AN INVESTIGATION
OF THE
RELATION BETWEEN REMEMBERING AND LEARNING

By

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ABSTRACT

Remembering requires an awareness of prior occurrence. In contrast, learning is indicated by savings on performing a task; no awareness of prior occurrence is necessary. Previous research has shown that performance on measures of learning can be functionally and statistically dissociated from performance on remembering tasks. Some investigators have concluded that these dissociations indicate that there are separate memory systems. The experiments performed in this thesis investigate the alternative explanation that dissociations between measures of memory result because of differing retrieval requirements. Whereas previous experiments employed learning and remembering tasks that were mismatched in their reliance on conceptual processes, the present experiments employ a learning task that focuses on the conceptual relations between words.

Meaningfulness of study processing was manipulated by requiring categorization of word pairs as similar or dissimilar. When the same categorization was performed at transfer, learning was of greater magnitude and of longer duration for more meaningfully related words. When repeated words were categorized by different attributes virtually no learning was observed. Therefore, in contrast to other research (e.g., Jacoby & Dallas, 1981), the meaningfulness

and context of processing words were important determinants of learning.

The relation between remembering and savings on categorization was investigated by requiring a recognition decision after each categorization at transfer. Effects on recognition paralleled those on categorization. Better recognition performance was observed for more meaningfully related words and for words repeated in the same task context. Discrimination of task context also was better for more meaningfully related words. Therefore, the effect of equating processing requirements between measures was to produce a functional dependence between remembering and learning. A statistical dependence between measures also was obtained: At transfer, faster than average categorizations were associated with "old" recognition decisions in conditions in which subjects based their recognition decision on familiarity only. However, the conclusion of statistical association is tentative because the requirement to recognize after categorization interfered with categorization.

Manipulations of retrieval processes were successful in converting dissociations into associations. Therefore, this investigation supports the differing retrieval requirements explanation of dissociations between measures of memory.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER ONE

Introduction

What is the difference between the memories that support our interpretation of ongoing events and the memories that are used when we remember past events? Possibly the knowledge used in dealing with current events is retained in a way that is very different from the way our record of our personal past is retained. It is self-evident that one's awareness of the prior experience is quite different in the two cases. In order to remember, one is focally aware of the prior experience. However, when knowing, the focus of awareness is on completion of a task: or on interpretation of an event that is in the present. It may be that this is the extent of the difference: one can be aware of the same memory in different ways. If this is the case then knowing and remembering are related activities. Alternatively, the difference in quality of awareness may be symptomatic of a profound separation between knowing and remembering.

The focus of this thesis is on the acquisition of new information, as measured in tasks that either require completion of a task (knowing) or require a judgement about

the prior occurrence of an event (remembering). In the experiments reported in this thesis, the knowing and remembering tasks are always performed after exposure to the same acquisition condition. In the acquisition condition, subjects categorize pairs of words as similar or dissimilar according to either graphemic, phonemic, or semantic attributes. After this initial categorization of word pairs, these pairs are presented again for categorization. If the time taken to categorize the repeated pairs is faster than the time taken for the initial categorization, then an improvement in knowing, or more simply, learning, is inferred. In some experiments, subjects were also asked whether they recognized categorizing the pairs before. If the probability of a correct recognition (i.e., a hit) is greater than the probability of an incorrect recognition (i.e., a false alarm), then remembering is inferred.

The central question of this thesis is whether improvements in knowing (hereafter referred to as simply, "learning") require information to be represented in a format that is different from the information necessary for remembering. If learning is represented by information that is inaccessible for remembering, then no relation between learning and remembering exists. Conversely, if the information supporting learning is represented in the same format as the information supporting remembering, then a

relation between them could exist. In describing the types of relationships between remembering and learning it will be important to distinguish between memory "representations" and memory "processes". The claim that there is no relation between remembering and learning implies that the memories of experience supporting remembering are different from those supporting learning. In the terminology used here, the claim is that the memory representations used for learning are different from those used for remembering. An alternative account claiming the presence of a relation between learning and remembering might emphasize the different ways in which the prior experience is retrieved. In the present terminology, learning and remembering employ different retrieval processes, but have a common memory representation. I will describe this type of relationship as a correlation between the retrieval processes of learning and remembering. A more demanding type of relation would be one of causation. The outcome of retrieval by one processing mode (learning or remembering) might be sufficient to cause a decision by the other processing mode without this latter mode independently retrieving the memory representation. For example, if a task can be fluently performed, one might infer that the task had been performed before.

The relation between measures of learning and remembering can be described either in statistical terms or

in functional terms. If a functional relationship exists, then both measures will be affected similarly by the same variable. If a statistical relationship exists, then a measurement of learning will predict the measurement of remembering. Theoretical interpretations of such relationships must be made cautiously, however. Accounts suggesting that the representations supporting learning are different from those supporting remembering do not predict the existence of either functional or statistical relationships. In contrast, accounts suggesting that similarly represented memories are retrieved differently when learning than when remembering predict that such relationships should exist. However, neither account, in abstract, can be rejected by the discovery of a relation (i.e., dependence of measures) or a nonrelation (i.e., independence of measures). Theoretical inferences can be made only as a summary of the pattern of relationships found over a number of experiments that manipulate theoretically important variables. If dependence is consistently found with different preparations, if dependence is systematically a function of theoretically important variables, and if these variables control both types of dependence, then the inference can be made that representations exist that are common to learning and remembering processes. This is the logic for experimentation that is pursued in this thesis.

Brief History of Theories of the Relation Between Remembering and Learning

As early as 1885, Ebbinghaus (1964) distinguished learning (as defined above) from remembering. "Voluntary" remembering required an effort to bring a prior experience back to mind, whereas for "involuntary" remembering the prior experience returned to mind without request or effort, and most importantly, it might even lack a feeling of having occurred before. For Ebbinghaus there was no question about the relationship between these modes of remembering because he assumed that there was just one memory system. His distinction was made for methodological reasons. Involuntary remembering was important because it avoided the problems then associated with introspection. In order to measure involuntary remembering Ebbinghaus used the "savings" in relearning of items. This turned out to be an important methodological insight. This procedure is currently referred to as a "transfer-of-learning" paradigm, or more simply as a "transfer" paradigm. In the research described here, a variant of the transfer paradigm, savings on performing a task, is employed as the primary index of learning.

The theme of the two different manifestations of memory in remembering and learning was picked up again by Bergson (1913). In illustrating the contrast he used the

example of learning sentences by rote. When a lesson has been learned, sentences can be reproduced fluently and in the same manner on any occasion. Although each instance of repeating the sentences can be recalled later, each is a distinct event that cannot be reproduced again. Whereas the former manifestation of memory is an action in the present, the latter manifestation is a representation of the past. Bergson's purpose in drawing this distinction was to assert the duality of mind and body. Consequently he viewed these differences as fundamental and as evidence for the existence of two independent memory systems. Learning to reproduce sentences was represented in the perceptuo-motor mechanisms (i.e., the body), but the images of repeating the sentences in the past were represented in the mind only. This position (without the mind/body attribute) has many modern proponents (e.g., Cohen, 1984) and subsequently will be referred to as the "representation" hypothesis of the relation between remembering and learning.

Bergson gave a completeness to the representation hypothesis not often seen in modern accounts, by also asserting the independence of retrieval processes. Anticipating the modern position that recognition can have two independent bases (e.g., Mandler, 1980), Bergson argued that perceptuo-motor "movements" might automatically give rise to a sense of familiarity, but at other times the familiarity might be caused by "...an effort of the mind

which seeks in the past...those representations which are best able to enter into the present situation" (p. 87). While claiming the independence of retrieval processes, Bergson also acknowledged that effortful remembering could elaborate the familiarity generated by perceptuo-motor mechanisms. In fact, such elaboration was claimed to be necessary in order to create a representation of any perceptuo-motor event in awareness. Bergson described the mediating process, attention, as a translator (e.g., a telegraph operator) that is able to speak both "languages". Without this intermediary process, however, perceptuo-motor recognition would proceed without any effortful retrieval in awareness. Evidence of independent retrieval processes was found in the clinical condition known as psychic blindness; patients so afflicted will react to an object, but at the same time claim not to have seen or have been aware of it.

A very different account of the distinction between learning and remembering was given by Polanyi (1969a, 1969b, 1969c). Interestingly, his point of departure was not the mind/body duality, but rather the fallacy of the logical positivist claim of total objectivity in scientific knowledge. Briefly, he argues that there are unidentifiable (or subjective) elements in any act of knowing. Objective knowledge exists whenever specific elements are held in focal awareness and attended to. However, if these elements now participate in a larger Gestalt, then this Gestalt will

replace the constituent elements in focal awareness. These elements are still contributing to the interpretation of the Gestalt, but one is aware of these elements only subsidiarly, only in how they participate in the Gestalt. When elements move from focal awareness to subsidiary awareness, Polanyi calls the knowledge provided by these elements "tacit". It is possible, therefore, that any form of objective knowledge could serve as tacit knowledge if different task goals are present at a later time. In fact, Polanyi claims that objective knowledge cannot exist without "relying on" tacit knowledge. Polanyi describes this as the "vectorial property of meaning": In tacit knowing, one always attends from elements in subsidiary awareness to elements in focal awareness. As an example, Polanyi cites the process of reading. One relies on the marks on the page in order to attend to the meaning of the sentence. While the meaning of the sentence is in focal awareness, the marks on the page are in subsidiary awareness. The marks on the page contribute to the meaning of the sentence to the extent that they participate in forming the larger whole - from letters to words, from words to sentences. The purpose an object serves in a task is critical for distinguishing between tacit and objective knowing. If the object (e.g., a hammer) contributes to a larger task goal (using it as a tool to hit nails) then our knowledge of the hammer is tacit and resides in subsidiary awareness. If the object is

itself the task goal (appreciating the hammer) then our knowledge of the hammer is objective and resides in focal awareness.

In terms of the transfer paradigm, in which savings in performing a task are taken as evidence of learning, Polanyi's analysis indicates that the memory supporting learning resides in subsidiary awareness: The goal of the task, which occupies focal awareness, does not change between successive performances. In contrast, remembering requires that some event, necessarily residing in focal awareness, be judged as having occurred previously. For Polanyi, the distinction between learning and remembering is just a difference in the type of awareness required by the measure of memory. In his terms, the type of task determines how element events are "integrated" (i.e., which events act subsidiarly). In the terms of this thesis, the difference between learning and remembering is in the type of retrieval process, not in the memory representation. Polanyi implies throughout that the only form of memory representation is of specific events, and he is explicit that when a more general conception is required (e.g., for communication), the specific representations are tacitly integrated in producing the focal awareness of the desired concept (pp. 190-191). This position also has several modern proponents (e.g., Jacoby & Brooks, 1984) and subsequently will be referred to as the "retrieval"

hypothesis of the relation between remembering and learning.

In summary, the representation and retrieval hypotheses of the relation between remembering and learning can be distinguished by the roles that are assigned to the representation and retrieval of memories. The representation hypothesis requires that remembering and learning be supported by qualitatively different memory representations (e.g., Cohen, 1984; Tulving, 1983). The problem for a retrieval hypothesis is to specify how the same memories can influence both remembering and learning. One version of the retrieval hypothesis, closer to Polanyi's work, asserts that different retrieval processes make use of common memory representations (Humphreys & Bain, 1983, footnote 5). Another version extends this position by proposing that the different retrieval processes can bear a causal relation to each other. Like the "telegraph operator" in Bergson's account, the Jacoby and Dallas (1981) fluency hypothesis suggests that processes employed during remembering can interpret fluent re-performance of a task as evidence of prior occurrence.

The Relation of Remembering and Learning in Experimental Psychology

Since the "cognitive revolution" of the 1960's, questions about memory have been generally asked using tasks

like recognition and recall. These tasks epitomize the term "remembering" because they explicitly require reinstatement of a prior event in focal awareness. Before this period in psychology, the issue of memory was perceived in terms of "verbal learning", and thus the transfer paradigm was the predominant measure of memory. The fact that the history of memory research can be so easily partitioned into a period that measured only learning and a period that measured only remembering should make it less surprising that the relation between remembering and learning has been poorly investigated and poorly understood.

In this section I will briefly outline the relatively complete accounts of the relationship that exist. A major distinction to be made is between accounts that place learning and remembering on a continuum and accounts that posit a discontinuous relationship. It will be argued that the evidence favours the discontinuous accounts. Among these accounts, the critical issue is whether to favour the representation hypothesis and assign the discontinuity to independent memory representations, or whether to favour the retrieval hypothesis and assign the discontinuity to independent retrieval processes.

The earliest accounts of the relation placed remembering and learning on a continuum. Considerations of parsimony would suggest that remembering and learning are qualitatively similar unless forced to acknowledge a

fundamental difference. The striking introspective difference between these forms of memory performance is that whereas remembering requires awareness of the contextual details of the prior event, asymptotic learning is characterized by the absence of such details from awareness. Therefore, a common assumption of continuous accounts is that, through practice, irrelevant details from the original representation are lost, whereas the relevant details are retained, perhaps in a form that will speed subsequent application. For example, Bransford and Franks (1976) present an account of learning in which the same representations that support remembering also support or "set the stage" for learning. Through repeated use, a sub-set of representations of specific events become progressively more "decontextualized" to allow more efficient "knowing" (i.e., the end product of learning). This process of decontextualization consequently blocks the ability to remember the specific events that comprise the learning.

Piaget and Inhelder (1973) offer an account that is strikingly similar to that proposed by Bergson (1913). A strong distinction is made between the products of perception and the operation of intelligence. To perceive is to form an internal replica of reality (by means of the figurative function). Piaget and Inhelder refer to this contextually-rich representation as the memory-image and

claim that this is what is retrieved when remembering occurs. In contrast, they claim that the intelligence, the state of learning at a point in time, is supported by a very different memory representation, the schema. Through "schematism", objects (including memory-images) are abstracted and transformed (i.e., assimilation), and the schemata themselves may be modified through this activity (i.e., accommodation). Schemata and memory-images are independent memory representations, the former supporting learned behaviour, the latter supporting remembering. As in Bransford and Franks' model, the process of learning (schematism) involves the abstraction of task-relevant details from the contextually-rich memory-images.

Recently, Anderson (1982; Neves & Anderson, 1981) has presented this same account of remembering and learning, but has substituted "declarative storage" for memory-images, "procedural storage" for schemata, and "proceduralization" for schematism. This is an advance only in that it takes a questionable separation of perception and memory and substitutes a distinction that is valid within computer systems. The analogy to procedural and declarative storage in computers has become an important representational hypothesis in other accounts of the relationship as well. Computers can represent information in two alternative ways. Information can be represented explicitly and isomorphic to the actual event, or it can be represented as an algorithm

or set of formulae by which the important characteristics of the actual event can be computed and reproduced. The former describes declarative storage, and the latter describes procedural storage. The explicitness of declarative storage is similar to the memory-image of Piaget and Inhelder, as well as to the phenomenal experience of remembering. The efficiency of procedural storage is similar to the schemata of Piaget and Inhelder, as well as to the phenomenal experience of knowing.

An important characteristic of all continuous accounts is the claim that new memories are acquired in a form that supports remembering, and these are then gradually transformed through use into a form supporting learned skills. Such accounts must predict that amnesic patients, who are unable to remember, are also unable to learn. Disconfirming data began to appear when the amnesic, H.M., showed near-normal improvement with practice on tasks such as mirror drawing, completing tactile mazes, and identifying Gollin figures (Milner, Corkin & Teuber, 1968). Normal learning of verbal materials, as measured in a transfer paradigm, also occurs in amnesics: A word fragment is completed more readily if the patient has had recent experience with the intact word (Warrington & Weiskrantz, 1973). Graf and Schacter (1985) have shown that this learning depends on contextual details of the initial experience, so the transfer to word fragment completion

cannot be caused just by activating abstract linguistic units. Demonstration of near-normal learning, and the patients' accompanying denial of familiarity with the learning situation, has become so common in the literature that a complete rejection of continuous accounts is warranted (see also Moscovitch, 1982).

Many current accounts of the amnesics' memory abilities are beginning to favour a discontinuity between the abilities underlying learning and remembering. As mentioned above, one class of discontinuity accounts is the representation hypothesis, which maintains that there are independent memory representations that support learning and remembering. Kinsbourne and Wood (1975) suggested that Tulving's (1972) distinction between episodic and semantic memory could account for the amnesics' preserved learning but lack of awareness of it. Episodic representations preserve the autobiographical and contextual details of specific events, whereas semantic representations preserve only abstracted and general knowledge. If episodic representations were prevented then remembering of events would not occur; however, the amnesics' near-normal learning could be supported by preserved semantic representations. A more recent version claims that both episodic and semantic representations support learning (Feustel, Shiffrin & Salasoo, 1983), so the near-normal learning in amnesics should never be quite as good as in normals by this account.

Another version of the representation hypothesis states that procedural and declarative representations are stored independently, and that only the storage of declarative representations is impaired in amnesia (Cohen, 1984; Cohen & Squire, 1980; Moscovitch, 1982).

The other class of discontinuity accounts is the retrieval hypothesis, which maintains that learning and remembering are supported by the same representations, but that the retrieval process for learning is independent of that for remembering. Some accounts claim that both retrieval processes independently access the memory representation, whereas other accounts claim that the two retrieval processes are hierarchically structured. An example of this latter scheme is provided by Baddeley (1982). He suggested, from an anecdotal analysis of remembering, that at least two sequential stages are involved in retrieving a memory into awareness. The first stage is largely automatic (memories simply "pop out"), and is governed by the principle of encoding specificity (Tulving & Thomson, 1973). Baddeley suggests that this stage is largely intact in amnesics. The second stage of retrieval is under strategic control, and its function is to evaluate the memories generated by the first stage. He claims that amnesics are lacking this second, evaluative stage of memory retrieval. Thus, learning is supported by an automatic retrieval process, whereas remembering

initially requires the automatic process, then the strategic retrieval process.

An early example of the independent access scheme identified states of awareness with retrieval processes (Weiskrantz, 1978). Access to a memory representation could be gained either through conscious "monitoring" or through an unconscious mechanism. In amnesia, conscious monitoring is impaired but unconscious access is preserved.

Jacoby (1983, 1984) has presented a version of the retrieval hypothesis in which the two retrieval processes independently retrieve memory representations, and in which they also can be hierarchically related. Data-driven and conceptually driven retrieval are independent processes because they proceed from different retrieval cues, and because they retrieve, from the same memory representations, qualitatively different information. In normal memory, contextual evidence can be generated from conceptually driven retrieval, whereas only processing "fluency" is generated from data-driven retrieval (Jacoby & Dallas, 1981). Because a relationship can exist between the two retrieval processes in normal memory (Jacoby & Witherspoon, 1982), Jacoby suggested that the conceptually driven process can employ a "fluency heuristic" in judging prior occurrence (i.e., remembering). That is, conceptual processes can infer that the reason for an unusually fluent task performance is prior practice on that task. Therefore, when

a relationship exists, remembering is sequentially dependent on learning. However, such a relationship is not possible in amnesics because they lack those conceptually driven processes responsible for active reconstruction and metamemory. This account of amnesia and normal memory relies heavily on an investigation of a variable dissociation between learning and remembering, similar to that in amnesics, which is found in people with normal memory abilities, and an analogy to the relation between recognition and recall. These two topics will be discussed next.

The Variable Dissociation of Remembering and Learning in Normal Memory

The transfer paradigm can be used to assess the degree of learning on some task. In this procedure a subject performs a task on some material, then at a later time the same task, or a new task (the transfer task) is performed on the same material. The degree of transfer (or learning) is calculated by taking the difference between performance on the repeated material and material presented for the first time on the transfer task. An alternative measure of memory (viz. remembering) is obtained by substituting a recognition test for the transfer task. The major difference between these alternative measures of

memory is that, whereas remembering requires an explicit judgement of prior occurrence, learning does not.

Kolers (1975, 1976) measured the development of the skill of reading inverted typography and found transfer in reading speed over periods of two months and one year. Of most importance was the result that the benefits in reading speed were uncorrelated with recognition. Kolers interpreted these results, and other similar results, which showed that transfer in reading speed was dissociated from recognition performance, as evidence of another memory system, which he called "operational/procedural" memory. This form of memory will be optimized if the same pattern of encoding operations is repeated again. He is explicit that the representation of operations is independent of the representation of meaning ("semantic/substantive" memory). Whereas the former does not rely on a semantic interpretation, the latter does (e.g. Craik & Tulving, 1975). Kolers explained the dissociation between recognition and transfer performance by suggesting that recognition memory relied on information from both memory systems, whereas transfer performance relied only on operational/procedural memory. Later, Kolers (1979) suggested that procedural representations might underlie semantic/substantive memory as well. However, other researchers maintain that a procedural memory system exists independent of declarative memory systems (e.g., Cohen,

1984; Tulving, 1983).

Jacoby and Dallas (1981) used identification of briefly presented words as their transfer task, and recognition as their measure of remembering. When subjects were asked to categorize words by semantic, phonemic, or graphemic criteria on original presentation, recognition performance was best for words that were semantically categorized, and it was worst for words that were graphemically categorized. However, semantic categorization did not facilitate word identification to a greater degree than graphemic categorization did. Again, this is a dissociation of effects on measures of learning and remembering in normal memory performance. Using similar procedures, Jacoby and Witherspoon (1982) demonstrated that the probability of word identification was statistically independent of the probability of recognition. Dissociations between recognition and transfer to another task also have been demonstrated in word fragment completion (Tulving, Schacter & Stark, 1982), in lexical decision (Carroll & Kirsner, 1982), and for similar tasks employing pictorial stimuli (Carroll, Byrne & Kirsner, 1985). However, the relation between word identification and recognition is variable. Jacoby and Witherspoon also discovered that the probability of pseudoword identification was statistically dependent on the probability of recognition.

Jacoby (1983) interpreted these variable dissociations as the operation of two modes of retrieving information from the same representation. When performing the same or a different task on material encountered previously, there will be perceptual or cognitive "fluency" in dealing with that material again (i.e., the representation can be "data-driven"). However, a test of remembering requires retrieving the context of a prior encounter with the material (i.e., the representation can be "conceptually driven"). Under this theoretical framework, the relation between remembering and learning should vary on the basis of the compatibility of retrieval processes used to perform the two tasks. In support of this distinction, Jacoby (1983) showed that processing a word in isolation (data-driven processing) benefitted word identification most and recognition least, but generating the word from its antonym (conceptually driven processing) benefitted recognition most and word identification least. The correlation between facilitated word identification and recognition, although negative in this experiment, depended on the type of processing performed in the tasks.

Of greatest relevance to this thesis is a dissociation between recognition and transfer performance reported, but not interpreted, by Craik and Tulving (1975). They were interested in the effects of varying meaningfulness of word categorization on later recall and

recognition. In their third and fourth experiments they also repeated words in the same categorization task during the acquisition phase of the experiment. The time to make the word categorization was recorded on both presentations so that the degree of transfer from the initial categorization could be determined. Although a large effect of the meaningfulness of word categorization was observed in recognition performance, word categorization on repetition was facilitated equally for graphemic, phonemic and semantic categorizations. This result would be predicted from Kolers' "remembering operations" view of memory: Memory is optimized only to the degree that the original encoding operations are repeated during retrieval.

Recently, Logan (1985) has reported greater facilitation of response time for semantic categorizations than for phonemic categorizations. Both Craik and Tulving and Logan report greater facilitation for positive categorizations ("yes") than negative categorizations ("no"). Between the two experiments there were a number of procedural differences that may account for the discrepant findings. For example, when categorizations were repeated in Craik and Tulving's experiments a different comparison word was used, but repeated categorizations in Logan's experiments always used the same comparison word.

In the research reported here, a transfer paradigm similar to that used by Craik and Tulving and Logan is

employed. A key issue is whether benefits on categorization parallel recognition performance when meaningfulness of categorization is varied. In more general terms, the issue is whether there is necessarily a dissociation between learning and remembering, as the representation hypothesis suggests, or whether the relationship depends on the retrieval process used, as the retrieval hypothesis suggests. Jacoby (1983) has argued that recognition and word identification are differentially sensitive to manipulation of data- and conceptually driven processing. According to Jacoby's analysis, a variable should have similar effects on measures of learning and recognition if retrieval for both tasks is predominantly conceptually driven. Transfer to word categorization was chosen as the measure of learning because word categorization was thought to require more conceptually driven processing than word identification does.

Conceptually driven processes are distinguished by their reliance on prior knowledge: a task employs conceptual processes to the extent that information not contained in the stimulus is required. Categorization of words as having similar graphemic, phonemic, or semantic attributes will rely more on prior knowledge than word identification tasks do because reference to some category of "things" not explicitly contained in the stimulus is required. Assuming that this task requires a type of processing similar to that

required for remembering, transfer to word categorization should be sensitive to the extent of conceptually driven processing required by the initial word categorization. The extent of conceptually driven processing was manipulated by varying the type of attributes (graphemic, phonemic, or semantic) required to categorize the words. Semantic attributes are by definition conceptual, whereas graphemic attributes closely represent the information contained in the visual stimulus. Phonemic attributes of printed words are conceptual insofar as sounds must be generated from visual stimuli. However, except for experts in pronunciation, the implications of word pronunciations are meager. Therefore, categorization of phonemic attributes employs conceptually driven processing intermediate to the degree it is employed for categorization of semantic and graphemic attributes. Because the retrieval hypothesis predicts relations between measures of memory on the basis of the similarity in processing required by tasks, a functional relation should be observed between the facilitation of categorization due to repetition and the type of categorization. Because categorization involves conceptually driven processes, the more conceptually driven the word categorization is, the greater the benefits of repetition for word categorization should be.

