MEMORY, AGE AND CONSCIOUS AWARENESS

Rosalind Irene Java

Department of Social Sciences

City University

Thesis submitted for the degree of

Doctor of Philosophy at City University, London.

September 1991

CONTENTS

List of Tables in Text

List of Tables in Appendix

List of Figures

Acknowledgements

I am especially grateful to my Supervisor, Professor John M. Gardiner who has given me encouragement and constructive advice throughout every phase of this research.

I would also like to thank City University, London, for the provision of facilities for this research and their financial assistance, the University of the Third Age in London (U3A) for their co-operation in providing subjects, Dr. Zofia Kaminska for her support, and Barbara Brooks for typing this thesis.

Declaration of University Librarian

I grant powers to the University Librarian to allow this thesis to be copied in whole or in part without further reference to me. This permission covers only single copies made for study purposes, subject to normal conditions of acknowledgement.

ABSTRACT

The work that follows is concerned with dissociations between explicit and implicit memory and the effects of age. Incorporating ideas from a framework combining both systems and processing accounts of memory functioning (Tulving and Schacter, 1990), this thesis seeks to discover how conscious awareness influences these dissociations. Furthermore, it is proposed to extend previous work that has shown the relatively preserved implicit memory of older adults, with particular reference to the classification of tasks according to whether their major components are conceptually or data driven.

The experiments can be divided into three main groups. The two studies in the first experimental chapter confirm and extend previous findings of an age equivalence for the perceptual task of word stem completion priming to anagram solution.

Chapter 4 contains three experiments that showed the appearance and disappearance of the read superiority effect according to whether or not word stem completion was presented as an embedded task. Post hoc questioning of "test awareness" was applied in the third study (Schacter, Bowers and Booker, 1990).

In the final experimental chapter, the first of two experiments showed little effect of age on the conceptual task of word association priming. Experiment 7 measured conscious awareness in explicit and implicit tests using Tulving's (1985b) "Remember" and "Know" responses, and indicated that age differences in cued recall corresponded with differences in the components of conscious awareness. This method was considered more satisfactory than that of Schacter and his colleagues.

Chapter 6 summarizes the principle findings, and their implications for theory and future research are discussed.

CHAPTER 1

EXPLICIT AND IMPLICIT MEMORY

1.1 **Introduction**

The studies that follow set out to investigate the dissociations between explicit and implicit memory tests, and seek to discover what is inherent in implicit memory tasks that affords the phenomenon of a relatively preserved capacity with age. Section 1.2 of this chapter introduces the concepts of explicit and implicit memory, describing priming studies with young adults, while Section 1.3 describes priming studies with amnesic patients. The next section discusses task classification, following the work of Roediger, Weldon and Challis (1989) who sought to classify tasks according to their data or conceptually driven components. Section 1.5 considers the systems and processing accounts of memory (see e.g. Cohen, 1987; Tulving, 1985; Jacoby, 1983; Roediger et al, 1989) including an integration of the two, as suggested by Hayman and Tulving (1989a and b) and expanded upon by Tulving and Schacter (1990). This latter account is an eminently suitable theoretical background from which to explain the dissociations between explicit and implicit memory found in normal, amnesic and elderly subjects. Tulving and Schacter's (1990) combined approach is applied throughout this thesis that extends the work of previous studies with amnesic patients and the elderly, with particular reference to the classification of tests and the problem of conscious awareness.

The idea of investigating awareness has come into being largely due to the finding that amnesic patients have been shown to perform many tests of implicit memory at a similar level to that of normal control subjects. Since normal elderly subjects have also tended to show less of an impairment at this type of memory task (see section 2.2), the implication that a lack of awareness accompanies this facility has been investigated. Thus Section 1.6 introduces the ideas of Schacter, Bowers and Booker (1990) who sought to discover the effects of test awareness on tasks intended to be implicit, while the last section of this chapter deals with memory and consciousness as assessed by Tulving's (1985b) "Remember" and "Know" measures.

Chapter 2 involves three sections concerning research in aging. The first part (2.1) covers functional explanations of an age related decline in explicit memory, while part 2.2 reviews the literature that deals with explicit and implicit dissociations with age. The third section (2.3) introduces the experimental chapters.

1.2 <u>Explicit and Implicit Memory Tests and Priming Effects</u>

The multiplicity of memory tasks to be found in the literature can be conveniently considered under two main headings. There are the types of test that require conscious recollection, tests in which one is explicitly asked to refer back to a previous event or experience, and those that do not. The terms "explicit" and "implicit" were coined by Graf and Schacter (1985). Explicit memory relates to the former kind of test, examples of which are cued and free recall and recognition. An implicit memory task, however, makes no overt reference to a previous study occasion. It simply requires subjects to carry out a particular task, the completion of which shows a facilitation due to the earlier study experience. Johnson and Hasher (1987) used the terms "direct" and "indirect" to allude to the same classifications.

Implicit memory tasks are growing in number and are quite varied in type. Typical examples of tests used in the verbal domain include word stem and word fragment completion, perceptual identification and the generation of category exemplars. In order to describe these kinds of test, and to explain how they indicate the effects of priming - the aforementioned facilitation due to prior exposure to the study list, it is proposed to illustrate each test with an example from the literature.

Greene (1986) gave subjects a set of words to study. Word stem completion involved a set of word stems to be completed, half of which were the beginnings of words seen at study. Subjects were to complete each stem with the first word that came to mind that began with those three letters. Stems on the test list that had not been presented at study, acted as a baseline against which priming could be measured.

Tulving, Schacter and Stark (1982) used a word fragment completion task in which subjects were given a set of fragmented or partial word cues such as -E-D-L-M (Pendulum), half of which referred to study items. Earlier seen items were found to be easier to complete than unseen items.

Jacoby (1983) tested perceptual identification by asking subjects to identify briefly presented words, with the expectation that more accurate responses would occur for items that had been seen at study.

Graf, Shimamura and Squire (1985, Expt. 2) had subjects study words which were exemplars of particular target categories. The priming task involved word production. Subjects were told they would be given category labels, and they were required to respond with eight exemplars from each category. Some of the category labels were not those of the study phase and these constituted a baseline against which priming could be measured.

These types of tests, along with others that will be referred to later in these first two chapters when other work is described, have been used as implicit memory measures along with traditional explicit memory tests. Section 1.3 describes priming studies that have involved amnesic patients.

1.3 **Amnesic Studies and Priming**

One of the fascinating differences between conventional memory tests and implicit tests, is that some subject groups who are considered to be impaired at the former type of test, show a "preserved ability" for the latter, that is, they perform at a level similar to that of normal control subjects.

Twenty years ago, Warrington and Weiskrantz (1968, 1970) pointed out that amnesic patients are "not so forgetful as was once thought". New retention tests that required these subjects to identify words from partial information such as degraded words and three letter stems, showed their ability at these tasks to be indistinguishable from that of normal control subjects, despite the great difference that was found when free recall and recognition were tested. The ability of these amnesic patients at these tasks offering partial information as cues, illustrated the fact that they had consolidated the information, and suggested that other traditionally used retrieval tests were insensitive to this. Warrington and Weiskrantz (1974, 1978) later reported consistently "normal" performance with amnesic patients when word stems were used as cues, as did Graf, Squire and Mandler (1984; Graf, Shimamura and Squire, 1985, Expt. 1). Jacoby and Witherspoon (1982) found that amnesic patients performed similarly to normal controls in a test involving the spelling of homophones. Thus patients who were asked at study to give an example of a reed instrument, later spelled the homophone READ/REED with the low frequency spelling. A recognition test showed a difference in ability between the two sets of subjects.

Shimamura and Squire (1984, Expt. 3) showed that amnesic patients performed at a similar level to normal controls in a word association test. Subjects were given an incidental learning test which involved highly related word pairs being assessed for relatedness. At test, subjects were presented with the first word of the pair, and were asked to say the first word that came to mind related to the cue word. It was found that amnesic patients performed at a similar level to control subjects in this implicit word association task.

Jacoby and Witherspoon (1982) described this phenomenon of amnesic patients' ability to perform at a level similar to normal controls on certain tasks, as a dissociation between memory and awareness, and considered the possibility of "passive processing" (p.321) as an early phase of many cognitive tasks. Similar findings of normal priming in amnesia include the identification of Gollin figures (Milner, Corkin and Tueber, 1968), solution of the Tower of Hanoi problem (Cohen and Corkin, 1981), generating category instances (Graf, Shimamura and Squire, 1985, Expt. 2) and making preference judgements after exposure to unfamiliar melodies (Johnson, Kim and

Risse, 1985). The topic of awareness will be further discussed in Section 1.5. The next section (1.4) however, which deals with test classification, considers the perceptual (data driven) or conceptual (conceptually driven) components of explicit and implicit tests.

1.4 **Explicit and Implicit Memory Test Classification**

An interesting feature of explicit and implicit memory tests is that variables that affect one type of test may fail to affect the other, or affect it in a different way. Thus for example, a levels of processing study manipulation (Craik and Lockhart, 1972) as applied to a test of explicit memory, usually affords superior performance for semantically encoded material. Yet implicit memory tests such as word stem completion (e.g. Graf and Mandler, 1984) and perceptual identification (e.g. Jacoby and Dallas, 1981) have tended to show little sensitivity to this study manipulation. Similarly, the manipulation of items read and generated at study usually affords higher scores for generated material in tests of explicit memory (Slamecka and Graf, 1978) yet the reverse has been shown to occur when study items containing more superficial and less contextual information are tested by implicit and some explicit memory tests (Jacoby, 1983; Blaxton, 1985, Expt. 1; Blaxton, 1989; Roediger and Blaxton, 1987).

An explanation of the functional dissociations found between explicit and implicit tests was suggested by Roediger, Weldon and Challis (1989), who put forward four basic assumptions to their interpretation. They considered that memory tests are best benefited by a match or overlap of study procedures, and that the two types of test require different retrieval operations, or access to different types of information benefiting from different types of processing at study. In addition, they suggested that explicit tests tend to rely on "conceptually driven" processing, the meaning of the study material, while implicit tests rely more on the matching of perceptual or "data driven" processing. Roediger et al (1989) operationally defined the data driven/conceptually driven distinction as follows: a data driven test is one in which items read produce better performance than those generated, while conceptually driven tests produce the reverse of this effect.

Srinivas and Roediger (1990) sought to classify the tasks of free associating to category names and solving anagrams, according to their processing requirements. They showed that the former task was classifiable as a conceptually driven task since it behaved like free recall and showed an effect of generation at study, levels of processing and no effect of study modality. However, they found that their anagram solution task was difficult to classify absolutely as one requiring mainly data driven processing, but suggested that its behaviour was similar to a word fragment completion task when levels of processing and modality were manipulated. Experiment 2 in Chapter 3 of this thesis uses anagram solution as an implicit test and investigates the task's processing components.

Roediger et al (1989) suggested that although their explanation of the functional dissociation between explicit and implicit tests followed a processing interpretation, the explanation was also fully consistent with the idea that priming in implicit memory refers to changes in "perceptual representation" or "semantic" systems, while explicit recall or recognition reflects operations in the episodic system. Section 1.5 that follows, sets out to discuss theoretical explanations of the explicit/implicit distinction, to include processing accounts (e.g. Graf and Mandler, 1984; Jacoby, 1983; Roediger et al, 1989), a systems approach (e.g. Cohen, 1981; 1984; Squire and Cohen, 1984; Tulving, 1985b) and a combination of both systems and processing viewpoints (e.g. Hayman and Tulving, 1989a; 1989b; Roediger, 1990; Tulving and Schacter, 1990).

1.5 Theoretical Explanations of the Explicit/Implicit Distinction

For some time there have been two main competing theories offering explanations for findings related to the explicit/implicit memory distinction. These are the memory "systems" viewpoints of Squire and Cohen (1984), and Tulving (1985) and "processing" accounts of Graf and Mandler (1984), Jacoby (1983) and Roediger et al (1989).

Cohen (1981, 1984), Squire (1982a) and Squire and Cohen (1984) distinguished between "declarative" and "procedural" memory systems, suggesting that declarative memory is available to consciousness and involves both memory for facts and events. Procedural memory on the other hand, does not require conscious awareness and is shown in tasks which utilize specific operations. Thus knowing that an event took place and knowing how to carry out a certain task illustrates the division between knowledge and skills. Cohen (1987) noted that procedural memory, which tends to be spared in amnesia and normal aging, is not accessible to conscious recollection and is thus evidenced only in performance. Other dual system distinctions like those of Cohen and his colleagues have included "taxon" vs. "locale" (O'Keefe and Nadel, 1978), "semantic" vs. "cognitive mediation" (Warrington and Weiskrantz, 1982), "automatic" vs. "conscious recollection" (Baddeley, 1982a), "skills" vs. "conscious recollection" (Moscovitch, 1982) and "habits" vs. "memories" (Mishkin, Malamut and Bachevalier, 1984).

Tulving (1983; 1985a) separated memory into three systems. He proposed "procedural memory" to be the lowest in a hierarchy of the three systems. This system precedes "semantic" memory, with episodic memory at the top of the hierarchy. Thus, as described above, procedural memory can be described as knowing how to carry out a previously learned task. Semantic memory might refer to our knowledge that say, William the Conqueror and 1066 go together. Episodic memory on the other hand, refers to our ability to reflect upon personally experienced events. Thus explicit memory tasks reflect the use of episodic memory since they ask the subject to refer back to the prior study episode, while implicit tests can be said to be facilitated by procedural, semantic, or even some other system which is not yet known (Tulving, 1985a).

Graf and Mandler's (1984) dual process theory describes two ways of experiencing remembering. One involves deliberate, conscious effort, and is reliant on the elaboration of mental events and structures. The other relates to automatic processing for which no deliberate conscious effort is required. The "fast access" automatic type of remembering can be illustrated by the memory that "pops into mind" (Mandler, 1986). Mandler referred to the task of word stem completion, suggesting that a presented word stem partially activates a schema. This activation spreads to related components, thereby allowing access to the missing component, by integrating or strengthening the organization of components within the schema. Recall and recognition, however, rely on prior elaboration, that is, the establishment of a relationship between the to-be-remembered item and other existing mental events or concepts. This slower process of deliberate retrieval lies opposite that of activation and integration along a processing continuum. Mandler, Harrison and Dorfman's (1990) recent study on tests of the dual process theory on word stem completion priming and recognition, addressed the distinction between implicit and explicit memory. Mandler and his colleagues suggested that word stem completion priming is only dependent upon activation/integration, while recognition relies upon elaboration too. They further suggest that activation/ integration can be produced by "any active perceptual process" such as vowel counting.

Jacoby (1983) and Roediger et al (1989) have also described memory as a unitary system involving different methods of processing information. These authors suggested that it is the match between processing at study and test that is relevant. Roediger and his colleagues call their approach a "simpler alternative" to that of separate memory systems, suggesting that explicit and implicit tests tap different retrieval operations aided by different kinds of processing at study. Explicit tests tend to rely on the conceptual meaning of the studied items while implicit tests lean more on the processing of corresponding surface features between study and test. Jacoby (1983) distinguished between methods involved in memorizing and reading as conceptually and data driven processing, and these two methods were considered by Roediger and Blaxton (1987) to be at opposite ends of a processing continuum. Conceptually driven processing refers to an item being studied in a "top down" fashion, that is, with reference to its concept or meaning, while data driven ("bottom up") processing, relies on the use of the data alone, with little attention directed to meaning. Thus for example, Jacoby (1983), had subjects generate an antonym to the word HOT, anticipating the use of conceptually driven processing. However, reading the word COLD presented alone, without its opposite connotation, emphasized the study of the letters that formed the word, the only data present.

Blaxton (1985, Expt. 1; 1989; Roediger and Blaxton, 1987) varied study conditions between "no context", "context" and "generate" using two sets of conceptually and data driven tasks, one set of each being incorporated within tests of explicit memory, the other in tests of implicit memory. Thus, the data driven explicit task was a graphemic cued recall test, while its implicit data driven counterpart involved word fragment completion. The conceptually driven explicit task was a free recall test while the implicit one concerned general knowledge.

While both conceptually driven tasks showed the greater effect of items generated at study, the data driven tasks reflected greater facilitation of the "no context" study condition. These dissociations can be explained within a transfer appropriate processing framework (Morris, Bransford, Franks, 1977), a concept that can be described as being rather like "encoding specificity" (Tulving, 1983) in that it refers to the match between relational information at study and test. Transfer appropriate processing, however, refers specifically to the match of the procedures involved at study and test.

The most recent theoretical explanation of the explicit/ implicit memory distinction has been a combination of both systems and processing views. Hayman and Tulving (1989a and b) in their endeavour to explain priming effects referred to Roediger et al's (1989; see also section 1.4) approach involving transfer appropriate procedures and suggested that, although it could account for many of the findings of priming studies, it did not explain the dissociations between explicit and implicit memory as found in amnesic patients. These authors suggested that such patterns of performance reflected different brain systems and could not be accounted for adequately by the processes used at encoding and retrieval. Thus they put forward the need for an "integration of processing and systems approaches to implicit memory" (p.33).

Roediger (1990) also suggested combining the two approaches, for the same reasons; that the transfer appropriate procedures approach does not fit with amnesic findings, whereas a multiple memory systems account does. He referred to the work of Tulving and Schacter (1990) who also suggested that the two approaches were not incompatible. Tulving and Schacter (1990) said that findings with amnesic patients and the elderly, work that has shown a dissociation between explicit and implicit memory performance with drugs, and that which has shown the functional and stochastic independence of the two types of task, reflects the use of an additional specific memory system, a "perceptual representation system". Thus subjects involved in a priming task adopt a perceptual mode, while an explicit task calls for a "memory mode of cognitive operation" (Tulving and Schacter, 1990). In a priming task, details of study items are matched up with items that are stored in the perceptual representation system, explict memory tests involve the match between cue information and information that is stored in episodic memory. These authors further suggest that access to primed information is hyperspecific. Thus, being able to complete the fragment "A--A--IN" (assassin) does not ensure that "-SS-SS--" will also be correctly completed. This implies, using processing terminology, that specific data driven matches are involved in this type of priming test.

Tulving and Schacter also distinguished between perceptual and conceptual priming, the latter using semantic or conceptually driven processing operations. They referred to this type of priming as "process semantic learning" which is brought about by the modification of, or addition to semantic memory by new information. Thus Tulving and Schacter have proposed a "systems" approach to memory that distinguishes between episodic memory and perceptual and conceptual priming systems, incorporating the idea of explicit and implicit memory, in which matching processes within each system help to achieve the retrieval of stored information.

The experimental chapters that follows (Chapters 3 to 5 inclusive) fit within this "combined" approach. While study manipulations and the types of task used are explained according to the processes involved at study and test, they also fall within the framework of episodic memory and perceptual representation systems, drawing upon retrieval from semantic memory. Section 1.6 investigates how involuntary awareness of the relationship between test material intended to be implicit and the study phase, can affect the results of such tests.

1.6 **Implicit Memory and Test Awareness**

It was more than a hundred years ago that Ebbinghaus (1885, 1913, 1964) noted the distinction between voluntary memory as shown in recall and recognition, and involuntary recollection which escapes introspection. In order to capture the latter type of memory, he measured the "savings" between the time taken initially to memorize a set of items and the lesser time taken on a second occasion. Rather more recently, Schacter, Bowers and Booker (1990) discussed the nature of intentionality in memory and awareness, in a chapter that investigated the features of the explicit/implicit dichotomy.

Schacter et al (1990) referred to work by Graf and Schacter (1985) which differentiated between explicit and implicit memory according to whether or not conscious recollection was involved. Schacter and his colleagues suggested that the term "conscious recollection" is an ambiguous one, since it relates not only to the deliberate thinking back to the earlier study period, but can also refer to the re-experiencing of an event (e.g. Tulving, 1983, 1985b; see also section 1.7). They pointed out that memory without conscious recollection in an implicit test might refer to subjects' unawareness of the study episode, at test, but that not intentionally thinking back to the study episode also fits in with this terminology. In order to overcome this ambiguity, they suggested that explicit and implicit memory should be described according to whether or not intentionality of retrieval is required (see also Richardson-Klavehn and Bjork, 1988). However, Schacter et al did point out a problem that can arise in a test deemed to utilize unintentional memory; perhaps a test cue might inadvertently invoke conscious recollection of the encoding period, and produce an "involuntary explicit memory".

Schacter and his colleagues put forward five possible outcomes of presenting subjects with word stems to be completed in a test intended to be implicit. The first example had subjects showing a priming effect but no explicit recognition ability, while the second had subjects showing the facilitation of the study period in both types of test. Example three suggested that subjects might become aware of the relationship between study and test after having completed some of the word stems, but nonetheless they continued to complete them as instructed. In the fourth example, some of the subjects had a recollective experience of the study event, but they too continued as instructed, while in the fifth example, the subjects that had the recollective experience altered their method of stem completion by intentionally reinstating study list material. In an endeavour to overcome these problems, the authors devised an empirical method of making the distinction between explicit and implicit memory tests. Firstly, they suggested that external cues should remain constant for both types of test, with only the instructions differing, and secondly, a manipulation should be applied so that performance might be affected on one type of task but not the other. Any differences found should then be attributable to the use of intentional/unintentional processes.

