experiments 2 and 3, factors previously shown to benefit metamemory predictions were investigated to see if they had a similar effect on good and poor learners' decisions to terminate study. As mentioned above, these factors enhanced metamemory decision making and improved recall. Once again, no differences were apparent between good and poor learners. Good and poor learners alike compensated for item difficulty more in the test or delay conditions as compared with their respective control conditions. Furthermore, good and poor learners benefitted similarly from testing and delay. Overall, no significant differences emerged between good and poor learners in any study condition within the three experiments. The fact that learners who differ widely in learning ability are equally sensitive to differences in item difficulty, and benefit similarly from testing and delayed decision making, provides a paradox in adult metamemory research. Although effective regulation of study would seem to be paramount to one's ability to learn, no relationship emerged between learning ability and control of study.

When studies of adult metamemory first failed to find correlations between metamemory performance and learning ability, researchers found the results surprising and counterintuitive (e.g., Lovelace, 1984). When additional studies using different item types showed similar results,

the lack of a relationship became more perplexing (e.g., Maki & Swett, 1987). Now that studies focusing directly on the relationship between metamemory and learning ability have also failed to find any relationship (Kearney & Zechmeister, 1989; present study), it is time to confront the question of why there may be no metamemory differences between good and poor learners in simple learning tasks. Brown (1978) has suggested that "...in the domain of deliberate learning and problem-solving, conscious executive control of the routines available to the system is the essence of intelligent activity" (p.79). Why has adult metamemory research provided little support for this belief?

One possible reason for this paradox is that the ability to learn a list of items is not, in fact, correlated with intelligent study activity. This seems unlikely in the case of multi-trial, self-paced learning with highly heterogeneous items. It is possible, however, that the learning tasks used to date do not place sufficient demand on metamemory skills. One solution is to increase task complexity. Clever research using more complex learning tasks may be necessary to resolve the present learning ability paradox in adult metamemory research.

Although the simplicity of the task may account for the lack of general relationships between metamemory and learning abilities, this explanation provides little insight into why good and poor learners benefit similarly from

testing and delay. Brown and Palinscar (1982) revived Piaget's distinction between "...active regulation as part of any knowing act, and conscious regulation and direction of thought, the keystone of formal operations" (p. 2). They went on to say that young children are very capable of regulating their activities and that some form of error correction is part of all active learning. What younger children, and perhaps poorer learners, are incapable of doing is reflecting back on their own thought or learning and using this conceptualization to initiate more complex cognitive strategies (Brown & Palinscar, 1982).

Accordingly, good and poor learners in the present study may have been equally capable of using corrective information from testing and delay, but if asked to reflect upon and design their own method of optimizing study, perhaps good learners would study more effectively.

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The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

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