In summary, a dissociation between remembering and learning can be demonstrated in people with normal memory

abilities as well as in amnesics. Therefore, the dissociation in amnesics is not just a peculiar side effect of their disorder, but is a general characteristic of memory. This result is inconsistent with the claim that remembering and learning are the endpoints on a continuum of representational abstraction. Instead, these results force accounts of the relation between remembering and learning to propose a discontinuity in the mechanisms supporting these two manifestations of memory. Retrieval accounts propose that different retrieval processes in remembering and learning are responsible (e.g., Jacoby, 1983), whereas representation accounts propose that "some other memory system" is responsible (e.g., Tulving et al., 1982). Although the concept of a memory system has been poorly defined in the past, Tulving (1984) listed some defining features of memory systems. Of these, the only one incompatible with all retrieval accounts is that the same event is represented in different formats in different memory systems. Tulving (1985) encapsulated this list of defining features of memory systems with the statement that "processes within a system are more closely related to one another than they are to processes outside the system" (p. 386). The focus of the research reported in this thesis is to test whether different representations of the same event support improvements in knowing (i.e., learning) and remembering that event. The logic used for investigation is

that manipulations of retrieval processes should not influence the relation between learning and remembering according to the representation account, whereas such manipulations should affect the relation according to the retrieval account. Conversely, manipulations of variables thought to differentiate representational types should affect the relationship according to the representation account, but not according to the retrieval account.

In attempting to list the defining features of memory systems, Tulving (1984) has also pointed out some problems in determining from behavioural data whether the representation hypothesis or the retrieval hypothesis is the best way to conceptualize learning capabilities. Tulving states that "the cooperation among the systems may be so effective and smooth that [it]...creates the impression of a single system in action" (p. 179). Allowing cooperation between independent memory systems is a compromise which detracts from the persuasive simplicity of the representation account of the discontinuity between learning and remembering. The representation hypothesis has the greatest persuasive simplicity, and thus, the greatest heuristic power, if there is a list of manipulations that affect one of the memory stores, and a different list that affects the other. To the extent that the same manipulations affect both memory stores, it becomes harder to distinguish this position from the retrieval hypothesis.

and the heuristic power of the position declines. Distinguishing memory systems is only interesting if their empirical manifestations are consistently dissociable. Because of this, the arguments in this thesis will be aimed at the heuristically strongest version of the representation hypothesis. This version minimally claims that dissociations between remembering and learning are caused by independent memory representations; manipulations of retrieval processes should not determine the status of the relation between remembering and learning.

In arguing the case for different retrieval processes being the cause of dissociations between remembering and learning, it will be instructive to refer to a similar dissociation between cued recall and recognition memory. Because both these measures require explicit retrieval of a prior episode, theorists were never tempted to postulate separate memory systems as the reason for the dissociation. Instead, explanation of the dissociation centred on differences in retrieval processes. Some of these accounts appealed to the retrieval of familiarity information as the reason for dissociation (e.g., Kinstch, 1978; Mandler, 1980), whereas others appealed to cue differences (e.g., Begg, 1979; Flexser & Tulving, 1978). Because one version of the retrieval hypothesis states that fluency in task performance due to learning contributes to the judgement of familiarity (Jacoby & Dallas, 1981),

discussion will center on the role of familiarity in recognition.

An Analogy to the Relationship Between Recognition and Recall

As early as 1922, Luh had demonstrated that recognition performance was superior to recall performance. For many years after a threshold explanation of these results was given: recall and recognition are similar processes, but recognition is easier or a "low threshold process". However, this "continuum" account of the relation between recognition and recall was rejected when it was discovered that many experimental manipulations have different effects on recognition and recall (see also Gillund & Shiffrin, 1984; Tiberghien, Cauzinille & Mathieu, 1979). This dissociation of effects has forced accounts of the relationship to postulate the existence of at least two retrieval processes.

The "generate-recognize" model (e.g., Kintsch, 1970) was an early account of memory retrieval as a composite of two processes. In free recall, an initial process generates plausible candidates from memory. A second process, recognition, evaluates the relative familiarity of each candidate. Recognition was thought to be dependent on familiarity, an attribute of abstract representations of

items, and to be independent of interitem (or contextual) associations. Generation was thought to be dependent on an explicit search of interitem associations, and the retrieval of context. By this model, recall performance required the retrieval of context-specific information, then the judgement of the (context-independent) familiarity of this information, whereas recognition performance was mediated only by the familiarity information evoked by the test stimuli.

The generate-recognize model was rejected when it was discovered that words not recognized could be recalled (Begg, 1979; Tulving & Thomson, 1973), and when it was discovered that recognition could be mediated by contextual retrieval (see Mandler (1980) for a review). Mandler suggested that, though recognition decisions are initially based on familiarity, contextual information is retrieved when familiarity information is either not strong enough, or not weak enough (Atkinson & Juola, 1973; Mandler, 1980). That is, an explicit search for contextual information is conditional on familiarity information not being sufficient to make a judgement of prior occurrence. Therefore, this model claims that recognition, like recall, can be mediated by both contextual and familiarity information. Like the generate-recognize model, this "conditional search" model also contends that different aspects of representations support the retrieval of context and of familiarity.

Familiarity information is independent of context information and it is represented by the degree of intraitem integration of items. This form of integration is sensitive only to the perceptual aspects of items, that is, to their internal structure (spelling, pronunciation, etc.). In contrast, contextual information is represented by the degree of interitem integration, that is, relations between memory representations.

Jacoby and Dallas (1981) also suggested that recognition performance might be mediated by two retrieval processes: familiarity and retrieval of context. The experience of familiarity, they proposed, was inferred from the relative "fluency" in performance of a task (or learning). In the terms of the present thesis, recognition performance can be a mix of the information retrieved by the processes supporting both learning and remembering. Relative fluency in processing some item can be used as a basis for the inference that the item has been encountered previously; in other words, there can be a causal relation between learning and remembering. Jacoby and Dallas have referred to the mechanism responsible for this relationship as the "fluency heuristic". A major difference between this model and the conditional search model is that any facilitation of processing can serve as a cue for recognition, whether conceptually driven or data-driven processes are facilitated, or whether semantic or perceptual

attributes are responsible for facilitation. Thus, there is no restriction on the type of information which can support familiarity in recognition. Further, familiarity is as context-specific (or independent) as is the learning that has taken place.

Gillund and Shiffrin (1984) have also proposed a two-process model of recognition. Similar to the Jacoby and Dallas model, familiarity is produced by a different retrieval process, rather than by a different representational format. The model they propose produces familiarity by summing the degree of similarity (or activation) that a cue has with all representations in memory. In the model, no extension of this mechanism to information generated by nonremembering tasks was attempted. In such an extension, if this information was used heuristically to infer familiarity, then the model would parallel the Jacoby and Dallas model in most important aspects. However, if this information was not used to infer familiarity, but rather familiarity was separately computed by summing memory activation, then their model would be a noncausal account. That is, dependence in the relationship between remembering and learning would occur because different retrieval processes access common memory representations (i.e., they are correlated: see Humphreys & Bain, 1983, footnote 5).

Although both processing fluency and

contextually-specific information can support recognition. Jacoby and Brooks (1984) have argued that the specific mixture of information that recognition relies on depends on whether decisions are made analytically or nonanalytically. Only in the nonanalytic decision mode will both types of information be employed. An analytic decision is based on just the information that is definitionally relevant to the task. For example, if the task is to decide whether a particular animal is four-legged, an analytic basis for the decision is simply to count legs, isolating the "leg" attribute from the other attributes of that animal. The analytic decision mode represents the "common-sense" view of how decisions are made. Jacoby and Brooks argue that there is an alternative decision mode that may be used as often as the analytic decision mode. In this other, nonanalytic mode, decisions are based on definitionally irrelevant information as well as on definitionally relevant information: memory representations of prior events are used as a heuristic for decisions about similar situations in the present. In terms of the four-legged task mentioned above, a nonanalytic basis for the decision would be to compare the conjunction of all attributes of the animal to recent experiences with known four-legged animals, inferring "four-leggedness" from similarities in posture and other holistic characteristics. The fluency heuristic can be seen as a special case of nonanalytic decisions, because

processing fluency is not definitionally relevant to the task of remembering. Rather, processing fluency is a characteristic of learning. Therefore, according to Jacoby and Brooks (1984), the existence of a relation between remembering and learning may depend on whether an analytic or nonanalytic decision mode is used on the recognition test.

If a fluency heuristic is adopted when making recognition decisions, then any item judged to be processed more fluently than normal would lead to the decision that the item had occurred previously. That is, the time to judge an item "old" would be faster than the time to judge an item "new", whether correct or not. This prediction is, however, common to all models of self-terminating memory retrieval. A stronger prediction of the fluency heuristic is that items producing transfer on a task not involving remembering should be the same items that are judged as being "old" on recognition. This prediction has been confirmed in word identification (Feustel, Shiffrin & Salasoo, 1983; Johnston, Dark & Jacoby, 1985) and sentence reading (Masson, 1984). The procedure employed to test this prediction is notable in that a recognition decision is required immediately after performing the transfer task on each item. This simultaneously controls for lag effects on degree of facilitation, and allows the facilitation on the transfer task, if not specific to the item, to be

incorporated in the recognition decision. An untested assumption of all studies using this procedure is whether knowing that recognition immediately follows transfer influences how the transfer task is performed (e.g., by involving recognition processes). To the extent that remembering is involved in transfer performance, the test of the fluency heuristic is correspondingly weakened (e.g., is it fast recognizing or fast transfer performance that is correlated with "old" recognition decisions?).

A rough assessment of the involvement of recognition processes in transfer task performance could be obtained by comparing performance on items in acquisition (when recognition is never performed) to nonrepeated items in the transfer phase (when recognition is always performed immediately afterward). This within-subjects comparison is confounded only by general practice effects. However, any such practice effects should only facilitate performance on nonrepeated items in the transfer phase. In contrast, an effect of the secondary recognition task on categorization would be indicated by a reverse effect on these items (i.e., prolonging response times or decreasing categorization accuracy). Therefore, deleterious effects on nonrepeated items in the transfer phase can be interpreted as an effect of the secondary recognition task. Further conclusions about the magnitude of interference would require a between-subjects control condition. The research reported

here employs the procedure of requiring recognition judgements immediately after each categorical judgement, and monitors the influence of recognition judgements on categorization using the within-subjects control.

Overview of the Thesis

Currently there are two alternative accounts of the relation between the manifestation of learning in fluent re-performance of a task, as measured in the transfer paradigm, and explicit remembering of past events, as measured by recognition performance. The strong representation hypothesis proposes that both the memory representations and retrieval processes for remembering and learning are independent of each other. The retrieval hypothesis asserts that the same memory representations support both remembering and learning, and that these representations can be retrieved in at least two different ways.

A common approach taken to assess the attributes of representations is to manipulate variables known to influence retention on one measure, and then determine if similar or different effects are observed on the other measure. Achieving similar effects of a number of variables on both measures is evidence that the representations supporting the two measures of memory possess similar

attributes. Such a result would be consistent with the claim of the retrieval hypothesis that the same memory representations support both remembering and learning. To the extent that these variables are important in distinguishing one type of representation from another type, similar effects of these variables on both learning and remembering is inconsistent with the representation hypothesis. This experimental strategy is employed in Chapter 2 to evaluate the representation and retrieval hypotheses.

The tasks of Craik and Tulving (1975) were selected to measure learning because, like recognition, they rely on conceptually driven processing, and because the extent of conceptually driven processing required in the task is easily manipulated. Word pairs are categorized as similar or dissimilar according to either graphemic, phonemic, or semantic attributes, and these categorization tasks are performed both at acquisition and at transfer. With these categorization tasks, meaningfulness of processing is defined as the degree of conceptually driven processing required in each task. The point of this manipulation is to determine whether meaningfulness of processing influences the magnitude of transfer found in categorization performance. Schulman (1971), Craik and Tulving (1975) and others have shown that meaningful processing produces superior recognition performance, whereas Craik and Tulving

(1975), Jacoby and Dallas (1981) and others have shown that meaningful processing does not affect the amount of transfer. Deficits in meaningful processing have been associated with amnesia (e.g. Cermak, 1979); therefore, the lack of influence of this variable may be a representational characteristic of preserved learning abilities. If it is true that meaningfulness of processing does not influence learning then the representation account, which stresses representational differences between learning and remembering, would be supported. Against this conclusion, Logan (1985) has found an effect of meaningfulness of processing on word categorization. However, the interpretation of Logan's result is equivocal because different word pairs were used in the two categorization tasks. Superior transfer from semantic categorization compared to phonemic categorization could be an item effect, rather than a task effect. Therefore, to ensure comparability of categorization tasks, the word pairs used in the present research could be categorized in either categorization task and yield the same response.

Another variable important in differentiating representational types is whether preserving the context of prior occurrence improves memory. For example, semantic memory representations do not preserve context, but episodic memory representations do (Tulving, 1972). As noted above, Kinsbourne and Wood (1975) have claimed that learning in

amnesics is supported by the decontextualized semantic memory representations. Graf and Mandler (1984) have interpreted the absence of an effect of semantic processing on facilitation of word fragment completion as evidence that this transfer effect is mediated by activation of decontextualized memory representations (see also Morton, 1979). These claims imply that the relation between the context of acquisition and that of transfer should not influence the degree of transfer. If this were true then the representation account would again be supported.

A number of experiments have shown that the context of acquisition does influence the degree of transfer (e.g., Graf & Schacter, 1985; McKoon & Ratcliff, 1979). In these experiments, context was defined by the presence or absence of the same word pairing as during acquisition. Therefore, these experiments have demonstrated that the item context can influence degree of transfer. The present research attempts to generalize this result by determining whether task context also affects transfer performance. The word pairs used here can be categorized in either word categorization task. When a word pair is presented at transfer, the categorization task performed at acquisition was repeated, or a new categorization of the word pair was required. Repeating a pair in the same categorization task preserves the task context, whereas repeating a pair in a different categorization task changes

the task context. This definition of context relies on Kolers' (1976, 1979) suggestion that the operations performed at the acquisition of objects is the critical determinant of memory representation. If transfer is mediated by activation of decontextualized word representations, then there should be no effect of task context. Further, if maintaining item context (i.e., word pairing) is sufficient for transfer, then no effect of task context would be expected either. Alternatively, transfer may be mediated by representations of items in the context of their prior use, in which case an effect of task context would be expected.

In Chapter 3 and 4, the relation between learning and remembering will be assessed directly by requiring a recognition judgement after each categorization response. In Chapter 3, the variables tested on categorization performance are now tested for their effects on recognition performance. This experiment is necessary to ensure that effects found in categorization learning in Chapter 2 are evaluated against effects that are obtainable with these materials in recognition. In Chapter 3 and 4, it also is determined whether pairs that are quickly categorized are called "old" on the recognition test. If such a relationship exists, and if it is to be interpreted as the use of a fluency heuristic, then it is important that the relationship occur irrespective of its accuracy.

Significant correlations between speed of categorization and recognition decisions should be observed for both repeated and new word pairs, and for repeated word pairs in both the same and different contexts. The noncausal version of the retrieval account will also predict correlations between speed of categorization and recognition decisions provided that common memory representations are used by the two tasks. At the other extreme, accounts of learning and remembering as relying on independent representations and retrieval processes do not predict that speed of categorization should be correlated with recognition decisions.

Finally, in Chapter 4, the retrieval account is tested by manipulating the recognition decision strategy. Because the representation hypothesis explains the relation between learning and remembering only in representational terms, recognition decision strategy should not affect the relationship. In contrast, the Jacoby and Brooks (1984) retrieval hypothesis predicts that the relation between learning and remembering will be affected by altering the decision strategy used in recognition. They hypothesized that a nonanalytic decision mode will maximally rely on processing fluency, whereas analytic verification of the recognition decision through retrieval of context will be minimized. This hypothesis implies that a stronger relation between speed of categorization and recognition be observed

when a nonanalytic decision mode is employed than when an analytic decision mode is employed. In the experiments reported here, familiarity instructions were given to encourage a nonanalytic decision mode on the recognition test. Either nondirective or contextual reconstruction instructions were given to encourage an analytic decision mode on the recognition test.

In Chapter 5, a final test of the fluency heuristic is performed. Rather than performing recognition as the secondary task, subjects rated their fluency of categorization. Because judging fluency and recognizing are highly similar tasks according to the fluency heuristic, similar effects on categorization should be observed. Two predictions vital to the fluency heuristic are evaluated. First, subjects must be capable of determining when their categorization performance is actually fluent. Second, fluency judgements must be capable of discriminating repeated from nonrepeated items.

Finally, in Chapter 6, the results of all experiments are discussed as they relate to the representation hypothesis and both versions of the retrieval hypothesis.

CHAPTER TWO

Learning in Word Categorization

This chapter presents three experiments that investigate the nature of learning in word categorization. Beyond demonstrating that learning, as manifested by the facilitation of word categorization, does occur, these experiments demonstrate some qualities of the memory representation that are necessary to support this learning. The experimental strategy used to identify representational qualities is to determine whether variables having known effects on recognition have similar effects on learning in word categorization. These variables are the meaningfulness of the word categorization, and the context of word categorization. To the extent that these variables have similar effects on the two measures it is possible that the same memory representations support both learning and remembering. It is less likely that separate representations of the same event support learning and remembering if these variables have similar effects on learning in word categorization and recognition memory.

Although the effects of these variables on other transfer tasks (viz. word identification) have not always

been similar to their effects on recognition (e.g., Jacoby & Dallas, 1981), such differences may result from the use of learning and remembering tasks that require different retrieval processes (e.g., Jacoby, 1983; Roediger & Blaxton, 1987). The retrieval process in word identification may be data-driven, whereas the retrieval process in recognition may be more conceptually driven. In the experiments reported here, word categorization was chosen as the transfer task by which to measure learning specifically because it requires more conceptually driven retrieval than word identification tasks do. The argument is that a better test of the effects of a variable on learning and remembering will be obtained by equating, as much as possible, the retrieval characteristics of the tasks measuring learning and remembering.

In the experiments reported here the meaningfulness of word categorization was defined as the degree of conceptually driven processing required in each task. It has been argued that categorization of semantic attributes requires more conceptually driven processing than categorization of phonemic attributes does, and similarly, that categorization of phonemic attributes requires more conceptually driven processing than categorization of graphemic attributes. If the effect of this variable on categorization learning parallels its effect on recognition,

then greater transfer should be observed for more meaningful processing. Word pairs were equally categorizable in either task, so differential transfer cannot be attributed to the use of different items in each task, nor can it be attributed to different categorization responses made to the same items. The second variable, the context of word categorization, was operationalized as the type of categorization performed on repetition of the words. If the effect of this variable on categorization learning parallels its effect on recognition, then greater transfer should be observed when context is preserved on repetition (i.e., when pairs are repeated in the same categorization task), than when the context is changed. Representation of situation-specific context is important for distinguishing between types of memory representations. One account claiming that remembering and learning are supported by independent representations holds that the basis of transfer performance is the activation of pre-existing and relatively abstract memory representations (Graf & Mandler, 1984; Morton, 1979). Therefore, at least some versions of the representation hypothesis predict that situation-specific context should not affect transfer performance.

Experiment One

The purposes of this experiment were twofold.

First, in order to demonstrate that within these particular experimental parameters learning in word categorization could be measured, the shortest possible repetition interval between acquisition and transfer was employed. This interval was set at two intervening categorizations in order to avoid contamination of transfer performance by non-mnemonic sources such as sensory after-images (e.g., Walker & Marshall, 1982). Second, in order to evaluate the effects of categorization context and meaningfulness on transfer performance, a more reasonable repetition interval, twenty-five intervening categorizations, was selected. This interval, about one minute, is approximately the same interval employed by Craik and Tulving (1975).

Retention interval was a between-subjects variable, whereas the other independent variables, categorization context and meaningfulness, were manipulated within subjects. Because these manipulations required that the same pair of words be equally categorizable in all categorization tasks there was a practical constraint on the number of different categorization tasks possible for a given stimulus set. It was desired that a large number of pairs be available to decrease measurement variability, so only the minimum of two different categorization tasks were used. Further, it was desired that word length and frequency be held constant because these factors are important determinants of response time. Because of these

considerations, phonemic and graphemic categorization were employed in Experiment 1. Such tasks allowed selection of the largest pool of words meeting all of the above constraints.

Method

Subjects. Thirty-two university students from an introductory psychology course participated in return for course credit. Experimental sessions lasted approximately 45 minutes.

Materials. A pool of approximately 600 words was selected from the Thorndike and Lorge (1944) word frequency norms such that the words possessed five letters, one syllable, and were not extremely common (more than 50 occurrences per million), nor extremely rare (fewer than 5 occurrences per million). Forty-eight pairs that fulfilled both task requirements were selected. Both members of each pair contained the same vowel sounds and the same second and last letters. About a quarter of these pairs were constructed from words in which the same vowel sounds were produced by different letters. Another 48 pairs that did not satisfy either task requirement were chosen. Each word in these pairs had the same number of vowels and the same first and fourth letter as the other member of the pair, so

that at first glance these pairs would be plausibly similar under both tasks. A final set of 48 pairs fulfilled the requirements of one task but not the other task. These were included as distracter displays because they prevented subjects from adopting the strategy of merely repeating their previous responses to repeated pairs. The data from these displays were not analysed. The three sets of pairs are listed in Appendix A. Sixty four-letter pairs were selected as practice items (thirty pairs for each task and response category).

Apparatus. Stimulus displays were presented on a CRT controlled by a microcomputer. Subjects responded "yes" or "no" on each trial by pressing one of two telegraph keys, which then completed a circuit to the computer. The computer recorded response times and errors.

Procedure. Subjects were not informed that repetitions of displays would occur. They were told that the purpose of the experiment was to determine how well they could switch their attention between the two different tasks. They were instructed to respond quickly but emphasis was placed on accuracy. Error feedback was provided.

Task cues were centered on the CRT eight lines from the top of the screen. For the phonemic categorization the cue was "SAME VOWEL SOUNDS?", and for the graphemic

categorization the cue was "SAME SECOND AND LAST LETTERS?". The rationale for requiring categorization of two letters was to create tasks of comparable difficulty and to ensure that words were processed in their entirety. There was a 1500 ms interval between the onsets of the cue and the comparison word, of which 500 ms was blank. The comparison word was presented by itself (just to the left of mid-screen) for 1500 ms, after which the target word was presented beside the comparison word (just to the right of mid-screen). The display remained on until responded to. There was a 500 ms blank interval after a response was recorded until the next cue was presented.

The response time was defined as the time elapsing between onset of the target word and the depression of a telegraph key. Only response times for correct responses and response times for repetitions that were correctly responded to when originally presented were analyzed.

Word pairs were presented in one of two random orders. Presentation of pairs was subject to the constraint that previously presented pairs be repeated immediately after the given repetition interval. For half the subjects the repetition interval was twenty-five trials and for the other half the interval was two trials. One-half of the repeated pairs were presented with the same task as performed at acquisition, and the remaining half of the repeated pairs were presented with the other task. The type

of task transition on repeated pairs was counterbalanced across subjects. The words within pairs were counterbalanced across subjects so that each word served equally often as comparison and target word. Response mappings between hands and keys were counterbalanced across subjects as well.

Subjects first completed the practice which contained no repetition of any pair. After completing the experiment, subjects were asked whether any pairs were repeated during the experiment, and whether the same categorization or another was requested on repetition. Additionally, subjects serving in the long repetition interval condition were asked to judge the proportion of pairs which were repeated (either "a lot" or "just a few").

Results and Discussion

The alpha level in this, and all subsequent experiments, was set at .05 for all tests of significance. Analysis of variance (ANOVA), supplemented by the appropriate post hoc tests, was employed throughout to test for significant differences. In order to compensate for skewness in response time distributions, median response times were used in all tests of significance. Because at least two dependent measures were taken in all experiments (viz. response time and errors), each measure is reported in

its entirety before discussing the next measure.

Response Time. The mean median response times, averaged across repetition interval and categorization response ("yes" or "no"), are presented in Table 1. With the exception of two marginal interactions (discussed below), these variables did not affect response times. The most striking result was that repeating a pair in the same categorization task decreased response times relative to the time taken to make the categorization initially. However, repeating a pair in the different categorization task had little effect on response times relative to initial categorization. In support of this interpretation there was a significant effect of repetition condition, $F(2,60)=17.41$, $MSe=18162$. Dunnett's tests showed that there was no difference between the conditions in which pairs were repeated in the different task and the initial categorization of pairs. This result was true for both phonemic and graphemic categorization. However, for both tasks, the response times for pairs repeated in the same task were significantly faster than initial response times.

The fact that response times decreased when categorization of pairs was repeated demonstrates that learning in word categorization does occur within these experimental conditions. The fact that the categorization context determined whether such learning was observed is contrary to the hypothesis that these transfer effects are

Transfer Task	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Graphemic	874	859	815
Phonemic	1015	1003	890

TABLE 1. Mean median response times for categorization in Experiment 1.

produced by activating pre-existing and abstract memory representations of the words. Because remembering is usually sensitive to manipulations of context, this influence of context on a measure of learning is consistent with the hypothesis that the remembering and learning are supported by the same memory representations

Another result evident in Table 1 is that the reduction in response times for pairs repeated in the same categorization task relative to initial response times was greater for phonemic categorization (125 ms) than for graphemic categorization (59 ms). This observation is supported by the significant interaction of repetition condition and transfer task, $F(2,60)=6.31$, $MSe=7634$. The occurrence of better learning for the more conceptual categorization (i.e., phonemic) is consistent with the hypothesis that the memory representations supporting recognition performance also support transfer performance. However, this result is qualified by a significant effect of transfer task, $F(1,30)=11.71$, $MSe=118172$, which indicates that the phonemic categorization took longer than the graphemic categorization. Because a floor effect might limit variance at shorter latencies, it may not be meaningful to compare differences if the time to perform the tasks is in a different absolute range. This problem of scale interpretation is solved in Experiment 2 by adopting tasks with more comparable latencies.

Finally, there were two marginal interactions. The interaction of transfer task and categorization response, $F(1,30)=3.75$, $p<.06$, was caused by "yes" responses taking longer than "no" responses in the phonemic task, whereas this effect was absent in the graphemic task. A reasonable interpretation is that longer latencies are associated with more difficult decisions. Of more consequence was a marginal interaction of repetition interval and repetition condition, $F(2,60)=2.81$, $p<.07$. Simple effects were computed for each transfer task. For phonemic categorizations, the same interaction of repetition interval and repetition condition was observed, $F(2,60)=2.76$, $p<.07$. However, this interaction was not present in graphemic categorizations ($F<1$). Therefore, larger transfer effects occur in the phonemic task at short, as compared to long repetition intervals. This effect does not compromise the tentative conclusion of greater learning in the more meaningful phonemic task, because the triple interaction of repetition interval, transfer task, and repetition condition did not approach significance. One interpretation of the marginal interaction of repetition interval and repetition condition is that a short-term memory component affects transfer, especially for phonemic categorizations. Another possibility is that transfer performance will show progressively less facilitation as the repetition interval increases. Experiment 2 will examine this possibility.