Bowers and Schacter (1990) investigated test awareness in implicit memory in a set of three experiments. Their Experiment 1 buried a word stem completion test amongst various other tests in an attempt to disguise the target task, and to render fewer subjects aware of the relationship between the test and the study experiences. By varying levels of processing at study, and asking four pertinent questions about subjects' awareness after the test phase, the authors were able to discover that only those who said that they were aware of the study-test relationship were subject to elevated semantic scores. Thus it is implied that "aware" subjects behaved rather like those in Schacter et al's (1990) fifth example and for them, the test became one of intentional retrieval. Those subjects who said they were "unaware" of the study-test relationship and who showed no levels of processing effect apparently carried out the test without using intentional retrieval, thereby yielding their data unambiguously implicit. The work by Blaxton (1985, Expt. 1; 1989; Roediger and Blaxton, 1987) referred to in the previous section (1.5) fits nicely with this Schacter/Bowers model in that their variation between "no context" and "generate" showed the generation effect for explicit free recall and a superior effect of items studied without context in implicit word fragment completion. Experiment 1 of this thesis adheres more strictly to Schacter et al's retrieval intentionality criterion by holding the external cues constant while only allowing the instructions to differ.

Section 1.7 that follows deals further with the type of recollective experience mentioned by Schacter and his colleagues, in a discussion on memory and conscious awareness.

1.7 **Memory and Conscious Awareness**

The previous section noted that tests of explicit memory require a conscious memory search, while implicit ones do not. Studies of priming with amnesic patients (section 1.3) also distinguished the two types of memory test according to whether conscious awareness is required. Indeed, as Tulving (1985b) pointed out, the very act of remembering requires awareness.

Tulving distinguished between three types of consciousness, autonoetic, noetic and anoetic. Autonoetic consciousness, or self knowing, refers to the personalization of a memory, the remembering of an event as part of one's own existence, while noetic consciousness, or knowing, refers to our knowledge of objects and events of the world, and our awareness of them even in their absence. Anoetic consciousness, or non knowing however, refers to a conscious awareness that is bound to the present time and space. These three types of consciousness are correlated with episodic, semantic and procedural memory respectively.

Tulving described two experiments in which subjects were asked at test to put an "R" for "Remember" next to items whose prior occurrence in the study list they could consciously recollect, and a "K" for "Know" next to items they recalled or recognized on some other basis. By this, he demonstrated that subjects can make meaningful judgements about the nature of their conscious awareness during a memory test.

These two measures can be considered from a processing as well as a memory systems viewpoint, with "Remember" responses relating to conceptually driven processing and "Know" responses reflecting data driven processing. (See e.g. Jacoby, 1983; Jacoby and Dallas, 1981; section 1.4.)

In this respect, the two responses tend to mirror the processes involved in explicit and implicit tests of memory, the former tending to be of a conceptually driven nature, and requiring the subject consciously to recollect earlier studied items, the latter usually drawing more on data driven processing, requiring the subject simply to execute a task, the results of which illustrate a facility afforded by the previous study period. Thus variables that differentially affect tests of explicit and implicit memory tend similarly to affect "Remember" and "Know" responses.

Gardiner (1988a) showed that "Remember" rather than "Know" responses, were affected by a levels of processing study manipulation, the lack of effect on "Know" responses being reminiscent of implicit tests of perceptual identification or word fragment completion, in that these tests tend not to be affected by levels of processing study manipulations (see 1.4). Gardiner and Java (1990) found that word frequency affected the "Remember" response, while the "Know" response was sensitive to a word/non-word study manipulation, indicating that the conceptually driven processes involved in studying words present in semantic memory affected the "Remember" response, while non-words, having no place in the semantic network and therefore utilizing mostly data driven processing, affected the "Know" response.

Gardiner and Parkin (1990) used a divided attention task to test the hypothesis based on the parallel of the dissociations between "Remember" and "Know" and explicit and implicit measures of retention. Their task had subjects shadow a series of auditory tones, a task which tends to impair explicit recognition memory but not implicit word fragment completion. As anticipated, the authors found the "Remember" but not the "Know" response to be impaired by this manipulation since, by definition, explicit tasks require "on-line" consciousness while implicit ones do not.

Other independent variables have also been shown to affect "Remember" responses without influencing "Know" responses. Macken and Hampson (in press) varied incidental learning versus rehearsal, Gregg and Gardiner (1991) studied modality and Mogg, Gardiner, Stavrou and Golombok (1991) used threatening and non-threatening words. However, Gardiner and Java (in press) showed that, rather like priming in implicit memory, the "Know" response is more resistant to the effects of time, at least for periods of up to one week, whereupon both "Remember" and "Know" responses decline at a similar gradual rate over periods of one and six months. Parkin and Walter (1991) showed that elderly adults produced more "Know" and fewer "Remember" responses than younger subjects.

Blaxton (1991) drew attention to the correspondence between consciousness in memory as measured by "Remember" and "Know" responses, and conceptually and data driven processing. Blaxton devised tests that were either conceptually or data driven: her Experiment 3 involved a set of abstract visuo-spatial designs to be studied under two different orienting conditions. One condition was designed to induce data driven processing and involved neurological patients answering questions about vertical and horizontal lines which were present in the designs. Subjects in the conceptually driven processing condition were asked to state which of two verbal labels was best suited to fit the designs. The use of these tests showed that epileptic patients with left temporal lobe lesions tended to be better at data driven tasks (since they were less able to conceptualize the study material) while right temporal lobe lesioned patients were better at the conceptually driven tasks (since their type of deficit affected the study of the surface features of the material). When patients were asked to make "Remember" and "Know" responses in a recognition test, more "Remember" responses were made by the right temporal

temporal lesioned patients, and more "know" responses were made by patients with left temporal lobe lesions. This work strongly suggests that the conscious "Remember" response does map onto conceptually driven processing, while the "Know" response maps onto data driven processing. Moreover, this study together with the others discussed above, that have shown how certain variables affect the "Know" response leaving the "Remember" response relatively unaffected, argues against the idea that "Know" responses are merely a reflection of weak trace strength.

Experiment 7 in Chapter 5 uses "Remember" and "Know" responses to measure conscious awareness in the explicit and implicit memory of young and older adults. Chapter 2 that follows discusses functional explanations of the decline of explicit memory with age, while a second section of that chapter reviews the recent literature on explicit and implicit memory and age.

CHAPTER 2

MEMORY AND AGE

2.1 Functional Explanations of an Age-Related Decline in Explicit Memory

This section of the thesis discusses the functional explanations of the impairment with age of explicit memory.

Birren, Woods and Williams (1980) suggested that memory decline in older adults is due to a general slowing down in behaviour. Salthouse (1980) further considered that the process most likely to be affected by this loss of speed and ability is rehearsal. According to Salthouse, memory processes are similar across age; what differs is the speed of function.

Hasher and Zacks (1979) suggested that the processes involved in encoding differ along a continuum between effortful and automatic. They suggested that spatial location, time, frequency of occurrence and word meaning can be encoded using automatic processing, while imagery, rehearsal, organization and mnemonic processes are effortful, the latter group requiring a greater expenditure of attention and effort to maximize efficiency. Hasher and Zacks cited research on aging that illustrates deficits on tasks requiring substantial attentional capacity. For example, in tasks of free recall, older adults use organizational and clustering techniques less frequently, and are less likely to use mnemonic devices in paired associate tasks than younger adults. The elderly are also less competent in the use of imagery and tend to use rehearsal techniques less frequently. However, in a test of frequency judgements, an automatic process, these authors found no such evidence of an age difference. Hasher and Zacks (1989) have more recently suggested that age differences may be due to the elderly's lack of ability to inhibit irrelevant extraneous information. Reduction in inhibition, by enriching the contents of memory with unnecessary information, thus makes retrieval of the required information more difficult. These authors suggested that some of the tasks involving implicit memory call upon a minimum of interference.

It has also been postulated (Eysenck, 1974) that older adults find it more difficult to process information deeply; that they do not spontaneously perform deep semantic processing tasks. Since this type of processing is considered to produce a deeper memory trace (Craik and Tulving, 1975) which effects a greater resistance to forgetting, it is an important area to investigate. Craik and Simon (1980) suggested that, by giving subjects an orienting task which directs them to process items more deeply, age differences should diminish. However, in tasks concerning free recall Eysenck (1974), Erber, Herman and Botwinick (1980) and White (cited in Craik, 1977) still found age differences when semantic orienting tasks were included. Perlmutter (1978, 1979a), Mason (1979) and Zelinski, Walsh and Thompson (1978) also failed to find any improvement in older subjects' ability when intentional learning instructions were given, or orienting was manipulated. However, tests of recognition do not show such clear cut evidence. Craik and Simon (1980) reported a replication of White's experiment, with recall and recognition as a between subjects variable. Fewer age differences were found in recognition when encoding was controlled. Perlmutter (1978, 1979a) found that a free association task assisted the recognition of older subjects. However, Mason (1979) found that young subjects still outperformed the elderly when a category judgement task was used, and Smith and Winograd (1978) showed that older adults still performed badly when orientation was guided in a face recognition task. Indeed, Erber et al (1980) found that recognition deteriorated when a semantic orientation task was used. However, as Burke and Light (1981) pointed out, the fact that subjects are guided to perform certain orienting tasks, does not guarantee that exactly the same performance is actually occurring across for both age groups.

Rabinowitz and Ackerman (1988) reported two experiments that studied age differences in semantic encoding. They felt that older subjects used qualitatively different processing techniques from younger subjects, in that the older subjects employed more general, global features of study items, rather than specific contextual features which were likely to be more helpful to later episodic retrieval. In their Experiment 1, it was shown that the older group benefited less than the younger group from generating their own contextual cues. Experiment 2, a replication of Thomson and Tulving's (1970, Expt. 3) work comparing weak, strong and matching retrieval cues, showed that the older subjects fared as well with same strong as different strong cues, whereas the younger group reaped the benefit of matching cues, whether weak or strong, according to the logic of the encoding specificity principle (Tulving, 1983). Thus these experiments indicate a more general encoding process of the elderly by their failure to integrate the specific contextual study environment.

The elderly have thus been said to differ from younger adults at traditional laboratory tasks involving episodic memory because of their slowness in behaviour, a lesser ability at effortful processing, a lack of ability to process information deeply and their qualitatively different encoding techniques.

The experiments reported in this thesis, like the vast majority of the studies referred to in the literature has employed cross-sectional designs. This type of design has acknowledged problems associated with it, so that in a study of aging, effects other than the advancement of age and the possible decline in cognitive abilities may be being measured along with the task of interest, and may therefore result in inappropriate conclusions. Thus, for example, standards of living, medical care and nutrition have changed considerably over the last 50 years, so that comparisons between the memory abilities of 20 and 70 year olds may reflect these environmental issues too. Conclusions of causal inference and generality may therefore relate to "cohort" effects - differences between a set of subjects due to the lifestyle into which they were born and brought up, rather than the effect of chronological age on the task of interest.

A longitudinal design measuring changes in the same individuals over a period of years should overcome such problems, but this method also has its disadvantages. Research funds tend not to extend to the necessary length of time involved, and it is also quite possible that by the end of the study, ideas in that discipline might well have changed. A combination of cross-sectional and longitudinal techniques could be a solution to this problem,but there would need to be sufficient versions of the type of test to ensure against carry-over effects of learning, and that would still leave an effect of practice for that type of task.

Nevertheless, the results of the present investigation is readily interpreted within the context of an extensive corpus of work which provides converging evidence for causal interpretations of age-related changes in performance.

A further problem with attempting to use a longitudinal design to address the present issues would be that repeated testing of the same individuals would be likely to lead to the confounding of the results by the effects upon later performance of knowledge of the study's purpose.

The following section (2.2) discusses the recent literature concerning a comparison of explicit and implicit memory with age, and considers the types of tasks at which age similarities as well as differences are to be found.

2.2 A Review of the Literature concerning Aging and Priming

Recent memory research has compared the ability of different age groups on different types of explicit and implicit memory tasks. The studies included in this summary are categorized as far as possible in relation to the manner in which the implicit tasks were processed, either conceptually or perceptually. The first part of this section commences with papers involving tests that use a conceptual framework, that is, subjects are required to utilize the meaning of the material. The second part involves perceptual tests, to include lexical decision tasks (Richardson-Klavehn and Bjork, 1989, included word stem and fragment completion along with lexical decision tasks among their indirect memory tests of the "lexical domain"), procedural and skill learning, picture naming and visual closure tasks, perceptual identification, word fragment and word stem completion. Studies that include both conceptual and perceptual priming will be considered in the third part of this section.

2.2(i)

The first five studies to be considered involve conceptual priming tasks. Howard, Heisey and Shaw (1986) investigated the priming of newly learned associations, to see whether this ability differed according to age. The authors pointed out that the ability to learn new associations underlies language comprehension, memory search and problem solving. Subjects studied short sentences in the form of noun/verb/noun, for example, "The dragon sniffed the fudge", for periods of up to 20 seconds each. Priming was measured via a recognition test in which all of the nouns plus an equal number of distractors were presented for "yes" or "no" decisions, and reaction times were recorded. It was found that only the young group showed an effect of priming after the first presentation, but two or more presentations of each sentence afforded similar priming across age. Tests of cued recall showed differences in age. The authors argued that the priming measure they employed was similar to that used by Jacoby and Witherspoon (1982, see also below, this section), since it involved memory without awareness. Thus Howard et al suggested this methodology to be useful for discovering whether or not an item has been stored, rather than traditional retrieval methods.

Rabonowitz (1986) also studied priming as measured by reaction time in an episodic recognition task, as well as testing recognition and recall. He compared related and unrelated word pairs, for example, STRING-GUITAR and CARD-GUITAR. He found no effect of age on priming, though age did affect cued recall and recognition. Additionally, in the cued recall test, older subjects recalled more related than unrelated words. Rabinowitz suggested that his result reflected the continuum of automatic and effortful processing (Hasher and Zacks, 1979; see also section 2.1) with the test of cued recall being at the effortful end. Furthermore, he suggested the results indicate that any age related deficits can be accounted for by retrieval processes rather than an integration deficit (see e.g. Graf and Mandler, 1984; Mandler et al, 1990; section 1.5), as the competence of older subjects at encoding both related and unrelated word pairs was highlighted by the priming task.

Rose, Yesavage and Hill (1986), in a replication of Jacoby and Witherspoon's (1982) study with amnesic patients, gave subjects a "general information Questionnaire" in which homophones were embedded within the questions. One such question asked "where did the founding fathers of our country gather to WRITE the constitution?" The intention was that a later spelling test would pick up evidence of priming, according to the particular meaning of the homophones as biased by the questionnaire. A recognition test followed, whereupon subjects were quizzed as to their awareness of the study's purpose. While none of the subjects noticed the relationship between the study task and the spelling test, some realized that items on the recognition test related to items in the questionnaire.
It was found that only the younger group showed a priming effect for the biased meaning of the study words, although the two groups performed similarly in recognition. Thus the study failed to replicate in the elderly, Jacoby and Witherspoon's finding that amnesic patients show similar priming ability to normal control

subjects at this task. The authors concluded that perhaps this study used an automatic task at which older adults are less successful, or that the task relied on the specific contextual information of the study items, a process that elderly subjects are said to find difficult (Rabinowitz and Ackerman, 1988; see also section 2.1). Nonetheless, it seems unusual to find a study in which the explicit task, albeit one of recognition in which differential effects of aging have been found (for a review, see Burke and Light, 1981) shows less of an effect of age than the implicit one.

Howard (1988) however, reported a series of three experiments that were also based upon the semantically biased homophones experiment of Jacoby and Witherspoon (1982). Experiment 1 posed a number of orally presented questions, a proportion of which were homophones biased to their less frequent meaning, e.g. "If you were making a pizza which kind of cheese would you GRATE?" Subjects were tested for explicit recognition and implicit memory, the latter test requiring them to write down each biased word. Results showed that although both age groups showed a significant spelling bias, the younger group outperformed the older subjects. However, Howard suggested that the implicit test might have been contaminated to some extent by explicit strategies, since post hoc testing revealed a relationship between the two types of tests for both subject groups. Experiment 2 followed another procedure. This time subjects were to listen to a set of related word pairs, a proportion of which were biased homophones as before, e.g. Cheese-GRATE. Subjects were tested for immediate and delayed recognition, cued recall and implicit spelling bias. Results showed no age differences in recognition for either the immediate or delayed tests, though differences in age occurred for both types of test in cued recall. The implicit test showed no age difference for the immediate test, but differences became apparent after the two day delay, when the older group, though still showing a significant priming effect, produced a lower spelling bias than in the immediate test. Howard noted however, that subjects tended to be aware of the purpose of the "implicit" test, and hence she set out to make the test less "transparent" in her third experiment. This time subjects were asked to make a novel sentence each containing one of the study words, rather than simply to spell them. Results of this experiment showed no effects of age on spelling bias for the immediate or delayed tests. Since none of the subjects revealed spontaneous awareness of the study's purpose, the author proposed that spelling bias can be a long lived effect, possibly based on contextually appropriate activation. (See also Davis, Cohen, Gandy, Colombo, Van Dusseldorp, Simolke and Romano, 1990; section 2.2(iii).)

Light and Albertson (1989) used the task of generating category members as their implicit test, comparing this with category cued recall. Thus for the implicit test, young and older adults were asked to generate members of categories after a study phase involving the rating of a list of words, some of which were the target categories, for pleasantness. Category names served as retrieval cues in cued recall. The authors found no reliable age differences in the implicit task, but there was a difference in age for cued recall. Subjects were questioned post hoc, about their awareness of test items as study list members. It was found that significantly more younger subjects than old were aware of the relationship between test and study, and that more of the young aware subjects said they had deliberately generated words from the study list. However, while Light and Albertson considered the possibility that deliberate retrieval by a greater number of young subjects might account for small but unreliable age differences sometimes found in priming ability, they pointed out that in cued recall, elderly subjects tend not to benefit from intentional retrieval instructions. Thus these authors suggested that age differences in memory relate to intentionality or the deliberate recollection of events.

2.2(ii)

This part of this section summarizes studies concerning priming and aging that deal with tasks of a perceptual nature. The first study by Moscovitch (1982) distinguished between conscious recollection and procedural or skill memory, and suggested that it is the former that is assessed by traditional memory tests, while the latter requires subjects simply to perform a task. He considered conscious recollection would be more severely disadvantaged by age than procedural memory. Moscovitch tested this hypothesis using a lexical decision task involving words and pronounceable non-words. The decision as to whether a string of letters is or is not a word, results in shorter reaction times on a second presentation of the item. This repetition priming effect was similar for both age groups. However the results of another experiment involving the reading of geometrically transformed script did not show a preserved capacity in normal elderly subjects. Thus Moscovitch concluded that while conscious recollection is severely impaired in the elderly, widespread damage due to aging may affect some procedural tasks too.

Howard, McAndrews and Lasaga (1981) in another lexical decision task, asked young and older adults to decide whether pairs of word strings were real words and respond with a "yes" or "no" in respect of the two words together. Comparable response times across age were recorded, although a free recall test given to the same subjects, though using a different set of target words, showed a difference in age. The authors discussed their results according to the automatic/effortful hypothesis of aging (see section 2.1).

Read (1988) studied age and implicit memory using a "visual closure" task as a measure of visual perceptual skill. Ability at this task is said to decline more quickly with age than verbal ability (Botwinick, 1977; Kausler, 1982), although the task had not been used before as a "covert" test. In this study involving 734 subjects of three age groups between the ages of 50 and 79, subjects were presented with line drawings of four levels of perceptual difficulty. They were asked at each level to identify the pictures. Delayed recall and recognition were also tested, and implicit memory was measured by percentage savings scores. Age differences were shown for all of the tests. Read questioned why some implicit memory tasks show evidence of aging while others do not, and suggested that tasks of higher perceptual difficulty, like Moscovitch's (1982) tests of transformed script might present too great a perceptual load for some elderly subjects.

Mitchell (1989) suggested that evidence from his study on aging provides support for the theory that memory involves more than one system (see section 1.5). He manipulated codability and lag, as well as investigating age related differences in the proposed three systems of episodic, semantic and procedural memory. Codability can be explained as the ease of naming a drawing or picture. Thus a picture of a chair is usually defined by most people as a chair, whereas a picture of a dresser might well result in several different definitions. Codability was taken as a measure of both semantic and episodic memory. Items of higher codability are said to be easier to access from semantic memory than items of lower codability, but low codability items are easier to recognize in episodic memory tests. Lag effects, the effect of the number of items between repeated target items, were used as a measure of both episodic and procedural memory, since episodic memory performance was expected to improve with increased lag, while repetition priming was expected to deteriorate. Priming was measured by the difference in the time taken to respond to the second occurrence of an item's presentation and a baseline item. No significant effect of age was found for this measure. While items of low codability produced greater priming, these did not differ with age. However priming declined across lag for both age groups. Naming, the measure of semantic memory, also failed to show any age differences. Episodic memory measures, on the other hand, illustrated the anticipated differences in age, with older subjects performing less well than the young in tests of recall and recognition. Thus Mitchell's investigations showed that older adults were only impaired in episodic tasks.

Factor analysis revealed three distinct memory systems. In his final consideration as to whether there is one, or there are several memory systems, Mitchell considered a processing account (see section 1.5) of the data, that matching study and retrieval processes are a reasonable interpretation. However, he suggested that the elderly only showed a difference in ability at tasks involving episodic memory, and since all the stimuli and tasks were performed by both age groups, matching encoding and retrieval processes were irrelevant. In a further study of priming as assessed by picture naming, Mitchell, Brown and Murphy (1990) again showed no reliable age differences.

Light, Singh and Capps (1986) in a replication of the work of Tulving et al (1982) comparing yes/no recognition with word fragment completion, tested young and older age groups. They found for example, that recognition of the word ASSASSIN was not as good in older subjects as young subjects, yet asking subjects to replace the dashes in the fragment A--A--IN produced similar ability for age. The authors attributed these differential results of age and test type to a lack of impairment when memory without awareness is tested. They considered their data within the framework of Graf and Mandler's (1984; see also section 1.5) dual process theory, suggesting that only activation and integration processes were involved in word fragment completion, the test not requiring the invocation of elaborative processes.

Light and Singh (1987) conducted three experiments involving explicit and implicit memory, again considering their findings from a memory processing approach. Experiments 1 and 2 compared word stem completion, free and cued recall and recognition. The results showed no effect of age on word stem completion, while the usual age effects were found in recall and recognition. Experiment 2 used the same stems for cued recall as word stem completion; only the instructions differed. Thus it was possible to show whether instructions merely to carry out a task, rather than to use conscious retrieval, could alter apparent ability at the task. Experiment 3 used perceptual identification as the implicit task, as well as tests of recall and recognition. Again, only the explicit task was affected by age. Light and Singh suggested their findings to be compatible with the view that older adults are less capable than the young of performing tasks involving the integration of items, or processing items in context, and that implicit tasks utilize automatic processes which do not necessitate such integration (Burke and Light, 1981; Kausler and Puckett, 1980, 1981; Rabinowitz, 1984; Rabinowitz and Ackerman, 1982; Winocur and Moscovitch, 1983; see also section 1.5 and 2.1). However, Rabinowitz's work involving related and unrelated word pairs, implies that older adults are capable of encoding using these processes; perhaps it is just that tests of recall and recognition are not sufficiently sensitive tests of retrieval to illustrate this ability.

The last study in this section on perceptual priming tasks involves a word stem completion test in which age differences have been found. Chiarello and Hoyer (1988) showed significant effects of both levels of processing and age in word stem completion, failing to replicate

Light and Singh's (1987) findings. Chiarello and Hoyer suggested that the small but non-significant age differences found in previous studies of word stem completion may be real and they stressed the need for a powerful experimental design (they used twice the number of subjects used by Light). These authors concluded that since there are age differences in some implicit memory tasks, it cannot be said that implicit memory tasks are uniformly unimpaired by age.

2.2(iii)

This last section describes three studies that involve conceptual and perceptual priming. Moscovitch, Winocur and McLachlan (1986, Expt. 1) had memory impaired institutionalized subjects, normal, old and young subjects read sentences in geometrically transformed script. After one to two hours and four to fourteen days, they were to say which sentences they recognized as old. Young and normal old subjects showed a similar pattern of results for this task. When reading speed was taken into account, there was found to be only one dissociation between the two measures. The neurologically disordered subjects' reading time was similar to that of the other subject groups, but their recognition ability was impaired. Experiment 2 investigated item specific information, and the three groups studied weakly associated word pairs and sentences. They were tested after a few minutes for recognition and reading speed. Although the young had faster reading times than the older group, it was only the institutionalized subjects who had impaired recognition ability. Experiment 3 obtained similar results using randomly associated word pairs. Despite a weakness in the data due to the young having faster reading speeds than the older group, Moscovitch et al, felt it was possible to put forward the view that the type of memory measured by reading speed deteriorates more slowly with age than that requiring conscious recollection. These authors' experiments suggest that even memory disordered people can form and retain new associations, but recognition, requiring conscious recollection, is impaired. In considering that data and previous work with amnesic patients, the authors considered that an interpretation according to systems or processing approaches were not mutually exclusive, and that a theory of memory systems should also take into account what conditions and processes each system characterizes.

Howard (1988) assessed implicit memory by exposing young and older adults to newly associated word pairs, using a word stem completion task. At study, subjects were to make a sentence out of each pair of words and to rate this task for difficulty in each case (Expt. 1). At test, they were given the first of the word pairs and a three letter stem to complete e.g. QUEEN-STAIRS/QUEEN-STA___. Howard found no difference in age for this experiment. However, when she presented the same word pairs in the form of a sentence to be studied (Expt. 2), e.g. "The queen fell down the stairs", so that the target words were not highlighted, results showed that the older group's implicit memory was impaired by this difference in study task. Howard suggested that in the second experiment, the older adults failed to establish a relationship between the target words, and concluded that while there tends to be an age equivalence for implicit word stem completion, this is not always the case for implicit associative memory.

Davis, Cohen, Gandy, Colombo, Van Dusseldorp, Simolke and Romano (1990) not only questioned whether implicit memory is spared in the elderly, but whether their performance is qualitatively similar to that of amnesic patients. They noted the mixed findings in the literature concerning priming and age, and suggested this might be due to the different methods used. Their Expt. 1 used the homophone priming task of Rose et al (1986). Davis et al found no effect of priming for their elderly group, and suggested that their results were confounded by the high baseline scores of the older subjects. They further suggested that the task was unsuitable as an assessment of implicit memory ability and age. Experiment 2 involved a word stem completion task given to young and older subjects between the ages of 20 and 80 plus. The authors found that both subject groups showed significant priming effects for this task, but that subjects in their seventies and eighties had significantly lower priming scores than the other subjects. Davis and his colleagues thus concluded that since implicit memory seems not to be uniformly spared in the elderly, a parallel cannot be drawn between the abilities of amnesic patients and elderly subjects.

Thus this review of the literature concerning aging and priming that includes studies both of a conceptual and perceptual nature has shown both equivalence of age as well as an impairment with age for both types of task. A smaller proportion of the conceptual priming tasks referred to in Section 2.2(i) than those of perceptual priming (Section 2.2(ii)) showed the preserved ability of the elderly. Section 2.2(iii) in which three studies involving both types of task were discussed, also showed that the more perceptually oriented tasks tended to afford an age equivalence, while a mixed design of conceptual study conditions and perceptual priming task showed differential results with age according to the mode of study presentation.

From the above, it appears that the evidence for a preserved priming ability with age leans towards the idea that tasks of a perceptual nature produce this effect. It is important therefore to investigate priming tasks of both types in order to discover what might effect these differential findings of age equivalence and differences in implicit memory tests. Section 2.3 that follows introduces the experimental chapters that compare memory and age, using word stem completion, anagram solution and word association as the perceptual and conceptual implicit tasks.

2.3 An Introduction to the Experimental Chapters

The literature cited in Section 2.2 of this chapter illustrates the differential findings with regard to older subjects' ability at explicit and implicit memory tests. Most of the research indicates an impaired ability at explicit tasks. Indeed, as Perlmutter (1980) pointed out, so many studies have been designed to highlight this deterioration with age, that we have now come to accept this failure of memory with age as a fact. However, of the implicit memory tasks discussed in the previous section, over 65% showed the preserved ability of older adults for this kind of test.

The first experimental chapter describes two experiments which compare explicit and implicit memory in young and older adults. Experiment 1 uses word stem completion as its implicit task, with cued recall as the explicit counterpart. Experiment 2 compares anagram solution and recognition. By including levels of processing as a study manipulation in both of these experiments, converging evidence with regard to the tasks' implicitness is obtained.

Experiment 1 was originally concerned with the intention of extending the work of Light et al (1986) to a word stem completion test. These authors investigated memory in young and older adults using word fragment completion as the priming task (see section 2.2). Word stem completion was originally used by Warrington and

Weiskrantz (1970) in their work with amnesic patients (see section 1.3) and has been quite popularly employed as a priming task since then (see e.g. Graf, Mandler and Hayden, 1982; Graf et al, 1984; 1985; Greene, 1986; section 1.2). The paper by Light and Singh (1987) in which older adults showed preserved memory for the implicit task of word stem completion (see section 2.2) was published while Experiment 1 was already in progress.

Thus for Experiment 1, it is predicted that there should be no effect of age or levels of processing in word stem completion, while evidence of the effects of both of these variables should be shown in cued recall.

Experiment 2, which uses anagram solution as its task of implicit memory, is an investigation into the generality of the types of task that reveal little effect of age.

While anagram solution has been used before as a priming task (see e.g. Dominowski and Eckstrand, 1967; Jablonski and Mueller, 1972; Perruchet and Baveux, 1989 and Gardiner, Dawson and Sutton, 1989), this task has never been employed in a study concerning age. Srinivas and Roediger (1990; see also section 1.4) in an endeavour to classify anagram solution according to its processing components were unable to state definitely that the task was classifiable as data driven, but noticed that its behaviour was similar to word fragment completion when levels of processing and modality were manipulated. If, as these authors suggest, anagram solution does involve a large data driven component like word fragment and stem completion, then it is predicted that there should be no evidence of a levels of processing effect (see section 1.4). In addition, since the literature discussed in Section 2.2 has indicated that elderly subjects are more likely to show a preserved priming ability at perceptual or data driven tasks, this task should show little evidence of age. However, it is predicted that both levels of processing and an effect of age should occur in an explicit recognition task.

Chapter 3 covers work on three experiments which vary read and generate, the two extreme study conditions used by Blaxton (1985, Expt. 1; 1989; Roediger and Blaxton, 1987; see also section 1.4). It is proposed to use this study manipulation in order to extend these authors' findings with word fragment completion to word stem completion in a study of age. Thus free recall is representative of the authors' conceptually driven explicit task in the present Experiments 3 and 4, and word stem completion its data driven counterpart in all three experiments. It is predicted that, in free recall, the younger subjects will outperform the older group, and the standard generation effect will be produced. However, if word stem completion is classifiable as a data driven test, according to the Roediger et al (1989; see section 1.4) criteria, the generation effect should be reversed. Since age has tended not to be a distinguishing feature in many implicit memory tasks of a perceptual nature, it is anticipated that the three implicit tests used in this chapter will show a lower level of impairment with age compared to the explicit tasks.

While Experiment 3 compares straightforward word stem completion task with free recall, Experiment 4 embeds word stem completion within a set of other tasks, in an endeavour to disguise the purpose of this part of the study, in order to render the task genuinely implicit. This embedded form of the word stem completion task is to be compared with explicit free recall. It is predicted that the embedded task should incur an even smaller age difference than one that might be found in Experiment 3, since explicit strategies should be less available for use by the younger group, who would otherwise be more likely to avail themselves of this ability.

Experiment 5 investigates subjects' awareness in the two types of word stem completion task used in the previous two experiments, comparing them directly, within subjects, and asking the four questions devised by Bowers and Schacter (1990) and Schacter, Bowers and Booker (1990) (see section 1.6) to detect test awareness. By applying these questions to both of the word stem completion tasks designed to be implicit, and designating subjects post hoc to "aware" and "unaware" groups; it is predicted that in Experiment 5, a greater effect of read should occur among the unaware group, since this finding appears to be related specifically to data driven implicit memory, according to the work of Blaxton (1985, Expt. 1, 1989; Roediger and Blaxton; see also section 1.4) who showed this effect in a word fragment completion task. Blaxton also showed an enhanced read effect in her data driven task of graphemic cued recall, but on this occasion the read superiority appeared to be somewhat reduced. Furthermore, it is predicted in the present experiment that old and younger subjects in the "aware" group should show a greater difference in age than "unaware" groups, since tasks involving conscious awareness tend to benefit younger adults.

The work discussed in Chapter 4, the final experimental chapter, extends the findings of the earlier experiments in this thesis in two ways. Experiment 6 investigates conceptual priming, to see whether the relatively preserved capacity of older adults which has been shown to occur mostly in perceptual implicit tasks (see section 2.2), generalizes to this mode of priming on this occasion. However, Light and Albertson (1989; see also section 2.2) did show an age equivalence in a priming task involving the production of category members. Work with amnesic patients (Shimamura and Squire, 1984, Expt 3; see also section 1.3) has shown this subject group to perform at a similar level to normal controls in a word association task.

Experiment 6 uses a word association task as the conceptual implicit test and incorporates it within the format of a verbal skills test, as in the previous two studies, in order that an implicit measure of memory might be more readily achieved. It is anticipated that since tests of perceptual priming have shown the effect of transfer appropriate processing (Morris et al, 1977; see also section 1.5) highlighting the data driven properties of study and task procedures thereby showing a read superiority effect (in straightforward non-embedded tests), it is also likely that the effect of generating at study might enhance the conceptually driven processes of word association at test. Results are awaited as to whether this task will show similar priming across age as there is less work involving conceptual than perceptual priming and age in the literature (see section 2.2). In free recall, while the younger group is expected to outperform the older group, both groups should benefit from the generation of material at study.

Experiment 7 draws upon the work of Tulving (1985b) together with that of Gardiner (1988a) concerning measures of consciousness in memory as assessed by "Remember" and "Know" responses (see section 1.7). This experiment employs the basic methodology of Experiment 1, in which the same word stems are used as cues for both word stem completion and cued recall, but further asks subjects to indicate with an "R" or "K" response, their mode of consciousness for recognized completions and items recalled. It is therefore predicted that, not only should the younger subjects outperform the elderly in cued recall, and that an age equivalence should be shown for word stem completion as in Experiment 1, but that the difference in age for cued recall should only occur for conscious "Remember" responses, since older adults have been shown to be less adept at tasks involving conscious awareness (see section 2.2). It is further predicted that fewer of the stem completions will be correctly recognized by the older subjects than the young, since recognition is an explicit task.

On a methodological note, it is necessary to point out that apart from Experiment 5, all of the experiments involve comparisons between explicit and implicit tasks in order that differential effects of age and/or study manipulation may be seen. In each of these experiments, subjects are informed that the study includes a memory test, the nature of which is not initially specified. This follows the method of Light, Singh & Capps (1986) who instructed their subjects to "Learn each word" as their memory for these words would be tested later. There is good evidence to show that incidental vs intentional study instructions have little effect on implicit word stem completion (see eg. Bowers & Schacter, 1990; Greene, 1986).

The decision to warn subjects of an impending memory test was taken in order to encourage subjects to encode the study material deeply, as elderly subjects have been shown to be less efficient at this procedure (see section, 2.1), and it was important to ensure that sufficient data should be available so that the effects of study manipulation on both implicit and explicit tasks might clearly be seen.

Any risk of subjects guessing that the implicit task was the "memory" task and deviating from the instructions given by using explicit strategies is controlled for in each experiment. The manipulation of study variables known to affect explicit but not implicit memory, or to affect the two in different ways (in the earlier experiments) together with two types of measures of conscious awareness (in two of the later experiments) all provide converging evidence that this did not happen.

In summary, Chapter 3 covers work on explicit and implicit memory tasks, involving two studies of age that manipulate levels of processing at study. The first experiment uses word stem completion as the implicit task, the second, anagram solution. Chapter 4 discusses the effect of manipulating read and generate at study, in three experiments involving word stem completion. Experiment 3 compares straightforward word stem completion with free recall, while Experiment 4 embeds word stems to be completed within a set of other tasks and compares this with free recall. Experiment 5 compares the two types of word stem completion tasks and investigates test awareness. The final experimental chapter investigates conceptual priming and measures the conscious awareness involved in implicit and explicitly produced material.

CHAPTER 3

IMPLICIT MEMORY TESTS: WORD STEM COMPLETION AND ANAGRAM SOLUTION

3.1 Introduction

The two experiments described in this chapter compare explicit and implicit memory and age using word stem completion and anagram solution as the implicit tasks, with cued recall and recognition as the tests of implicit memory. At the time of designing these experiments, neither of the priming tasks had been used in research concerning the elderly. The aim of these experiments was to extend previous work that has shown the elderly to have a relatively preserved implicit memory capacity to these two perceptual tests.

A levels of processing study manipulation was included in both of the experiments for two reasons. Firstly, it is an important manipulation in supplying converging evidence with regard to the implicitness of the tasks. That is, implicit tasks tend not to be sensitive to this manipulation (see e.g. Graf and Mandler, 1984; Jacoby and Dallas, 1981; see also section 1.4). Light and Singh (1987; see section 2.2) showed that in a word stem completion task, young and older adults similarly showed little effect of this manipulation at study, and no significant age difference in overall ability at the task. Secondly, since it has been suggested that older adults tend to process to be remembered information in a different manner from young adults (section 2.1), it was considered important to include a semantic encoding task, both as an environmental support, and in order to ensure that any perceived age related findings should be attributable only to intentional study manipulations.

It was predicted that in Experiment 1, there would be an age difference in explicit cued recall, with higher scores for items studied under semantic encoding conditions for both age groups. Neither the effects of levels of processing nor age were anticipated in the implicit task. Experiment 2 employed anagram solution as its implicit task, with recognition as the explicit task. It was predicted that if anagram solution is a data driven test and behaves like word fragment and stem completion, there would be no effect of levels of processing or age for this task, but that both of these variables would affect recognition.

3.2 Experiment 1

Introduction

Young and older adults studied a list of words, half of which were encoded with respect to a semantic task, half of which were encoded with respect to a graphemic task. The semantic task was to produce an associate of the word. The graphemic task was to produce any two letters that were not present in the word. All subjects were then given a word stem completion test, presented as a filler task, and after that they were given a cued recall test with word stem cues.

The semantic task used in this experiment involved the production of an association to the target word rather than pleasantness ratings (see e.g. Light et al, 1986; Light and Singh, 1987) since the former task seemed more ecologically valid, particularly for older subjects who tend to be less used than students to psychology laboratory techniques.

The Mill Hill Vocabulary test was included (in this and in the following experiments) partly as a filler task before the implicit test. More importantly however, it was used to assess verbal ability as a measure of intelligence, since it is necessary to establish that any differences found should be due to age and memory and not intellectual factors.

The use of a vocabulary test as a measure of verbal intelligence is customary in studies of memory and age. Light, in her laboratory, uses the 40 item vocabulary subtest of the Shipley-Hartford Institute of Living Scale (Shipley, 1940) to assess verbal ability, while in Craik's laboratory the Mill Hill test is used. Very often older subjects are shown to be superior to their younger counterparts on these tests (see eg. Light & Singh, 1987; Light, Singh & Capps, 1986; Loewen, Shaw & Craik, 1990) and it is important to note that the words involved are in current regular use. This is mentioned in the light of evidence that age related deficits in recall can be eliminated when the material used benefits the particular age group being tested. (Barrett & Wright, 1981). However Rabbitt (1986) has shown that the correlation between chronological age and Mill Hill score is close to zero, indicating that high scores on the Mill Hill test should not relate inappropriately to the beneficial effects of the material involved.

This experiment was thus designed to compare explicit and implicit memory and age, using word stems as cues and varying levels of processing at study. Since the same lists of word stems were used for both the implicit word stem completion task and explicit cued recall (counter-balanced for order), a direct comparison could be achieved between the two types of test in which only the instructions differed. This comparison was made within subjects. (This experiment differed from the work of Light and Singh (1987, Expt. 1; see section 2.2) who compared word stem completion with free recall and varied levels of processing between subjects.) Furthermore, the levels of processing study manipulation acted as a check to corroborate the explicit/implicit difference between tests.

Thus it was predicted that younger subjects would outperform the older adults at cued recall but not implicit word stem completion. In addition it was anticipated that the levels of processing effect should occur only in cued recall.

Method

Subjects

The young group comprised 16 students from City University in London, with a mean age of 21.7 years (range = 18-29). The older group comprised 16 volunteers from day centres near the university, voluntary workers from Age Concern, Islington, and members of the University of the Third Age, all of whom reported themselves to be healthy and were living in the community. Their mean age was 72.9 years (range = 67-81).

A shortened form of the Mill Hill Multiple Choice Synonyms tests on which the maximum score is 21 was administered to assess verbal ability. Mean scores were similar for both groups; young = 16.1, old = 15.9, ranges = 12-19 and 4-21 respectively, $t < 1$. Subjects were tested individually and were paid for their participation.

Design and Materials

There were 80 six letter words taken from "The Little Oxford Dictionary", the stems of which could be used to form at least 10 words of varying length (e.g. DEFend, DEFer). These items were handprinted individually on index cards, which were randomly split into two sets A and B. Within each of these sets, a further random split (a) and (b) was made, representing blocks of semantic and features study tasks, the order of presentation being balanced across subjects and conditions. Since word stem completion was presented as a filler task and subjects were not be alerted to the fact that this task also was a test of memory, the order of testing was not varied; subjects always did the word stem completion task followed by cued recall, thus test sheet (i) was a word stem completion test for half of the subjects and test sheet (ii) for the other half, within each age group. The test sheets were constructed of 40 word stems each, 20 of which were distractors from the unseen set A or B. Ten of the target items had been studied using the semantic orientation task and 10 as the features task. Thus for both study and test lists, materials were fully counterbalanced across all other experimental conditions. The study used a 2 x 2 x 2 factorial design, with the first variable of age as a between subjects factor, the other two of task and study orientation, as within subject variables.

Procedure

Subjects were given blank sheets of paper and pencils, and the appropriate instruction sheet for the first study task. They were advised that they would be shown words on cards presented individually at intervals of about 4/5 seconds, and were to try to retain these items for a later unspecified memory test. At the same time, they were to write down an associate to the target word (semantic orientation task) or any two letters NOT present in the word being shown (graphemic orientation task), according to which condition was required of them first. When both tasks had been completed, (40 words studied), subjects were told that there would be two more tasks to be completed before the memory test. One of these was the Mill Hill Synonyms test and the other was the word stem completion test, in which they were asked to complete all of the stems on the sheet with the first English word that came to mind that began with those initial letters and was not a proper noun. Lastly, they were given the other sheet of word stems, introduced as the "memory test", and were asked to use these stems as cues to help remind them of items they saw earlier in the study period. They were only to fill in those they remembered, trying not to guess, having been informed that only half of the stems related to words they had seen earlier.