One reason that response times for word categorization decreased on repetition might be that subjects could more easily make the categorization again. Another possible reason might be that subjects recognized the pair and remembered what their previous response had been, thus taking a short cut in categorization (e.g., Jacoby, 1978). However, this strategy would fail on the one-third of the pairs that required a different categorization response when repeated in the different task. Nevertheless, an attempt to answer this question empirically was made by asking each subject after completion of the experiment whether he or she had noticed the repetition of any pairs. It turned out that almost everyone in the short repetition interval condition noticed at least one repeated pair. A more discriminating answer was required of subjects in the long repetition interval condition. If subjects noticed repeated pairs, they were then required to say whether "a lot" of pairs were repeated, or "just a few". Nine subjects said there were a lot of repeated pairs, and seven said that there were just a few repeated pairs. In order to determine whether those subjects claiming to see a lot of repeated pairs also produced more facilitation of response times, this self-report measure was included as a between-subject variable in an ANOVA of just the long repetition interval condition. Although there was an effect on repetition condition, $F(1,14)=8.98$, and a marginal effect

of self-report (those reporting a lot of repetitions were slightly faster), $F(1,14)=3.68$, $p<.08$, there was no interaction between these variables (all F's<1). As a tentative conclusion, it appears that recognition processes are not contributing to the facilitation of categorization, at least for repetition intervals of about a minute.

Errors. The most important result from the analysis of raw errors was a significant effect of repetition condition, $F(2,60)=3.93$, $MSe=.877$. Dunnett's tests applied to these data showed a significant reduction in errors for pairs repeated in the same task (.10 error rate on these pairs) compared to initially categorized pairs (.15 error rate). In contrast, there was no reduction in errors for pairs repeated in the different task (.13 error rate) compared to initially categorized pairs. Therefore, this measure is also sensitive to learning in word categorization. Further, the effect of the context of categorization parallels that found for response times. These results are inconsistent with the hypothesis that transfer effects are produced by the activation of pre-existing memory representations, but they are consistent with the hypothesis that the same memory representations support both remembering and learning. Further, the parallel between accuracy and latency measures of learning prohibits interpretation of these results in terms of a speed-accuracy trade-off.

In contrast to the results from response times, there was not a significant interaction of repetition condition and transfer task. That is, there was no greater reduction in errors for the more conceptual task. However, there were more errors overall for the phonemic task, $F(1,30)=12.19$, $MSe=1.769$, than for the graphemic task (error rates of .16 and .10 respectively). This agrees with the response times which suggested that the phonemic task was harder to perform than the graphemic task. In addition, there was a triple interaction of transfer task, categorization response, and repetition interval, $F(1,30)=5.87$. Simple effects were calculated for each transfer task. Some of this interaction was caused by a large number of errors made in the phonemic task at the short repetition interval for "no" responses. There was also a marginal interaction in the graphemic task such that at the short repetition interval there were more errors for "yes" responses, whereas at the long repetition interval there more errors for "no" responses. This interaction does not compromise the main conclusion that categorization was performed more accurately on repetition provided that task context was preserved.

Experiment Two

One goal of Experiment 2 was to determine whether the learning in word categorization found in Experiment 1 could also be observed at longer repetition intervals. Because a future goal of this research is to require a recognition decision after every repeated categorization, a minimal requirement is that this learning be observable over the study/test interval required by the typical recognition paradigm. In addition, a more difficult graphemic task was used in an attempt to equate the response times for the two categorization tasks. The task adopted was the same as the task used by Craik and Tulving (1975) for this purpose, namely, judging whether two words had the same sequence of consonants and vowels.

A further goal of Experiment 2 was to determine whether response strategy influenced the functional relation between facilitation of categorization and the meaningfulness and context of categorization. Experiment 2a and 2b differed only in the instructions given to the subjects in the transfer phase. In Experiment 2a subjects were told to use the same strategy as in the acquisition phase, which was to respond quickly without sacrificing accuracy. In Experiment 2b subjects were told to change

their response strategy in the transfer phase so that only the speed of responding was important. It was hypothesized that a response strategy emphasizing just speed would provide a less analytic basis for categorization decisions. According to Jacoby and Brooks (1984), nonanalytic strategies make use of different information than analytic strategies do. Consequently, a different functional relation between facilitation of categorization and the meaningfulness and context of categorization was expected for speed instructions than for accuracy instructions.

Method

Subjects. Subjects for both Experiment 2a and Experiment 2b were students from an introductory psychology course who participated in return for course credit. Experimental sessions lasted approximately 45 minutes. Twelve subjects participated in Experiment 2a; twenty-four subjects participated in Experiment 2b.

Materials. Word pairs were selected from the same pool used to select the stimuli in Experiment 1. Ninety pairs that fulfilled both task requirements were selected. Both members of each pair contained the same vowel sounds and the same sequence of vowels and consonants. Another 90 pairs that fulfilled neither task requirement

were selected. These stimuli are listed in Appendix B. An additional ten pairs were selected for buffer items at the beginning of the acquisition and transfer phases. Sixty four-letter pairs were selected as practice items.

Procedure. The same apparatus and misdirection of subjects regarding the purpose of the experiment were employed as described for Experiment 1. Error feedback was provided during the acquisition phase, but not during the transfer phase. Task cues were centered on the CRT eight lines from the top of the screen. For the phonemic categorization the cue was "SOUNDS ?", and for the graphemic categorization the cue was "LETTERS ?". There was a 2000 ms interval between the onsets of the cue and comparison word, of which 250 ms was blank. The comparison word was presented by itself (just to the left of mid-screen) for 1000 ms, after which the target word was presented beside the comparison word (just to the right of mid-screen). The display remained on until responded to. The response time was defined as the time elapsing between onset of the target word and the depression of a telegraph key. Only response times for correct responses, and response times for repetitions that were correctly responded to when originally presented were analyzed.

One hundred and twenty pairs were presented in the acquisition phase (60 in each task and response type).

These pairs, along with the remaining 60 pairs, were presented in the transfer phase. Across subjects, pairs were presented for the first time in the transfer phase as often as they were presented in the acquisition phase. Of the pairs repeated from the acquisition phase, one half were presented with the same task as performed at acquisition, and one half were presented with the other task. The type of task transition on repeated pairs was counterbalanced across subjects. The words within pairs were counterbalanced across subjects so that each word served equally often as comparison and target word. Response mappings between hands and keys were counterbalanced across subjects and two random orders for presentation were used.

Subjects first completed the practice which contained no repetition of any pair. There was no additional practice before the transfer phase.

Results and Discussion

Response Time. The only effect in Experiment 2a was of transfer task, $F(1,11)=6.08$, $MSe=115260$. This effect indicates that the phonemic categorization took longer to perform than graphemic categorization (995 and 855 ms respectively). The only effect in Experiment 2b was of categorization response, $F(1,23)=15.43$, $MSe=32745$. This effect indicates that "no" responses took longer than "yes"

responses (710 and 794 ms respectively). Because this result did not occur in Experiment 2a, and the opposite occurred in Experiment 1, it may be attributed to the "set" adopted by subjects when given speed instructions. In particular it indicates that subjects readily made "yes" responses under these conditions, although they did not when given the standard instructions. Another consequence of the speed instructions was the elimination of slower responding in the phonemic task. An interpretation consistent with both of these results is that, if given the opportunity, subjects will conduct more analysis on the more "elaborate" memory (viz. phonemic and "yes" categorizations) before responding. However, when subjects are hurried, this extra analysis is omitted. Consequently, categorization is made on a more nonanalytic basis.

An effect which is notable for its absence is the facilitation of response times. Because the conditions in Experiment 2a are similar to Experiment 1, this result supports the hypothesis that transfer performance continues to diminish as the repetition interval increases. However, the speed instructions given in Experiment 2b will make differences in categorization errors more likely than in response times. Despite this effect of speed instructions, there was a consistent trend in Experiment 2b towards facilitation of phonemic categorizations repeated in the same task (734 ms) over initial phonemic categorizations

(773 ms). Phonemic categorization of pairs initially categorized graphemically were intermediate (755 ms). Statistically, this trend was represented by the marginal interaction of transfer task and repetition condition, $F(2,46)=2.29$, $p=.11$. There was no hint of a similar trend in Experiment 2a: phonemic categorizations repeated in the same task took 1000 ms, initial phonemic categorizations took 979 ms, and all F's involving repetition condition were less than 1. Not only did speed instructions change the pattern of response times, but the prior categorization facilitated subsequent categorization more. These effects can all be ascribed to the use of nonanalytic decisions in categorization.

Errors. For Experiment 2a there was a marginal effect of repetition condition, $F(2,22)=3.04$, $MSe=.008$, $p<.07$. Dunnett's tests indicated that this marginal effect was caused by a reduction in the proportion of errors for pairs repeated in the same task (.09) compared to pairs categorized for the first time (.13). There was no reduction in the proportion of errors for pairs repeated in the different task (.12). Complicating the interpretation of this marginal effect were two significant interactions involving the repetition condition factor. Transfer task interacted with repetition condition, $F(2,22)=4.85$, and both transfer task and categorization response interacted with repetition condition, $F(2,22)=4.31$. The triple interaction

was analyzed by calculating the simple effects for both levels of the categorization response factor. There were no effects in the analysis of "no" responses, but there was an interaction of transfer task and repetition condition, $F(2,22)=9.56$, $MSe=.006$, in the analysis of "yes" responses. The mean proportions of categorization errors made on "yes" responses are presented in Table 2. Although the reduction in categorization errors for the phonemic task occurs when pairs are repeated in the same task, the reduction in errors for the graphemic task occurs when pairs are repeated in the different task. Therefore, the triple interaction can be summarized as a reduction in errors made on pairs requiring "yes" responses that were initially categorized in the phonemic task. This is a "levels" effect in that only the more meaningful word comparisons produce transfer to later categorization. For these categorizations, transfer was obtained irrespective of context. Although transfer in Experiment 1 was restricted to repetition of categorization in the same context, the present "levels"-like result is also consistent with the hypothesis that the memory representations supporting recognition also support transfer performance.

A very different pattern of results was found in Experiment 2b. There was an effect of repetition condition, $F(2,46)=5.68$, $MSe=.011$; the mean proportion of errors made on pairs repeated in the same task was less than for pairs

Transfer Task	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Graphemic	.12	.05	.12
Phonemic	.14	.17	.04

TABLE 2. Mean proportion of categorization errors for pairs requiring "yes" responses in the transfer phase of Experiment 2a.

categorized for the first time. Dunnett's tests indicated that this was not true for pairs repeated in the different task. Although there were no higher order interactions with repetition condition, the mean proportion of errors is presented in Table 3 separately for the two transfer tasks. It is obvious from these data that a larger reduction in errors was observed in the phonemic task than in the graphemic task. This observation was confirmed by simple effects calculated for each transfer task. For the phonemic task there was an effect of repetition condition, $F(2,46)=5.32$, $MSe=.015$, but for the graphemic task there were no effects of repetition condition ($F's<1$).

In both Experiment 2a and 2b evidence of learning was indicated by the reduction in categorization errors for repeated items. However, qualitatively different patterns were found in the two experiments. The major difference between these two experiments was that the response strategy used during the transfer phase emphasized accuracy for Experiment 2a and speed for Experiment 2b. With an emphasis on accuracy, evidence of learning was found only for pairs requiring "yes" responses that had been phonemically categorized at acquisition. With an emphasis on speed, evidence of learning was found only in pairs that were phonemically categorized both at acquisition and at transfer. Although this latter result is consistent with a procedural account of learning (maximal transfer should

Transfer Task	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Graphemic	.21	.19	.19
Phonemic	.23	.22	.16

TABLE 3. Mean proportion of categorization errors in the transfer phase of Experiment 2b.

occur when procedures used at acquisition are reinstituted at transfer (Kolers & Roediger, 1984)), the former result is not.

A possible explanation of this pattern of results is suggested by the effect of categorization response, $F(1,23)=14.96$, and the interaction of categorization response and transfer task, $F(1,23)=10.29$, which was found in Experiment 2b. Simple effects calculated for each transfer task indicated that, for the graphemic task, more errors were made on pairs requiring a "no" response (.28 error rate) than on pairs requiring a "yes" response (.11 error rate), $F(1,23)=25.32$, $MSe=.039$. This was not true of the phonemic task, although a similar trend was present (.23 and .17 error rates respectively). This result supports the conclusion from response times that subjects "set" themselves towards making "yes" responses when given speed instructions. Correct "no" responses took longer to make, and more errors were made on items requiring "no" responses. It was argued that this change in "set" may have been caused by the use of a less analytic basis for responding. Nonanalytic decisions are based on any similarities between the current item and memory information, even if irrelevant to the task (Jacoby & Brooks, 1984). If subjects were considering all similarities in making their categorizations, this would have caused more errors than normal on pairs requiring "no" responses. Because this

result was achieved, it is possible that the "set" towards "yes" responses was caused by a nonanalytic response strategy. In Chapter 4, a similar manipulation of response strategy will produce a similar effect in recognition accuracy.

As predicted by Jacoby and Brooks, the consequences of the nonanalytic strategy (speed instructions) were different from those of the analytic strategy (accuracy instructions). Because an analytic strategy requires retrieval of only task-relevant information, only the most elaborate memory representations would be consistently involved in the categorization decision. Consistent with this prediction, reductions in categorization errors were observed in Experiment 2a only for pairs requiring "yes" responses that were phonemically categorized at acquisition. Because a nonanalytic strategy would make use of any perceived similarities, only when the transfer situation was similar to the acquisition situation could memory information be involved in the categorization decision. Consistent with this prediction, reductions in categorization errors were observed in Experiment 2b only for pairs repeated in the same task. Further, there was a trend towards facilitation of categorization response times in Experiment 2b, but not in Experiment 2a. At minimum, this trend means that the effect of speed instructions cannot be interpreted in terms of a speed-accuracy

trade-off. A less conservative interpretation of these results is that nonanalytic processing of information is responsible for the reductions in categorization latencies caused by repetition of pairs in the same task.

Experiment Three

Although Experiment 2 demonstrated that learning in word categorization persists over the retention interval necessary for separating acquisition and transfer trials into study/test blocks, reliable evidence of this learning was found in accuracy rather than speed of categorization. The fluency hypothesis suggests that a fluency heuristic may be adopted by subjects if they can perform a task more easily than they normally could (Jacoby & Dallas, 1981). It might be argued that reductions in response time would be better evidence of "easier performance" to subjects than reductions in errors. The larger the reduction in response time, the more reassurance there is that subjects are aware of their more-fluent-than-normal performance. It is important to the fluency hypothesis that subjects can detect the increase in fluency of their performance. Only when subjects can "wonder why" their performance is more fluent than normal would they attribute it to a "prior occurrence". These considerations suggested that adoption of a fluency

heuristic would be more likely if there were very large reductions in both errors and response times. A categorization task likely to produce these results would be one that deals directly with the semantic referents of words.

In Experiment 3, subjects were asked in one categorization task to determine whether word pairs were associatively related. For the less meaningful categorization, subjects were asked to determine whether pairs possessed the same number of vowels. It was expected that, in extension of the first two experiments, the more meaningful categorization will facilitate repeated categorization to a greater extent than a less meaningful categorization does. It was also expected that facilitation of categorization will occur only when the same categorization as performed at acquisition was performed at transfer. As in prior experiments, the pairs that matched under one task also matched under the other task. Equivalent categorizability of pairs in both tasks allowed the categorization context of the pairs to be changed or preserved on transfer without also changing the categorization response for those pairs. All manipulations of variables occurred within subjects.

Method

Subjects. Twenty-four subjects from an introductory psychology course participated in return for course credit. Experimental sessions lasted approximately 45 minutes.

Materials. Word pairs were selected from two different word association norms (Keppel & Strand, 1970; Marshall & Cofer, 1970). At least four distinct associative relationships existed in the stimuli. Words that were associatively related could belong to the same category (e.g., apple, pear), they could be idiomatically related (e.g., sour, grapes), they could be semantically related (e.g., death, grave), and they could be simply associatively related (e.g., lagoon, mermaid). The constraints on selecting and pairing of words were that the associative relation was of moderate strength (produced by norming subjects between 2 and 5 times), that both words contained the same number of vowels (with a maximum of 3 vowels per word), that no pair formed a compound word, and that no word was used more than once. Pairs requiring a negative response were created by arbitrarily dividing the stimulus set in half and re-pairing one half such that no pair formed an associative relation and neither word in these pairs contained the same number of vowels. Two stimulus formats were created such that across formats, each word was a member of one pair requiring a positive response, and of one pair requiring a negative response. In total there were 180

critical pairs, 10 buffer pairs to introduce the acquisition and transfer phases, and 40 practice pairs. The critical pairs are listed in Appendix C.

Procedure. The same apparatus and misdirection of subjects regarding the purpose of the experiment were employed as described for Experiment 1. Error feedback was provided during the acquisition phase, but not during the transfer phase. Task cues were centered on the CRT ten lines from the top of the screen. For the semantic categorization the cue was "RELATED ?", and for the graphemic categorization the cue was "LETTERS ?". There was a 1000 ms interval between the onsets of the cue and comparison word of which 250 ms was blank. The comparison word was presented by itself (just to the left of mid-screen) for 1000 ms, after which the target word was presented beside the comparison word (just to the right of mid-screen). The display remained on until responded to. The response time was defined as the time elapsing between onset of the target word and the depression of a telegraph key. Only response times for correct responses, and response times for repetitions which were correctly responded to when originally presented were analyzed.

One hundred and twenty pairs were presented in the acquisition phase (60 in each task and response type). These pairs, along with the remaining 60 pairs, were presented in the transfer phase. Of the pairs repeated from

the acquisition phase, one half were presented with the same task as performed at acquisition, and one half were presented with the other task. The type of task transition on repeated pairs was counterbalanced across subjects. The words within pairs were counterbalanced across subjects so that each word served equally often in pairs requiring negative and positive responses. Response mappings between hands and keys were counterbalanced across subjects and two random orders for presentation were used.

Subjects first completed the practice which contained no repetition of any pair. Subjects were instructed to respond quickly without sacrificing accuracy in both acquisition and transfer phases.

Results and Discussion

Response Time. There was an effect of transfer task, $F(1,23)= 29.24$, $MSe=222479$, indicating that the graphemic categorization (1234 ms) took longer than the semantic categorization (934 ms). This effect is important only in that any greater facilitation of response times for semantic as compared to graphemic categorizations will not be complicated by scale differences.

The only other effect to approach significance was for the repetition condition, $F(2,46)=4.32$. Because the variances associated with the graphemic categorization were

double those associated with the semantic categorization, separate analyses were performed on the data for each transfer task. There was an effect of repetition condition for semantic categorizations, $F(2,46)=13.75$, $MSe=30009$, but no effects approached significance for graphemic categorizations (all $F's<1$). The application of Dunnett's tests to the median response times for semantic categorizations showed that pairs repeated in the same task were responded to more quickly than pairs categorized for the first time. However, there was no difference in response times for pairs repeated in the different task and pairs categorized for the first time. The effect of repetition condition on response time for both graphemic and semantic categorizations is presented in Table 4.

The semantic categorization task had the intended effect of producing facilitation in response times for repeated pairs. Because no facilitation was observed for graphemic categorization at transfer, it can be concluded that better learning occurred for the more meaningful categorization. In agreement with the previous experiments, this learning was evident only if the categorization context was identical at acquisition and transfer.

Errors. The most important result was an effect of repetition condition, $F(2,46)=26.62$, and the interaction of repetition condition with categorization response, $F(2,46)=4.52$, $MSe=.007$. This interaction is

Transfer Task	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Graphemic	1275	1211	1216
Semantic	990	984	827

TABLE 4. Mean median response times for categorization in the transfer phase of Experiment 3.

presented in Table 5. Dunnett's tests showed that the mean proportion of errors made on pairs repeated in the same task was less than those made on pairs categorized for the first time. This was true for both "no" and "yes" categorization responses. The interaction is therefore caused by a greater reduction in errors for "yes" responses than for "no" responses. It is possible that a floor effect may be responsible for this interaction. However, no reduction in errors was found for pairs repeated in the different task irrespective of the categorization response. Therefore evidence of learning in word categorization occurred in accuracy as well as in response times. Although this learning was present in the accuracy of both semantic and graphemic categorizations, it was present only if the categorization context was the same at transfer as at acquisition.

There was also an effect of categorization response, $F(1,23)=16.26$, and this interacted with transfer task, $F(1,23)=4.86$. These effects indicate that more errors were made on pairs requiring a "yes" response than on pairs requiring a "no" response for semantic categorizations (.10 and .04 error rates respectively), but not for graphemic categorizations (.08 and .07 error rates).

Categorization Response	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Yes	.12	.12	.03
No	.07	.05	.03

TABLE 5. Mean proportion of categorization errors in the transfer phase of Experiment 3.

Summary

These experiments have investigated the nature of learning in graphemic, phonemic, and semantic categorization tasks. Two different repetition conditions were employed. The same pair of words was repeated either in the same categorization task as performed at acquisition, or the same pair of words was repeated in a different categorization task from the one performed at acquisition. Learning was observed if the same categorization was performed at acquisition as at transfer. With the exception of Experiment 2a (accuracy instructions), learning was not observed if the different categorization was performed at transfer. Because the same pair of words was presented in both cases, the absence of learning when the categorization context was changed indicates that the learning observed in these experiments could not be caused by the temporary activation of pre-existing and abstract memory representations of these [illegible]. Rather, this learning must be mediated by a memory representation that includes the way in which words were dealt with on their prior encounter. A representation with these qualities is also thought to support remembering.

Learning of a greater magnitude and a longer persistence was found for more meaningful categorization tasks. In Experiment 1, facilitation of response times was

greater for repeated phonemic categorizations than for repeated graphemic categorizations. Reductions in errors were similar in magnitude for the two categorization tasks. Experiment 2 employed a much longer repetition interval than Experiment 1. In this experiment there was no significant facilitation of response times for repeated pairs in either task. However, a reduction in errors was observed for repeated phonemic categorizations, but not for repeated graphemic categorizations. Using this longer repetition interval, Experiment 3 found a reduction in response times for repeated semantic categorizations, but not for repeated graphemic categorizations. Reductions in errors were similar for the two categorization tasks. Therefore, a pervasive result of the experiments reported in this chapter is that the meaningfulness of acquisition processing determines the magnitude of transfer.

In these experiments, the context and meaningfulness of categorization were found to have effects on learning like those found by others for remembering (e.g., Craik & Tulving, 1975; Light & Carter-Sobell, 1970). This result is consistent with the retrieval hypothesis which holds that the same memory representation supports both remembering and learning. However, this result was not obtained if similar categorization tasks were employed at acquisition but a word identification task was employed on transfer (e.g., Jacoby & Dallas, 1981). In those experiments, meaningfulness of

prior categorization did not affect the learning found in word identification, though it had large effects on remembering. One explanation of these discrepant findings is that the processing at transfer is identical to the acquisition processing in Experiments 1 through 3, whereas the processing between acquisition and transfer is very different in experiments employing word identification. This explanation is not sufficient because it cannot account for why more facilitation was obtained for more meaningfully acquired pairs. A sufficient explanation would also acknowledge that the two different transfer tasks (word identification, word categorization) require different retrieval processes. In the terms of Jacoby (1983), retrieval in word identification is predominantly data-driven, whereas retrieval in word categorization employs more conceptually driven processing. Although meaningfulness determines the degree of transfer for conceptually driven processes, it may have little influence on data-driven processes.

According to the strong representation hypothesis, differences between learning and remembering are attributed to different memory stores containing qualitatively different memory representations. By this account the type of retrieval process should not determine when learning and remembering tasks behave similarly. Therefore, the representation hypothesis does not naturally account for

parallel effects of variables on remembering and learning, especially variables like context and meaningfulness that distinguish memory stores. The representation hypothesis could be maintained only by proliferating memory stores. It could be argued that learning in word categorization is different from learning in word identification because they depend on representations in different memory stores. Learning in word identification might be supported by abstract representations of words (e.g., lexical memory), whereas learning in word categorization might be supported by a more elaborate representation of specific experiences with words. Against this argument are the results of Experiment 2 which found that the characteristics of learning depended on the subjects' response strategy. In particular, speed instructions produced evidence of nonanalytic responding, and they also produced results in both categorization accuracy and latency similar to those found in Experiments 1 and 3: Both the context and meaningfulness of processing were determinants of learning. In contrast, evidence of learning under accuracy instructions was determined only by the meaningfulness of acquisition processing. Because the nature of the retrieval process is most plausibly affected by the manipulation of response strategy, this result suggests that appealing to different retrieval processes rather than to different memory stores is a better explanation of the different

characteristics of learning found in word categorization and word identification.

CHAPTER THREE

Sensitivity of Recognition to Learning in Word Categorization

The primary issue investigated in this chapter is whether recognition of word pairs is sensitive to the context provided by the categorization operations. Although subjects must make reference to representations of prior experience in performing the recognition task, it is not necessarily true that the specific categorization operations need be retrieved or even be represented in recognition memory. Empirical confirmation that the categorization operations are represented and retrieved for recognition is necessary to complete the argument of Chapter 2 that the effect of context and meaningfulness on learning in word categorization parallels their effects on recognition. Although many experiments have found that the meaningfulness of word categorization determines the level of recognition performance (e.g., Craik & Tulving, 1975), few experiments have investigated the effect of categorization context on recognition. It is necessary to the retrieval account that the categorization context provide retrieval information for recognition because this account claims that the same memory

representations support learning and remembering.

Another important issue investigated in this chapter is whether there is a relation between the speed of categorization and the recognition response. The existence of such a relationship can be deduced by arranging the data in a contingency table. The advantage of this approach is that analyses will be performed on the level of individual items. The retrieval and representation accounts make different predictions as to whether a relation between the speed of categorization and the recognition response should exist at the item level. The strong representation hypothesis does not predict that such a relationship should be found. According to this account, the parallel between learning and remembering in Chapter 2 was the result of a coincidence that both memory stores separately represented categorization context and meaningfulness. It would be another coincidence if the same items were separately represented in both memory stores such that those items quickly categorized were also more likely to be recognized. In contrast, the retrieval hypothesis expects a relation between categorization and recognition because it holds that the same representation supports both learning and remembering. According to this account, the parallel observed for medians in Chapter 2 should also be true on the level of individual items.

This experiment also checks a critical assumption behind the analysis of relationships. If categorization is performed independently of recognition, a statistical relationship could be straightforwardly interpreted as a relation between categorization and recognition. This outcome was the one hoped for because it would make experimental investigation much simpler. However, it could also be the case that recognition is performed concurrently with categorization (i.e., that categorization response time includes recognition response time). This outcome would mean that if a relationship were obtained, it would have an equivocal interpretation because there would be no way of knowing whether the relation is between the speed of categorization and the recognition response, or between the speed of recognition and the recognition response. In this case, a much more complicated experimental design would be required to tease apart these alternative interpretations of relationship.

Experiment Four

The primary goals of Experiment 4 were to determine the sensitivity of recognition to categorization context, and to determine whether there is a relation between the speed of categorization and the recognition response. The

graphemic and phonemic categorization tasks, and the structure of the acquisition phase in this experiment were identical to those in Experiment 2. The context for categorization of words was manipulated at transfer by repeating the words either in the same task as at acquisition or in the other task. In the transfer phase of this experiment, categorization served as context for recognition by requiring a recognition decision after every categorization. This arrangement also maximized the opportunity for subjects to use categorization speed as a basis for recognition (i.e., to adopt a fluency heuristic). Other experiments using this procedure have shown that performance on a task (not involving remembering) was related to the subsequent recognition decision (Feustel et al., 1983; Johnston et al., 1985; Masson, 1984). However, these experiments were not able to determine whether the knowledge that a recognition decision would have to be made after performing the transfer task changed the way the transfer task was performed (e.g., recognizing concurrently with performance of the transfer task). In the present experiment, the effect of recognition on categorization was roughly estimated by comparing categorization performance at acquisition to categorization of once-presented pairs in the transfer phase.

This experiment is primarily a demonstration that nature is never as simple as it ought to be. Not only was

no relation between categorization speed and recognition obtained, but the data also suggested that recognition was performed concurrently with categorization. There are many reasons why a relationship might not surface on the first attempt. Other bases for recognition are available before completing categorization (e.g., word identity). Allowing recognition to be based on these other sources of information to the exclusion of information from categorization would minimize any relation between categorization speed and recognition. Some steps were taken in this experiment to discourage reliance on these other sources, and at the same time, to discourage concurrent performance of recognition and categorization. Word pairs were presented with a recognition cue after categorization, subjects were told that recognition response times were not recorded (i.e., they need not hurry recognition), and they were told that recognition was a secondary task. These steps were not sufficient. The more complicated experimental analyses required to obtain and distinguish the different possible interpretations of a relationship are reported in the following chapter.

Method

Subjects. Twenty-four university students from an introductory psychology course participated in

return for course credit. Experimental sessions lasted approximately 60 minutes.

Procedure. The same materials, apparatus, and misdirection of subjects regarding the purpose of the experiment were employed as described for Experiment 2. The same procedure was followed as that described for Experiment 2, except that after each transfer trial a verbal recognition response ("old" or "new") was given. Immediately following the categorization response on these trials, the cue "WORDS OCCURRED BEFORE?" was printed on the CRT eight lines from the top of the screen. The word pair and the cue remained on the screen until the experimenter recorded the recognition response and started the next trial. Subjects were instructed to call repeated pairs "old" regardless of how they were categorized at acquisition.

Subjects first completed the practice which contained no repetition of any pair. They were instructed to make their categorization responses quickly without sacrificing accuracy in both acquisition and transfer phases. At the beginning of the transfer phase, subjects were told that the recognition decision was their secondary task and that response time was not being recorded for it. They were instructed not to begin the secondary task until they had completed the primary task of categorization.

Results and Discussion

Recognition Accuracy. Because the acquisition condition in recognition often controls most of the variance (e.g., Craik & Tulving, 1975), a more appropriate factor, acquisition task (none, graphemic, phonemic), was substituted for the repetition condition factor in all analyses of recognition performance.

Although there was an effect of categorization response, $F(1,23)=27.23$, $MSe=.037$, this variable did not interact with any other variable. (The effect of categorization response indicates that there were more hits and false alarms for "yes" responses (.43) than for "no" responses (.32).) Therefore, Table 6 presents the proportion of hits and false alarms averaged across categorization response. There was an effect of acquisition task, $F(2,46)=106.12$, $MSe=.017$, such that there were more hits for pairs acquired in the phonemic task than for pairs acquired in the graphemic task, and more hits in both these conditions than false alarms for pairs not presented in the acquisition phase. This result, in agreement with many other experiments (e.g., Craik & Tulving, 1975), indicates that the more meaningful the prior processing, the more accurate recognition performance is.

The most important result seen in Table 6 is that

Transfer Task	Acquisition Task: Not Presented	Graphemic	Phonemic
Graphemic	.25	.41	.47
Phonemic	.20	.37	.52

TABLE 6. Mean proportion of hits and false alarms for recognition in Experiment 4.

pairs acquired and repeated in the phonemic task (.52) were recognized more often than pairs acquired in the phonemic task, but repeated in the graphemic task (.47). Similarly, pairs acquired and repeated in the graphemic task (.41), were recognized more often than pairs acquired in the graphemic task, but repeated in the phonemic task (.37). In the analysis of these data, this result was indicated by the interaction of acquisition task with transfer task, $F(2,46)=6.78$, $MSe=.013$. Pairs not presented at acquisition were not responsible for this interaction. Simple effects computed for just the repeated pairs also showed an interaction of acquisition task with transfer task, $F(1,23)=5.09$. As required by the retrieval account of remembering and learning, the categorization context does influence recognition.

A major concern of this experiment was determining that changing categorization tasks reduced recognition performance relative to conditions in which the categorization task was repeated. Because the acquisition task is a major determinant of recognition performance, context conditions were compared on this basis. However, these conditions are comparable only if the nature of the transfer task does not by itself alter recognition performance. This assumption was checked by comparing performance on the two transfer tasks for pairs not presented at acquisition. If the transfer task was not

affecting performance, then the false alarm rates between transfer tasks for these items should not differ. If the false alarm rates differ, then comparisons of conditions with the same acquisition task may have to be qualified by the effects of the different transfer tasks.

Looking at Table 6, the absolute differences in hit rates between conditions with the same acquisition tasks but different transfer tasks appears to be similar for graphemic and phonemic tasks. However, comparison of differences between graphemic and phonemic tasks is confounded by the higher false alarm rate for graphemic categorizations, $F(1,23)=8.79$. As indicated in Table 6, subjects were more willing to call items "old" when presented in the graphemic task at transfer than when presented in the phonemic task at transfer. A consequence of this effect is that the magnitude of the context effect is underestimated for pairs acquired in the phonemic task, but overestimated for pairs acquired in the graphemic task. In fact, a simple hits minus false alarms correction of these differences indicates that there was no effect of categorization context for pairs acquired in the graphemic task. At minimum, the magnitude of the effect of context must be smaller for pairs acquired in the graphemic task than for pairs acquired in the phonemic task. Just as the magnitude of transfer in categorization was greater for the more meaningful task, so reliance of recognition on categorization information was

greater for the more meaningful task. This parallel between learning and remembering is striking for pairs acquired in the graphemic task. Although these pairs were discriminated from pairs not presented in the acquisition phase, recognition relied little, if at all, on categorization information. Similarly, Experiment 2 failed to find transfer in graphemic categorization over the same repetition interval. These results suggest that there is a relation between learning and remembering as the retrieval account claims.

Categorization Response Time. There were no effects in the analysis of responses times of repeated and once-presented pairs in the transfer phase. This indicates that repetition did not facilitate categorization response time, and that the prolonging of categorization was similar for repeated and nonrepeated pairs (see below). In Experiment 2, these same materials were used but recognition was not required after every categorization in the transfer phase; facilitation of categorization response time due to repetition was also absent.

The mean median response times to categorize pairs in the acquisition phase and to categorize once-presented pairs in the transfer phase are presented in Table 7. It is clear that categorization of once-presented pairs is prolonged in the transfer phase. In the analysis of these data, this conclusion is supported by an effect of

Transfer Task	Experimental Phase: Acquisition	Experimental Phase: Transfer
Graphemic		
Yes	1246	1349
No	1226	1405
Phonemic		
Yes	1184	1440
No	1226	1333

TABLE 7. Mean median response times for "yes" and "no" categorizations of pairs in the acquisition phase and once-presented pairs in the transfer phase of Experiment 4.

experimental phase, $F(1,23)=7.94$, $MSe=157375$. Practice effects would account for facilitated categorization of nonrepeated items in the transfer phase; prolonged categorization of these items indicates that the requirement for subsequent recognition influenced categorization. The recognition requirement similarly affected categorization of repeated pairs. (For comparison with Table 7, pairs repeated in the graphemic task and requiring a "yes" response took 1384 ms, whereas those requiring a "no" response took 1373 ms. Pairs repeated in the phonemic task and requiring a "yes" response took 1408 ms, whereas those requiring a "no" response took 1371 ms.) Further, subjects uniformly reported difficulty in properly sequencing categorization and recognition. Therefore, it is likely that response times in the transfer phase reflect both categorization and recognition processes. This result is problematic for using this procedure to determine the relation between transfer and recognition performance (cf. Feustel et al., 1983; Johnston et al., 1985; Masson, 1984) because any relationship may be caused solely by recognition processes.

Another reason for the prolonging of categorization by recognition is that the secondary recognition task causes a depletion in general resources, thus slowing categorization performance without the specific involvement of recognition processes. Fischler and Goodman (1978) also

found that performance on a primary task was disrupted by a secondary remembering task. They reported that priming of lexical decision was eliminated when subjects recalled the target word immediately after lexical decision. They suggested that a general depletion in processing resources (i.e., a psychological refractory period) may have been responsible. This hypothesis will be tested in Chapter 5.

Experimental phase also interacted with the categorization response and and the transfer task, $F(1,23)=4.67$. Looking at the mean prolongations in Table 7 it can be seen that this interaction is caused by phonemic categorizations being prolonged more than graphemic categorizations for "yes" responses, whereas the opposite is true for "no" responses.

Categorization Errors. The mean proportions of categorization errors averaged over categorization response are presented in Table 8. These data indicate a reduction in categorization errors in the phonemic task irrespective of the categorization context at transfer. The analysis of these data support this observation. There was an effect of repetition condition, $F(2,46)=3.82$, $MSe=.006$, and an interaction of transfer task and repetition condition, $F(2,46)=4.03$, $MSe=.008$. In contrast to all previous experiments, these results suggest that there was as much learning for pairs acquired in the graphemic categorization but tested in the phonemic categorization, as

Transfer Task	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Graphemic	.09	.11	.09
Phonemic	.14	.09	.08

TABLE 8. Mean proportion of categorization errors in transfer phase of Experiment 4.

pairs acquired and tested in the phonemic categorization. The principal difference between this experiment and prior experiments is the requirement for a recognition judgement after every categorization in the transfer phase. It is possible that this recognition requirement changed the nature of the categorization process.

Gamma Coefficients. Indexes of relationship are usually based on the chi-square statistic. However, Nelson (1984) advised that when a recognition task is used, and when marginal performance deviates greatly from .5, the gamma coefficient should be used. This index was used because recognition performance after the graphemic task was expected to be poor, whereas recognition performance after the phonemic task was expected to be somewhat better. Categorization speed was determined by a median split on each experimental condition and each subject. Responses were called "fast" if they fell in the top half of response time distributions, and "slow" if they fell in the bottom half. If a gamma coefficient could not be calculated the mean gamma for that experimental condition was used for that subject in the analysis. Typically, one or two gammas per condition were derived in this manner.

The analysis showed only an effect of categorization response, $F(1,23)=10.86$, $MSe=.247$; the gamma for "yes" responses was more positive (.15) than the gamma for "no" responses (-.05). This means that for "yes"

responses, there was a slight association of fast categorizations with "old" recognition decisions, whereas for nonmatching pairs there was virtually no association between categorization latencies and recognition decisions. However, individual tests revealed that no mean gamma differed significantly from zero (i.e., no relationships were obtained).

In summary, although there are different relationships for pairs requiring "yes" responses than for pairs requiring "no" responses, this experiment provides only weak evidence that a relation between categorization speed and the recognition response exists. Further, if a relationship was found, its interpretation would be complicated by the likely interference of recognition with categorization response times.

Summary

This experiment has demonstrated that recognition is sensitive to the categorization context. Recognition was enhanced if the same categorization performed at acquisition was performed again at transfer. In Chapter 2, evidence of learning in categorization was rarely obtained if the same categorization performed at acquisition was not performed again at transfer. Therefore, categorization operations must be represented in the memories supporting both

remembering and learning. Further, in confirmation of many previous experiments, better recognition performance was obtained for more meaningful categorizations. An additional contribution of the present research is that the magnitude of the effect of context on recognition was greater for more meaningful categorizations. In Chapter 2, learning in categorization was of greater magnitude for more meaningful categorizations. According to the retrieval account, these parallel effects are evidence that the same memory representations support both remembering and learning. Representation accounts have more difficulty with the parallel effects mostly because context and meaningfulness have been central in distinguishing the representational differences between remembering and learning. However, if pressed on this issue, a supporter of the representation account could claim that the representations supporting learning coincidentally represent categorization context and meaningfulness, just as the representations supporting remembering do. In short, these results support a retrieval account, but they do not disconfirm the representation account.

A more serious problem for the representation account would be an analysis on the item level that showed, for example, that items categorized quickly were also recognized as having occurred previously. Although it can be argued that categorization, context and meaningfulness are

coincidentally represented in both memory stores, it is less plausible that the same items represented "well" in one store are also the items represented "well" in the other store. Experiment 4 did not provide strong evidence of an item-specific relationship, but there were encouraging trends. For "yes" responses, a small association between fast categorizations and "old" recognition decisions was found. This result may indicate that subjects are employing other retrieval strategies in addition to a fluency heuristic.

There are three experimental manipulations that might increase the influence of the fluency heuristic on the recognition decision. First, the categorization tasks used in Experiment 4 do not show facilitation of response times for repeated pairs at long repetition intervals. Without speeded response times to distinguish repetitions, subjects may not feel confident to rely principally on a fluency heuristic. The experiments in Chapter 4 will contrast categorization tasks that show and do not show facilitation of response times in order to determine whether increased discriminability strengthens the relation between categorization and recognition. Second, subjects could be instructed to adopt a fluency heuristic. Without explicit instruction, university students serving as subjects may have a preference for making analytic recognition decisions and thus minimizing use of categorization fluency as a basis

for recognizing. Third, judging by the results presented in Chapter 2, fluent categorization can provide evidence only that a pair is repeated in the same categorization task, whereas recognition requires evidence for whether a pair is repeated irrespective of the categorization task. Subjects could be reassured that fluency from categorization is sufficient evidence for recognition by modifying the recognition test so that a pair would be called "old" only if the pair was categorized in the same task at acquisition. These procedural modifications will be employed in Chapter 4 to determine whether a stronger relation between categorization speed and recognition decisions can be obtained. Chapter 4 will also present logical and empirical arguments as to the correct interpretation of such a relationship.

CHAPTER FOUR

Relation between Categorizing and Recognizing

This chapter reports two experiments that attempt to determine whether a relation exists between the speed of categorization and the recognition response. The testing procedure used in Experiment 4, categorization followed by recognition on each transfer trial, was employed again in these experiments. However, this basic procedure was systematically modified in each experiment to try to induce subjects to use predominantly a fluency heuristic for recognition.

All experiments reported in this chapter employed a modified recognition test. In this test, word pairs were to be classified as "old" only if the pair was categorized at transfer in the same task as at acquisition. The motivation for modifying the recognition test was to make the ease with which subjects categorize relevant to the recognition decision. Because categorization fluency is specific to pairs repeated in the same task, fluency is sufficient evidence of prior occurrence only if the recognition task requires identification of pairs repeated in the same task. If there is to be a relation between categorization and

recognition, it is logical that there should be an information compatibility between them.

Modification of the recognition test also allowed an effective contrast of analytic and nonanalytic strategies in recognition. The results of this contrast will help choose between the representation and retrieval hypotheses. In one experimental condition, subjects were instructed before the transfer phase to use fluent categorization as evidence of previous categorization of pairs (nonanalytic strategy). Without such instruction, subjects could treat the modified recognition test as a source-judgement task (i.e., if you remember seeing this word pair before, how did you categorize it?), which would be an analytic strategy for recognition. This possibility was tested by a second experimental condition in which subjects, at transfer, were given no specific instruction (Experiment 5) or were encouraged to reconstruct the prior context (Experiment 6). This instructional manipulation effectively addresses the representation and retrieval hypotheses because instructional conditions have identical acquisition conditions. With memory representation held constant between instructional conditions, any differences between them must be ascribed to the differences in processing at retrieval (cf. Anderson, 1978). Further, a specific prediction of the retrieval hypothesis is that stronger

relationships should be obtained when nonanalytic recognition decisions are made (i.e., when a fluency heuristic is used) than when analytic recognition decisions are made (Jacoby & Brooks, 1984). In contrast, the representation account asserts that different memory stores, containing different representations, separately support remembering and learning. This account does not predict that retrieval processes should cause or affect a relation between speed of categorization and the recognition decision.

The two experiments reported in this chapter differ in two principal ways. First, phonemic and graphemic categorization tasks were used in Experiment 5, whereas semantic and graphemic categorization tasks were used in Experiment 6. Semantic categorization was employed in order to determine whether the presence of facilitation in response time strengthened the relation between categorization and recognition. If it is the subjects' ability to discriminate repeated categorizations on the basis of processing fluency that determines the relation between categorization and recognition, then a stronger relation would be expected for the semantic categorization task.

Second, in addition to the two instructional conditions described above, a third instructional condition

was employed in Experiment 6 to aid in the interpretation of gamma coefficients. In this condition, subjects were instructed to perform only the recognition task in the transfer phase. By comparing the gamma coefficients obtained in this condition to those in the other instructional conditions, it will be possible to determine precisely the importance of categorization for obtaining a relation between response time and recognition. It is important to the strong representation hypothesis that categorization not be important for obtaining such a relationship. In defining memory systems, Tulving (1985) claimed that "processes within a system are more closely related to one another than they are to processes outside the system" (p. 386). If recognition and categorization are subserved by independent memory systems, then recognition response time should not be less correlated with recognition decisions than joint categorization and recognition response time is.

Experiment Five

The goal of this experiment was to determine if a relation between categorization speed and recognition decisions could be obtained by instructing subjects to use a nonanalytic basis for recognition. Instruction was manipulated between subjects. It was assumed that if

subjects were not told otherwise (nondirective condition), they would attempt to recognize pairs repeated in the same task by reconstructing the episode in which the prior categorization was performed. It was expected that there would be little relation between the ability to categorize words fluently and the ability to reconstruct the task in which words were previously categorized. In the familiarity condition, subjects were explicitly told to base their recognition decisions on the fluency with which they categorized the pair. The retrieval hypothesis, but not the representation hypothesis, predicts that fluent categorization can contribute to judgements of familiarity. If this were true, a relation between categorization speed and recognition should be observed. With the exception of this instructional manipulation and the use of a modified recognition task, this experiment was identical to Experiment 4.

If a relation between categorization speed and the recognition decision is found, there is still the important question of how to interpret it. The prolonging of response time which occurs when categorization is followed by recognition probably indicates that both recognition and categorization influence response times. A correlation between response time and recognition decisions can therefore be given at least four possible interpretations. First, a positive correlation might indicate that fast

recognition decisions are associated with "old" recognition decisions. Second, a positive correlation might indicate that "old" recognition decisions cause fast categorizations to be made. Third, a positive correlation might indicate that fast categorizations cause "old" recognition decisions to be made (i.e., the fluency heuristic). Finally, a positive correlation might indicate that there is a common representational basis for fast categorizations and "old" recognition decisions. Only the last two interpretations are interesting to the present argument.

The following is an argument based on logical considerations that some of these interpretations can be distinguished on the basis of which conditions support a correlation between categorization and recognition. Because such a poor representation for recognition is created in the condition in which pairs are graphemically categorized at both acquisition and transfer, retrieval of these memories is a priori unlikely to the subject. When confronted with this situation subjects are likely to issue fast rejections for recognition. When a subject does accept a word pair in this condition as "old", it will likely occur only after much deliberation in order to overcome the a priori unlikeliness of retrieval. Therefore, if the correlation reflects the association of recognition response time with the recognition decision, a negative correlation ("old" associated with slow responses, "new" associated with

fast responses) would be expected in this condition. A similar prediction would be made if it was held that "old" recognition decisions cause fast categorizations to be made. If recognizing a pair is difficult, it should be even harder to remember what the prior answer was, so remembering the prior decision may not be faster than performing the categorization again (cf. Jacoby, 1978). Further, fast rejections would reduce the recognition component of the joint response time and offset any advantage there may be for remembering the categorization response. Therefore, if the correlation reflects recognition processes causing categorization, then a zero or a negative correlation would be expected in the condition in which pairs are graphemically categorized at acquisition and transfer.

The logic behind these predictions is supported by at least two experiments. Kolers and Palef (1976) asked subjects to determine whether they had been to cities of varying size and location. Very rapid rejections occurred for the most unlikely (e.g., small Canadian, Asian). Glucksberg and McCloskey (1981) presented statements for verification which concerned memorized, fictional events and real-world knowledge. In this verification paradigm, responses were "yes" if the statement was known to be true, "no" if the statement was known to be false, and "don't know" otherwise. When the subject possessed some relevant information for making the decision, "don't know" responses

were slow. However, when no relevant facts were known, "don't know" responses were very rapid.

In the present experiments, it is argued that few facts about items repeated in the graphemic categorization can be retrieved; therefore, these items will be rapidly rejected as unlikely to have occurred previously. If recognition processes are solely responsible for a relationship between response time and recognition decisions, then this experimental condition should never produce a positive gamma coefficient. The results of Experiment 4 provide some empirical support for this argument. The gamma coefficient for pairs repeated in the graphemic categorization was negative for pairs requiring "yes" responses (-.07) and for pairs requiring "no" responses (-.20). That is, there was an association of fast categorizations and "new" recognition responses (i.e., rapid rejections) as would be expected if recognition processes were solely responsible for the relationship. It is noteworthy that all other conditions requiring "yes" responses in Experiment 4 produced a positive correlation, as also would be expected by interpretations of the relationship that are based on recognition processes.

The experimental condition in which pairs are graphemically categorized at acquisition and transfer is of special interest because the other two interpretations, categorization causation and common representation, make the

opposing prediction that a positive correlation should occur. In the case of categorization causation (i.e., the fluency heuristic), any facilitated categorization should result in an "old" recognition decision. By this account, positive correlations should occur in all experimental conditions (excepting pairs requiring "no" responses; see below). If a common memory representation is the source of relationship, a positive correlation is expected only if recognition and categorization rely on the same memory representation. Reliance on similar representations can always occur in any experimental condition because some new pairs can have encoded attributes that are similar to those of old pairs. The prediction of a positive correlation is even stronger for pairs acquired and repeated in the graphemic categorization because both the pair and the categorization are repeated identically. By this account also, positive correlations are expected in all experimental conditions.

Whereas all conditions in Experiment 4 requiring "yes" responses (excepting pairs acquired and repeated by graphemic categorization) produced a positive correlation, all conditions requiring "no" responses produced a nonpositive correlation. A more complex line of reasoning may be needed for pairs requiring negative categorization but positive recognition decisions. It is possible that familiarity from prior categorization may make pairs seem

more related regardless of the actual relation between the pairs. Whereas familiarity could only facilitate categorization of pairs requiring "yes" responses, familiarity could push categorization processes in the wrong direction for pairs requiring "no" responses. Because of conflicting information, familiar pairs that did not match would be slowly categorized; these slow categorizations would be associated with "old" recognition decisions, thus producing a negative correlation. Because other factors, like information conflict, could contribute to correlations found in conditions requiring "no" responses, these correlations cannot be used to distinguish explanations of the relation between recognition decisions and categorization speed. Therefore, only the sign of the gamma coefficient for pairs acquired and repeated by graphemic categorization and which require "yes" responses, is of *a priori* interest in distinguishing between different explanations of the relationship.

In summary, the principal prediction of this experiment was that a correlation between categorization speed and recognition decisions be observed when subjects were given nonanalytic recognition instructions, but not observed when subjects were not given this instruction. In order that a correlation be interpreted as a relation between categorization and recognition, it is important that some correlation also be observed for pairs acquired and

repeated in the graphemic task that required a "yes" response. Finally, in support of the assumption that the manipulation of recognition instructions changed the nature of the memory information used for recognition, it was hoped that recognition and categorization performance would differ between instructional conditions in ways indicative of that change (i.e., analytic or nonanalytic processing).

Method

Subjects. Forty-eight university students from an introductory psychology course participated in return for course credit. Experimental sessions lasted approximately 60 minutes.

Procedure. The procedure for the nondirective condition was identical to Experiment 4 except that the recognition cue was "TASK OCCURRED BEFORE?". In addition to this modification, the familiarity condition was instructed to base their recognition decisions on a general feeling of familiarity. These instructions are presented in Appendix D.

Results and Discussion

Recognition Accuracy. Because of the

importance of the acquisition condition in recognition, an acquisition task factor (none, graphemic, phonemic) was substituted for the repetition condition factor in all analyses of recognition performance. If conditions having the same acquisition task are comparable, pairs in both transfer tasks that were not presented at acquisition must have the same false alarm rates.