Results

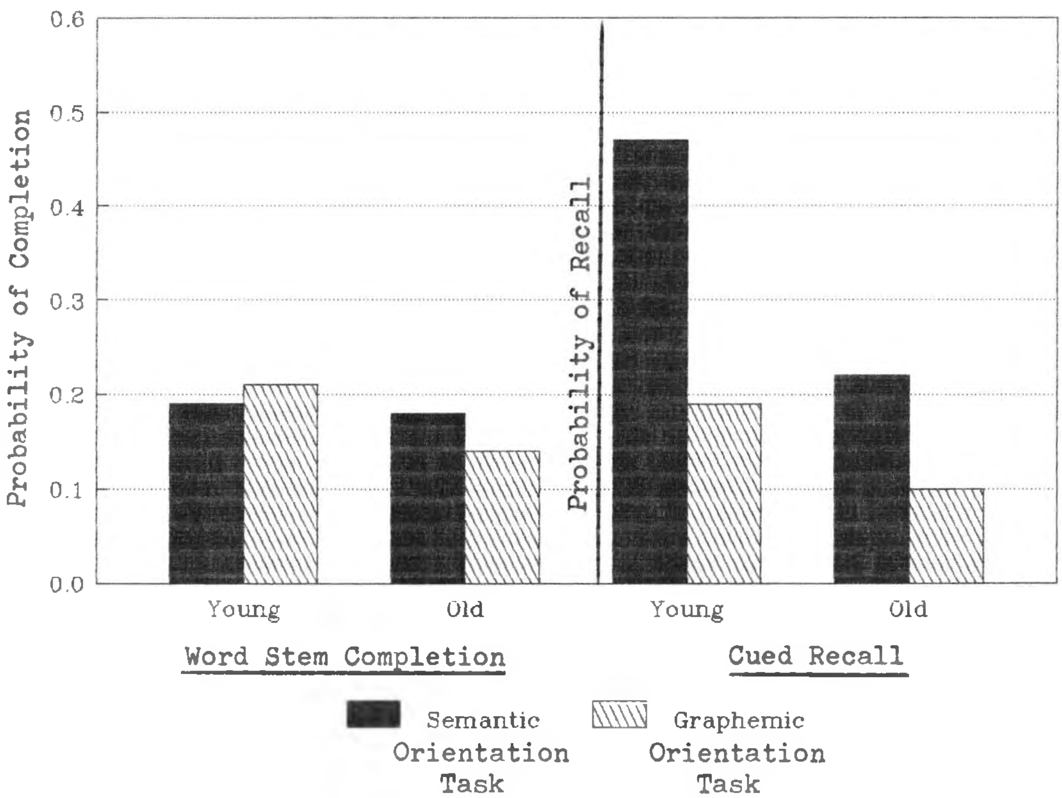
The mean probabilities of correct responses for both age groups according to study orientation and task type are summarized in Figure 1. These results indicate the difference in ability of the two age groups, and the effect of study orientation according to whether explicit or implicit memory was tested.

The left hand panel of Figure 1 shows word stem completion rates after subtracting the respective baseline rates for each set of items in each condition; the measure of priming. The figures indicates that there is little difference of age or levels of processing for this priming measure. However the right hand panel of the figure shows a difference in ability according to

FIGURE 1 - EXPERIMENT 1

Probability of Word Stem Completion and

Cued Recall as a Function of Age and Task



age, and a levels of processing effect which is attenuated for the older group. Baseline rates for the semantic and graphemic orientation tasks in implicit word stem completion were .15 and .11 for the young group, and .12 and .14 for the older subjects. Corresponding intrusion rates for cued recall were .01, .00, .03 and .03 respectively. Baseline adjustments have been dealt with in the literature in several ways. Some authors have taken one overall baseline figure for nonstudied items and subtracted this figure from both study conditions (see eg. McClelland & Pring, 1991) while others (see eg. Bowers & Schacter, 1990) have obtained an overall baseline score from a matched though non-participating group of subjects and subtracted this figure from their target data. Another method involves subtracting the baseline probability for each condition. (see eg. Light & Singh, 1987; Light, Singh & Capps, 1986).

The first method, while simplifying the experimental design, might be considered less desirable since it obscures more subtle baseline differences, while the second method incorporates differences in samples. Thus the third method was chosen for this experiment, and for others in the thesis where two study conditions are involved, since by including targets and baseline measures separately in the analysis, any influence of the encoding task on the effect of priming would be revealed by an interaction with item type.

The decision of which method to use was a difficult one. Since implicit scores tend to be lower than those of explicit tasks, it is important that effects should not become obscured in the analysis. An alternative method not yet mentioned, would have been to correct each subject's score by subtracting their baseline score for each condition and incorporate these corrected data into the analysis. However,this would have allowed an interpretation of a first order interaction only. The inclusion of target and baseline scores for each subject in each study condition in the analysis in this experiment, affords not only the same effect size, but shows how the first order interaction comes about in relation to studied and nonstudied differences.

Analyses of variance (ANOVA) were applied separately to the word stem completion and cued recall data, to include 2 (age, young vs. old) x 2 (orientation, semantic vs. graphemic tasks) x 2 (item type, target vs. baseline - word stem completion only). The 0.05 level of significance is used throughout this thesis, for all experiments. Analysis of the word stem completion data showed that the main effects of age and orientation were not significant, $F < 1$ in each case, indicating the task was neither sensitive to the levels of processing manipulation nor to age, as predicted. However, the main effect of item type was significant $F(1,30) = 60.99$, $MSe = 1.67$, showing the high level of priming for both age groups. The two-way interactions of age x item type and orientation by item type were not significant, F < 1 in each case, and neither was the three way interaction of age x orientation x item type, F < 1, indicating that priming did not differ reliably with age or orientation.

Analysis of the cued recall data showed significant main effects of age and orientation, F(1,30) = 5.39, MSe = 5.6 and F(1,30) = 22.7, MSe = 2.65 respectively, reflecting as predicted, the better ability of the younger adults at this explicit task and the levels of processing effect. The interaction between age and levels of processing was not significant, F(1,30) = 2.86, MSe = 2.65, indicating that both age groups benefited from the semantic study condition.

An ANOVA combining the data from both tests with "type of test" as a factor, was carried out to check on the conclusions based on the separate analyses. In particular, the 2 and 3 way interactions of test x item type and age x test x item type approached significance, f(1,30)= 3.97, MSe=1.82 and F(1,30)=2.94, MSe=1.82, respectively. These effects of near significance reflect differences between target and baselines scores for both groups, and the superior cued recall scores of the younger subjects. The 3 way interaction of test x item type x orientation was significant, F(1,30)=7.19, MSe=1.41, indicating the effect of the levels of processing study manipulation for list items only in cued recall. The 4 way interaction of age x test x item type x orientation did not reach significance, $F(1,30)=2.85$, $MSe=1.41$.

It was decided however,that since data from the implicit tasks alone have relevant baseline scores (intrusions rarely occurred in cued and free recall) it would be more appropriate to continue to analyse the two sets of data separately for the experiments that follow.

Discussion

The results of this experiment show just how different an individual's ability can be, according to whether explicit or implicit memory is being tested. No significant effects of age or levels of processing occurred in word stem completion, yet the effects of both of these variables were shown in cued recall. This difference in ability was found in the same sets of subjects using the same test material; only the instructions differed.

The younger group outperformed the elderly in cued recall as predicted, seeming to make better use of the semantic study condition than the older subjects, although the age x study orientation interaction failed to reach significance. As Light and Singh (1987, Expt. 1) pointed out in their study (which did show a reliable age x orientation interaction for free recall), this apparent difference occurred despite the inclusion of a task intended to assist the deeper elaborative processing of the older group. Craik and Simon (1980; see also section 2.1) had suggested that such an inclusion should narrow age differences by affording the older group an enhanced study environment, thereby reducing any processing resource deficit in the elderly that might occur. However, the present work, along with that of Light and Singh, fails to support these ideas. It was only when subjects were not instructed to use conscious retrieval that some parity was reached.

The word stem completion task, as predicted, showed no such differences in ability according to age, and no sensitivity to the levels of processing study manipulation. As some amnesic studies have also shown (e.g. Graf, Squire and Mandler, 1984; Graf, Shimamura and Squire, 1985; see also section 1.3), the competence of two sets of subjects whose abilities at standard explicit memory tests tend to differ greatly, can become comparable by the simple exclusion of a request for explicit memory to be used.

Thus the differential effect of the two types of test according to age and study manipulation confirm and extend previous findings of work concerning explicit, implicit memory and age. (See section 2.2 for a full review.) The next experiment in this chapter investigates anagram solution as an implicit test, with recognition as the explicit counterpart, in a study that compares age and levels of processing effects.

3.3 Experiment 2

In this experiment, anagram solution was used as the implicit task, in order to test the generality of the types of priming task that do and do not show sensitivity to the effects of age and levels of processing. Since the finding of a levels of processing effect suggests the use of explicit strategies, the lack of such an effect in anagram solution should indicate that the task is classifiable as an implicit test. Following from this, since more implicit than explicit tests tend to show an age equivalence, it was predicted that there should be little effect of age in anagram solution, while the effects of age and levels of processing were expected to be found in explicit recognition.

Method

Subjects

The young group comprised 16 students at City University, London, whose mean age was 19 (range = 18-20). The older group comprised 16 members of the University of the Third Age, whose mean age was 69.6 (range = 57 - 82). The Mill Hill Vocabulary test was administered to assess verbal ability. Mean scores for the older group, 19.24 (range = 15-21) significantly exceeded those of the younger group, 15.44 (range = 11-19), $t(30) = 6.33$, $p < 0.01$. All the subjects in the older group reported being in good health. Subjects were tested individually, and they were paid for their participation.

Design and Materials

The factors were again 2 (age) x 2 (orientation task) x 2 (item type).

The materials were 80 six letter words taken from Longman's Anagram Dictionary, the letters of each of which as an anagram were ordered alphabetically, each item having two or more possible solutions. Anagrams with more than one possible solution were specifically chosen, to be compatible with word stem completion tasks and to prevent ceiling effects in highly skilled subjects. Examples of the anagrams used are: MARBLE/ABELMR, blamer, ramble, lamber or ESCORT/CEORST, corset, sector, rectos, scoter. Those words were randomly divided into equal sets A and B. Study lists and orienting tasks were presented as in Experiment 1.

There were two alternative test lists for both the anagram solution test and the recognition test, each consisting of 40 different items. Within each test, half the items were from set A and half from set B, so that for any subject, the test was divided equally into studied and non-studied items. These non-studied items provided the baseline measures of priming, and false alarm rates in recognition. Furthermore, each of the study list items in each test was divided equally between those presented in the semantic task and those presented in the graphemic task. Thus for both study and test lists, materials were fully counterbalanced across all other experimental conditions. However, as in the previous experiment, all subjects took the anagram solution test before the recognition test, because the anagram solution test was presented as a filler task interpolated between study and test sessions.

Procedure

Study lists were again hand printed on separate index cards and presented at about a 4 s. rate. As in the previous experiment, subjects were told there would later be a memory test, the nature of which was not specified. The study orientation tasks were presented in a similar manner to that of Experiment 1.

After the study list had been presented, subjects were told that there were two other tasks to do before the memory test. The first of these was the Mill Hill Vocabulary test, the second was the anagram solution task. The anagram solution task took the form of a three page booklet in which anagrams were hand printed in capital letters in a single column, with a space for each solution next to it. Subjects were told that this was another task to be completed before they did the memory test. They were instructed to work through the test, one item at a time, and that they would be allowed up to 10 seconds to solve each one. A cardboard mask was used to cover all the items except the one they were currently attempting, and they were told not to go back to an item once they had passed it. In the recognition test, target and lure items were hand printed in capital letters in two columns with 20 words in each. Subjects were told that only half of the items represented words from the study list, and to circle those they recognized as previously studied items.

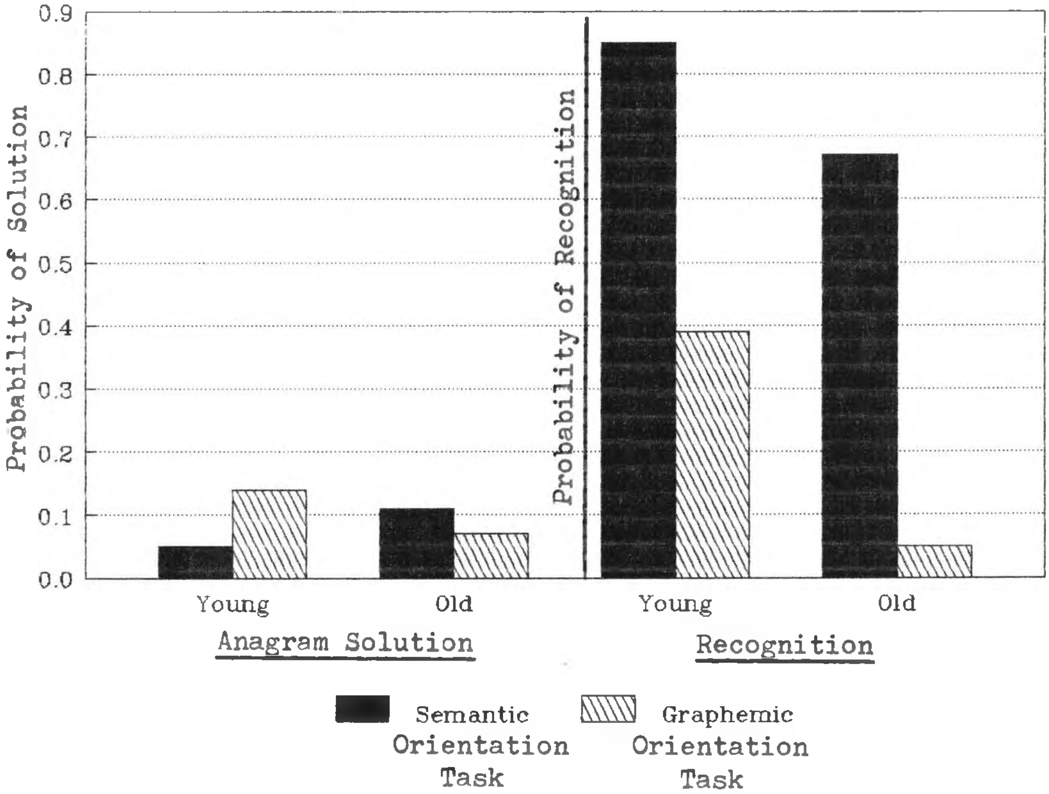
Results

The mean probabilities of correct responses for both age groups according to study orientation and task type are summarized in Figure 2. The left hand panel of the figure shows anagram solution after subtracting the respective baseline rates for each set of items in each condition; the level of priming. This panel of the figure indicates that there is little difference of age or levels of processing for this priming task. The right hand panel of Figure 2 shows the mean proportions of correct recognition responses after subtracting false alarms and indicates a pronounced levels of processing effect, with little apparent age difference in the semantic orientation task, but a large one for the graphemic task. Baseline rates for the semantic and graphemic orientation tasks in anagram solution were .19 and .15 for the young group and .21 and .24 for the older group. False alarm rates in recognition for semantic and

FIGURE 2 - EXPERIMENT 2

Probability of Anagram Solution and Recognition

as a Function of Age and Orientation Task



graphemic orientation tasks for the young group were .07 and .09 while those of the older subjects were .08 and .06.

An analysis of variance (ANOVA) was carried out on each of the two tasks of anagram solution and recognition to include 2 (age) x 2 (orientation task) x 2 (item type).

Analysis of the anagram solution data showed the main effect of age not to be significant, $F < 1$. Thus age did not affect this task. There was a significant main effect of item type, $F(1,30) = 11.02$, $MSe = 2.47$, indicating the effect of priming for this task, but no significant interaction of age x item type, $F < 1$, again indicating little difference in priming ability according to age. The two way interaction of item type x orientation was not significant, $F < 1$, and neither was the three way interaction of age x item type x orientation, $F(1,30) = 2.64$, $MSe = 1.31$, showing that this task was neither sensitive to age nor the levels of processing study manipulation.

An ANOVA carried out on the recognition data, however, showed significant main effects of age and item type, $F(1,30) = 18.45$, $MSe = 3.51$ and $F(1,30) = 330.16$, $MSe = 2.32$ respectively, indicating the large effects of age and recognition ability. The significant interaction of age x item type indicates the younger group's superior performance for both semantic and graphemically recognized items, $F(1,30) = 23.22$, $MSe = 2.32$.

There was a significant interaction of item type x orientation, $F(1,30) = 100.14$, $MSe = 2.34$, showing the effect of the levels of processing study manipulation. The three way interaction of age x item type x orientation failed to reach significance, $F(1,30) = 2.09$, $MSe = 2.34$, showing the effect of levels of processing occurred for both groups.

Discussion

These results support and extend the generality of previous studies in which elderly subjects have shown preserved memory function in certain implicit tests (see section 2.2 for a review). Although anagram solution has been used in previous work concerning implicit memory (e.g. Dominowski and Ekstrand, 1967; Gardiner et al, 1989; Jablonski and Mueller, 1972; Perruchet and Baveux, 1989; see also section 2.3), this is the first time the task has been used in research on aging. The present study shows that anagram solution behaves rather like word stem and fragment completion and perceptual identification in that it is insensitive to the effects of both age and levels of processing study manipulations. By not being sensitive to the conceptually driven component of this study manipulation, the test shows itself to be classifiable as a data driven implicit test, according to the criteria of Roediger et al (1989) and

Srinivas and Roediger (1990; see also Gardiner et al, 1989; and section 1.4).

Performance in the recognition test was vulnerable to the effects of age, a finding that is in accordance with other work on recognition and aging in which reliable age differences have tended to be obtained (for a review, see Burke and Light, 1981; also section 2.2). While the younger group outperformed the older group in both semantic and graphemic orientation tasks, and the levels of processing effect was produced as anticipated, the older group's ability at the graphemic study task was particularly low. One possible reason for this is that this particular orienting task may on this occasion have prevented older subjects from conceptually encoding items with this orientation.

This experiment has thus shown an anagram solution task to be effective as an implicit test which involves a large data driven component, since it is neither sensitive to a levels of processing study manipulation nor the effect of age. This employment of anagram solution in a study of aging extends and further tests the generality of previous studies using word fragment and stem completion and perceptual identification (e.g. Light and Singh, 1987; Light, Singh and Capps, 1986; see also section 2.2) which illustrate preserved implicit memory function in the elderly.

General Discussion

Experiment 1 showed that a simple alteration in test instruction could produce divergent results in an apparently similar task involving word stems. Levels of processing were manipulated at study, and the instructions either to complete the stems with the first word that came to mind, or to use the stems as cues to remind subjects of study list items, show the disappearance or appearance of the levels of processing effect, respectively. Additionally, the former test instruction effected no age differences while the latter showed an effect of age.

Thus the first experiment in this chapter has extended and developed the work of Light and Singh (1987, Expt. 1; see section 2.2), showing in this case, how the same sets of subjects, using the same study and test material, produced startlingly different effects in implicit and explicit memory tests.

Experiment 2 compared anagram solution and recognition as the implicit and explicit tasks. Levels of processing were again included as a check that explicit strategies were not being used in this new task, and indeed no effect was shown. Thus the purpose of this experiment, to employ anagram solution as a further implicit memory task to see whether the test could be included among the others that illustrate preserved implicit memory function of older adults, was fulfilled.

Furthermore, since both age groups in this second experiment showed similar priming effects and no effects of levels of processing in anagram solution, as in the word stem completion of Experiment 1, support can thus be given to the proposal that anagram solution can be classified as a data driven test (see e.g. Roediger et al, 1989; Srinivas and Roediger 1990; Gardiner et al, 1989; and section 1.4).

The following chapter further investigates the classification of implicit memory tests manipulating read and generate at study and comparing age.

CHAPTER 4

TEST CLASSIFICATION AND TEST AWARENESS

4.1 Introduction

This chapter describes three experiments that further investigated implicit, explicit memory and age, by varying read and generate at study and evaluating the effect of this variation on the tasks in terms of test classification.

Each of the experiments used word stem completion as the implicit task, with free recall as the explicit counterparts in Experiments 3 and 4. Jacoby (1983); Blaxton (1985, Expt 1; 1989); Roediger and Blaxton (1987; see also section 1.5) showed that when the study condition of items generated from a contextual cue, read with a contextual cue or read alone, were manipulated (e.g. HOT XXX, HOT/COLD, COLD) explicit tasks were facilitated by the generate condition, while implicit tasks such as perceptual identification and word fragment completion reflected the non-context, read only condition. Thus a reverse of the traditional generation effect (Slamecka and Graf, 1978) was shown in the implicit memory tasks. Thus by including read and generate at study in the experiments in this chapter, it was intended to generalize and further extend the work of Jacoby, Blaxton and Roediger and Blaxton to a word stem completion task, and to see how these processes were affected by age.

The results of Experiment 1 (section 3.2) showed that the implicit word stem completion task might be classifiable as a data driven test, since it was not sensitive to the effects of a levels of processing study manipulation. Roediger et al (1989; see section 1.4) suggested that the effect of a superiority of items read over those generated, operationally defines a data driven test, while the traditional generation effect operationally defines a conceptual test. Since Experiment 3 which manipulated read and generate at study, used word stem completion and free recall as the implicit and explicit memory tests, it was predicted that the implicit task should show little effect of age while the explicit task should show the effect of this variable. Furthermore, if word stem completion does contain a large data driven component, there should be a significantly greater number of read items completed than those generated. It was also predicted therefore that if free recall is classifiable as a conceptually driven test, there should be a greater number of generated items recalled than read, as well as an effect of age.