Averaging over all other factors, the mean probabilities for responding "old" in each instructional condition and for each categorization response are presented in Table 9. In both instructional conditions more "old" responses were made for pairs requiring "yes" responses, $F(1,46)=61.14$, $MSe=.056$. This effect, obtained in Experiment 4 as well, indicates that a bias to label items as "old" is created by pairs requiring "yes" responses. Because the categorical similarity of pairs is definitionally irrelevant to the recognition decision, it can be claimed that a nonanalytic component is involved in recognition irrespective of the strategy employed by the subject.

Categorization response also interacted with instructional condition, $F(1,46)=5.55$, and there was an effect of instructional condition, $F(1,46)=3.94$, $MSe=.143$. The interaction was caused by a larger proportion of "old" responses given for pairs requiring "yes" responses when familiarity, as opposed to nondirective instruction was

Categorization Response	Instructional Condition	
	Non-directive	Familiarity
Yes	.46	.57
No	.36	.37

TABLE 9. Mean probabilities for responding "old" in Experiment 5.

given. Pairs requiring "no" responses were not affected by instructional condition. The interaction indicates that an additional bias in recognition, specific to pairs requiring "yes" responses, is created by familiarity instruction. As argued above, the fact that categorical similarity influenced recognition is evidence of a nonanalytic component in recognition. The fact that familiarity instruction increased the influence of this nonanalytic component suggests that the instructional manipulation did alter the types of information that recognition relied on.

The conclusion that familiarity instruction increased the bias to respond "old" to pairs requiring "yes" responses was also supported by a signal detection analysis of hits and false alarms. The mean betas and d' for recognition of pairs requiring "yes" responses are presented in Table 10 separately for each instructional condition. There was an effect of instructional condition in beta, $F(1,42)=3.86$, $MSe=.817$, $p=.053$, but no effects of instructional condition in d', $F's<1$. The smaller beta under familiarity instruction indicates that a less conservative response criterion was adopted (i.e., subjects were more willing to respond "old" when asked for a recognition decision). The absence of effects of instructional condition in d' indicates that the strategy used for recognition did not affect the overall accuracy of recognition.

	Instructional Condition	
	Non-directive	Familiarity
d'	.56	.50
beta	1.16	.97

TABLE 10. Mean d' and beta for recognition of pairs requiring "yes" responses in Experiment 5.

The probabilities of responding "old", averaged over all conditions except the acquisition and transfer tasks, are presented in Table 11. Analysis of these data indicated that there was an effect of acquisition task, $F(2,92)=90.98$, $MSe=.025$, but that this factor also interacted with the transfer task, $F(2,92)=10.79$, $MSe=.016$. Looking at Table 11, it is obvious that the main effect should be interpreted: more "old" responses were made to repeated pairs than to pairs not presented at acquisition. This result indicates that pairs repeated in a task different than acquired in were more difficult distracters on the modified recognition task than were pairs not presented at acquisition. In contrast to facilitation of categorization, which depends only on repeating the prior categorization, recognition must also depend on some other source of information. This conclusion is consistent with two-factor theories of recognition (e.g., Mandler, 1980; Jacoby & Dallas, 1981).

The effect of acquisition task also can be interpreted as a "levels of processing" effect: the more meaningful the processing at acquisition, the greater the benefits for remembering. This interpretation is supported by comparing the probabilities of responding "old" for pairs repeated in the same task: More "hits" occurred when pairs were processed phonemically (.56) than when processed graphemically (.50). This comparison is the only

Transfer Task	Acquisition Task: Not Presented	Acquisition Task: Graphemic	Acquisition Task: Phonemic
Graphemic	.34	.50	.52
Phonemic	.31	.42	.56

TABLE 11. Mean probabilities for responding "old" in Experiment 5.

interpretable comparison because of the interaction of acquisition and transfer tasks.

Because of the "levels" effect, the interaction of acquisition and transfer tasks can only be understood by comparing repetition conditions having the same acquisition tasks. Looking at Table 11, it can be seen that more "old" responses were made to pairs acquired and repeated in the phonemic task (.56) than to pairs acquired in the phonemic task but repeated in the graphemic task (.52). Similarly, more "old" responses were made to pairs acquired and repeated in the graphemic task (.50) than to pairs acquired in the graphemic task but repeated in phonemic task (.42). Simple effects calculated for repeated pairs indicated that pairs not presented at acquisition did not contribute to this interaction. These results suggest that subjects were capable of remembering the task in which pairs were originally categorized. This conclusion is consistent with the effect of categorization context found in Experiment 4.

As argued above, conditions having the same acquisition task can be compared only if the false alarm rates do not differ for pairs in the transfer phase that were not presented at acquisition. The marginal effect of transfer task, $F(1,46)=3.86$, $p=.052$, indicated that this assumption might not be true. The signal detection analysis of pairs requiring "yes" responses eliminates the possible confound of response bias by taking into account false alarm

rates. Therefore, this analysis will provide the best assessment of knowledge about prior categorization. The mean d' for pairs requiring "yes" responses are presented in Table 12 separately for each acquisition and transfer task. Analysis of these data showed an effect of acquisition task, $F(1,42)=19.81$, $MSe=.106$, and an interaction of acquisition and transfer tasks, $F(1,42)=33.13$, $MSe=.114$. Orthogonal comparisons showed that pairs acquired and repeated in the phonemic task were better discriminated from once-presented pairs than pairs acquired in the phonemic task but repeated in the graphemic task ($p<.001$). Similarly, pairs acquired and repeated in the graphemic task were better discriminated from once-presented pairs than pairs acquired in the graphemic task but repeated in the phonemic task ($p<.05$). This result supports the conclusion that, for both categorization tasks, subjects were able to remember the task in which pairs were originally categorized in. In addition, the signal detection analysis shows, at least for pairs requiring "yes" responses, that this discrimination was better for the more meaningful acquisition task. These results extend those of Experiment 4 in showing the parallel between facilitation of categorization and recognition. Just as Chapter 1 demonstrated a greater facilitation of categorization for more meaningful processing, this experiment has demonstrated that <u>explicit</u> knowledge about categorization is greater for more meaningful

Transfer Task	Acquisition Task: Graphemic	Acquisition Task: Phonemic
Graphemic	.47	.54
Phonemic	.31	.82

TABLE 12. Mean d' for recognition of pairs requiring "yes" responses in Experiment 5.

processing.

Categorization Response Time. Analysis of median response times for pairs in the acquisition phase and once-presented pairs in the transfer phase showed an effect of instructional condition, $F(1,46)=8.14$, which indicates that subjects responded faster overall (i.e., before differential instructions were given to the two groups) in the familiarity condition than in the nondirective condition. The only other effect was of experimental phase, $F(1,46)=42.46$, $MSe=108811$. This indicates that responses made in the acquisition phase (1036 ms) were faster than responses made in the transfer phase (1255 ms). The result that the requirement to make a recognition decision after categorization prolonged categorization also was found in Experiment 4 when the standard recognition test was employed. As in Experiment 4, experimental phase did not interact with the transfer task.

The mean median response times for pairs categorized in the transfer phase, averaged over categorization response, are presented in Table 13. As indicated from the analysis of once-presented pairs, there was an effect of instructional condition, $F(1,46)=7.75$, $MSe=2097345$; responses were faster in the familiarity condition than in the nondirective condition.

Table 13 also shows that, in the nondirective condition, much longer response times were obtained for

Transfer Task	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Nondirective Instructional Condition			
Graphemic	1400	1499	1359
Phonemic	1423	1404	1488
Familiarity Instructional Condition			
Graphemic	1070	1107	1087
Phonemic	1126	1074	1094

TABLE 13. Mean median response times for categorization in transfer phase of Experiment 5.

pairs acquired by phonemic categorization than pairs acquired by graphemic categorization. In support of this conclusion there was an interaction of transfer task and repetition condition, $F(2,92)=7.19$, $MSe=32193$, and a triple interaction of transfer task, repetition condition, and instructional condition, $F(2,92)=3.68$. Simple effects calculated for each instructional condition showed an interaction of transfer task and repetition condition in the nondirective condition, $F(2,46)=8.58$, but no effects in the familiarity condition. This result can be taken as support for the assumption that, if not told otherwise, subjects would try to recognize pairs as being in the same task by trying to reconstruct the prior categorization experience. This additional reconstructive activity could be indicated by longer response times. It is plausible that subjects would be able to do this only for the most distinctive categorizations (i.e., those acquired phonemically).

Response times for repeated pairs were not faster than response times for once-presented pairs. Repetition effects in response time also did not occur in Experiment 2 and 4 for these categorization tasks and for this repetition interval. Only in Experiment 1 in which the repetition interval was approximately one minute did repetition effects in response time occur reliably. Although it is tempting to conclude that this categorization learning is temporary, repetition effects in categorization accuracy were

demonstrated in Experiment 2, and knowledge about categorization influenced recognition implicitly in Experiment 4 (see also Masson, 1984) and explicitly in this experiment. These observations suggest that (a) the categorization learning investigated here is relatively long-term and that (b) different measures of categorization learning vary in their sensitivity to such learning. Facilitation of response time appears to be the least sensitive measure of categorization learning in these experiments.

Categorization Errors. The mean proportions of categorization errors, averaged over instructional condition and categorization response, are presented in Table 14. Analysis of these data showed effects of transfer task, $F(1,46)=4.20$, $MSe=.007$, repetition condition, $F(2,92)=4.21$, $MSe=.006$, and the interaction, $F(2,92)=7.01$, $MSe=.013$. The interaction of transfer task and repetition condition was still obtained when simple effects were calculated for just the repeated pairs, $F(1,46)=5.81$. In contrast to the results obtained when categorization was performed without subsequent recognition (see Experiment 2a), there was no reduction in categorization errors for pairs acquired by phonemic categorization. Instead, the interaction indicates that these pairs were now categorized most inaccurately. A similar result was obtained in Experiment 4. It was concluded then that the recognition

Transfer Task	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Graphemic	.10	.12	.09
Phonemic	.15	.10	.11

TABLE 14. Mean proportion of categorization errors in the transfer phase of Experiment 5.

requirement may have changed the manner in which categorization was performed. The nature of the change is somewhat surprising, though. Because both recognition and categorization learning are best after more meaningful processing, one may have predicted that joint performance of these tasks would only enhance this effect. Instead, the opposite is true. The retrieval account of learning and remembering could explain this result by appealing to independent retrieval processes attempting to retrieve and process the same memory information. Other accounts could explain this conflict only by attributing it to a depletion in processing resources (i.e., a consequence of having to perform any secondary task). This issue will be addressed further in Chapter 5.

Gamma Coefficients. The mean gamma coefficients for each categorization response in each instructional condition are presented in Table 15. The effect of instructing subjects to base their recognition responses on familiarity was to produce a stronger association of fast categorizations and "old" recognition decisions, but only for pairs requiring "yes" responses. This interpretation is supported in the analysis of these data by an effect of categorization response, $F(1,46)=4.62$, $MSe=.313$, and an interaction of categorization response and instructional condition, $F(1,46)=6.13$. Evidence that the larger gamma coefficients in the familiarity condition were

Categorization Response	Instructional Condition	
	Non-directive	Familiarity
Yes	.04	.29
No	.05	.07

TABLE 15. Mean gamma coefficients for Experiment 5.

not caused by recognition response times, nor by successful recognition speeding categorization, was provided by the planned comparison of pairs requiring a "yes" response that were categorized graphemically at acquisition and transfer. The gamma coefficient for these pairs in the familiarity condition (.40) was more positive than in the nondirective condition (-.01). These results indicate that a relation between speed of categorization and the recognition decision occurred when a nonanalytic strategy for recognition was adopted. This outcome was not predicted by the strong representation account of remembering and learning. In contrast, the retrieval account would be very happy with these results because it emphasizes retrieval process as the determinant of the relation between remembering and learning.

The mean gamma coefficients for each categorization response in each repetition condition are presented in Table 16. In general, there was an association of fast categorizations and "old" recognition responses. However, pairs requiring "no" responses that are repeated in the same categorization task at transfer as at acquisition do not support such a relationship. For these pairs, there is a tendency for an association of slow categorizations and "old" recognition responses. This interpretation of Table 16 is supported by the interaction of categorization response and repetition condition, $F(2,92)=3.48$, $MSe=.392$.

Categorization Response	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Yes	.16	.11	.22
No	.13	.13	-.07

TABLE 16. Mean gamma coefficients for Experiment 5.

Neuman-Keuls tests showed that gamma coefficients for pairs requiring "yes" responses did not differ, whereas gamma coefficients for pairs requiring "no" responses did. As argued in the introduction to this chapter, prior categorization of pairs requiring "no" responses may produce a sense of familiarity on repetition, but this familiarity would only make these pairs seem more similar to each other. Consequently, overcoming this effect of familiarity may slow categorization response time, but this familiarity would also enable an "old" recognition decision to be made (i.e., a negative gamma coefficient would be produced). Although this is only one way a negative gamma coefficient could be obtained for pairs requiring "no" responses, it is encouraging to note that the occurrence of negative gamma coefficients was restricted to pairs repeated in the same categorization task as at acquisition. This supports an explanation of familiarity based on fluency or categorization because this fluency is restricted to pairs repeated in the same categorization context.

In summary, two results were taken as evidence that the instructional manipulation was effective in inducing qualitatively different retrieval processes for recognition. First, it was hypothesized that if subjects were not instructed otherwise they would recognize pairs repeated in the same task by trying to reconstruct the experience in which that pair was categorized. In support, long response

times were observed in the nondirective condition, but not the familiarity condition, for pairs acquired in the most meaningful categorization. It was argued that only the representations of these pairs would be sufficiently elaborate to support reconstructive activity. Second, it was hypothesized that when subjects were given familiarity instruction they would use a more nonanalytic retrieval strategy for recognition. In support, subjects in the familiarity condition showed a greater bias towards calling pairs requiring "yes" responses "old" than subjects in the nondirective condition. The similarities in vowel sounds and letter patterns that these pairs possess are definitionally irrelevant to recognition, but recognition was nevertheless influenced by them. Therefore, this result can be interpreted as evidence for the use of a more nonanalytic basis for recognition in the familiarity condition.

As predicted by the retrieval hypothesis, use of a nonanalytic basis for recognition produced an item-specific relation between recognition and categorization response times. Gamma coefficients for pairs requiring "yes" responses were more positive in the familiarity condition than in the nondirective condition. Further, the fact that gammas for pairs acquired and repeated in the graphemic task that required a "yes" response were also significantly greater in the familiarity condition than in the

nondirective condition allowed the conclusion that recognition processes in themselves did not produce the relationship. It was concluded that the positive gamma coefficients in the familiarity condition reflected a correlation between the speed of categorization and the recognition decision. The strong representation hypothesis does not naturally account for such an item-specific relation between categorization and recognition.

Besides demonstrating an item-specific relation between recognition and categorization this experiment also found more evidence of the parallel effects of a prior presentation on recognition and categorization. Discrimination of prior categorization on recognition was superior for pairs acquired by phonemic categorization as opposed to pairs acquired by graphemic categorization. This result was unequivocally obtained in the signal detection analysis of pairs requiring "yes" responses. In Chapter 2, facilitation of categorization was greater and more enduring for pairs acquired by phonemic categorization than for pairs acquired by graphemic categorization. This parallel between learning and remembering is most easily understood by the retrieval account, which holds that the same representations support both learning and remembering, and that learning and remembering require different retrieval mechanisms.

Experiment Six

The materials used in Experiment 5 did not support reductions in response times over the repetition interval used. It is possible that the inference of fluency and reliance on a fluency heuristic will be enhanced if materials were used that supported facilitated response times. This possibility is evaluated in Experiment 6 by employing the stimulus materials from Experiment 3 in which categorizations were facilitated over this repetition interval. If it is the subjects' ability to discriminate repeated categorizations on the basis of fluency of processing that determines the relation between categorization and recognition, then a stronger relation is expected in this experiment than in the previous experiment.

The experimental procedure closely followed that used in Experiment 5. As in Experiment 5, the recognition test required subjects to determine whether a word pair was categorized previously in the same task as presented for recognition. As in Experiment 5, nonanalytic and analytic bases for recognition were contrasted by instructing one group to use familiarity to recognize, and instructing another group to reconstruct the previous categorization experience. (The explicitness of the reconstruct instruction is a deviation from the procedure of Experiment 5.) The retrieval hypothesis predicts that when a

nonanalytic basis is used predominantly for recognition, a relation between categorization speed and recognition should be observed.

Two important modifications to the procedure used in Experiment 5 were made in the present experiment. First, a third instructional condition was added to aid in the interpretation of gamma coefficients. Recall that the major problem in interpreting gamma coefficients was the likely involvement of recognition processes in response times (i.e., the prolongation of response times). The concern is that a correlation between response time and recognition may be only a correlation of recognition response time and recognition decisions. In Experiment 5, an argument from logical considerations was presented to distinguish alternate interpretations of gamma. However, rather than rely on logical argument, it can be determined empirically what gamma coefficient results when only recognition response time is correlated with recognition decisions. This was accomplished by instructing a group of subjects to perform only the recognition task in the transfer phase. This group was given familiarity instruction in order to compare gamma coefficients in this condition to those obtained in the condition in which recognition by familiarity followed each categorization. It is important to the retrieval hypothesis that a stronger relation occur between joint response time and recognition decisions than

between recognition response time and recognition decisions, if it is to be concluded that categorization performance can inform recognition. It is important to the representation hypothesis that the relation between response time and recognition not be stronger when categorization is jointly performed with recognition than when recognition is performed by itself. If recognition and categorization are subserved by independent memory systems, then recognition response time should not be less correlated with recognition decisions than joint categorization and recognition response time is (Tulving, 1985).

The second principal modification to the procedure of Experiment 5 was not to cue recognition, nor to display pairs for recognition after the categorization response was made. The display was blanked out after each categorization response. This revised procedure encourages maximal reliance of recognition on the outcome of categorization; that is, subjects could not as easily consider the recognition task in isolation from the categorization task.

In summary, these procedural changes were made to set up optimal conditions for the adoption of a fluency heuristic, as well as optimal conditions for detecting its application. The principal predictions of this experiment are identical with those of Experiment 5. A correlation between response times and recognition decisions was expected in the familiarity condition, but not in the

reconstruct or recognition-only conditions. Further, it was hoped that recognition and categorization performance would differ between instructional conditions in ways indicative of a change in use of memory information.

Method

Subjects. Seventy-two subjects from an introductory psychology course participated in return for course credit. Experimental sessions lasted approximately 60 minutes.

Procedure. The same materials, apparatus, and misdirection of subjects regarding the purpose of the experiment were employed as described for Experiment 3. The same procedure was followed as that described for Experiment 3, except that after each transfer trial a verbal recognition response ("old" or "new") was required in the familiarity and reconstruct conditions. In the recognition-only condition, the recognition response was made on response keys labelled "old" and "new". No categorization response was made in the transfer phase of this condition.

In the familiarity and reconstruct conditions, subjects were told that the recognition decision was their secondary task and response time was not being recorded for it. They were instructed not to begin this secondary task

until they had made their categorization response. In the reconstruct condition subjects were told to recognize in a two-step fashion (i.e., first determine if both words were presented before, then determine if they were categorized in the same task). They were advised that imaging or reconstructing their prior experience was the most reliable method for determining the prior categorization. In the familiarity and recognition-only conditions, subjects were instructed to base their recognition decisions on a general feeling of familiarity, and to avoid deliberation. More elaborate familiarity instructions were given in the familiarity condition in order to encourage reliance on the outcome of categorization; these instructions are presented in Appendix D.

Subjects first completed the practice which contained no repetition of any word pair. There was no practice between acquisition and transfer phases. In both acquisition and transfer phases subjects were instructed to make their categorization responses quickly without sacrificing accuracy.

Results and Discussion

<u>Recognition Accuracy</u>. Because of the importance of the acquisition condition in recognition, an acquisition task factor (none, graphemic, semantic) was

substituted for the repetition condition factor in all analyses of recognition performance. If conditions having the same acquisition task are comparable, pairs in both transfer tasks that were not presented at acquisition must have the same false alarm rates.

A surprising result is that there was no effect of instructional condition, nor did it interact with any other factor. In contrast to Experiment 5, familiarity instruction did not bias subjects toward "old" responses for matching pairs. The absence of an effect of instructional condition also indicates that recognizing without first categorizing the pair was similar to recognizing after categorizing the pair. One possibility is that subjects were implicitly performing the categorization even though only recognition was required. Other possibilities are that the recognition decision did not use categorization information, and that categorization information was redundant with recognition information.

Table 17 presents the probabilities of responding "old" averaged over instructional condition. These data will be interpreted first by contrasting between categorization responses, and then by averaging over categorization response. There was an effect of categorization response, $F(1,69)=22.26$, $MSe=.03$, which indicated that more "old" responses were made to pairs requiring "yes" responses than to pairs requiring "no"

Transfer Task	Acquisition Task: Not Presented	Graphemic	Semantic
Graphemic			
Yes	.15	.34	.37
No	.11	.30	.40
Mean	.13	.32	.39
Semantic			
Yes	.08	.18	.86
No	.07	.14	.63
Mean	.08	.16	.75

TABLE 17. Mean probabilities for responding "old" to "yes" and "no" categorizations in Experiment 6.

responses. This result was also obtained in Experiments 4 and 5. As before, this effect can be interpreted as evidence of a nonanalytic influence on recognition.

Categorization response also interacted with transfer task, $F(1,69)=15.03$, $MSe=.014$, with acquisition task, $F(2,138)=9.54$, $MSe=.013$, and with both transfer and acquisition tasks, $F(2,138)=36.55$, $MSe=.012$. Except for pairs acquired and repeated in the semantic categorization, the largest advantage of pairs requiring "yes" over pairs requiring "no" responses is four percent. However, for pairs acquired and repeated in the semantic categorization, the advantage of pairs requiring "yes" over pairs requiring "no" responses is twenty-three percent. All three interactions with categorization response are attributable to this very large difference. One reason that pairs requiring "yes" responses are more memorable than pairs requiring "no" responses is that the former define a relationship. This relationship, based on semantic attributes, could add a very distinctive component to the memory representation (e.g., Humphreys, 1976).

Averaging across categorization response and transfer task in Table 17, it can be seen that, with semantic categorization at acquisition, there is a greater probability of responding "old" than in all other conditions. Although the effect of prior processing is quite large with meaningful categorization, graphemic

categorization at acquisition also produced a greater probability of responding "old" than pairs not categorized at acquisition. This "levels of processing" effect is supported in the analysis by an effect of acquisition task, $F(2,138)=466.63$, $MSe=.035$. Newman-Keuls tests demonstrated that each condition differed from the others.

Analysis of these data also produced an effect of transfer task, $F(1,69)=15.03$, $MSe=.029$, and the interaction of transfer task and acquisition task, $F(2,138)=161.28$, $MSe=.033$. Identical effects resulted when pairs not presented at acquisition were excluded from the analysis; therefore, only repeated pairs are responsible for these effects. Of these effects only the interaction is interpretable. Because of the "levels" effect, this interaction only can be understood by comparing repetition conditions having the same acquisition tasks. Looking at Table 17 it can be seen that more "old" responses were made to pairs acquired and repeated in the semantic task (.75) than to pairs acquired in the semantic task but repeated in the graphemic task (.39). Similarly, more "old" responses were made to pairs acquired and repeated in the graphemic task (.32) than to pairs acquired in the graphemic task but repeated in the semantic task (.16). These results suggest that subjects were successful in distinguishing pairs repeated in the same task from pairs repeated in the different task. Further, there was greater task

discriminability for pairs acquired by semantic categorization than by graphemic categorization. Superior task discrimination for more meaningfully acquired pairs was also obtained in Experiment 5, and parallels the magnitude of facilitation of semantic and graphemic categorization found in Experiment 3.

It was noted above that comparison of conditions having the same acquisition task is justifiable only if the false alarm rates for the two categorization tasks do not differ. However, analysis of just the pairs not presented at acquisition indicated that false alarm rates did differ. The effect of transfer task, $F(1,69)=29.20$, indicated that there was a greater probability of responding "old" if a pair was presented in the graphemic task at transfer than if the pair was presented in the semantic task at transfer. Notice, however, that the conclusion of superior task discrimination for more meaningfully acquired pairs is strengthened rather than weakened by this response bias. That is, "old" response probabilities for pairs recognized after graphemic categorization at transfer may be overestimated by about five percent. Compensation for this bias reduces the estimate of task discrimination for pairs acquired by graphemic categorization, but increases the estimate of task discrimination for pairs acquired by semantic categorization.

<u>Recognition Response Time</u>. It should be noted

that the labels for the factors in the following analyses are defined independently of categorization performance.

The mean median response times for correct recognition responses in the recognition-only condition are presented in Table 18. All effects in the analysis of these data were significant. However, only three effects are interpretable. There was an effect of acquisition task, $F(2,46)=17.92$, $MSe=82667$, such that pairs not presented at acquisition were rejected faster than repeated pairs could either be accepted or rejected. Because retrieving a memory representation for these nonpresented pairs was unlikely, the recognition decision was considerably simpler (i.e., there would be no need to deliberate upon how the pair was categorized at acquisition).

There was an effect of transfer task, $F(1,23)=18.79$, $MSe=112105$, and transfer task interacted with acquisition task, $F(2,46)=9.17$, $MSe=53000$. The effect of transfer task indicates that pairs in the semantic transfer task were recognized faster than pairs in the graphemic transfer task. The interaction indicates that this was not true of pairs not presented at acquisition.

The large difference in response time (333 ms) between pairs acquired and repeated in the semantic categorization that require a "yes" response and those requiring a "no" response is reflected in all the effects involving categorization response. There was an effect of

Transfer Task	Acquisition Task: Not Presented	Graphemic	Semantic
Graphemic			
Yes	1029	1301	1259
No	932	1361	1327
Semantic			
Yes	936	1057	925
No	993	1013	1258

TABLE 18. Mean median response times for correct recognition of "yes" and "no" categorizations in Experiment 6 (recognition-only condition).

categorization response, $F(1,23)=4.16$, $MSe=68975$, $p=.05$, categorization response interacted with acquisition task, $F(2,46)=7.98$, $MSe=43376$, with transfer task, $F(1,23)=4.64$, $MSe=42617$, and with both acquisition and transfer tasks, $F(2,46)=4.63$, $MSe=46690$. Simple effects calculated for each level of transfer task showed that an interaction of categorization response and acquisition occurred for pairs presented with the semantic categorization cue, $F(2,46)=12.17$, but not for pairs presented with the graphemic categorization cue, $F(2,46)=1.97$.