Experiment 4, like its predecessor, varied read and generate at study in a word stem completion test, but this time embeds the target word stems to be completed within a set of other verbal tasks in a "verbal skills" test, in order to disguise the task of interest. The aim of this experiment was to hide the word stems within a greater verbal skills test, thereby disarming subjects who might otherwise have noticed the relationship between study and test items, and decide to use methods other than those instructed. This embedded task was designed to deter younger subjects from using explicit strategies likely to be less available to the elderly, and reduce the effect of age for this implicit task. Mitchell (1989) and Light and Singh (1987) noted that although age differences in many tests of implicit memory tend not to be significant, these differences are nonetheless in existence and could be due to the aforementioned reasons. It was predicted therefore that in Experiment 4, the implicit task should show an effect of read superiority and no significant effect of age. The endeavour to render the task genuinely implicit should effect an even smaller age difference than in Experiments 1 and 3 which also used word stem completion as the implicit tasks. Explicit free recall should show effects both of generation and age.

The aim of Experiment 5 was to compare two word stem completion tasks. One of the tasks followed the straightforward format of those word stem completion tests used in Experiments 1 and 3, while the other utilized the embedded verbal skills test list of Experiment 4. By questioning subjects as to their awareness of the purpose of the task of interest in each case, as Bowers and Schacter did (1990; see section 1.6; also Experiment 5 below for the specific questions), it was proposed to examine the variables of read and generate and age in the light of whether subjects reported themselves to have been "aware" or "unaware" during the test procedure.

In an implicit word fragment completion test, Blaxton (1985, Expt 1; 1989; and Roediger and Blaxton, 1987; see also section 1.5) showed an effect of read superiority over items generated at study, while in an explicit graphemic cued recall test, this effect seemed to be slightly less pronounced. Therefore it was predicted that in Experiment 5, the word stem completion tests as data driven tests like those of Blaxton above, should show a greater effect of read superiority for "unaware" than "aware" subjects, reflecting implicitness and explicitness, respectively. Similarly, there should be an age difference between "aware" subjects as would be anticipated in a test that has become explicit in nature. The embedded task should show fewer "aware" than "unaware" subjects due to the disguise of the study's purpose.

4.2 <u>Experiment 3</u>

Introduction

Old and younger subjects studied a list of words, half of which were generated, half read. The generate task entailed reading a semantic clue, and gave the initial letter of the target word which was provided to guarantee that subjects produced the designated target. The clue was either a descriptive phrase or the opposite of the target word. In the read condition, subjects simply read the target word, presented alone, in the absence of any semantic context. After finishing the study list, all subjects were given a word stem completion test, presented as a filler task, then a test of free recall. This constant test order, like that of Experiment 1, was designed to divert subjects' attention away from treating the word stem completion test as a memory test.

Method

Subjects

The young group comprised a further 16 students from City University in London, with a mean age of 20.8 years (range = 18 - 30) and a mean Mill Hill test score of 15.8 (range = 13 - 19). The older group comprised 16 volunteers, mostly members of the University of the Third Age, all of whom reported themselves to be healthy, and were all living in the community. Their mean age was

70.1 years (range = 62 - 87) and mean Mill Hill score, 17.88 (range = 13 - 21), this latter set of scores being significantly higher than those of the young group, $t(30) = 2.86$, $p < 0.01$. Subjects were tested individually and paid for their participation.

Design and Materials

The design was largely the same as Experiment 1 but 31 of the 80 items were exchanged for others considered to be more suitable for generating within the 4/5 sec. time interval. Once again, the 80 items were split into two sets A and B, from which a further subset a and b was presented either as Read or Generate, balanced across subjects and conditions. Read and Generate items were presented within a random mixed list of 40 items. The word stem completion test sheets were as Experiment 1, but of course included the new target words. The order of testing was unchanged, the word stem completion test now preceding one of free recall. However since this experiment used free recall as the explicit task rather than cued recall as before, there were twice as many possible items to be recalled as completed.

Procedure

Subjects were told that they would be shown a set of 40 index cards on which was printed either a clue and the initial letter of a one word answer (the generate condition), e.g. a reddish, yellow, citrus fruit: O_____, or just one word alone (the read condition), e.g. ORANGE. In the case of the former, they were to read the clue silently to themselves, and the target word aloud; for the latter, they were to read the presented word aloud. They were instructed in both cases to try to retain these target items for a later unspecified memory test. The Mill Hill Synonyms test was followed by the word stem completion task. The free recall test followed in which subjects were given a blank sheet of paper on which to write down any of the original target items they could recall, in any order.

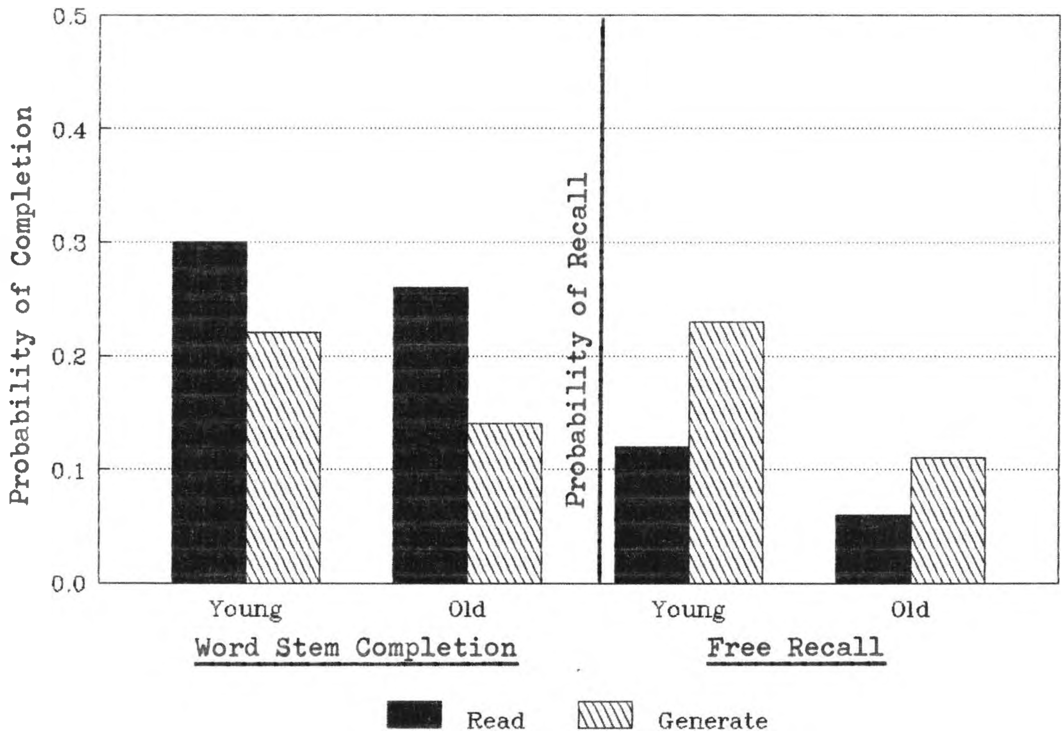
Results

Figure 3 shows the mean probabilities of correct responses for both groups according to study presentation and task type. The left hand side of the figure summarizes the data for the implicit task as baseline probabilities subtracted from target completions. It can be seen from the figure that for both groups, items in the read condition were more readily produced than those generated. The mean proportion completed by the older group was only 0.04 lower than those of the young group in the read condition with an overall difference of only 0.06 between the two groups. However the right hand side of Figure 3 shows that the pattern of results for free recall was reversed, as predicted, with higher scores for the generate condition for both groups, the younger group

FIGURE 3 - EXPERIMENT 3

Probability of Word Stem Completion and Free Recall

as a Function of Age and Presentation



showing a greater ability at this task, and the older group showing less of an advantage for the generate study condition. These free recall data relate to overall free recall scores pooled over both previously tested and untested words, since few previously untested words were recalled. Mean probabilities of previously untested words for Read and Generate conditions were .02 and .08 for the young adults and .02 and .04 for the older subjects.

Analyses of variance (ANOVAs) were applied separately to word stem completion and free recall data. Analysis of the word stem completion data included 2 (age) x 2 (mode of presentation, read or generate) x 2 (item type) with repeated measures on the last two factors.

As predicted, there was no significant main effect of age, $F(1,30) = 2.46$, $MSe = 2.86$. The main effect of presentation and interaction of age x presentation were likewise not significant, $F < 1$ in each case. However the main effect of item type was significant, $F(1,30) = 105.32$, $MSe = 1.58$, revealing the high level of priming for both groups. The interaction of age x item type was not significant, $F(1,30) = 1.60$, $MSe = 1.58$, indicating once again, a lack of age differences in this priming task. The interaction of presentation x item type was significant, $F(1,30) = 5.25$, $MSe = 1.34$, reflecting the difference between read and generate for study list items only, while the three way interaction of age x presentation x item type was not significant, $F < 1$, since age made no difference on this task.

Analysis of the free recall data included 2 (age) x 2 (mode of presentation) with repeated measures on the second factor. There were significant main effects of age and presentation for this explicit task, $F(1,30) = 15.24$, $MSe = 3.22$, $F(1,30) = 11.72$, $MSe = 7.56$, respectively showing the difference in age and the effect of generation for this task. The interaction of age x mode of presentation was not significant, $F(1,30) = 2.10$, $MSe = 2.61$, reflecting the advantage afforded by the generate study condition to both age groups.

Discussion

While it has again been shown that age differences produced in an explicit task involving conscious retrieval decrease when an implicit task is performed by the same group of individuals, it was further shown that in the word stem completion task, items read facilitated better completion than those generated, for both age groups.

In free recall, both groups produced the anticipated generation effect, although the older group's generate scores appeared to be somewhat attenuated. McFarland, Warren and Crockard (1985) studied the effect of generation and age in a free recall test and found that it was only after the older group had completed 2 to 3 trials that the generation effect became apparent. Nevertheless, older tend to show generation effects in recognition (see e.g. Johnson, Schmitt and Pietrukowicz, 1989; McFarland et al, 1985; Rabinowitz, 1989; and cued recall (Mitchell, Hunt and Schmitt, 1986). It should be noted however that the older group in this study produced extremely low scores for this task. The previous studies mentioned above that involve generation effects in young and older adults have followed the procedure of Slamecka and Graf (1978) in which the semantic clue is presented in both read and generate conditions. This differs from the present procedure which was adopted because it provides the strongest contrast between data and conceptually driven processing. These two extreme conditions were chosen in order to determine whether or not word stem completion can be classified as a data driven task according to the criteria developed by Roediger et al (1989). The results are quite clear in this respect: both elderly and young adults showed higher levels of priming for items read than for those generated, a reversal of the generation effect found in free recall. Thus word stem completion can be added to other tests that, by these same criteria, may be classified as being data driven.

Experiment 4 that follows, again varies read and generate at study, in an age related comparison of a word stem completion test designed to disguise the purpose of the task, and free recall.

This might be a suitable point to discuss the implications of balancing the order of task procedure. In Experiments 1 to 3 inclusive, the implicit task was carried out first so that subjects would be less likely to realise that that task was a test of their memory for study words. However, it was decided to alternate the order of testing in future experiments, so that conclusions about differences between implicit and explicit memory should not be confounded by the order in which the tests were taken.

4.3 <u>Experiment 4</u>

Introduction

The results of the previous experiment, the work in the previous chapter, as well as that of Light and her colleagues (Light et al, 1986; Light and Singh, 1987) has shown that while these implicit tests tend not to show a significant effect of age, the older groups do tend to perform at a slightly lower level. This disparity possibly could be due to the younger groups employing explicit strategies in the word stem completion test to a greater extent than the older subjects since, despite the fact that they have not been asked to do so, they might realize the relationship between the test stems and study items and decide to perform the test in a different manner from that instructed.

In an endeavour to overcome this possibility, this experiment was designed so that the target task should be disguised, and it was thus embedded among other verbal tasks in a single "Verbal Skills Test". Since this test was also planned to be of use in a later experiment (Expt. 6, see section 5.2), to conceal a word association task, it was decided to include conceptually driven types of tasks as well as data driven ones. Subjects either read or generated items at study, since the effects of these variables on word stem completion and free recall have already been shown in Experiment 3 and also extend the findings of Blaxton (1985 Expt. 1, 1989; Roediger and

Blaxton, 1987) with word fragment completion. Thus this test involved word stem completion like Experiments 1 and 3, but this test was embedded within the general context of a set of questions, half of which called upon data driven processing and involved anagrams and word fragments, and half used conceptually driven processing; involving antonyms and category exemplars.

The explicit task was a free recall test. Subjects were given a blank sheet of paper on which to write down items they could recall from the study list in any order. Half of the subjects were given the implicit test first, while the other half did the explicit free recall test first.

Subjects

There were 16 subjects in each group. The young group were all students at City University, London, with a mean age of 21.9 years (range = 18-32) and a mean Mill Hill score of 15.8 (range = 12-18). The older group were recruited mostly from the University of the Third Age in London and had a mean age of 68.9 years (range = 61-79), their mean Mill Hill score being 19.1 (range = 14-21). The Mill Hill scores for the older group were significantly above those of the younger group, $t(30) = 6.3$, $p < 0.05$.

Design, Materials and Procedure

The target words used for this experiment were from the same pool of 80 used in Experiment 3. It was decided to use only half the number of words this time, in an attempt to elevate the elderly subjects' ability in the explicit test, so that any effect of generation might be more clearly shown. Thus a set of 40, six letter nouns was split into sub-sets A and B. Each word was presented on an index card in either the Read or in the Generate condition exactly as Experiment 3, at approximately a 4 sec. rate. Again read and generate items were presented in a mixed list in a new random order for each subject. Subjects in the read condition were to read the target words aloud, while in the generate condition they were asked to read the semantic clue first silently to themselves, and then say the target item aloud as in Experiment 3. The presentation of read and generated items was reversed so that half of each subject group processed them in their opposite form.

The implicit test took the form of a verbal skills list which contained five different types of test item: antonyms, category exemplars, anagrams, word fragments and the essential word stem completion task. These were presented in a constant random order in the form of a nine page booklet with approximately ten questions per page. Subjects covered each page with a cardboard mask so that only the current question could be viewed. They were told that they had a maximum of ten seconds per question, but that they could move on to the next one as soon as an earlier one had been dealt with. They were instructed not to go back to an item once they had passed it.

For free recall, subjects were asked to write down all of the items they could recall from the study list, in any order. The order of the two tests was counterbalanced so that half of the subjects in each age group carried out the verbal skills test first, the other half being tested for free recall first.

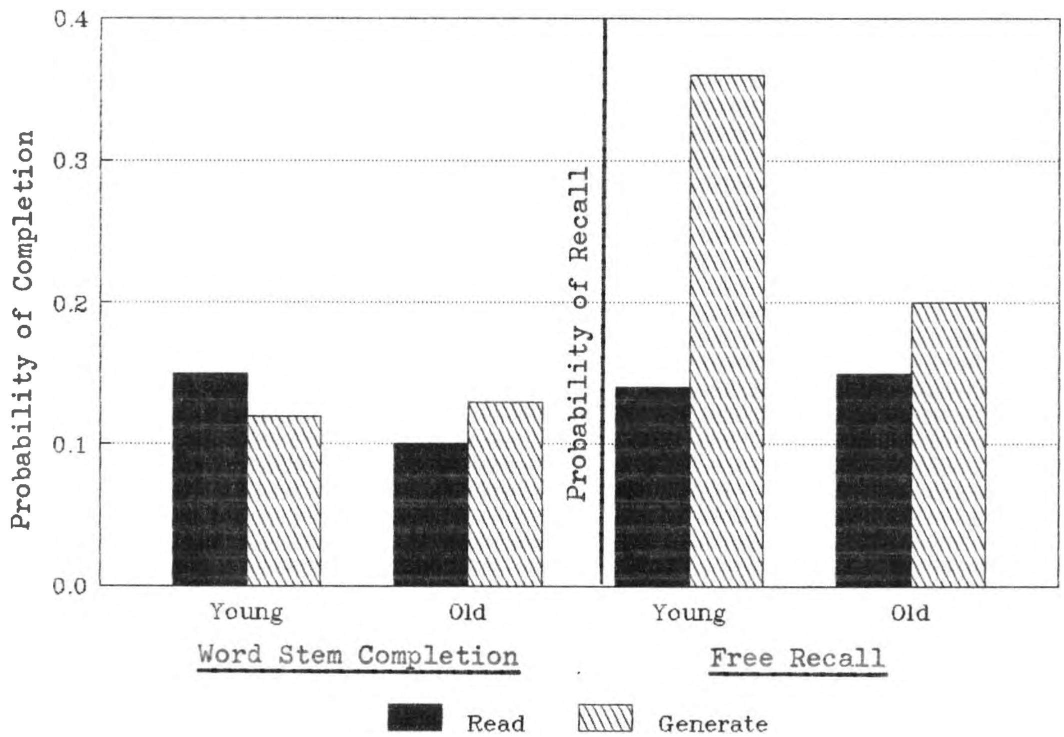
Results

Figure 4 shows the mean probabilities of correct responses for both groups according to study presentation and age. The left hand side of the figure summarizes the word stem completion data in the verbal skills list for the two age groups. As in the previous experiments, these data refer to priming as calculated by subtracting baseline probabilities from target completions. Baseline rates for read and generate for the verbal skills test were .19 and .13 for the young and .2 and .16 for the older subjects, respectively. The right hand side Figure 4 shows the free recall data for the same groups. This time a large generation effect is indicated for the young subjects with an apparently reduced effect for older subjects.

The data were subjected to separate analyses of variance. Looking first at the word stem completion data, there was no significant effect of age, $F < 1$, but there was a

FIGURE 4 - EXPERIMENT 4

Probability of Embedded Word Stem Completion and Free Recall as a Function of Age and Presentation



large effect of item type, $F(1,30) = 28.4$, $MSe = 1.89$, indicating the high level of priming. The two way interaction of item type x mode of presentation was not significant, $F < 1$, confirming that in this embedded priming task, the read superiority effect obtained in Experiment 3 was lost. The three way interaction of age x item type x mode of presentation also failed to reach significance, $F < 1$, showing that neither priming nor the read vs. generate study manipulation were affected by age.

A separate analysis of the free recall data indicated that the main effect of age, $F(1,30) = 2.2$, $MSe = 3.8$, was not quite significant, but there was a significant interaction between age and mode of presentation, $F(1,30) = 7.07$, $MSe = 1.6$, showing that on this occasion the generation effect was more pronounced for the younger group.

The data were subjected to further analysis to see whether there was an effect of test order. No significant main effects or interactions were found.

Discussion

This experiment comparing an embedded word stem completion task with free recall has shown that age is not a potent factor in this form of word stem completion, as in the straightforward tests of Experiments 1 and 3. However the effect of read superiority shown in the previous experiment disappeared when the test presentation was altered to this new form. There was no significant age difference for free recall either, possibly as a result of reducing the number of study items. Moreover, the interaction between age and mode of presentation indicated the lower generation scores of the older group. Indeed, as already mentioned (see discussion, section 4.2) McFarland et al (1985) showed that initial free learning trials do not always reveal an effect of generation in older adults.

The introduction of a task specifically designed to disguise the target word stem completions and decrease the possibility of the use of explicit strategies, did show a lower performance of the younger group compared to the more overt test of Experiment 3. Priming probabilities for read and generate conditions for the young group in the present study were .15 and .12 respectively while those in Experiment 3 were .30 and .22. However, this conclusion must be treated with caution, since different subjects were used in each study.

The most important finding was that in this embedded word stem completion task, the read superiority effect disappeared. The inference that this occurred as a direct result of precluding explicit strategies makes previous findings both in this (Section 4.2) and other work that has shown the effect of read superiority in implicit memory (see Blaxton, 1985, Expt. 1; 1989; Roediger and Blaxton, 1987; see also sections 1.4 and 1.6) somewhat enigmatic. Blaxton's explicit graphemic cued recall test (chopper/copper) did show a greater effect of items studied with no context (read) as opposed to generated items, but her implicit word fragment completion test showed an even greater read superiority effect, thereby implying that the larger read advantage is a phenomenon of implicit memory. However, Blaxton made no attempt to disguise the nature of her test. It should be noted however, that the effect of varying read and generate does seem to be rather volatile. Gardiner, Dawson and Sutton (1989; see also section 1.6) showed that an implicit word fragment completion test could produce a generation effect when items at test and study matched exactly. McClelland and Pring (1991) while reproducing the read superiority effect in word stem completion when material was presented visually at both study and test (Expt. 1) showed the effect's disappearance for cross modal priming, that is, when word stem completion was presented auditorily. According to Roediger et al (1989; see also sections 1.4 and 1.6) a test that shows the effect of read superiority can be classified as data driven, and thus the word stem completion test as presented in Experiment 3 can be said to be data driven. However, the lack of the read superiority effect in the present embedded task, a task that embeds the very same word stem completions, suggests that this classification can no longer be applied. The findings of the aforementioned work by Gardiner and his colleagues and McClelland and Pring suggest that it is important to be aware of the part played by the match of study and test procedures. It is possible that the competing data driven and conceptually driven strategies of the tasks surrounding the word stem completion task precluded the appearance of the read superiority effect.

The final experiment in this chapter investigates similarities and differences found between the two word stem completion tasks used in Experiments 3 and 4. While both the straightforward and embedded word stem completion tasks have been shown to produce priming unaffected by age relative to explicit free recall tests, the task used in Experiment 3 produced the read superiority effect while that of Experiment 4 did not. Thus Experiment 5 directly compares the two types of word stem completion task in an age related study that varies read and generate, seeking to tease out the part played by conscious awareness in the appearance and disappearance of the effect of read superiority, by questioning subjects immediately after the completion of each test about their awareness of the relationship between test and study material. A post hoc comparison of "aware" and "unaware" read and generate scores should provide the answer to the implicit or explicit nature of the read superiority effect.

4.4 Experiment 5

Introduction

This experiment compared performance in two word stem completion tests in a study of implicit memory and age. One test used the straightforward format of a list of word stems for completion as Experiment 3, while the other was presented as the "Verbal Skills" test of Experiment 4. The study task of items to be read or generated was conducted as an incidental memory test, since it was presented as the first in a set of four tasks concerning verbal skills.

It was predicted that there should be no significant age difference in priming, and that priming between the two groups should be even closer together for unaware subjects who were thus less likely to be using explicit strategies. If the read superiority effect shown by Blaxton is an implicit memory phenomenon, then by asking subjects immediately after each test the four questions that Bowers and Schacter (1990) used to denote the difference between test "aware" and "unaware" subjects, read superiority should be effected in "unaware" subjects only, for both age groups in both tests. However, since Blaxton's experiment like that of Experiment 3 in this thesis, made no attempt to disguise the word stem completion task, the effect could be considered to be related to tests in which explicit strategies may have been used. The disappearance of the read superiority effect in the verbal skills test of Experiment 4 further supports this latter case. Thus a pronounced read effect for unaware subjects in either test would substantiate this possibility.

Subjects

The young group comprised 14 people from the local community who were members of the administrative staff of City University or friends of the Experimenter, and 2 City University students, whose mean age was 25.2 years (range = 19 - 32). The older group comprised 16 volunteers, some of whom were members of the University of the Third Age, whose mean age was 70.3 years (range = 61 - 81). All of the elderly adults reported being in good health. The Mill Hill vocabulary test was administered to assess verbal ability, the mean score for the young group being 15.1 (range 13 - 18) and the old group, 17.6 (range = 10 - 21). This latter score significantly exceeded that of the young group, $t(30) = 3.03$.

Subjects were tested individually and they were paid for their participation.

Design, Materials and Procedure

The words used and the design of the experiment was similar to Experiments 3 and 4, except that items were divided and counterbalanced between the embedded and non-embedded tests rather than between word stem completion and cued recall. The order of testing was counter-balanced so that half the subjects in each age group received the straightforward test first and the verbal skills test second, while the other half of the subjects were presented with these tests in the opposite order. The factors were age (young versus old), mode of presentation (read vs. generate) and test (straightforward vs. embedded word stem completion). Mode of presentation and test were within subjects factors in the word stem completion task. Subjects were instructed to word quickly down each column and complete each word stem in turn with the first English word that came to mind that was not a proper noun. For the verbal skills test, subjects were given the cardboard mask and instructions were generally as for Experiment 4. After each of the tests had been completed, subjects were asked the same four questions. The first question asked what they thought was the purpose of the test, and the second asked what strategy they had used in completing the word stems. Question 3 asked whether they noticed any relationship between the words seen earlier on the cards and those in the stem completion test, and the last question asked if they noticed that they had completed any of the stems as words seen on the original list. These questions were posed orally.

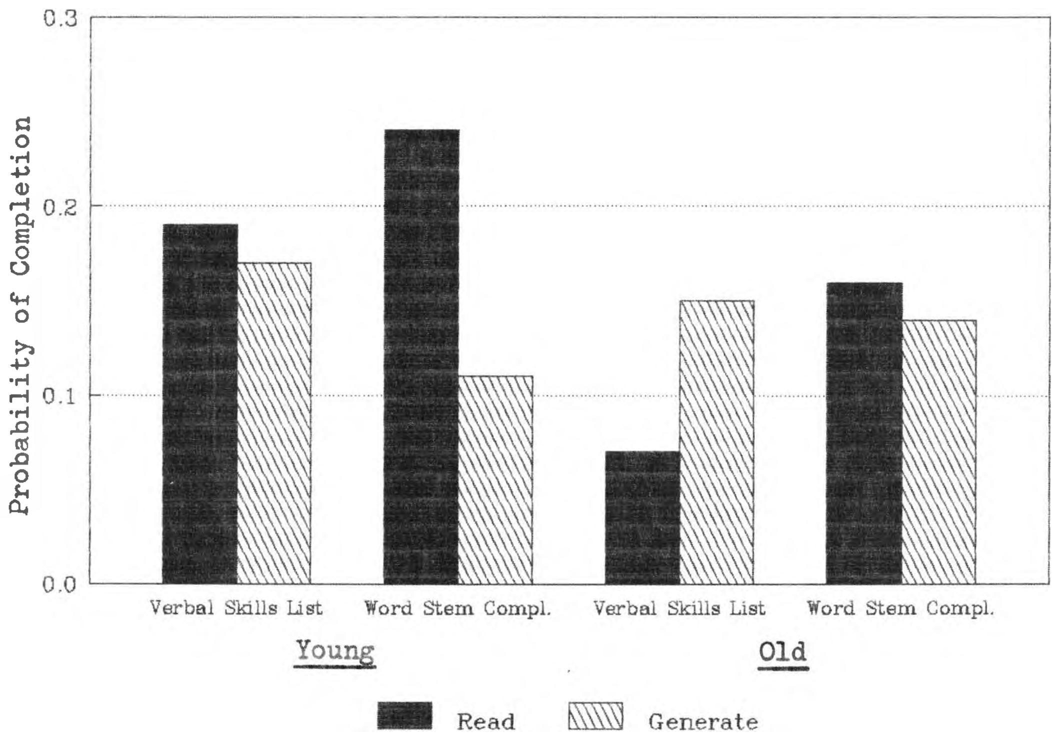
Results

The results of both tests are summarized in Figure 5. These are the mean probabilities of primed responses under the read and generate conditions for both age groups. That is, the figure shows completion rates after subtracting the appropriate baseline completion rates for each set of items in each experimental condition. Baseline rates of read and generate for the young group in verbal skills and word stem completion were .20, .18, .16 and .16 respectively. Those of the older group were .19, .13, .19, .19.

The left hand side of Figure 5 indicates that the young group produced greater priming for items read rather than generated in word stem completion, while no such effect occurred in the verbal skills test. (This result for the embedded task is rather similar to that of Experiment 4, read and generate probabilities for the young group being .15 and .12 respectively, and .10 and .15 for the older group.) The right-hand panel of Figure 5 shows that the older group had no effect of read superiority for either test. The verbal skills list indicates an advantage of items generated at study. The younger group appears also to have outperformed the older group overall. A post hoc median split analysis of the older group's verbal skills

FIGURE 5 - EXPERIMENT 5

Probability of Completion in Embedded and Non-Embedded Tasks as a Function of Age and Presentation



data showed that the 8 highest scoring subjects' read and generate probabilities were .21 and .20, indicating that the apparent effect of generation relates to the generally rather low level of performance.

The above data were subjected to separate analyses of variance, and the factors were 2 (age) x 2 (mode of presentation) x 2 (item type) in each case. An ANOVA carried out on the non-embedded word stem completion data for both groups showed the main effect of age to be approaching significance, $F(1,30) = 3.36$, $MSe = 2.32$. The main effect of item type was significant, $F(1,30) = 36.82$, $MSe = 2.21$, while the 2 way interaction of mode of presentation x item type approached significance, $F(1,30) = 3.01$, $MSe = 1.76$, this near interaction indicating the closeness to an effect of greater priming for items read rather than generated. The 3 way interaction of age x mode of presentation x item type failed to reach significance, $F(1,30) = 1.14$, $MSe = 1.76$, reflecting the lack of the read superiority effect for the older group at this word stem completion task.

A similar analysis of the verbal skills test data shows significant main effects of both age and item type, $F(1,30) - 6.75$, $MSe = 1.19$ and $F(1,30) = 58.03$, $MSe = 1.1$ respectively, indicating the better overall ability of the young group for this embedded word stem completion task, and the effect of priming. The interaction of age x item type approached significance, $F(1,30) = 3.18$, MSe = 1.19, reflecting the poor ability of the older group at this task. The interactions of item type x mode of presentation and age x item type x mode of presentation did not reach significance, $F < 1$ in each case. Thus, there was no difference for primed items under either read or generate study conditions for either age group in this embedded task.

The experiment was designed so that the order of presentation of the two priming tasks was counter-balanced, and unfortunately, significant effects of order were found such that the young group's verbal skills test data, but not that of the older group, showed a significant 3 way interaction of order x item type x mode of presentation, $F(1,14) = 9.04$, $MSe = 3.66$, indicating for those subjects who did the verbal skills test before word stem completion a pronounced effect of read superiority. Those who carried out the verbal skills test after word stem completion showed a high level of priming for items generated at study. Thus the data concerning word stem completion for both sets of subjects and the verbal skills test for the older group are the ones that can be considered with interest.

Table 1 shows a comparison of the tasks and groups for test awareness. Among the young group, while there was an overall read effect for all subjects in word stem completion, there appears to be a greater read superiority effect for unaware subjects ($N = 7$).

However, in the verbal skills test, only those subjects in the young group who were unaware showed the effect of read superiority at all (N = 8). The older group's "aware" subjects (N = 6) showed an apparent effect of generate superiority over read in the verbal skills test, while the remaining sections of this group's data indicate little effect of either variable. There appears to be a greater age difference between aware subjects than those unaware for the verbal skills test, but no apparent difference in age or awareness in the word stem completion task.

Table 2 compares awareness and age collapsed across the read and generate conditions. This shows that for both tests, young aware subjects had the higher scores, with the greatest apparent age difference occurring for the aware subjects in the verbal skills test.

The data in these tables were not subjected to ANOVAs since the post hoc designation of subjects to aware and unaware groups does not allow this factor to be treated as an experimentally manipulated variable. While Bowers and Schacter (1990) carried out a non parametric test of two proportions (Bennett and Franklin, 1954), the large number of within subject variables for the number of subjects in the present experiment precluded statistical analysis. Thus the data have been discussed descriptively rather than analytically.

TABLE 1

RESPONSE PROBABILITIES FOR TASK TYPE, TEST AWARENESS AND PRESENTATION

	Verbal Skills List				Word Stem Completion			
	Aware		Unaware		Aware		Unaware	
	Read	Generate	Read	Generate	Read	Generate	Read	Generate
Young	.19	.24	.20	.10	.24	.15	.24	.07
Old	.02	.18	.10	.14	.20	.13	.11	.13

TABLE 2

RESPONSE PROBABILITIES FOR TASK TYPE AND TEST AWARENESS

	Verbal Skills List		Word Stem Completion	
	Aware	Unaware	Aware	Unaware
Young	.22	.15	.20	.16
Old	.10	.12	.17	.12

Discussion

This experiment that compared two word stem completion tasks, one of which was disguised in an endeavour to ensure the implicitness of the test, has revealed some interesting findings. Firstly, the straightforward word stem completion task that has throughout the series of experiments in this thesis, like those of Light and Singh (1987, see section 2.2), shown the relatively preserved capacity of the elderly, this time showed an effect of age that approached significance. The embedded test did show a significant age difference. However, Howard (1968; see also section 2.2) showed that target items embedded within a sentence at study, afforded a significant age difference in word stem completion, and Chiarello and Hoyer (1988; see section 2.2) found that under some conditions, younger subjects still outperformed the elderly in implicit word stem completion. Therefore the finding of a relatively preserved facility of the elderly for this kind of task is not always reliable. Indeed, as pointed out in Section 4.1, both Mitchell (1989) and Light and Singh (1967) noted small but non significant age differences in their implicit memory tests.

A second important finding was that although one test was designed to disguise the task of interest, while the other was not, in both tests approximately half of each subject group reported themselves to be "aware". Insofar as the prediction that "unaware" subjects in the two age groups would perform more similarly, greater evidence for this finding occurred in the verbal skills data, in which the younger group's "aware" scores appeared to be superior to that of the older group and those of both "unaware" groups.

In this experiment, subjects were asked the same four questions posed by Bowers and Schacter (1990; see section 1.6), set to discover who was aware of the relationship between test and study items. While approximately half of each age group claimed to be "unaware" for each type of test, it is possible that some of the older subjects were susceptible to a response bias with regard to these questions. That is, asking them whether they noticed a relationship between test and study material may have primed subjects to report themselves to be "aware" in order not to appear foolish when in fact they may have been "unaware". Indeed, as Bowers and Schacter (1990) suggested, it might be better to inform subjects of the possibility of a relationship between some of the test items with study items, as Tulving et al (1982) did, since they might alter their mode of operation to comply with what they think is being required of them.

Nonetheless, as Schacter et al (1990) pointed out, the indication of awareness by a subject does not necessarily mean that s/he was aware for every tested item.

A third aim of this experiment was to investigate the behaviour of the variable read and generate according to awareness and age. Within this one study it has been shown that the read superiority effect occurred only in straightforward word stem completion and not in the verbal skills test, thus replicating the combined findings of the previous two experiments in this chapter. The finding of an enhanced read effect in the undisguised test seems to indicate that the phenomenon may be related to the use of explicit strategies, contrary to the findings of Blaxton and her colleagues (Section 1.4), yet further examination of the present undisguised word stem completion task reveals that while the read superiority effect did occur for both aware and unaware groups, it was the unaware group that appeared to show a greater effect of this variable, rather like Blaxton's findings between implicit word stem completion and explicit graphemic cued recall. The order effect in the young group's verbal skills test precludes further scrutiny of this test, as does the lack of read superiority by the older group.

With hindsight, a between subjects design might have been more appropriate for this experiment, in anticipation of a problem with order of testing. Such a design, though costly in terms of subject numbers, should have overcome this difficulty, and allowed the statistical analysis between awareness and items read or generated at study.

There is a possibility that in this experiment, in the verbal skills test, the "disappearance" of the read superiority effect originally shown in Experiment 3, might thus have been due to the order in which the two tests were taken. Nevertheless, the results of Experiment 4 similarly showed no effect of read superiority, and no significant effect of order was found on that occasion.

A further experiment involving a non embedded word stem completion task alone, was conducted with another group of City University students, and again showed the effect of higher scores for items read over those generated, but questioning regarding awareness yielded only four subjects unaware, too few a number to consider in a comparison of aware versus unaware subjects.

4.5 **General Discussion**

This chapter described three experiments that sought to investigate test classification, using word stem completion as the implicit test and varying read and generate at study.

The results of the first experiment strongly suggested that word stem completion could be classified as a data driven test, since an effect of read superiority, the reverse of the generation effect, was shown (see e.g. Roediger et al, 1989; also section 1.4). In free recall, the traditional generation effect was produced, thus illustrating this test's large conceptually driven component. Since little effect of age was shown in the implicit test and an effect of age in the explicit test, this experiment further extends and generalizes previous work that has shown these differential results (see e.g. Light, Singh and Capps, 1986; Light and Singh, 1987; also section 2.2).

The second of these three experiments sought to overcome the effects of contamination by the possible use of explicit strategies in a test assumed to be implicit, by embedding the same word stem completion task as used in the previous chapters, within a set of other tasks. On this occasion the read superiority effect was lost, while a generation effect was produced in free recall by the same sets of subjects. This result suggests that the read superiority effect might be a data driven explicit phenomenon, since an attempt was made to disguise the purpose of the word stem completion test.

The third experiment directly compared the two types of word stem completion task, one straightforward, the other embedded. Young and older subjects were questioned after completion of each test as to their awareness of the study's purpose. This form of questioning rendered approximately 50% of each subject group "aware" and "unaware" for each of the two tests. (See e.g. Bowers and Schacter, 1990; Schacter et al, 1990; also section 1.6). However although the effect of read superiority in straightforward word stem completion and its disappearance in embedded word stem completion replicated the findings of the first two experiments in this chapter, further investigation of test awareness by applying Bowers and Schacter's, Schacter et al's questions was unsuccessful.

Thus it has been shown in this last experiment that attempts to manipulate awareness by disguising the test did not lead to the expected differences in awareness as measured by Schacter and his colleagues. It is suggested therefore that the usefulness of these criteria may well be limited, one reason being the possibility of this direct form of questioning resulting in a response bias whereby subjects say they are aware of the study's purpose when in fact they are not.

The following chapter deals with outstanding points that need to be addressed in this study of priming, age and awareness. While Experiment 6 considers the effect of age on conceptually driven priming, Experiment 7 seeks to measure conscious awareness in a different manner from that of Experiment 5 in this chapter; by comparing "Remember" and "Know" responses in explicit and implicit tests.

CHAPTER 5

AGE, CONCEPTUALLY DRIVEN PRIMING AND FURTHER MEASURES OF CONSCIOUSNESS

5.1 Introduction

This final experimental chapter set out to address some matters that were outstanding from the previous chapters. Experiment 6 dealt with conceptual priming, to see whether, like the perceptual priming tasks in this thesis, this too extends to work with the elderly. Experiment 7 applied Tulving's (1985b; see also section 1.7) "Remember" and "Know" responses to explicit and implicit memory tests, in order to obtain an improved measure of conscious awareness than that used by Schacter and his colleagues (see sections 1.6 and 4.3).

As discussed in Section 2.2, most of the work that has been successful in showing an equivalence of age in priming has involved perceptual or data driven processes. Conceptual priming tasks have shown differential results (see sections 2.2(i) and 2.2(iii)). Thus it is important to investigate this phenomenon too, in a set of studies that deals with aging and implicit memory.

Experiment 6 thus employed a word association task (see e.g. Shimamura and Squire, 1984; also section 1.3) as the implicit conceptually driven test. Words to which associations were to be made were embedded within a set of other tasks as in Experiments 4 and 5, word associations being substituted for word stems. Read and generate were manipulated at study, in order to see how this would affect conceptual priming. Free recall was included as the explicit task. An age difference was predicted for free recall, with the likelihood that this might occur for the priming task too on this occasion, bearing in mind the smaller number and more variable findings of work with the elderly on conceptual priming. Furthermore, if the word association task is to be classified as a conceptually driven test according to the criteria of Roediger et al (1989; see also section 1.4), it was predicted that the generation effect should occur for both the implicit as well as the explicit test.

Experiment 7 investigated the phenomenon of conscious awareness in implicit memory (see section 1.7) and measured awareness item by item for each subject. Subjects studied a set of words using a semantic study manipulation in order to control for semantic encoding ability (see e.g. Craik and Simon, 1980; also section 2.1). The implicit task was a straightforward word stem completion task, after which subjects were requested to indicate which completed items they recognize, and put and "R" or "K" response (Tulving, 1985b; see also section 1.7) next to each recognized item. A test of graphemic cued recall required subjects to give "R" or "K" responses for each item recalled. This method of measuring the conscious awareness of items that had been implicitly produced (in the word stem completion test) investigated whether a link can be made between conscious and non-conscious events. That is, to see whether items produced while awareness has been directed away from conscious retrieval, might be brought to consciousness by to consciousness by the recognition procedure. Since older adults have tended to perform less well than younger subjects at tasks involving conscious awareness, it was predicted that fewer completed items will be recognized by the elderly than the young. Similarly, since "Remember" responses are a measure of conscious recollection, these should be fewer for the older group than the young, for both implicit and explicit tests. "Know" responses being a measure of memory without conscious recollection or awareness, a mode of memory that tends to show fewer age differences, should show little evidence of age.

In summary, it was predicted that in word stem completion, there should be no difference in conscious "Remember" responses or age, while in free recall, the effect of both variables should be shown. There should also be more correctly recognized completed items for the young than the older group.

5.2 Experiment 6

Introduction

A word association task was used as the implicit measure of memory in this experiment, in order to investigate conceptually driven priming in young and older adults. The verbal skills test of Experiments 4 and 5 was used in an endeavour to disguise the task of interest and render it genuinely implicit, word associations being substituted for the previous stems to be completed. By manipulating read and generate at study, it was proposed to test the classification of this implicit task according to the criteria of Roediger et al (1989; see also section 1.4). Thus if word association priming is classifiable as a conceptually driven test, an effect of superior generation should occur. Results of a similarity or difference with age for this task is awaited, since findings for age and conceptual priming have been inconclusive (see section 2.2). An effect of age and superior generation is predicted for explicit free recall.

Subjects

The young group was another 16 City university students, with a mean age of 20.9 (range = 18 - 26) and a mean Mill Hill score of 15.8 (range = 13 - 19). The older group comprised community dwelling people from the University of the Third Age, Mensa and a careers advisory agency called "Success after 60". Their mean age was 66.4 (range = 60 - 87) and their mean Mill Hill scores was 19.1 (range = 15 - 21). The older group's Mill Hill scores were significantly higher than those of the younger group, t(30) = 5.0.

Design, Materials and Procedure

The study materials were exactly the same as those of Experiments 4 and 5 and the test materials differed only in the implicit target task. Here subjects received the verbal skills test that involved antonyms, category exemplars, anagrams, word fragments and the essential word association task. Thus subjects might be asked to free associate to the word HAYFEVER, the target word being POLLEN. Similarly ANGEL was an associate for HEAVEN. These associates to the target words were composed by the experimenter and tested on pilot subjects of both age groups in order that baseline probabilities of producing the target words might be equated. As in Experiment 4, subjects received the Mill Hill vocabulary test immediately after the study period, while the order of word association and free recall test was counter-balanced. Thus, apart from the target test being one of free association rather than word stem completion, the design of this experiment was similar in all respects to that of Experiment 4.

Results

The principal results of both tests are summarized in Figure 6. These are the mean probabilities of correct responses for both groups in both study conditions after baseline measures had been subtracted. The left hand side of Figure 6 summarizes the word association data for both age groups. As can be seen from the figure, the young group show the facilitation of items studied under the generate condition, while the older group show little effect of either study manipulation. The free recall data on the right hand side of the figure, indicate a similar effect of generating study material for each age group.