It can be argued that the large reductions in recognition response time in three of the four conditions involving repeated pairs in the semantic transfer task occurs for different reasons. Two of these conditions contain the least memorable pairs (pairs acquired by graphemic categorization), but the other condition contains the most memorable pairs (pairs acquired by semantic categorization and requiring a "yes" response; e.g., see Table 17). The pairs that are least memorable have reduced recognition times for the same reason that pairs not presented at acquisition do. More interesting is the fact that the most memorable pairs also have reduced recognition times. In contrast to all other repeated pairs, these pairs (925 ms) do not take longer to accept than it takes to reject nonpresented pairs (936 ms). One explanation is that, for pairs requiring a "yes" response that are acquired

and repeated in the semantic task, the categorization information is integral with the representation of the words (e.g., Jacoby & Brooks, 1984). For the other repeated pairs, the extra 300 ms may be attributable to a loss of, or search for, this categorization or "source" information which is not represented integrally with the representation of the pairs.

Why do pairs requiring a "yes" response that are acquired semantically, but repeated in the graphemic transfer task not also have such ready access to this integral representation of categorization information? Jacoby and Dallas (1981) argue that fluency in cognitive operations can affect the recognition decision. If subjects implicitly perform the categorization in recognizing, then the semantic relation between the pairs will be integral only with pairs repeated in the semantic transfer task. All experiments using the semantic categorization task have shown large facilitation effects for repeated semantic categorization. It is possible that this fluency informed recognition and allowed the 300 ms shortening of the search for "source" information. Another explanation, derived from Humphreys' (1976) model of recognition memory, is that the presence of relational information can enhance recognition performance, but it may be used only if appropriately cued at retrieval.

<u>Categorization Response Time</u>. Analysis of

median response times for pairs in the acquisition phase and once-presented pairs in the transfer phase showed an effect of transfer task, $F(1,46)=36.26$, $MSe=231158$, and an interaction of transfer task with categorization response, $F(1,46)=8.52$, $MSe=31150$. These effects indicate that the graphemic categorization (1542 ms) took longer to perform than the semantic categorization (1246 ms), and that "no" categorizations (1291 ms) took longer than "yes" categorizations (1201 ms) for the semantic task, but not for the graphemic task (1534 and 1549 ms respectively). The only other effect was an effect of experimental phase, $F(1,46)=47.63$, $MSe=188016$; pairs in the acquisition phase (1246 ms) were categorized faster than pairs in the transfer phase (1534 ms). The requirement to make a recognition decision after categorization prolongs categorization, and equally so for both graphemic and semantic categorization. There were no effects of instructional condition.

As with once-presented pairs, there were no effects of instructional condition on response times for pairs categorized in the transfer phase. The mean median response times for these pairs, averaged over instructional condition, are presented in Table 19. There was an effect of transfer task, $F(1,46)=30.95$, $MSe=408167$, and an interaction of transfer task and categorization response, $F(1,46)=38.99$, $MSe=70862$. In agreement with once-presented pairs, graphemic categorization took longer than semantic

Transfer Task	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Graphemic			
Yes	1684	1903	1813
No	1656	1658	1649
Semantic			
Yes	1397	1434	1264
No	1449	1447	1593

TABLE 19. Mean median response times for "yes" and "no" categorizations in the transfer phase of Experiment 6.

categorization, and "no" categorizations took longer than "yes" categorizations in the semantic task. In contrast to once-presented pairs, "yes" categorizations took longer than "no" categorizations in the graphemic task. This latter effect may be attributable to recognition rather than to categorization processes, or perhaps an interaction between the two tasks.

If recognition processes are responsible for the interaction of categorization response and transfer task, then repeated pairs should have longer response times (reflecting the search for prior categorization task) than once-presented pairs. In support, there was an interaction of categorization response and repetition condition, $F(2,92)=12.53$, $MSe=38919$, and a triple interaction of transfer task, categorization response, and repetition condition, $F(2,92)=9.95$, $MSe=51902$. Simple effects were calculated for each transfer task. The interaction of categorization response and repetition condition was obtained for semantic categorizations, $F(2,92)=20.13$, and for graphemic categorizations, $F(2,92)=5.23$. For semantic categorizations, Dunnett's tests showed that pairs requiring a "yes" response that were repeated in the same task were categorized faster than once-presented pairs; those repeated in the different task were not. This difference should be interpreted as the facilitation of categorization originally observed in Experiment 3 although it is much smaller in

magnitude. Dunnett's tests showed that pairs requiring a "no" response that were repeated in the same task were categorized slower than once-presented pairs; pairs repeated in the different task were not. A similar effect was obtained in the recognition-only condition, but not Experiment 3, so this difference should be attributed to recognition processes. For graphemic categorizations, Dunnett's tests showed that pairs requiring a "yes" response that were repeated in either the same or the different task were categorized slower than once-presented pairs. Because these effects were not observed in Experiment 3, they can be attributed to recognition processes as well. There were no differences among pairs requiring a "no" response.

In summary, with the exception of two experimental conditions (see below), categorization response times were prolonged in the same conditions as recognition response times were. It is argued that this prolongation can be attributed to the search for "source" information needed for the modified recognition test used in these experiments. This conclusion implies that the prolongation of categorization response time observed when a subsequent recognition decision is made is caused wholly, or at least partially, by processes specific to recognition.

The two repetition conditions in the instructional conditions requiring categorization at transfer that did not demonstrate the same prolongation as obtained for

recognition-only were pairs requiring a "no" response that were repeated in the graphemic task. One explanation is that there were a large number of incorrect recognition responses (fast rejections or acceptances) that were included in categorization response times. However, categorization response times conditionalized on correct recognition do not support this interpretation. Another possibility is that information from categorization (e.g., nonfluent or unfamiliar) allowed subjects to truncate the search for "source" information in recognition. If nonfluent categorization did inform recognition, then learning and remembering can be related as the causal version of the retrieval hypothesis suggests.

Categorization Errors. There was an effect of instructional condition, $F(1,46)=9.37$, $MSe=.017$; familiarity instruction increased categorization errors (.10) relative to the reconstruct condition (.06).

The mean proportions of categorization errors, averaged over instructional condition (viz. familiarity and reconstruct conditions), are presented in Table 20. More errors were made on pairs requiring a "yes" response than on pairs requiring a "no" response. This effect also occurred in Experiment 3 (for semantic categorizations) and indicates that subjects were biased to respond "no". The only exception to less accurate categorization of pairs requiring "yes" responses occurs in the condition in which semantic

Transfer Task	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Graphemic			
Yes	.11	.13	.10
No	.06	.05	.05
Semantic			
Yes	.14	.13	.04
No	.05	.05	.06

TABLE 20. Mean proportion of "yes" and "no" categorization errors in the transfer phase of Experiment 6.

categorization is required at acquisition and at transfer. This effect is evidence of categorization learning. In support of this interpretation, there was an effect of categorization response, $F(1,46)=33.30$, $MSe=.012$, an effect of repetition condition, $F(2,92)=9.65$, $MSe=.005$, an interaction of categorization response and repetition condition, $F(2,92)=12.72$, $MSe=.005$, and the triple interaction of categorization response, repetition condition, and transfer task, $F(2,92)=7.08$, $MSe=.006$. The triple interaction was not observed in Experiment 3: learning was observed for repeated graphemic categorizations when recognition did not follow categorization. Recognition may have interfered with categorization.

Gamma Coefficients. Gammas for once-presented pairs were not analyzed because they could not be calculated for about half the subjects. Response times in the recognition-only condition could not be conditionalized on correct categorization because no categorization responses were made in the transfer phase. Instead, all recognition response times were correlated with recognition decisions.

The mean gamma coefficients for each type of categorization response in each instructional condition are presented in Table 21. Positive gammas are associated with pairs requiring "yes" responses and negative gammas are associated with pairs requiring "no" responses. However, gammas for pairs requiring "yes" responses are much more

Categorization Response	Instructional Condition: Recognition Only	Reconstruct	Familiarity
Yes	.07	.02	.26
No	-.20	-.04	-.22

TABLE 21. Mean gamma coefficients for Experiment 6.

positive in the familiarity condition than in either the reconstruct or recognition-only conditions. Analysis of these data supported this interpretation. There was an effect of categorization response, $F(1,69)=40.53$, $MSe=.262$, and categorization response interacted with instructional condition, $F(2,69)=8.15$. The interaction was interpreted by computing simple effects for each categorization response. For "yes" responses there was an effect of instructional condition, $F(2,69)=4.47$, but no significant effects for "no" responses. Neuman-Keuls tests showed that gammas for pairs requiring "yes" responses in the familiarity condition were more positive than in either the reconstruct or recognition-only conditions. The gammas in these latter two conditions did not differ from each other, both being approximately zero. Therefore, as in Experiment 5, an item-specific relation between response time and recognition decisions was obtained only if familiarity instruction was given. This relationship cannot be caused by recognition response times because gammas in the recognition-only condition were less positive than in the familiarity condition. This conclusion is supported by the planned comparison of gammas for pairs requiring "yes" responses that were acquired and repeated in the graphemic categorization. Gammas in the familiarity condition (.25) were more positive than in the reconstruct condition (-.21), and marginally so than in the recognition-only condition

(-.06). A relation between speed of categorization and recognition decisions that is dependent on the type of retrieval strategy for recognition is consistent with the retrieval hypothesis. However, such a relationship is inconsistent with the strong representation hypothesis of remembering and learning.

Table 22 presents the mean gammas averaged over categorization response. Analysis of these data indicated that transfer task interacted with repetition condition; $F(1,69)=14.39$, $MSe=.333$, and both factors interacted with instructional condition, $F(2,69)=3.51$. Simple effects calculated for each repetition condition showed that transfer task interacted with instructional condition only for pairs repeated in the different task; $F(2,69)=5.15$. Simple effects calculated for each transfer task demonstrated an effect of instruction only for pairs acquired by graphemic categorization but repeated in the semantic categorization; $F(2,69)=4.57$. Neuman-Keuls tests indicated that the gamma for these pairs was more negative in the recognition-only condition (-.33) than in the reconstruct condition (.00) or in the familiarity condition (.02). In the recognition-only condition, pairs acquired by graphemic categorization but repeated in the semantic categorization were correctly and quickly rejected, and only incorrectly accepted after much deliberation. Therefore, without categorization before recognition, poorly encoded

Transfer Task	Instructional Condition: Recognition Only	Reconstruct	Familiarity
Graphemic			
Different	.13	-.05	.03
Same	-.15	-.17	-.03
Semantic			
Different	-.33	.00	.02
Same	.10	.17	.06

TABLE 22: Mean gamma coefficients for pairs repeated in the same or the different task in Experiment 6.

pairs were quickly rejected, whereas with categorization before recognition, this relationship was not obtained. This conclusion means that, at least for some repetition conditions, subjects were not implicitly categorizing in the recognition-only condition

Table 22 shows that the interaction of transfer task with repetition condition cannot be entirely attributed to pairs repeated in the different task (i.e., the triple interaction). Pairs repeated in the same task also differ between transfer tasks. For graphemic categorizations, the gammas for either categorization response were generally negative; the only exception was noted above: pairs in the familiarity condition that required a "yes" response. For semantic categorizations, the positive gamma for pairs requiring "yes" responses generally outweighed the negative gamma for pairs requiring "no" responses. Therefore, the above interpretation of the triple interaction can be extended to pairs repeated in the same task: Without categorization prior to recognition and without familiarity instruction for recognition, poorly encoded pairs were implausible candidates for recognition and were quickly rejected.

In sum, the effects in gamma indicate that very different relationships occur when recognition response times are correlated with recognition decisions. The relationship is not as positive as the relation between

joint categorization and recognition response times and recognition decisions. This result supports the interpretation of gammas for pairs in the familiarity condition that require a "yes" response as a relation between categorization speed and recognition decisions. This is an important conclusion because it is inconsistent with the strong representation hypothesis. If recognition and categorization are subserved by independent memory systems, then recognition response times should not be less correlated with recognition decisions than joint categorization and recognition response times are. In contrast, the dependence of this relationship on a nonanalytic recognition strategy was a prediction of the retrieval hypothesis of remembering and learning.

The prediction that a relation between categorization speed and recognition would occur under familiarity instruction was confirmed. A second prediction that recognition and categorization performance would differ between instructional conditions in ways indicative of a change in the use of memory information was not. Facilitation of semantic categorization response times did not increase the differential effects of strategy. Except for gamma coefficients, differential effects of strategy were eliminated completely. In Experiment 5, the increased likelihood of responding "old" to pairs requiring "yes" responses in the familiarity condition was taken as evidence

or nonanalytic processing. Recognition in the familiarity condition in the present experiment did not differ from the other instructional conditions. However, it need not be concluded that familiarity instruction failed to make subjects adopt a more nonanalytic basis for recognition. Because semantic encoding produces such an easily retrieved memory, the contribution from this source to remembering may have outweighed evidence of reliance on a fluency heuristic.

Besides facilitation of categorization response times for pairs requiring "yes" responses that were acquired and repeated in the semantic task, these pairs also showed a huge recognition advantage over the corresponding pairs that required "no" responses. This latter effect, attributable to semantic relational information, parallels the presence of categorization fluency in that it allows excellent discrimination of the prior categorization task. In these experiments, the more meaningful the prior processing, the greater was the categorization learning and the better was explicit memory for prior categorization. Beyond this parallel, is there evidence that categorization learning participated in the explicit memory decision?

Consider just the recognition-only response times. Pairs not presented at acquisition were responded to quickest because no decision about prior categorization was involved. Rejecting or accepting repeated pairs in most conditions took about 300 ms longer than rejecting pairs not

presented at acquisition. This additional time probably was required to determine what the prior categorization was. However, pairs requiring a "yes" response that were acquired and repeated in the semantic task did not require this additional time. This result suggests that, for these pairs, prior categorization information was integral with pair recognition. One explanation might be that fluency of semantic categorization ("semantic familiarity") was informing recognition. This explanation requires that subjects implicitly categorize these pairs during recognition. Alternatively, an interaction between learning and remembering could be denied by claiming that retrieval of relational or interitem information (e.g., Humphreys, 1976; Mandler, 1980) was responsible for the reduction in recognition response times in this condition.

In the instructional conditions in which categorization immediately preceded recognition, rejecting or accepting repeated pairs also required additional categorization time relative to once-presented pairs. Because this effect was not obtained without the recognition requirement (see Experiment 3), this effect can be attributed to recognition processes occurring during categorization. However, as with recognition-only, if pairs were acquired and repeated in the semantic task, they did not require additional time to make a "yes" response. For these pairs, the fluency of categorization could have aided

recognition of the prior categorization. Interpretation of this effect as an interaction of categorization learning and remembering is corroborated by an effect in pairs requiring a "no" response. If these pairs were repeated in the graphemic task, they did not require additional time. However, additional time was required in the recognition-only condition. Recognition of these pairs was easier if immediately preceded by categorization. This result suggests that the lack of categorization fluency for these pairs aided the recognition decision.

Concluding that categorization learning informed recognition (i.e., the causal version of the retrieval hypothesis) also requires the conclusion that subjects were implicitly categorizing in the recognition-only condition. If categorization provided additional evidence for recognition, then removal of this information in the recognition-only condition should have correspondingly reduced recognition accuracy relative to the joint task condition. For example, Glisky and Rabinowitz (1985) argued that the exact repetition of acquisition operations enhanced recognition. However, repetition of the categorization before recognition (familiarity and reconstruct conditions) did not enhance recognition relative to the recognition-only condition in the present experiment. Assuming that subjects implicitly categorized before recognition would explain why there was no difference in recognition accuracy between

instructional conditions, and why additional recognition time was not taken for pairs requiring "yes" responses that were repeated in the semantic categorization in the recognition-only condition.

Several observations suggest that subjects were not implicitly categorizing in the recognition-only condition. These arguments favour interpretation of the relation between categorization and recognition in terms of the noncausal version of the retrieval hypothesis. First, when subjects were asked after the experiment whether they were categorizing in order to make the recognition decision, only one out of twenty-four said that they had. However, it is possible that implicit categorization is subjectively unlike explicit categorization. Second, response time in the recognition-only condition was much shorter than obtained in the joint task conditions (see Tables 18 and 19). Can this difference be accounted for by just the act of making an overt categorization response? Third, if implicit categorization is contained in recognition response times, then similar gamma coefficients to those obtained in the familiarity condition should have been obtained. Above, several important differences were noted. However, the chief differences between the familiarity and recognition-only conditions for matching pairs were between those acquired by graphemic categorization; virtually identical gamma coefficients were obtained for those pairs

acquired by semantic categorization. Therefore, it is possible that subjects performed implicit semantic categorization, but not implicit graphemic categorization, during recognition in the recognition-only condition.

Although it is not clear whether the causal or the noncausal version of the retrieval hypothesis is more consistent with these data, it is clear that the strong representation account of remembering and learning is not consistent with these data.

Summary

Both experiments in this chapter have demonstrated an item-specific relation between categorization response time and recognition of pairs presented in the same task. Those pairs that were categorized fastest were also more likely to be recognized as "old". Planned comparisons in both experiments, and a between-subject comparison in Experiment 6 demonstrated that recognition processes could not account for the relationship. A relation between categorization and recognition is inconsistent with the strong representation account of remembering and learning. Although it is possible that there are independent representations for learning and remembering, this result suggests that <u>some</u> memory representations support

both learning and remembering. The strong representation account cannot allow overlapping use of memory representations because it claims that learning is supported by a memory system distinct and independent from the memory system supporting remembering (e.g., Cohen, 1984).

Both experiments demonstrated that the relation between categorization and recognition depended on the use of a nonanalytic retrieval strategy for recognition. It was assumed that familiarity instruction would make adoption of a nonanalytic strategy more likely, and indeed, evidence from other sources was obtained in one experiment that familiarity instruction had achieved this purpose. The retrieval hypothesis of remembering and learning proposes that remembering and learning differ only in the retrieval processes used, not in the type of memory representations that are retrieved. This account predicts that when a nonanalytic decision strategy is used, information retrieved from memory will be shared by the tasks, and a relationship will be obtained (Jacoby & Brooks, 1984; Jacoby & Dallas, 1981). Therefore, the effect of instruction supports the retrieval account.

The effect of instruction also demonstrates that both statistical independence and dependence can be obtained on both sets of materials used in these experiments. Therefore, it is unlikely that item differences, one source

or artifactual relationships in contingency analyses, are responsible for the relation between categorization and recognition. It is also unlikely that subject differences are responsible for the relationship. Subject differences between instructional conditions were obtained in Experiment 5. Subjects in the familiarity condition of this experiment were faster responders than those in the nondirective condition. Other experiments that I have conducted have convinced me that subjects participating later in the semester have different purposes for serving in experiments than subjects participating earlier in the semester. Whereas the former often wish to get this course requirement out of the way, the latter are often more interested in the experiment itself and are therefore more conscientious. On the chance that this subject variable may have been responsible for the relationship in Experiment 5 (subjects in the familiarity condition were obtained late in the semester), subjects in the familiarity condition in Experiment 6 were obtained early in the semester whereas those in the reconstruct condition were obtained late in the semester. Although not significant, subjects did respond slower in the familiarity condition in Experiment 6 than subjects in the reconstruct condition, yet a relation between categorizing and recognizing was still obtained. A final source of artifactual relationship in contingency analyses is differences in subject-item interactions. The

purpose of the instructional manipulation was to control this interaction as much as possible (cf. Hintzman, 1980). This chapter has demonstrated that differential interaction between subjects and items can produce a relation between categorization and recognition. Rather than artifact, however, this effect has important implications for theories of remembering and learning.

The reason that familiarity instruction produced a relation between speed of categorization and recognition decisions varies over versions of the retrieval hypothesis. The causal version asserts that judgements of familiarity rely on information not definitionally relevant to recognition (e.g., the speed of categorization). The noncausal version might suggest that familiarity instruction causes a reduction in verification processes typically employed in recognition. Word pairs that are well-represented and well-retrieved are most subject to verification processes, thus slowing response times for the pairs that are recognized as "old". The net effect of verification is to obscure relations between response times and recognition decisions in just those pairs in which a relationship could be demonstrated otherwise. With familiarity instruction, these verification processes are minimized, and the relation between categorization response time and recognition decisions revealed.

Although these two alternative accounts cannot be

distinguished by the present experiments, some evidence in support of the causal account was obtained in Experiment 6. In the transfer phase, both recognition-only response times and joint categorization and recognition response times were slower for repeated pairs than for once-presented pairs. However, in all instructional conditions, decisions were not slowed for the least memorable pairs (pairs acquired graphemically and repeated in the semantic task; presumably these pairs acted like once-presented pairs), nor for the most memorable pairs (pairs acquired and repeated in the semantic task that required "yes" responses). These latter pairs are of interest because they consistently support facilitation of categorization on repetition. It can be argued that recognition decisions for these pairs were not slower than once-presented pairs because categorization learning informed recognition. One problem for this interpretation is that recognition of these pairs was not slowed when categorization was not performed before recognition (i.e., in the recognition-only condition). Therefore, in order to maintain that learning informed remembering, it must be assumed that, in the recognition-only condition, semantic categorization was implicitly performed during recognition.

Although facilitated categorization of pairs requiring "yes" responses that were acquired and repeated in the semantic task may have enabled recognition decisions not

to be slowed. Experiment 6 demonstrated that an absence of facilitated categorization could inform subsequent recognition. Whereas pairs requiring "no" responses that were repeated in the graphemic task were responded to slower than once-presented pairs in the recognition-only condition, they were not responded to slower when categorization was performed just before recognition. If an absence of categorization fluency can inform recognition, then the presence of categorization fluency might also inform recognition. The possibility of such an interaction between learning and remembering is allowed by the retrieval hypothesis, but not by the strong representation hypothesis.

It may be more than coincidental that the condition in which categorization was consistently facilitated by repetition was also the condition in which recognition for the prior categorization was best. It can be argued that the huge recognition advantage of "yes" over "no" responses for pairs acquired and repeated in the semantic categorization was in part due to the use of semantic categorization fluency for recognition. A recognition advantage of this size was not obtained in any experiment without speeding of categorization also present.

It can be concluded from Experiments 5 and 6 that an increase in categorization fluency paralleled an increase in the ability to discriminate the prior categorization. It

may seem puzzling that the better categorization learning in Experiment 6 also did not strengthen the relation between recognizing and categorizing. Gamma coefficients in both experiments were of comparable magnitudes. This result is less puzzling than it seems. The gamma coefficient used to describe the relationship divided items in each experimental condition into those categorized quicker than average and those categorized slower than average. This transformation of response time has little to do with learning, so it is not surprising that the relation between recognizing and categorizing was not a function of the degree of categorization learning. Had it been possible to relate facilitation of categorization speed with recognition decisions a stronger relation probably would have been obtained for pairs acquired and repeated in the semantic task. However, facilitation of categorization speed could not be inferred from individual items, primarily because of the context manipulation (i.e., subtracting initial response times from repeated response times was not possible for the items that changed context). Although the reliability of single item facilitation scores is doubtful, a better experiment for investigating the relation between remembering and learning would allow the measurement of learning, in addition to remembering, for single items. This could be accomplished by omitting the context manipulation.

The extent to which gamma coefficients do not reflect categorization learning was increased by computing gammas separately for each repetition condition of each transfer task. Whereas categorization learning was inferred by comparing performance on repeated pairs to once-presented pairs, gamma coefficients ignore the contrast between repeated and once-presented pairs. Although previous experiments investigating the relation between transfer performance and recognition have computed the relation separately for each repetition condition (e.g., Johnston et al., 1985), an analysis taking account of categorization learning would combine repeated and once-presented pairs before determining which items were categorized faster or slower than average. From the perspective of a fluency heuristic, combining repetition conditions is appropriate on theoretical grounds because subjects would be expected to judge fluency relative to the transfer task rather than to a specific repetition condition within that task. In fact, the subjects' recognition task is to determine which repetition condition a pair is in, so they could not judge fluency relative to what it is they want to determine.

It is obvious that computing gamma coefficients by combining repetition conditions within each transfer task would produce a much stronger relation between categorization speed and recognition for the semantic, as opposed to the graphemic transfer task. Response times for

pairs requiring "yes" responses that were acquired and repeated in the semantic task were decreased over a hundred milliseconds by repetition, and approximately 80 percent were recognized as being repeated. All other pairs presented in the semantic transfer task were not facilitated and they were falsely recognized as being repeated only 10 to 20 percent of the time. Combining these two groups of items could not fail to produce larger gamma coefficients than those produced from a similar combination of items that were presented in the graphemic transfer task (i.e., because of the many fast "old" and few slow "old" responses in the semantic transfer task). However, this assessment of the relation between categorizing and recognizing is inappropriate for these data on a number of grounds. The biggest problem is that response times for once-presented and repeated pairs were differentially affected by the secondary recognition task. Combining these response times would make interpretation of correlations impossible (e.g., repeated "yes" graphemic categorizations were slowed by several hundred milliseconds compared to once-presented). Further, pairs repeated in a different categorization task could not be included in such an analysis because different acquisition conditions lead to different item false alarm rates. A slow "old" decision is much more likely if pairs are acquired semantically and repeated graphemically, than if pairs are acquired graphemically and repeated

semantically.

The accepted and conservative method of calculating relationships for each experimental condition has shown that faster than average categorization of pairs can be associated with "old" recognition decisions. This statistical relationship is consistent with the retrieval hypothesis. A functional relationship, consistent with the retrieval hypothesis, was obtained also. Increases in categorization fluency were paralleled by increases in the ability to discriminate the prior categorization. The fact that the strength of the statistical relationship was not a function of the magnitude of categorization fluency is understandable because correlations between categorization speed and recognition were calculated so as to ignore categorization fluency. Considerations on other grounds suggest that, if a correlation between categorization fluency and recognition could be calculated, it would be much stronger when fluency is present than when absent.