The above data were subjected to separate analyses of variance (ANOVAs). The factors for the implicit test were age (young vs. old), mode of presentation (Read vs. Generate) and item type (target vs. baseline), while those for free recall were age and mode of presentation.

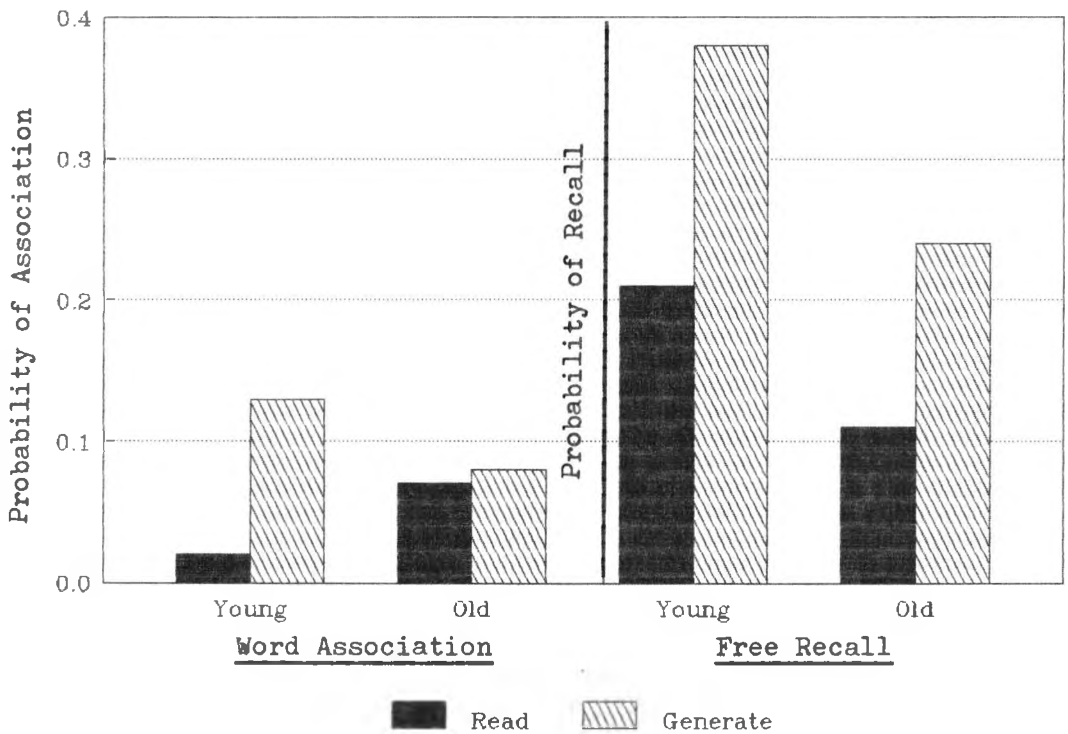
Looking first at the word association data, there was a significant main effect of item type, $F(1,30) = 12.5$, $MSe = 1.5$. There was however no significant main effect of age, $F(1,30) = 2.8$, $MSe = 0.8$ and no significant interaction of age x item type, $F < 1$. Thus priming for this implicit task was not affected by age.

The interactions of item type x mode of presentation $F(1,30) = 3.9$, $MSe = 0.7$ and age x item type x mode of

FIGURE 6 - EXPERIMENT 6

Probability of Word Association and Free Recall

as a Function of Age and Presentation



presentation, $F(1,30) = 3.1$, MSe = 0.7, only just failed to reach significance, indicating near effects of generation and a near interaction of age, priming and mode of presentation. Separate ANOVAs of the two separate age groups' data showed a significant interaction of item type x mode of presentation for the young group, $F(1,15) = 5.1$, MSe = 1.03, but not for the older group, $F < 1$. An examination of the corrected data of the 8 subjects of each age group whose word association scores were above the median scores, were .09 and .29 for read and generate items for the young group and .13 and .16 for the older group respectively, indicating that this difference between Read and Generate for the young does not reflect individual differences in word association priming. Thus the young group's data have shown this implicit word association task to be classifiable as a conceptually driven test according to the criteria set by Roediger et al (1989; see also section 1.4).

An ANOVA was also carried out on the free recall data. This showed a significant main effect of age, $F(1,30) = 10.1$, MSe = 2.2, and a significant main effect of mode of presentation $F(1,30) = 18.2$, MSe = 2. There was no significant interaction of age x presentation, indicating that on this occasion, unlike Experiment 4, both groups showed a similar advantage of items generated at study. (See McFarland et al, 1985; also sections 4.1 and 4.2.)

An ANOVA was also carried out to check whether the order in which the tests were conducted had any significant effects. For the word association priming task, there was a significant interaction of order x item type x presentation, $F(1,28) = 7.14$, $MSe = 0.58$, indicating that it was the subjects who did the word association task first who showed a greater effect of generation for primed items. This suggests that a generation effect for word association priming is a short lived phenomenon. However, these conclusions should be treated with caution, as an effect of order may have confounded the results to produce this apparent result of enhanced priming due to generation at study.

Discussion

This experiment has shown older adults to have a preserved capacity for a conceptual priming task in addition to the perceptual priming tasks discussed earlier in this thesis, thereby extending previous work that has shown the ability of older adults not to be restricted to implicit tasks that merely require attention to the physical or superficial properties of the material (see e.g. Rabinowitz, 1986; Howard, 1988, Experiment 1; Light and Albertson, 1989; see also section 2.2). Furthermore, the present study generalizes this finding to a word association priming task, a task that has not been used before in a study concerning age. When the word association data was analysed separately for each age group, only the younger group showed a superior generation effect for this task. However, Howard (1988; see section 2.2) showed a levels of processing effect in a word stem completion test for associated word pairs for her group of younger adults, and suggested that her subjects may have paid more attention to the meaning of the material, due to the demands of the study task. Hamann (1990) also showed the effect of a levels of processing study manipulation in a group of young subjects for implicit conceptually driven general knowledge and category exemplar generation tasks, but noted that this priming facility declined rapidly over a ninety minute interval. Blaxton's (1985, Expt. 1; 1989; see also section 1.5) work, manipulating read and generate at study and testing implicit conceptually driven general knowledge showed an effect of superiority for generated items. However, it is still possible that these later results are contaminated by explicit strategies since none of these studies attempted to disguise the tasks in the manner of the present study. For the older group, this experiment has shown the word association task to behave like the embedded word stem completion tests of Experiments 4 and 5, showing little effect of either read or generate at study. Thus it is possible that the younger group's results might still reflect explicit strategies, since although the test was disguised, no questioning as to conscious awareness was included this time. In free recall, both groups showed the effect of superior generation at study, the younger group outperforming the older subjects.

Experiment 7 that follows, sets out to get a purchase on conscious awareness in explicit and implicit memory tests, in this final study that also compares age.

5.3 Experiment 7

Introduction

Experiment 7 investigated consciousness in memory by measuring it in a way less likely to invoke demand characteristics than the use of the Schacter/Bowers questionnaire (see Expt. 5, section 4.2). Indeed, as Schacter et al (1990; see also section 1.6) suggested, just because a subject says s/he is aware of a relationship between test and study items, it does not mean that all of the items are uniformly apparent. Thus in this final experiment, subjects were asked to select from their completed list of word stems those items they recognized as "old" or from the original study list. Additionally, they were asked to indicate how they recognized those target items according to the methods used by Tulving (1985b) and Gardiner (1988a; see also section 1.7). It was predicted that there would be little effect of age for priming in word stem completion as the previous experiments in this thesis have shown. It was further predicted that fewer of the completed items would be recognized by the older group than the younger subjects, since this part of the task involves explicit memory processing. However, in a test of cued recall, the young subjects were expected to outperform the older group, this effect of age being shown in the conscious "Remember" response, since "Know" reflects an implicit memory component (see section 1.7). Implicit word stem completion instructions were not expected to incur such enhancement of the "Remember" response.

Method

Subjects

The young group were a further 16 City University students, whose mean age was 20.3 (range = 18 - 25). The older group was another 16 members of the University of the Third Age, whose mean age was 72.1 (range = 63 - 84). Mill Hill vocabulary scores differed significantly with age, $t(30) = 5.8$, $p < 0.001$, the mean score of the young group being 15.8 (range = 12 - 19), that of the older group was 19.5 (range = 15 - 21). All the subjects in the older group reported being in good health, and all subjects were tested individually and were paid for their participation.

Design, Materials and Procedure

This was essentially the same as that of Experiment 1, although there was no levels of processing study manipulation but a semantic free association study task included to encourage both sets of subjects to encode the study material deeply. The order of testing word stem completion and cued recall was counterbalanced so that half of each set of subjects did the word stem completion test first, the other half carrying out the cued recall test first. After finishing the page of word stem completions, subjects were instructed to use the completed stems rather like a recognition test, searching each of the two columns for study list members. Next to each recognized item, they were to indicate either with an "R" or a "K", their conscious awareness of the study material. In cued recall subjects were to place their "R" and "K" responses next to each recalled item immediately after its recall. This latter method was not used for word stem completion as it was considered likely to detract from the implicit nature of the task, by drawing attention to the presence of study list members. Thus for the word stem completion test, subjects made their "R" or "K" responses after all completions had been made, while in cued recall, these responses were made as each item was recalled. This procedure was adopted in order to make the explicit components of the study comparable.

Thus subjects studied the list items hand printed on index cards as in Experiment 1, but only writing on the sheet of paper provided, an associate to each word as it was presented to them, having been instructed to memorize the target words. After the Mill Hill test, subjects either carried out the word stem completion test or the cued recall test first, according to their test condition. Immediately after completing the stem completion test, they were given written instructions concerning the "Recognition" test and "Remember" and "Know" responses. They were given further oral instructions about Remembering and Knowing, with examples of each before commencing this part of the test. Before beginning the cued recall test, subjects were given written instructions on how to use stems as cues, as in Experiment 1, but in addition they received instructions regarding "Remember" and "Know" responses, which were exactly the same as those given after word stem completion, in both written and oral forms.

Results

Figure 7(i) summarizes the priming measures from the word stem completion test. That is, the figure shows completion rates after subtracting the appropriate baseline completion rates for each subject, and showing "Remember" and "Know" responses as proportions of these corrected scores. Correctly completed word stem data that subjects failed to recognize ($\overline{RK}$) were treated in the same way. These computations were carried out in order to deal with differences in baseline scores). The baseline rates for young and old groups were .13 and .20 respectively. (Corresponding intrusion rates in cued recall were .02 and .01).

Figure 7(ii) summarizes the principal results of the cued recall test. As predicted, these results indicate that the young adults were more successful in recalling study list words than the elderly subjects, and that this difference was largely restricted to the "Remember"

FIGURE 7(i) - EXPERIMENT 7

Probability of Word Stem Completion as a Function of Age and Conscious Awareness

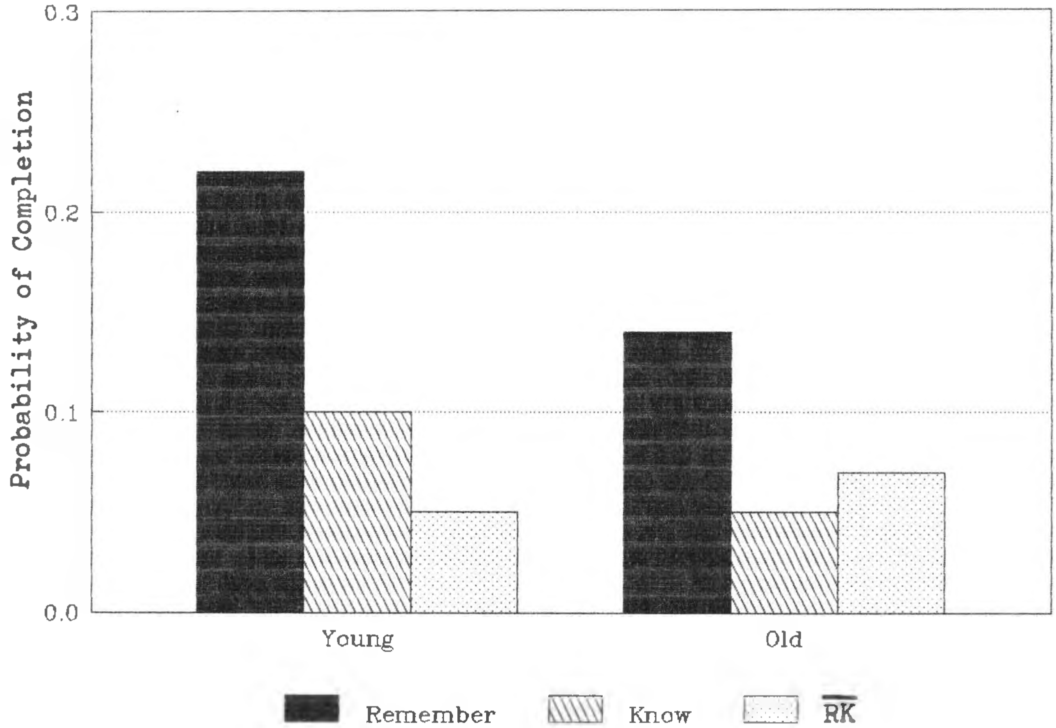
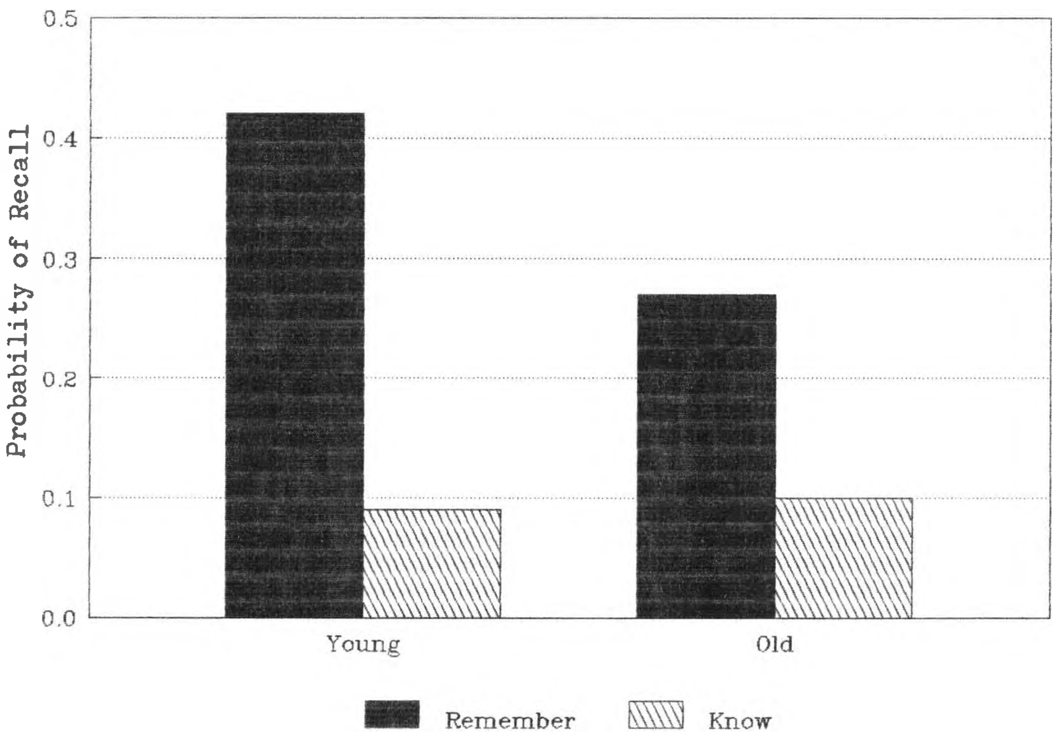


FIGURE 7(ii) - EXPERIMENT 7

Probability of Cued Recall as a Function of Age and Conscious Awareness



responses, while "Know" responses were similar for both age groups.

The results of an analysis of variance (ANOVA) of word stem completion scores showed a significant main effect of item type, $F(1,30) = 8.9$, $MSe = .02$, with neither the main effect of age, nor the interaction of age x item type reaching significance, $F(1,30) = 2.52$, $MSe = .01$, $F(1,30) = 1.63$, $MSe = .03$ respectively. t Tests to compare age differences in judgement were not significant, $t(30) = 1.48$ and 1.39 for "Remember" and "Know" respectively. There were no age differences for non-recognized items, $t < 1$. In a comparable ANOVA of the cued recall data, there was found to be a significant main effect of age, $F(1,30) = 4.9$, $MSe = 8.33$. A t test showed that the apparent difference in age for "Remember" responses was significant, $t(30) = 2.10$, $p < 0.05$. "Know" responses (young = 0.9, old = 0.10) were not analysed due to the obvious similarity between the two sets of scores.

Discussion

This experiment has replicated the findings of Experiment 1 of this thesis, showing a difference in age for explicit cued recall and indicating a relatively preserved implicit memory of the elderly for word stem completion. In addition, it has shown that all of the age difference in cued recall was in the conscious

"Remember" response. "Know" responses were similar for both age groups. These effects of age on judgement in cued recall seem to mirror findings of previous research that has shown effects of age in explicit memory. If "Remember" responses correspond with explicit memory and "Know" responses, implicit memory, it is not surprising that it is the "Remember" responses that differ with age, while "Know" responses, which might reflect an implicit component of recall, are by implication unaffected by age. Thus the lack of an effect of age on judgement in word stem completion extends some of the previous work in implicit memory, in which effects of age have tended not to be found when conscious recollection is not required (see section 2.2). Using implicitly produced word stem completions to assist subjects to make the link between these and items from the study list was not especially helpful to either age group. Indeed, Tulving and Schacter (1990) suggested that implicit memory using a "perceptual representation system" (see section 1.5) cannot be accessed. This lack of accessibility is highlighted by this part of the experiment.

Roediger et al (1989) referred to the concepts of data and conceptually driven processing as opposites at either end of a continuum, with most memory tests containing some components of each, and suggested that word stem and fragment completion are largely data driven (see section 1.4). The cued recall test in this experiment involved the same data driven cues as the word stem completion test, the two only differing according to the instructions given. Yet age differences occurred in cued recall and not in stem completion, this difference being reflected in "Remember" responses. Seemingly instructions consciously to refer back to the study list in a recall test activates a conceptually driven component that is redundant when subjects are asked merely to complete stems. Indeed Blaxton's (1991; see section 1.7) work with brain lesioned patients strongly indicates that "Remember" responses map on to conceptually driven processing while "Know" responses reflect perceptual processing.

5.4 General Discussion

The experiments in this chapter extend the earlier work of this thesis in two ways. Experiment 6 showed that not only was it possible to generalize the relatively preserved perceptual ability of the elderly to a conceptual word association task, but that according to the criteria of Roediger et al (1989; see section 1.4), the data of the young group indicates that this task can be classified as a conceptually driven test. Experiment 7, by applying Tulving's (1985b; see also section 1.7) "Remember" and "Know" measures of conscious awareness to implicit and explicit memory tests, showed that age differences in explicit cued recall reflects differences in conscious recollection, while no such differences occurred for word stem completion, a task that should incur little conscious awareness with regard to study list items.

The word association task of Experiment 6 was embedded among a set of other questions within a verbal skills test. The verbal skills tests of Experiments 4 and 5, which embedded word stem completion tests, failed to show the effect of Read superiority that had been obtained in a straightforward word stem completion test. The present word association test showed a superior effect of items generated at study, rather like the work of Hamann (1990) which showed a levels of processing effect and Blaxton (1985, Expt. 1; 1989; Roediger and Blaxton, 1989) who manipulated read and generate in conceptually driven implicit general knowledge tests. Hamann also referred to the rapid decline of conceptual priming in his study, a finding supported by the present study.

Experiment 7 overcame the problem of subjects stating that they were aware of the study's purpose in order not to look foolish (see Expt. 5) by requesting a simple "Remember" and "Know" response for every item. Therefore these results can be treated with some confidence. Blaxton (1991; see also section 1.7) noted that "Remember" and "Know" responses seem to map on to conceptual and data driven tasks respectively. The finding in the present experiment, that all of the difference in cued recall was shown in the conscious "Remember" response, while there was little difference between "Know" responses that do not involve conscious recollection, supports Blaxton's suggestions.

These two studies complete the experimental chapters of this thesis. A general discussion concerning all of the work involved follows in the next chapter.

CHAPTER 6

CONCLUDING DISCUSSION

6.1 Introduction

This concluding discussion is divided into five sections. The first, Section 6.2, restates the main aims of the thesis and Section 6.3 summarizes the experimental results. This is followed by an evaluation of the results with respect to the major goals, Section 6.4, and areas of study that would benefit from further development are identified in Section 6.5. Section 6.6 summarizes the thesis' main accomplishments.

6.2 **Aims of the Thesis**

The main aims of this thesis have been fourfold. Initially, it was important to extend and generalize previous work that has shown the relatively preserved ability of the elderly at implicit tasks, to other priming tasks of both a perceptual and conceptual nature. Tasks were classified according to their major components, either as conceptually or data driven tests (Roediger et al, 1989; see also section 1.4) by virtue of the manner in which variables manipulated at study behaved, and an integrative review of the current literature on aging and priming deals with these points, relating some of them to functional explanations of an age related memory decline and separating them into perceptual and conceptual tasks. A third purpose was to set the investigations within the combined framework of a systems and processing approach, such that while conceptual and data driven processes were studied, these were considered within Tulving and Schacter's (1990; see section 1.5) perceptual representation system and process semantic learning viewpoints for the implicit tasks, and episodic memory system or a memory mode for the explicit tasks. Placed last in this list of aims is the problem of awareness, arguably the most important consideration in a piece of work that deals with vagaries of explicit and implicit memory and age. This goal was pursued throughout the thesis, investigating the behaviour of study manipulations in both types of test by disguising the tasks of interest, and by directly questioning subjects as to their awareness of study list items in two ways. A summary of the main experimental results shows how these goals have been accomplished.