Finally, with respect to two-factor theories of recognition (e.g., Gillund & Shiffrin, 1984; Jacoby & Dallas, 1981; Mandler, 1980), the results from the experiments reported in this chapter suggest that two retrieval processes in recognition exist because different effects were obtained when subjects were instructed to use primarily only one of the retrieval processes. In conjunction with this instructional manipulation, the

modified recognition test also may have been responsible for separating the effects of the two retrieval processes. Theoretically, this test can be completed by two nonoverlapping retrieval processes: using the word pair as a cue to reconstruct the prior event in which the pair was categorized, or judging the familiarity of the present categorization. The purpose of the instructional manipulation was to bias which of these theoretically nonoverlapping retrieval processes was to be employed.

Empirically, results from both experiments were able to distinguish between two retrieval processes. Subjects took longer to respond to pairs acquired in the most meaningful categorization in the nondirective condition of Experiment 5, this extra time perhaps used for more extensive reconstruction of the prior categorization. Familiarity instruction in Experiment 5 also caused subjects to make more "old" responses if pairs matched, evidence that recognition decisions were based more on information irrelevant to prior occurrence (i.e., a nonanalytic basis), than on information definitionally relevant to prior occurrence. Finally, the most convincing evidence that judging familiarity and reconstructing context are different retrieval processes is that, in both Experiment 5 and 6, a relation between recognition and categorization was observed only in the familiarity condition. Therefore, with this modified recognition test, the evidence suggests that

judging familiarity and reconstructing prior context are separable retrieval processes.

CHAPTER FIVE

Judging the Fluency of Word Categorization

The primary issue of this chapter is whether judging fluency of word categorization produces equivalent effects to recognizing by judging familiarity. It is essential to the causal version of the retrieval hypothesis that subjects can infer fluency from task performance. Otherwise, fluency could not be used as a basis for recognition. Evidence that subjects are capable of judging fluency would be the occurrence of positive gamma coefficients (i.e., "fluent" judgements associated with fast categorizations, and "not fluent" judgements associated with slow categorizations). Further, if judging fluency of categorization is the sole determinant of judged familiarity, then the magnitude and pattern of gamma coefficients should resemble those obtained when subjects actually recognized on the basis of familiarity.

Substitution of fluency of categorization judgements for familiarity judgements will address two other issues essential to the causal account. First, if fluency of categorization can serve as a basis for judging familiarity, then fluency judgements should discriminate once-presented

items from repeated items. Second, if fluency of categorization is the only basis for familiarity judgements, then recognition judgements should follow categorization. However, the prolongation of categorization response times by recognition suggests that recognition preceded, or was concurrent with, categorization. Other bases for recognition are available before categorization (e.g., familiarity with individual words); these can be used as cues for additional memory retrieval or as bases for fluency judgements independent of categorization fluency. Interpreting the prolongation of categorization in this way does not mean that categorization fluency did not serve as a basis for recognition, but it does reduce the importance of this source of information in familiarity judgements.

Another possible interpretation is that categorization is slowed by secondary tasks in general. If a secondary task other than recognition (e.g., judging fluency) also slows categorization, then it is possible that the prolongation is caused by something like a general depletion in processing resources, or perhaps, a confusion in sequencing responses. For example, Eysenck and Eysenck (1979) have demonstrated that a concurrent signal detection task takes up processing resources for categorization tasks that are similar to those employed in these experiments. However, their experiments show that more capacity is used

for more meaningful categorizations; analyses of the data presented in Chapter 4 did not show that there was greater prolongation for more meaningful categorizations.

Judging fluency is a good choice for an alternative secondary task to recognition because it has been assumed that this is an important component in the familiarity conditions of the recognition task. If this secondary task does not slow categorization, then it suggests that a component of familiarity judgements does not rely on categorization fluency.

Experiment Seven

The primary goals of Experiment 7 were to determine whether subjects are capable of judging categorization fluency, whether such judgements discriminate repeated from once-presented items, and whether the requirement to make such judgements prolongs categorization.

The stimulus materials and tasks of Experiment 3 were employed in this experiment to ensure that response times were facilitated in at least one repetition condition. A minimal requirement for a causal account is that a greater proportion of "fast" judgements occur in conditions in which categorization response time is facilitated by repetition (viz. pairs acquired and repeated in the semantic task).

categorization accuracy, but not response time, for pairs acquired and repeated in the graphemic task was also facilitated by repetition. Further, pairs in this condition were accurately recognized by judging familiarity, and fast categorizations were associated with "old" recognition decisions. If the causal account is a sufficient explanation of judging familiarity, then a greater proportion of "fast" judgements should occur in this repetition condition as well.

Method

Subjects. Twenty-four university students from an introductory psychology course participated in return for course credit. Experimental sessions lasted approximately 45 minutes.

Procedure. The same materials, apparatus, and misdirection of subjects regarding the purpose of the experiment described for Experiment 3 were employed. The same procedure was followed as that described for Experiment 3 except that after each transfer trial a verbal fluency or categorization judgement ("fast" or "slow") was given. Instead of reading the full familiarity instructions to subjects (see Appendix D), portions referring to recognition memory were omitted, leaving only instruction on judgement of categorization fluency.

Subjects first completed the practice which contained no repetition of any word pair. There was no practice between acquisition and transfer phases. In both the acquisition and transfer phases subjects were instructed to make their categorization responses quickly without sacrificing accuracy.

Results and Discussion

Fluency Judgements. In order to compare fluency judgements to recognition performance in Experiment 6, an acquisition task factor (none, graphemic, semantic) was substituted for the repetition condition factor.

The mean probabilities for responding "fast" are presented in Table 23. There was an effect of categorization response, $F(1,23)=47.54$, $MSe=.061$; a "fast" judgement was more likely for pairs requiring "yes" responses than pairs requiring "no" responses. This effect parallels recognition performance in that "old" judgements are more likely for pairs requiring "yes" responses than pairs requiring "no" responses. There was an effect of transfer task, $F(1,23)=54.26$, $MSe=.039$; "fast" judgements were more likely for pairs categorized semantically at transfer than pairs categorized graphemically at transfer. This effect does not parallel recognition performance because "fast" judgements were more likely for all

repetition conditions in the semantic transfer task, not just those acquired and repeated in the semantic task. Categorization response interacted with transfer task, $F(1,23)=5.95$, $MSe=.028$. This interaction, shown in Table 23, does not compromise conclusions about either main effect discussed above. This interaction indicates that the advantage of pairs requiring "yes" responses over pairs requiring "no" responses in the likelihood of being called "fast" was greater if the transfer task was semantic (.23) than if it was graphemic (.14). A similar result was obtained in Experiment 6 except that acquisition task also interacted with transfer task and categorization response. Whereas the huge recognition advantage of pairs requiring "yes" responses over pairs requiring "no" responses was restricted to pairs acquired and repeated in the semantic task in Experiment 6, the advantage in fluency judgements is true of any pair (even pairs not presented at acquisition) presented in the semantic task in the transfer phase of Experiment 7. Subjects in Experiment 7 appear to have had a bias to respond "fast" if the pair matched and required semantic categorization. Unlike recognition judgements in Experiment 6, fluency judgements, in this respect, were not predicated on the prior experience with the pair.

Finally, there was an effect of acquisition task, $F(2,46)=4.90$, $MSe=.019$; pairs acquired semantically were more likely to be called "fast" (.71) than pairs acquired

Categorization Response	Transfer Task	
	Graphemic	Semantic
Yes	.65	.87
No	.51	.64

TABLE 23. Mean probabilities for responding "fast" in Experiment 7.

graphemically (.66) or pairs not presented at acquisition (.64). This result indicates that the prior experience with a pair did influence the likelihood of subsequent categorization being experienced as fluent. Whereas prior graphemic categorization did not make subsequent categorization seem more fluent than pairs categorized for the first time, prior semantic categorization did make subsequent categorization (semantic or graphemic) seem more fluent than pairs categorized for the first time.

In conclusion, fluency judgements did discriminate once-presented pairs from repeated pairs, but only if those pairs were acquired semantically. This result is a minimal requirement for the causal account. However, these results indicate that the causal account might not be a sufficient explanation of judging familiarity because the proportion of "fast" judgements were not greater in the conditions in which categorization was not speeded yet categorization learning occurred (in accuracy), recognition occurred, and fast categorizations were associated with "old" recognition decisions (see Experiments 3 and 6). Although it is possible that judging familiarity does rely on categorization fluency for pairs acquired in the semantic task, this explanation is not tenable for pairs acquired and repeated in the graphemic task. In defence of the causal account, recognition of these latter pairs may have been based on fluency in processing individual words rather than

on categorization fluency. This explanation would leave the association of fast categorizations and "old" recognition decisions unaccounted for.

The data from pairs not presented at acquisition show the importance of emphasizing relative rather than absolute fluency as a basis for recognition judgements (e.g., Jacoby & Dallas, 1981). For example, the probability of a "fast" judgement for nonstudied pairs was .64, whereas the probability of an "old" judgement for these same pairs in Experiment 6 was .10. Clearly, a judgement of categorization fluency does not automatically translate into a judgement of familiarity. Rather, facilitation in categorization must be computed relative to the expected processing requirements for items in that particular class. This relative increase in fluency could then be used as a basis for familiarity judgements.

Categorization Response Time. The response times for pairs presented in the acquisition phase and once-presented pairs in the transfer phase are presented in Table 24. No analysis of these data was performed because it is obvious that categorization of pairs in the transfer phase were not prolonged by fluency judgements (relative to pairs categorized in the acquisition phase). Therefore, prolongation of categorization is not caused by secondary tasks in general. Prolongation of categorization appears to be specific to secondary recognition decisions. Rather than

Transfer Task	Experimental Phase	
	Acquisition	Transfer
Graphemic		
Yes	1350	1197
No	1451	1282
Semantic		
Yes	988	908
No	1179	1057

TABLE 24. Mean median response times for "yes" and "no" categorizations of pairs in the acquisition phase and once-presented pairs in the transfer phase of Experiment 7.

depleting processing capacity, the secondary recognition decision may cause the prolongation of categorization because of concurrent retrieval of memory information. This conclusion implies that familiarity judgements do not rely only on categorization fluency.

The analysis of pairs categorized in the transfer phase produced effects similar to those of Experiment 3 in which only categorization was performed in the transfer phase. There was an effect of transfer task, $F(1,23)=37.79$, indicating that the graphemic categorization took longer to perform than the semantic categorization. The mean median response times for each experimental condition are presented in Table 25. There was an effect of categorization response, $F(1,23)=24.99$; for both tasks, pairs requiring "no" responses took longer to categorize than pairs requiring "yes" responses. More importantly, there was an effect of repetition condition, $F(2,46)=6.43$, but this factor interacted with transfer task, $F(2,46)=3.49$, and with categorization response, $F(2,46)=5.43$. These interactions indicate that although pairs repeated in the same task were more quickly categorized than either once-presented pairs or pairs repeated in the different task, this was only true of semantic categorizations, and it was more true of "yes" than "no" responses. This interpretation was confirmed by computing simple effects for each transfer task. For graphemic categorization, no effects of repetition condition

Transfer Task	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Graphemic			
Yes	1197	1265	1128
No	1282	1321	1314
Semantic			
Yes	908	879	704
No	1057	1002	990

TABLE 25. Mean median response times for "yes" and "no" categorizations in the transfer phase of Experiment 7.

approached significance. For semantic categorization, there was an effect of repetition condition, $F(2,46)=19.47$, and repetition condition interacted with categorization response, $F(2,46)=8.97$. The application of Dunnett's tests showed that pairs requiring "yes" responses were categorized faster than once-presented pairs (a difference of 204 ms), whereas pairs requiring "no" responses were 5 ms short of significant facilitation (a difference of 67 ms). No condition in which pairs were repeated in the different task was facilitated. Apparently, the secondary task of judging fluency of categorization interfered little, if at all, with performing the categorization.

Errors. Analysis of the proportion of categorization errors indicated that more errors were made on graphemic categorizations (.13) than semantic categorizations (.08), $F(1,23)=20.11$, $MSe=.01$. This effect, paralleling response time, indicates that graphemic categorizations were more difficult than semantic categorizations to perform.

Table 26 presents the mean proportion of categorization errors averaged over the transfer task. In contrast to response time, more errors were made on pairs requiring "yes" responses than pairs requiring "no" responses, $F(1,23)=5.91$. This effect occurred in both Experiments 3 and 6, and indicates that subjects were in general biased towards "no" responses. In addition, there

Categorization Response	Repetition Condition: Once-Presented	Task Repeated In: Different	Task Repeated In: Same
Yes	.14	.13	.08
No	.08	.10	.09

TABLE 26. Mean proportion of categorization errors in transfer phase of Experiment 7.

was an effect of repetition condition, $F(2,46)=3.19$, $MSe=.008$, and repetition condition interacted with categorization response, $F(2,46)=3.54$, $MSe=.007$. Although repetition did not reduce errors for pairs requiring "no" responses, pairs requiring "yes" responses that were repeated in the same task were categorized more accurately than once-presented pairs. The application of Dunnett's test confirmed that there was a reduction in errors for pairs requiring "yes" responses that were repeated in the same task, but no reduction for pairs requiring "yes" responses that were repeated in the different task. This result indicates that there was categorization learning, and that it was specific to the categorization context.

Gamma Coefficients. The gamma coefficient was used to describe the relation between categorization speed (fast or slow) and fluency decisions ("fast" or "slow"). Gammas for initial categorizations were all highly positive, ranging between .81 and .91. The occurrence of large and positive gamma coefficients was true of all repeated categorizations as well. The lowest gamma (.61), obtained in the condition in which pairs requiring "no" responses were acquired and repeated in the semantic categorization, was much larger than any gamma obtained in previous experiments. The rest of the gammas ranged between .74 and 1.0. These gammas indicate that subjects accurately labelled fast categorizations "fast" and slow

categorizations "slow". Therefore, subjects are capable of judging fluency of word categorization. However, the relation between fluency judgements and categorization speed is much stronger than the relation between familiarity judgements and categorization speed. The discrepancy between gammas obtained from judging fluency and judging familiarity is even more evident for pairs requiring "no" responses. Judgements of fluency yielded positive gammas for these pairs, whereas judgements of familiarity usually yielded negative gammas for these pairs. Therefore, although subjects are capable of judging categorization fluency, they clearly are not doing exactly the same thing when judging familiarity.

Summary

The data from Experiment 7 do meet two essential requirements of a causal version of the retrieval account. First, subjects are capable of judging fluency of word categorization. The highly positive gamma coefficients in every condition mean that the categorizations subjects called "fast" were relatively fast categorizations, and that the categorizations subjects called "slow" were relatively slow categorizations. However, these coefficients did not resemble those achieved when judging familiarity: They were much too large, and those for pairs requiring "no" responses

were oppositely signed. These discrepancies could be due to the different requirements for the tasks of recognition and fluency judgement, rather than indicating that recognition was not influenced by categorization fluency. In particular, the proportion of pairs called "fast" in this experiment was greater than the proportion called "old" in Experiment 6. This comparison indicates that judging fluency differed from judging familiarity in not relying as completely on the prior experience with the pair.

Another discrepancy between the effect of fluency judgements on categorization and the effect of familiarity judgements on categorization was that fluency judgements did not prolong categorization or interfere with categorization learning. This result suggests that familiarity judgements do not rely <u>only</u> on categorization fluency. That is, in judging familiarity subjects are retrieving memory information independent of, and concurrent with, categorization information. This conclusion is compatible with both the causal and noncausal versions of the retrieval hypothesis.

The second essential result for the causal account was that fluency judgements were capable of discriminating repeated from once-presented pairs. However, this discrimination was obtained only for pairs acquired in the semantic task; it was not obtained in other conditions in which recognition discrimination and savings in

categorization accuracy were obtained (viz. pairs repeated in the graphemic task). Again, this result suggests other sources of information besides fluency of processing are involved in familiarity judgements. However, if categorization fluency is a component of familiarity judgements, then familiarity must be derived in part from semantic sources. Some two-factor theories of recognition would not be able to account for this result because they state that familiarity rises from nonsemantic sources (e.g., Mandler, 1980). Other two-factor theories of recognition (e.g., Gillund & Shiffrin, 1984; Jacoby & Dallas, 1981) would have no trouble with this result because familiarity is based on a more general process (e.g., processing fluency).

CHAPTER 6

General Discussion

The research reported in this thesis was conducted to determine the nature of the relation between remembering and learning. Although other researchers have pointed out the differences between remembering and learning, this research has demonstrated that there are many parallels as well. Current explanations of the relationship center either on differences in memory representation or on differences in memory retrieval. A consistent result of the present research is that the parallels between remembering and learning were best explained as a function of memory retrieval.

A popular explanation of the relation between remembering and learning is that separate memory systems exist for every dissociable aspect of memory performance (Cohen & Squire, 1981; Cohen, 1984; Tulving et al., 1982; Tulving, 1983, 1984; 1985). Many criteria can be used to distinguish memory systems, but the one that most researchers agree on is the independent representation of the same experience in each memory system. In the case of remembering and learning, one memory representation supports

remembering, whereas another representation supports learning. As noted in the introduction, different assumptions can be made about how these multiple representations of the same experience are used. Heuristically, the strongest position is to assume that each system has access to only its own representations, and that each representation is used independently of representations in other memory systems. I have been referring to this position as the strong representation hypothesis. This account does not predict, or explain naturally, relationships between remembering and learning.

Another explanation of the relation between remembering and learning distinguishes between the memory representation and the manner in which it is retrieved. By this account, only one memory is created for every experience. Differences between remembering and learning occur because this memory can be retrieved in different ways. This account predicts that the relation between remembering and learning should depend on the similarity in the retrieval processing required by the remembering and learning tasks. I have referred to this position as the retrieval hypothesis of the relation between remembering and learning.

The strong representation and retrieval hypotheses can be evaluated by determining whether manipulation of

retrieval processes affects the relation between remembering and learning. The relation between remembering and learning was determined by functional test and by statistical analysis. The functional test determined whether measures of remembering and learning were affected similarly by the same variables. The statistical analysis determined whether items that were categorized well were also remembered well. Theoretical inference on the basis of the results of these assessments of performance is never easy. However, it was argued that an inference in favour of the retrieval hypothesis could be made if both functional and statistical relationships were obtained with different preparations, and if such relationships were a function of theoretically important variables.

Retrieval processes were manipulated in two ways. First, the task selected to measure learning employed processing similar to that needed for remembering (i.e., conceptually driven). Second, the type of decision strategy used for remembering was manipulated (by instructions) so as to encourage use of information both relevant and irrelevant to recognition (i.e., nonanalytic processing) or just the information relevant to recognition (i.e., analytic processing). This latter manipulation of retrieval is especially interesting because it cannot also be construed as a manipulation of the memory representation.

Effect of Conceptually Driven Learning Task

A functional independence between two tasks exists if a variable influences one task in a different way than it influences the other task. To date, there are many examples of functional independence between measures of learning and of remembering (e.g., Carroll & Kirsner, 1982; Jacoby & Dallas, 1981; Tulving et al., 1982). Some researchers (e.g., Tulving et al., 1982) have suggested that independence occurs because there are different memory systems supporting learning and remembering (i.e., the representation hypothesis). However, the measures of learning used in these experiments all require much data-driven processing (i.e., greater reliance on sensory data than conceptual data). In contrast, remembering requires much conceptually driven processing (i.e., less reliance on sensory data than conceptual data). According to the retrieval hypothesis, discovering a relation between remembering and learning depends on the similarity in the type of processing required by the remembering and learning tasks. In the experiments in which a functional independence between remembering and learning was found, the balance of data-driven and conceptually driven processes was not equated between measures. Therefore, the retrieval hypothesis does not necessarily predict a relation between remembering and learning. A more adequate test of the

retrieval hypothesis would equate the contribution of data-driven and conceptually driven processing to measures of remembering and learning. In the present experiments, the task chosen to measure learning (categorization of word pairs) relied to some extent on conceptually driven processing because reference to a category of "things" not contained in the stimulus is required. According to the retrieval hypothesis, the variables of meaningfulness and context, would be expected to affect recognition and facilitation of categorization similarly (i.e., functional dependence) because both relied on conceptually driven processing.

Meaningfulness was manipulated by requiring categorization of pairs according to either their graphemic attributes, phonemic attributes, or semantic attributes. In Experiment 1, greater facilitation of categorization in both accuracy and latency was obtained for phonemic categorization as opposed to graphemic categorization. In Experiment 2, a longer repetition interval was employed using the same categorization tasks. Facilitation in categorization accuracy was obtained only for phonemic categorization; no facilitation for graphemic categorization in either measure was obtained. In Experiment 3 the same long repetition interval was employed, but semantic categorization was substituted for phonemic categorization. Now facilitation of both accuracy and latency was obtained

for semantic categorization, whereas a smaller facilitation of accuracy for graphemic categorization occurred. Semantic and phonemic categorization were never compared in one experiment. However, the fact that the latency of semantic categorization was always facilitated across the longest repetition interval, but latency of phonemic categorization never was, suggests that there was a consistent effect of meaningfulness on facilitation of categorization, such that the more meaningful the categorization, the greater the facilitation of categorization. Just as consistently, Experiments 4 through 6 demonstrated that more accurate recognition of the words and the categorization occurred after more meaningful categorization. In Experiment 6, the especially large categorization fluency was paralleled by an especially good discrimination of the prior categorization. Therefore, as expected by the retrieval hypothesis, manipulation of meaningfulness affected measures of learning and remembering similarly.

Context was manipulated by requiring, on repetition of a word pair, categorization either in the same task as that used at acquisition, or in a task different than that used at acquisition. Although context is usually defined by the objects that were present at acquisition, Kolers (1976, 1979) suggested that the operations performed on objects at acquisition is a more critical determinant of memory representation. The present context manipulation is a

strong test of Kolers' position because changing the task context does not change the objects that were present at acquisition. With one exception (Experiment 2a (accuracy instructions)), any instance in which facilitation of categorization was observed in Chapter 2, always occurred when the task context was preserved. Experiment 2b (speed instructions) demonstrated that an appropriate manipulation of response strategy could restrict facilitation of categorization to conditions in which the task context was preserved. Minimally, it can be concluded that items are learned in the context of the operations that were performed on them at acquisition. Both McKoon and Ratcliff (1979) and Graf and Schacter (1985) have shown that items are learned in the context of other items present at the time of acquisition. In the present experiments, preservation of the item context was not sufficient to obtain transfer to later categorization. Preservation of both item and task context was necessary for learning to be observed.

Experiments 4 through 6 demonstrated that recognition is similarly sensitive to task context; when task context was preserved recognition was more accurate than when a new categorization was performed on the same words. Further, the effect of task context on recognition was greater the more meaningful the acquisition processing was. Therefore, manipulation of task context affects both measures similarly. Again, this functional dependence was

expected by the retrieval hypothesis, but not by the representation hypothesis, and particularly not those accounts that use representation of context to distinguish memory systems (e.g., Tulving, 1983). Functional dependence could be explained as coincidental representation of similar attributes in two memory systems. This is not an implausible explanation of the effect of meaningfulness: "good study improves performance on all tasks". However, the effect of context is not as easily explained. No matter how pairs were acquired, categorization of pairs repeated in a different task was functionally like categorization of a pair for the first time.

Jacoby (1978) has suggested that performance on a problem could be facilitated by remembering a solution faster than the problem could be solved again. Could recognition processes account for the speeding of categorization even though there were no task demands or requirements to do so? Remembering the prior solution ("yes" or "no") in Experiment 1 would have led to very large error rates because one third of the pairs were repeated with a different categorization response. Further, whether subjects remembered "a lot" or "a few" pairs that were repeated in Experiment 1 did not predict facilitation of categorization. Stronger evidence that facilitation of categorization was not due to recognition was obtained in Experiments 5 and 6. In these experiments, the task of

categorization and remembering the prior categorization task took about half a second longer than just categorization. The only condition to show facilitation of categorization consistently (pairs requiring "yes" responses that were acquired and repeated in the semantic task) was also slowed. If facilitation of categorization was due to recognition, this condition should not show prolongation at all, and at the very least, this condition should show much less prolongation than other conditions in which categorization was not facilitated. This was not true. Therefore, facilitation of categorization is not likely caused by remembering the prior response. Rather, the facilitation of categorization found in these experiments probably reflects a facilitation of the categorization processes themselves. This conclusion justifies the use of the term "learning" to describe the facilitation of categorization.

Effect of Decision Strategy

Jacoby and Brooks (1984) have distinguished between nonanalytic and analytic decision processes. A nonanalytic decision is based on all retrieved memory information, whether it is relevant or irrelevant to the task. In contrast, an analytic decision distinguishes irrelevant and relevant information, considering only the latter in making a decision. Jacoby and Brooks also argued that the

strongest relation between remembering and learning will be obtained when nonanalytic decisions are made. They argued that a specific type of nonanalytic decision for recognition, the fluency heuristic, was based on facilitated task performance. That is, if a nonanalytic decision mode was used, subjects would interpret facilitated task performance (which is definitionally irrelevant to recognition) as evidence that that item had been practiced before in that task, and therefore call it "old". Detecting such a relationship requires an analysis on the item level. The statistic used for this purpose was the gamma coefficient (Nelson, 1984).

If nonanalytic processing is a common way of making decisions, as Jacoby and Brooks argue, the relation between fast categorization and "old" recognition decisions should be obtained without special instructions. As Chapter 3 demonstrates, this relationship is not easily obtained. In Chapter 4, the recognition test was modified and differential instructions for recognition were given in order to separate analytic and nonanalytic processing. When a nonanalytic basis for recognition was used, which was encouraged by familiarity instruction, a relationship, although not large, was obtained in both experiments. Without familiarity instruction, both Experiment 5 and 6 showed that gamma coefficients were close to zero. That is, no relation between categorization speed and recognition

occurred when an analytic basis for recognition was used. These results suggest that when all sources of information are used for recognition, a relation does exist between categorization speed and recognition decisions. This outcome was predicted by the retrieval hypothesis. However, the weakness of the correlation and the special conditions under which it was obtained suggest that nonanalytic processing during recognition may not be as common as expected by the retrieval hypothesis. The positive aspect of the strength of the correlation is that these correlations were obtained by computationally ignoring categorization learning.

In Chapter 3 it was unexpectedly discovered that recognition slowed categorization. Although this result is interesting in itself, it substantially complicates interpretation of gamma coefficients. A positive gamma could indicate an association between fast categorizations and "old" recognition decisions, but it also could indicate that fast recognition decisions are associated with "old" recognition decisions, or that "old" recognition decisions allow fast categorization. Against both of these alternative interpretations, both Experiment 5 and 6 found a relationship in an experimental condition unlikely to support fast recognition. In Experiment 6, it was empirically determined that recognition processes by themselves could not produce the relation obtained between

categorization and recognition. Finally, it was argued in Chapter 4 that this relationship was not an artifact of the experimental procedure. Therefore, it can be concluded that the relationship obtained after familiarity instruction meant that quickly categorized pairs were also likely to be recognized as "old". The conclusion that this statistical relation is a function of nonanalytic processing is even more compelling because a manipulation in Experiment 2, which was similar to familiarity instruction, also produced a functional relation between facilitation of categorization and recognition. Because these instructional manipulations occurred after acquisition and did not alter the cues present at transfer, the resulting relation between categorization and recognition can be thought of only as a consequence of retrieval processes.

The statistical dependence between categorization and recognition is particularly hard to incorporate into a representation hypothesis because it is true on the item level. It is implausible that this dependence is a result of "good study" of some items coincidentally establishing "good" representations of those items in both memory systems. Besides the fact that there was an effect of instruction, the planned comparisons in Experiments 5 and 6, and the recognition-only condition in Experiment 6 demonstrated that the relationship depended on the items poorly studied. Further, use of semantic categorization in

Experiment 6 did not strengthen the relationship between categorization speed and recognition. Instead, the discovery that the same item behaves similarly for categorization and recognition must mean that some representations are used in common when remembering and when learning. This result disconfirms the strong representation hypothesis (i.e., no interaction allowed between memory systems). Separate memory systems for remembering and learning could be maintained provided that interaction between them was permitted (e.g., Feustel et al., 1983; Tulving, 1984). However, the evidence supports the retrieval hypothesis because dependence between categorizing and recognizing (functional or statistical) was obtained only if similar retrieval processes were employed in recognizing and categorizing. Because the relation between remembering and learning is a function of retrieval processes, the discontinuity between remembering and learning is most parsimoniously accounted for by assuming separate retrieval processes (which may or may not causally interact) and a common representation. The further assumption of independent representations is unnecessary to account for the relation between remembering and learning.

The differential effects of instruction to subjects to employ different retrieval processes for recognition lends support to two-factor theories of recognition. The distinction has intuitive plausibility because most subjects

did not require more instruction than mention of the phrases "judge familiarity" or "reconstruct in your mind". In Experiment 5, nondirective instruction lengthened joint response times for the most meaningfully acquired pairs presented in the different task for recognition, whereas these pairs were not similarly affected when familiarity instruction was given. This extra response time is evidence of additional analysis or verification required for recognition. In Experiment 5, pairs requiring "yes" responses were called "old" more often than pairs requiring "no" responses in the familiarity condition, but not in the nondirective condition. This finding suggests that familiarity instruction causes recognition decisions to be predominantly nonanalytic in nature because it is irrelevant to recognition whether a pair matches or not.

Experiment 7 demonstrated that subjects can judge when they have fluently categorized pairs, and further, that these judgements do discriminate repeated from nonrepeated pairs. Therefore, it is plausible to claim that subjects employed categorization fluency in judging familiarity, and that this information enabled subjects to distinguish repeated from nonrepeated pairs. Direct evidence that subjects were employing information from categorization in recognition was obtained in Experiment 6. In this experiment, one group of subjects did not perform the categorization tasks in the transfer phase, but instead,

performed recognition only. In this instructional condition, most repeated items took about 300 ms longer to judge "old" or "new" than it took to judge nonrepeated items "new". However, pairs requiring "yes" responses that were acquired and repeated in the semantic task did not take longer to judge "old" than it took to judge nonrepeated items "new". Because categorization of these pairs was speeded by repetition, the lack of prolongation of decision time could be explained as the use of this semantic fluency as the basis for recognition, thus avoiding additional memory retrieval. This conclusion is strengthened by the fact that an absence of categorization fluency (pairs requiring "no" responses that were repeated in the graphemic task) eliminated the prolongation of response time when categorization was performed just before recognition, but not when recognition was performed by itself. If an absence of categorization fluency can inform recognition, then it is likely that the presence of categorization fluency also informs recognition. Therefore, the evidence supports the Jacoby and Dallas (1981) two-factor theory of recognition. However, Experiment 7 also showed that categorization information was not the only source of information for recognizing by judging familiarity. The fact that fluency judgements did not prolong categorization, though judgements of familiarity did, means that it is not just performance of a secondary task that is responsible for the prolongation of

categorization.

The conclusion that categorization fluency was a source of information in judging familiarity implies that semantic processes were, in part, responsible for the fluency. The largest benefits in recognition accuracy and response time occurred in exactly the condition in which the largest facilitation of categorization occurred. In this condition, pairs were categorized semantically both at acquisition and on repetition; only semantic processing can be responsible for facilitation of this categorization. Further, to the extent that fluency judgements reflect categorization fluency, the results of Experiment 7 demonstrated that only pairs acquired semantically could support fluency sufficient to distinguish repeated from nonrepeated pairs. Demonstration that familiarity was derived from semantic sources is not consistent with the two-factor theory of recognition proposed by Mandler (1980). By this account, familiarity is represented by the degree of intraitem integration of items, a form of integration caused only by the perceptual processing of items. The present research has demonstrated that familiarity can also rise from semantic processing of items.

Implications of this Research

In the introduction it was noted that investigation

of the relation between learning (i.e., improvements in knowing) and remembering is relatively recent. Most comprehensive theories about this relationship are philosophical in origin, and are therefore not suitable for empirical test. Rather than a strong test of any one theory, this research is best treated as an exploration of relevant techniques, and the determination of some constraints on a theory of the relation between learning and remembering.

There are two important constraints that the results of this research place on theories of learning and remembering. The first constraint is that the effect of context on learning is much more severe than its effect on remembering. The second constraint is that the relation between learning and remembering is better described by differences in retrieval rather than differences in representation. These constraints are not likely independent of each other. An issue for future research is how the retrieval necessary for remembering can avoid, to some extent, the limitations of context, whereas the retrieval during learning cannot. However, the research reported here would have benefitted technically had these two constraints been investigated separately.

The conclusion that learning is more contextually-bound than remembering was derived from the fact that a repeated pair categorized in a task different

than acquired in was functionally like a pair categorized for the first time. In contrast, recognition of these pairs was unlike recognition of pairs not presented before. This result was obtained whether the recognition test classified pairs repeated in a different task as hits (Experiment 4) or as false alarms (Experiment 5 and 6). Although Chapter 3 found that recognition was specific to the context of acquisition, Chapter 2 discovered that categorization learning was "hyperspecific" to context. This hyperspecificity of learning is consistent with previous investigations of normal learning (e.g., Graf & Schacter, 1985; Jacoby & Dallas, 1981; McKoon & Ratcliff, 1979) and especially, investigations of amnesic learning (e.g., Glisky, Schacter & Tulving, 1986; Winocur, 1982). The conclusion that can be drawn from these findings is that the nervous system is modified by an experience so that the perceptual experience and consequent processing is maintained faithfully in the same representation. This conclusion suggests that perception and memory are not distinct functions. Further research is needed to determine if there are any boundaries for the specificity of learning. In conducting this research, remembering tasks should be eliminated. The strategy of maintaining the nominal event at transfer, but altering the modality (auditory or visual), the code (pictorial or verbal), or processing (semantic or phonemic) at transfer should be pursued.

The conclusion that the relation between learning and remembering is better described by differences in retrieval rather than differences in representation was inferred primarily from the differential effects of instruction. This manipulation could not have affected representation because it occurred after acquisition, and it did not alter the cues present at transfer from those at acquisition. The effects of meaning and context on a predominantly conceptually driven learning task cannot be so unambiguously interpreted. However, the functional dependence resulting from the use of a predominantly conceptually driven learning task stands in stark contrast to the functional independence usually obtained when predominantly data-driven learning tasks are used (e.g., Carroll & Kirsner, 1982; Graf & Mandler, 1984; Jacoby & Dallas, 1981). This contrast also suggests that different retrieval modes determine the relation between remembering and learning. The research presented in this thesis leaves as a puzzle the relation of conceptual and data-driven retrieval to nonanalytic and analytic processing.

The amnesics' spared memory capabilities may be clue to the characterization of retrieval modes. Although amnesics have great difficulty remembering an experience, they have near-normal learning capabilities. This fact suggests that there is a physiological distinction between reflecting on a memory and using that memory to perform a

nonreflective task. Therefore, there must be at least two distinct retrieval modes, though retrieval differences within each distinct mode may also exist. For example, Mishkin (1986) presented evidence of the existence of physiologically distinct retrieval mechanisms for remembering and learning. To this extent, it can be concluded that separate memory (i.e., retrieval) systems support remembering and learning. This position is consistent with the retrieval hypothesis providing that memory systems are not defined also in terms of multiple memory representations of an experience (cf. Cohen, 1984; Tulving, 1983).

Investigating the relation of remembering to learning by requiring a recognition response after each categorization suffered primarily from the nonindependence of task performance. It is not clear from this research what it means that recognition and categorization cannot be performed independently. However, the fact that subjects could not prevent themselves from recognizing at the same time as categorizing, and that recognizing slowed categorizing, suggests that subjects switched back and forth between the tasks. Assuming that subjects were switching between tasks supports Polanyi's distinction between using the mind as an object and using the mind as a tool. However, the nonindependent performance of the tasks indicates that subject's could not focus on one task to the

exclusion of the other. Perhaps focusing on a single task was impossible because recognizing and categorizing made use of the same memory information (both are conceptually driven), but each task had a different purpose for that information (i.e., "tool" or "object", performing or reflecting). The inability to focus on a task is nonanalytic processing in a sense, but not in the sense that Jacoby and Brooks (1984) defined it. Nevertheless, a better understanding of nonanalytic ~~process~~ing may be gained by experiments aimed at understanding why subjects were unable to categorize without also recognizing.

If it is true that different retrieval modes exist, then this fact will have important consequences for skill-learning of all kinds (e.g., sports, photography, welding, etc.). There are two important questions: "What advantage does reflecting impart?" and "When will reflecting help performing?". If it is true that learning (i.e., performing) is hyperspecific, then an obvious advantage of reflecting is the ability to integrate or generalize over different sensory modalities, different symbolic codes, and different processing. The methodology used here may be useful for investigating these questions. An important insight gained from this research is that a condition employing separate task performance must be included in order to look at conditions employing dual task performance. Further, the dimension of time is important for analyzing

the conflicts and/or compatibilities between reflecting and performing. Very small differences between the dual and single task conditions in accuracy were recorded in these experiments.

The question of what domain of learning to investigate with this technique is important. I suggested above that performance skills, like sports, may be optimal. The research reported here investigated verbal skills only. Verbal skills may be the wrong domain to investigate because linguistic knowledge has a naturally internal representation, which is very conducive to reflective retrieval. The problem encountered in this research was that graphemic and phonemic processing did not provide sufficiently longlasting learning, but at the same time, this processing provided the best separation of retrieval modes. Semantic processing produced very longlasting learning, but retrieval modes became less separated. If verbal skills are to be investigated, a productive task, like speaking, would be a better choice of a task in future research.

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APPENDIX A

Table of stimuli for Experiment 1.

Pairs requiring "yes" responses - both tasks

DEALT,TEMPT	BEARD,WEIRD	WIDTH,WITCH
SIXTH,DITCH	MARCH,MARSH	NERVE,MERGE
GROPE,DRONE	HINGE,RIDGE	CHEER,SHEAR
PLEAD,BLEED	DOUGH,POACH	CLASP,CLAMP
COUCH,SOUTH	BENCH,FETCH	COACH,LOATH
PRIZE,GRIPE	WEAVE,SEIZE	YOUTH,TOOTH
NOTCH,COUGH	BUDGE,BULGE	MOUTH,POUCH
SWEPT,DWELT	PHONE,CHOKE	WRITE,TRIBE
THEME,THREE	DROOP,GROUP	RHYME,WHINE
PITCH,PINCH	HATCH,RANCH	BORNE,GORGE
WINCH,HITCH	CRAZE,BRAVE	LAPSE,LANCE
JUICE,BUTTE	BELLE,HEDGE	JOINT,HOIST
GHANT,SHAFT	PORCH,FORTH	DRIFT,WRIST
DRAPE,TRADE	SHEEP,CHEAP	PROVE,BRUTE
WINCE,NICHE	BARGE,CARVE	SURGE,PURSE
BROKE,FROZE	SWIFT,TWIST	HORDE,FORGE

Pairs requiring "no" responses - both tasks

CHICK, CRACK	GLIDE, GRADE	SPACE, SLICE
PRINT, PLANT	POUND, POINT	SCALP, STALK
GROWL, GROWN	GRANT, GLINT	CREST, CRASH
GROVE, GLOVE	GLASS, GROSS	SLANG, SLINK
CRISP, CRUST	FLESH, FLASK	CHEST, CROSS
GLEAM, GREAT	PLUME, PRIME	TRUST, TRASH
SWUNG, SLING	THANK, TRUNK	CHOSE, CURSE
WHITE, WROTE	LARGE, LAUGH	PLANE, PRONE
CROWD, CRAWL	PHASE, PROSE	SKUNK, STINK
SPELL, SPILT	DREAM, DREAD	SHEAF, SWEAT
WHACK, WRECK	BREAD, BLOAT	BLUSH, BLAST
SLIDE, SHADE	BLEAK, BROAD	SPILL, SHALL
QUELL, QUILT	PROWL, PRAWN	SMILE, SHALE
SNUFF, SHIFT	TREAT, TREAD	SPINE, STONE
TRUCK, TORCH	CHINK, CLANK	CLOCK, CHECK
CHASE, CLOSE	PENCE, PEACH	BRISK, BURST

Pairs requiring "yes" for SOUND, "no" for LETTER

QUEER, SNEER	YOUNG, LUNCH	STORE, SNORT
FLIES, WIVES	SWEAR, SPARE	GRASS, DRAFT
SCOUT, TROUT	SWELL, SMELT	SPEER, SWEEP

PLUSH, BLUFF	STORK, SCORE	GRAIN, GRAPE
BEAST, STEED	SPOON, BOOTH	SHOWN, GROAN
CLAIM, SLATE	COUNT, SOUND	SMOCK, SMALL
VERSE, PEARL	GRIEF, CHIEF	SHOVE, SHRUB
QUART, DWARF	BUILD, GUILT	SINCE, WHICH

Pairs requiring "no" for SOUND, "yes" for LETTER

NIECE, MINCE	VERGE, HEAVE	DOUSE, VOICE
COULD, BOUND	SPORT, SPLIT	SLEPT, SLEET
STEEP, STRAP	SLAIN, CLEAN	DRAWN, BRAIN
TRIED, TREND	DRIED, BREAD	SHAVE, SHORE
STAKE, STYLE	TRAIT, WREST	GAUGE, BADGE
CRAVE, BRIDE	STUNT, STOUT	SLEEP, SLUMP
SPEED, SPEND	GLARE, FLAME	START, STILT
GRAVE, PRONE	TRAIL, TRILL	FLING, CLANG

APPENDIX B

Table of stimuli for Experiments 2, 4, 5

Pairs requiring "yes" responses

HINGE,RIDGE	CHEER,SHEAR	BEARD,WEIRD	VOICE,POISE	DOUGH,POACH
SNAKE,KNAVE	CRISP,CRIMP	MARCH,MARSH	BELLE,HEDGE	CHIME,SHINE
TRUCE,PRUNE	GLAZE,PLACE	DANCE,BADGE	FLAME,SLATE	BARGE,CARVE
WIDTH,WITCH	SHALE,PLANE	COACH,LOATH	WEAVE,SEIZE	YOUTH,TOOTH
PRIZE,GRIPE	KETCH,TENTH	PLEAT,SLEET	CRYPT,GRIST	JUDGE,LUNGE
DRAFT,TRACT	BUDGE,BULGE	HORDE,FORGE	STUCK,STUNK	JOUST,COUNT
GROPE,DRONE	SURGE,PURSE	CLOCK,CRAWL	PITCH,PINCH	WRITE,TRIBE
MOUTH,POUCH	GLIDE,SLICE	SWEPT,DWELT	HATCH,RANCH	SENSE,LEDGE
GRAZE,TRACE	FIEND,FIELD	DUNCE,FUDGE	WINCH,HITCH	LAPSE,LANCE
PHONE,CHOKE	BORNE,GORGE	CRAZE,BRAVE	GLEAM,BLEAK	RHYME,WHINE
BENCH,FETCH	LEECH,LEASH	VERSE,VERGE	BRICK,FRISK	GUISE,QUITE
DENSE,DELVE	CRUST,BRUNT	DROOP,GROUP	TEETH,REACH	PLATE,GLADE
NERVE,MERGE	BROKE,FROZE	CHUTE,PLUME	JOINT,HOIST	PLEAD,BLEED
CRANE,CRAVE	CHANT,SHAFT	DRIFT,WRIST	FLESH,SPELL	GRIME,BRINE
GOUGE,MOUSE	MULCH,LUNCH	SAUCE,GAUZE	SWIFT,TWIST	CLASP,CLAMP
PROVE,BRUTE	COUCH,SOUTH	SIXTH,DITCH	PORCH,FORTH	DRAPE,TRADE
CLEFT,CHESS	CHALK,SHOCK	DRIVE,BRIDE	LEAPT,MEANT	GEESE,HEAVE
GRAVE,BRACE	GULCH,HUNCH	SHEEP,CHEAP	SHAVE,WHALE	WINCE,NICHE

Pairs requiring "no" responses

CREST,WORSE	THERE,THIRD	BUNCH,BEAST	CHOSE,CURSE	WHISK,WAIST
WHOLE,WORLD	MOIST,MOOSE	CHART,CHORE	LARGE,LAUGH	STEED,SHRED
OUNCE,MUMPS	NEIGH,NIECE	THINK,TWINE	CRUDE,CRUMB	GUILE,GUILT
MINCE,NINTH	SHONE,SHUNT	TAUNT,TREND	BEIGE,BRIEF	ELVES,EAVES
SMEAR,SPRAY	TRUCK,TORCH	WHERE,WHEAT	GAUGE,GLASS	TASTE,CRASH
GLOSS,CROAK	BRISK,BURST	STRAP,STEAM	TONGS,TOUGH	STYLE,STILT
ROUND,NOTCH	TRASH,TREAD	GLAND,GREAT	JUICE,LURCH	BUTTE,BLUSH
CRACK,CRATE	PHASE,PLANT	PROSE,POINT	SKUNK,COUGH	STINK,SLIDE
CREST,CLOSE	GROVE,GROWL	GLOVE,CROWD	PRINT,PRIME	ROUGH,GHOST
BRAND,BREAD	BLANK,BATCH	WROTE,WRECK	GROSS,ROOST	SLANG,STRAW
FLASK,FLAIL	TRUST,THREE	GRANT,HAUNT	GLINT,QUELL	BLAST,BRAID
SLING,QUILT	SLINK,SPINE	BROAD,ROACH	POUND,SWUNG	CHICK,WHITE
THANK,THEME	TRUNK,HOUND	PRONE,PROWL	SPAIN,SPILT	FLING,MIDST
FLIRT,FRUIT	FLUSH,FEAST	STAKE,STALK	CLASH,COAST	CHEST,TREAT
SHADE,SHEAF	CRAFT,CHASE	DREAM,DEATH	WHACK,SWEAT	PRAWN,DREAD
GRIND,BIRCH	SNUFF,BRUIN	SHIFT,SMILE	CHECK,CLEAR	GROWN,DEALT
SPILL,BELCH	SHALL,FRAUD	CROSS,BLOAT	CLASS,CHAIN	TEMPT,PEARL
MIRTH,DWARF	STONE,SCOWL	LATCH,FLAIR	SHOWN,SCORE	STAIR,STRAY

APPENDIX C

Table of stimuli for Experiments 3, 6, 7 (Format 1)

Pairs requiring "yes" responses

ARMY, GREEN	HILL, TOP	BLACK, RED
GRASS, LAWN	CANDY, GOOD	CAT, PET
CLEAN, SOAP	COURSE, ACTION	DARK, DIM
DOWN, DUCK	DRUNK, BUM	FAST, CAR
DRUM, STICKS	CHURCH, PEW	FEET, BARE
FLOWER, BLOOM	MINT, GOLD	GIVE, SHARE
HAND, RING	HARD, ROCK	HOLD, DROP
GROUND, AIR	BREAD, EAT	HOUSE, BUILDING
LAW, JUST	LEG, CAST	LETTERS, LOVE
LOSE, GAME	LOUD, SHOUT	MAN, STRONG
MOUSE, ROARED	NURSE, MAID	ONE, MANY
MOTH, WINGS	LIFE, TIME	ORDER, NEAT
PILLOW, LIE	PRETTY, FACE	ROAD, WINDING
SAT, STAND	SEA, WAVE	SHOE, WEAR
SKY, VAST	SLOWER, TURTLE	SMOOTH, MUSCLE
SICK, SAD	ROUND, HOLE	SOCKS, SMELL
SORROW, TEARS	STAR, WISH	SCORPION, DEADLY
TALL, STILTS	THAT, WHICH	THREAD, THIMBLE
UNDER, BLANKET	WANT, WILL	WARM, SCARF

TOWN, HALL	TABLE, STUDY	WEB, COB
WHITE, PURE	WINDOWS, PANES	PEACE, QUIET
DOVE, GENTLE	STORK, BIRTH	KNEE, JOINT
TROUSERS, CREASED	KOREA, CHINESE	BRANDY, COGNAC
GOWN, CAP	MONSOON, INDIA	HARBOR, INLET
SWAMP, SINK	SARDINE, OILY	TULIP, PETAL
MELON, SUMMER	PRUNE, TREE	MECHANIC, GREASE
LINEN, FINE	STEEL, BEAMS	BUGLE, TOOT
BEE, SPELLING	CAMEL, ARAB	PILOT, FLIER
NUTMEG, GINGER	CHESTNUT, ROAST	NIGHT, OWL
BOMB, FALL	RIFLE, TARGET	ONION, ODOUR

Pairs requiring "no" responses

AWAY, GROVE	BED, LEARN	BOOK, FOREVER
SWORD, LINE	CARRY, CRAWL	CHAIR, DAMAGE
COLD, HANDLE	CROWD, SHIVER	DEATH, PUSH
CIRCLE, WORK	BUG, SOFA	DOOR, HOT
DREAM, SLIM	DRY, GRAVE	FAT, FREUD
FOGGY, CHILD	GIRL, BOARD	GLASS, MAPLE
ILL, CLEAR	HIGH, MESSY	HOME, BUSH
HAIR, BAD	FLOOR, JAR	LAMB, PARENTS
LEAF, STEW	LEMON, WORLD	LETTUCE, BREATH
LOST, DEAR	MAD, MOUTH	MIND, BEARD
CORN, BLADE	OLDER, WALL	OPEN, SELF

PLANT, WISER	REST, ROOT	ROUGH, NAP
OUT, SMALL	MOTHER, LEAVES	RUG, WAKE
SAW, FREE	SHARP, CANCER	SHORT, WHEEL
SLEEP, RIP	SMOKE, TACK	SNOW, SPACE
SPOKE, HURT	STEAL, STILL	SWEET, SKIN
SOFT, PLAIN	SIT, KEEP	TALK, FOREST
THEM, JUNGLE	THING, ISLAND	TIGER, SLUSH
WALKING, WHY	WAR, CATCHER	WATER, WE
WIDER, KILL	WITHOUT, MIMMICK	ANT, RAIN
WHEN, NICE	UGLY, CHAT	TORNADO, THIRSTY
PARROT, CUT	ELBOW, ALONE	STOMACH, DRESS
ENGLAND, THIS	TIBET, MERMAID	RYE, EAGER
SHIRT, ROOM	LIGHT, BITTER	LAGOON, HORSE
MARIGOLD, PICKLED	BEAVER, EAST	FOX, ACID
CEILING, FUZZY	ROOF, HUSK	HORNET, CLOTH
TIN, HIVE	DOCTOR, ORANGE	GARLIC, SUN
SILK, CURE	PEACH, SMART	SYRUP, BOX
CEDAR, SEX	CARROT, DOG	TOMATO, STICKY
DRIZZLE, HUSK	HERRING, ABOVE	DAGGER, SAUCE

APPENDIX D

The text of familiarity instructions

Remembering whether pairs were previously presented in the same task as they originally occurred in may seem nearly impossible. It might be if you attempt to remember in the usual sense - that is, trying to bring back to mind the previous experience with those pairs. Fortunately, there's a much simpler way to perform this memory task, if you can use the experience of familiarity. This is how you can use familiarity to perform this memory task:

1. Say "old" if the you were able to perform the comparison easily or fluently, or if the answer seemed obvious to you; as if it "jumped out" at you.

2. Say "new" if the comparison seemed laborious or novel, or if the answer did not seem obvious to, as if you had to "figure it out" from start to finish.

There are several things to keep in mind when using familiarity. Always do the comparison first and once you've done it, you don't have to try to remember anything - while doing the comparison there's either an immediate experience

of familiarity or there is not. Don't deliberate, since familiarity information dissipates quickly after the pair disappears. Rather, make your "old/new" response immediately after making the comparison. Since familiarity information never provides any "why, when or how" information, don't worry about the accuracy of your decision - just try to trust the familiarity feeling. Finally, the more similar you can perform the comparision to how you did them in the first phase, the greater will be the overlap of these experiences in memory, and the greater will be the resulting experience of familiarity. For example, if you didn't pronounce the words in the LETTER task in the first phase, don't do it here either.