6.3 **Summary of the Experimental Results**

Chapter 3 introduced two new (at the time) implicit tests to be compared with cued recall and recognition. Word stem completion and anagram solution showed themselves not to be sensitive to a levels of processing study manipulation, or age, while the explicit tests were sensitive to both of these variables. This lack of an effect of levels of processing afforded converging evidence as to the tasks' implicitness, and the finding that anagram solution thus behaved rather like word stem completion, indicated that anagram solution involves a large data driven component (Srinivas and Roediger, 1990; see also section 1.4).

Three experiments followed in Chapter 4, each one using word stem completion and varying read and generate at study, the first two including explicit free recall as a comparison. The first experiment showed an effect of read superiority for word stem completion, with the anticipated generation effect in free recall. Experiment 4 disguised the word stem completion task by using an embedded test, and showed the disappearance of the read superiority effect. Neither of these experiments showed an effect of age in implicit memory, while this effect became evident in free recall. The last of this set of three experiments directly compared the two types of priming task, embedded and non-embedded word stem completion, again varying read and generate at study. This time the read superiority effect of the straightforward word stem completion task of Experiment 3, and the disappearance of the effect in the embedded task of Experiment 4 were replicated within the same subject group. Subjects were questioned post hoc as to their awareness of the study's purpose (Bowers and Schacter, 1990; Schacter et al, 1990; see section 1.6). While it was found that approximately half of the subjects in each test and age group reported themselves as aware of the tests' purpose, results indicating a greater read effect for unaware than aware subjects were inconclusive, partly due to the possibility that some of the subjects adopted socially desirable demand characteristics, and also due to an order effect contaminating the young group's embedded verbal skills data.

Chapter 5 described two experiments, the first of which investigated conceptual priming and age, in an embedded word association task. Read and generate were manipulated at study, and an effect of superior generation occurred in the young group's word association data, indicating the inclusion of this task as a conceptually driven task according to the classification of Roediger et al (1989; see section 1.4). While there was no evidence of an age difference in the implicit task, a free recall test showed an effect of age as well as generation. Experiment 7 dealt with the problem of conscious awareness, by using Tulving's (1985b; see section 1.7) "Remember" and "Know" measures for each primed and recalled item, in a study involving word stem completion and cued recall. In word stem completion, subjects were instructed to return to their completed stems and select those they recognized as study list items, indicating with an "R" or a "K", their mode of conscious recollection at that time. Subjects made similar "R" and "K" responses for each item recalled. It was found that all of an age difference in cued recall was shown in the conscious "Remember" response, while no difference of age or response type occurred for completed word stems, thereby extending Blaxton's (1991; see section 1.7) findings that "Remember" and "Know" responses map on to conceptually and data driven tests, respectively. The absence of a significant difference in age between the number of completed word stems that were not recognized, is consistent with Tulving and Schacter's suggestion of a perceptual representation system (see section 1.5) that cannot be accessed. That is, if the non-recognized material corresponds with items processed within the perceptual representation system, then it is likely that these are the only ones that can be called implicit. Hence it follows that there was little age difference for this part of the experiment.

6.4 An Evaluation of the Findings

The conception of this thesis began with the intention of extending work that has shown the relatively preserved implicit memory of older adults (e.g. Light et al, 1986; Light and Singh, 1987; see section 2.2) and generalizing these findings to other priming tasks. This has been achieved in three ways. Firstly, four out of the five word stem completion tasks showed an equivalence of age, while only one of the six explicit tasks failed to show an age difference. Indeed, as shown in the review of the literature concerning implicit and explicit memory tests and age (Section 2.2), priming and age similarities can be inconsistent. Recently, Hultsch, Masson and Small (1991) showed differences in age for word stem completion following a lexical decision study task. As Craik (1991) pointed out, work with the elderly is notoriously difficult to replicate. Secondly, anagram solution can now be added to those priming tasks at which the elderly have shown a preserved capacity. By behaving rather like word stem completion, the task conforms with Srinivas and Roediger's (1990; see section 1.4) notion of a data driven or perceptual test. Finally, word association can be added to those few conceptual priming tasks that have shown little effect of age (see section 2.2). This test, which produced an enhanced effect of generation in a group of young adults may thus be classifiable as a conceptually driven test, according to the criteria of Roediger et al (1989; see section 1.4).

The subject of task classification was not without its problems. Roediger and his colleagues (see section 1.4) had stated that data driven tests tend to produce superior read performance while conceptually driven ones show an enhanced effect of items generated at study. In this thesis word stem completion (Expt. 3) showed itself to be classifiable as data driven since the read superiority effect was produced. However, when this same task was embedded among a set of others in an attempt to afford less opportunity for the use of explicit strategies by the younger adults (Expts. 4 and 5) this effect disappeared. How can this be explained? Could it be that read superiority is an explicit phenomenon? Or did the combination of processing techniques of the surrounding tasks effect this surprising result? Further work dealing with the processes involved in any surrounding tasks of disguise (see section 6.5) and incorporating study variables known to produce evidence of data driven/conceptually driven qualities should help to clarify the matter.

As stated in Section 6.2, the investigations of this thesis were set within the combined systems and processing approach suggested by Tulving and Schacter (1990; see section 1.5). Hayman and Tulving (1989a and b; section 1.5) had pointed out that the dissociations found between explicit and implicit memory with amnesic patients fitted more reasonably within a systems approach (e.g. Tulving, 1985) than one that considered only the processing components of a test (e.g. Jacoby, 1983; Roediger et al, 1989) and put forward the idea of an integrative approach. Roediger (1990) also noted these points and suggested a similar idea. The inconsistencies reported above, relating to task classification (see Expts. 4 and 5) rather point to the idea that a processing account alone, is insufficient to explain explicit and implicit dissociations. However, the results of the present studies do fit more comfortably within the combination framework set out by Tulving and Schacter (1990). These authors stated that access to primed information in the perceptual representation is hyperspecific. This allows, to some extent, the appearance and disappearance of the read superiority effect discussed above. "Process semantic learning" covers conceptually driven priming effects, and the "memory mode" deals with episodic/ explicit memory.

The theme of conscious awareness has been constant throughout this investigation of dissociations between explicit and implicit memory and age. Test awareness according to the work of Schacter et al (1990; see section 1.6) and "Remember" and "Know" responses (Tulving, 1985b; see section 1.7) were both applied to address the matter. Findings emanating from the work of Schacter and his colleagues will be discussed first.

These authors suggested differentiating between explicit and implicit memory according to whether intentionality of retrieval was required, but were quick to point out the caveat that subjects involved in an implicit test may suddenly and unintentionally become aware of the test's relationship to the study list. If this occurred they might well continue as instructed, by completing word items with the first word that came to mind, but conversely they might decide to reinstate study list items. Thus in order to make a finer distinction between the two types of test, Schacter et al suggested that firstly, external cues should remain the same in each case and secondly, a manipulation should be applied that affects one type of task but not the other. (See section 1.6). When they applied these criteria using a levels of processing study manipulation and asking four questions to select between "aware" and "unaware" subjects, they found that only "aware" subjects showed the levels of processing effect, with no such effect occurring for "unaware" subjects, implying that their "aware" subjects applied explicit strategies in the "implicit" test.

The present work has shown that there are several problems with these ideas. Firstly, since Experiment 3 showed evidence of read superiority in straightforward word stem completion while this effect disappeared in a test designed to disguise the purpose of the task (Expt. 4). Schacter et al's criteria were applied to both types of test in Experiment 5, in order to investigate how the study variables of read and generate behaved according to subject awareness. Experiment 5 showed approximately half the subjects of each age group to be "aware" for both tests, offering little explanation to the differential findings between the two types of word stem completion test. Secondly, stating "awareness" does not mean that subjects were aware for all of the items, yet Schacter et al's methodology necessarily involves allocating all of the data to one or other condition. Following from this, subjects who said they were aware, may well not have made use of this knowledge, and notwithstanding, adhered to the original instructions, a possibility those authors point out themselves.

The final experiment in this thesis using Tulving's (1985b; see section 1.7) "Remember" and "Know" responses, is arguably more successful than using Schacter et al's criteria for investigating dissociations in explicit and implicit memory according to subjective awareness or "consciousness". This method involved questioning subjects about their conscious recollection for every item on a response sheet, simply by asking them to indicate their memorial experience at the moment of retrieval. Subjects were asked to indicate which completed items following a word stem completion task they recognized as study list members, responding with an "R" or "K" in each case. In a cued recall test, retrieved items were similarly dealt with. The fact that there were found to be predicted age differences in explicit cued recall, and that this was shown in superior "Remember" responses, while there was no difference in age and no pronounced effect of "Remember" response for the recognition of completed word stems, reasonably suggests that this method was successful in dissociating between the two types of test. What was particularly interesting was the finding of age equivalence for non-recognized completed word stems. If, as some of the literature on age and explicit/implicit memory suggests (see section 2.2), age is not a distinguishing feature in many implicit memory tests, then the non-recognized items may be considered to be the only ones derived from implicit memory. Cohen (1987) as well as Tulving and Schacter (1990) suggested that the system involving implicit memory cannot be accessed. Cohen suggested that procedural memory was inaccessible as "specific facts, data or time and place events". Tulving said that the products of the perceptual representation system "do not provide a basis for awareness of previous experience". Nonetheless, Experiment 7 showed that approximately 60% of the implicitly produced test items were later available to conscious awareness for both age groups. If one accepts Cohen's and Tulving's suggestions, then it is indeed possible to consider that only the non-recognized items were produced using implicit memory. This matter will be considered again, along with others suggested as suitable for further development in Section 6.4 that follows.

6.5 <u>Lines of Further Development</u>

(i) Implicit Memory and Conscious Awareness

Four points in particular were suggested by the findings of Experiments 3, 4, 5 and 7 as being worthy of further development. These are as follows:

Firstly, it is considered that "Remember" and "Know" responses (Tulving, 1985b; see section 1.7) were successful as a measure of conscious awareness in distinguishing between explicit and implicit tests, as indicated by the findings of Experiment 7. It is suggested that these are a more suitable measure than those of Bowers and Schacter (1990) and Schacter et al (1990; see also section 1.6), since it is felt that these authors' questions could lead to a response bias. The second point from Experiment 7 is the idea that only those word stems that were completed and <u>not</u> recognized were retrieved from implicit memory, since, as Tulving (1990) and Cohen (1987; see also previous section) suggested, the system involving implicit memory cannot be accessed. Point three involves the mystery of the appearance and disappearance of the read superiority effect, and whether it is an explicit or implicit memory phenomenon. The appearance of the effect in the word stem completion test of Experiment 3 suggests that the effect reflects retrieval from implicit memory, and extends the findings of Blaxton (1985, Expt. 1; 1989; Roediger and Blaxton, 1987; see also section 1.5), yet no advantage of either read or generate occurred when word stems to be completed were embedded within another set of tasks in an endeavour to disguise the purpose of the target task (Expt. 4). Experiment 5 showed the appearance and disappearance of the read superiority effect, by manipulating the two types of task, straightforward and embedded word stem completions, as a within subjects variable. It is important to discover whether these findings were in fact due to a lack of test awareness brought about by the nature of the test, or indeed were related to the fact that the questions surrounding the target word stems were of a mixed data driven and conceptually driven type.

These points could be dealt with by designing an experiment involving word stems to be completed in both straightforward and embedded tasks as those of Experiment 6, but this time, the embedded word stems to be completed should be surrounded by tasks that are only of a data driven nature in order to match up with the target task. Read and generate should again be manipulated at study. After all the stems have been completed, subjects should be asked to state which items they recognize as study list members, indicating their mode of conscious awareness at the time with an "R" or "K" response, as in Experiment 7. If the read superiority effect <u>is</u> an implicit memory phenomenon, the effect should only occur for those items <u>not</u> recognized. Should the effect turn out to be a phenomenon of explicit memory, then the effect should be pronounced in the recognized set of items. Furthermore, it is likely that "R"; responses correspond with generated items and "K" responses with read items, since it is suggested that the "R" response maps onto conceptually driven processing and the "K" with data driven processing (see e.g. Blaxton, 1991; see also section 1.7).

(ii) "Remember" and "Know" as Measures of Contextual Encoding Techniques

All of the experiments included in this thesis have included a semantic or conceptual encoding procedure, not only to investigate the effects of these manipulations on the tests to follow, but also in an endeavour to offer the elderly subjects a greater opportunity to encode the study material deeply. Craik and Simon (1980; see section 2.1) indicated that older adults take little advantage of semantic encoding environments. Burke and Light (1981) pointed out that guidance towards a particular encoding mechanism does not guarantee its being carried out. Rabinowitz and Ackerman (1980; section 2.1) suggested that the elderly encode study materials qualitatively differently from younger adults; that rather than taking account of the more specific contextual experience of the study period, they lean towards a more global method. The findings of Experiment 7 seem to reflect this idea, since in cued recall, age differences were found only in the conscious

"Remember" responses and not in the "Know". That is, the older adults were less able than the young to bring to mind at retrieval, the specific conscious experience of the study moment.

Gregg and Gardiner (1991; see section 1.7) analysed the content of expressed "Remember" and "Know" responses of college students. By using these measures of recollective experience for recalled items and asking old and young subjects to give examples of each type of response, it should be possible to investigate qualitatively, any differences between age and elaborative study processing.

6.6 Conclusions

In summary, the present work has dealt with consciousness and aging in memory, while considering the concepts of task classification and test awareness within the boundaries of an integrated systems and processes approach.

There were problems raised about the subject of task classification due to the vagaries of the read superiority effect. Further work (see section 6.5(i)) has been suggested to resolve the matter.

The criteria set by both Schacter and Bowers (see section 1.6) for distinguishing between explicit and implicit tests according to subject awareness were also found to be problematic, and the method used in the present Experiment 7 to measure conscious awareness appeared to be more satisfactory.

Tulving and Schacter's (1990; section 1.5) combined theoretical systems and processes approach was applied to the present studies, and the findings complied well with these authors' suggests of a hyperspecific perceptual representation system, process semantic learning system and memory mode.

The question of how conscious awareness is implicated in findings of age differences and similarities in explicit and implicit memory is still to be resolved. Are results due to conscious awareness as such, or is it merely the direction away from conscious retrieval that effects these differential results? More age differences are to be found in explicit tasks requiring conscious retrieval than those involving implicit memory (see section 2.2) and the present work has supported these findings. Jacoby and Witherspoon (1982) described their findings of preserved priming in amnesic patients as a dissociation between memory and awareness, suggesting "passive" remembering to be an early phase of cognitive processing. The fact that this relatively preserved implicit memory facility has been shown in the elderly in this thesis strongly suggests that studied information has been correctly encoded. However, the present studies also suggest that access to this encoded information in the form of explicit retrieval tends to be denied.

[1]Footnote

Three of the experiments described in the thesis have been reported in different form in two manuscripts, one of which is co-authored by Professor John M. Gardiner and myself.

Experiments 1 and 3 are reported in a paper entitled "Priming and aging: Further evidence of preserved memory function" published in the American Journal of Psychology, (1991), 104, 89-100. (Java, R.I. and Gardiner, J.M.).

A paper currently in press in the American Journal of Psychology, "Priming and aging: Evidence of preserved memory function in an anagram solution task" (Java, R.I.) reports Experiment 3 of the thesis.

I would also like to submit as subsidiary material the following three papers, two of which are co-authored by Professor John M. Gardiner and myself and one of which is co-authored by Professor J. M. Gardiner, Doctors Z. Kaminska and E. F. Clarke, Mr. P. Mayer and myself.
I was principle co-author on two of these articles and contributed to the conception, design and interpretation of all of the work reported.

Gardiner, J.M., and Java, R.I. (1990). Recollective experience in word and non-word recognition. Memory & Cognition, 8, 23-30.

Gardiner, J.M., Kaminska, Z., Java, R.I., Clarke, E.F., Mayer, P. (1990). The Tulving-Wiseman law and the recognition of recallable music. Memory & Cognition, 18, 632-637.

Gardiner, J.M., and Java, R.I. (in press). Forgetting in recognition memory with and without recollective experience. Memory & Cognition.

REFERENCES

Baddeley, A.D. (1982a). Amnesia: A minimal model and an interpretation, in L. S. Cermak (Ed.), Human memory and amnesia, Hillsdale, N.J: Erlbaum.

Bennett, C.A., & Franklin, N.L. (1954). Statistical analysis in chemistry and the chemical industry. New York:Wiley

Birren, J.E., Woods, A.M., & Williams, M.V. (1980) Behavioral slowing with aging: causes, organization, and consequences. in L.W. Poon (Ed.), Aging in the 1980s: Psychological issues. Washington, DC: American Psychological Association.

Blaxton, T.A. (1985). Investigating dissociations among memory measures: support for a transfer appropriate processing framework. Unpublished doctoral dissertation, Purdue University, West Lafayette, IN.

Blaxton, T.A. (1989). Investigating dissociations among memory measures: support for a transfer-appropriate processing framework. Journal of Experiment Psychology: Learning, Memory & Cognition, 15, 657 - 668

Blaxton, T.A. (1991) The role of temporal lobes in memory function: Conceptual and data driven transfer. Manuscript submitted for publication

Botwinick, J. (1977) Intellectual abilities. in J.E. Birren & K.W. Shaie (Eds.), Handbook of the psychology of aging. New York: Van Nostrand Reinhold.

Bowers, J.S., & Schacter, D.L. (1990). Implicit memory and test awareness. Journal of Experimental Psychology: Learning, Memory, and Cognition, 16, 404-416

Burke, D.M., & Light. L.L. (1981) Memory and Aging: The role of retrieval processes. Psychological Bulletin, 90, 513-546

Chiarello, C., & Hoyer, W.J. (1988). Adult age differences in implicit and explicit memory: Time course and encoding effects. Psychology and Aging, 3, 358-366

Cohen, L.R. (1987) Memory and Brain. Oxford University Press, Inc

Cohen, N.J. (1981) Neuropsychological evidence for a distinction between procedural and declarative knowledge in human memory and amnesia. (Doctoral dissertation, University of California, San Diego). Dissertation Abstracts International, 41, 4733B

Cohen, N.J. (1984). Preserved learning capacity in amnesia: Evidence for multiple memory systems. In L.R. Squire & N. Butters (Eds.), The Neuropsychology of memory (pp. 419-432) New York: Guilford.

Cohen, N.J., & Corkin, S. (1981). The amnesic patient H.M.: Learning and retention of a cognitive skill. Society for Neuroscience Abstracts, 7, 235

Craik, F.I.M. (1977). Age differences in human memory. In J.E. Birren & K.W Shaie (Eds.), Handbook of the psychology of aging. New York: Van Nostrand Reinhold.

Craik, F.I.M. (1991). Personal Communication

Craik, F.I.M., & Lockhart, R.S. (1972). Levels of processing: A framework for memory research. Journal of verbal learning and verbal behavior, 11, 671-684

Craik, F.I.M., & Simon, E. (1980). Age differences in memory: The roles of attention and depth of processing. In L.W. Poon, J.L. Fozard, L. Cermak, D. Arenberg & L.W. Thompson (Eds.) New directions in memory and aging: Proceedings of the George Talland Memorial Conference. Hillsdale, N.J: Erlbaum

Craik, F.I.M., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. Journal of Experimental psychology: General, 104, 268-294.

Davis, H.P., Cohen, A., Gandy, M., Colombo, P., Van Dusseldorp, G., Simolke, N., & Romano, J. (1990). Lexical priming as a function of age. Behavioral Neuroscience, 104, 288-297

Dominowski, R.L., & Eckstrand, B.R. (1967). Direct and associative priming in anagram solving. Journal of Experimental Psychology, 74, 84-86.

Ebbinghaus, H. (1964). Memory: A contribution to experimental psychology. New York: Dover. (original work published 1885; translated 1913)

Erber, J.T., Harman, T.G., & Botwinick, J. (1980). Age differences in memory as a function of depth of processing. Experimental Aging Research, 6, 341-348

Eysenck, M.W. (1974) Age differences in incidental learning Developmental Psychology, 10, 936-941

Gardiner, J. M. (1988a). Functional aspects of recollective experience, Memory & Cognition, 16, 309-313.

Gardiner, J.M., Dawson, A.J., & Sutton, E.A (1989). Specificity and generality of enhanced priming effects for self-generated study items. American Journal of Psychology, 102, 295-305

Gardiner, J. M., & Java, R. I (1990). Recollective experience in word and nonword recognition, Memory & Cognition 18, 23-30

Gardiner, J.M., & Java, R I. (in press). Forgetting in recognition memory with and without recollective experience, Memory & Cognition.

Gardiner, J.M. & Parkin, A. J. (1990). Attention and recollective experience in recognition memory, Memory & Cognition, 18, 579-583

Graf, P , & Mandler, G. (1984). Activation makes words more accessible but not necessarily more retrievable Journal of Verbal Learning and Verbal Behavior, 23, 553-568

Graf, P , Mandler, G., & Haden, P.E. (1982). Simulating amnesic symptoms in normals, Science, 218, 1243-1244

Graf, P. & Schacter, D.L. (1985). Implicit and explicit memory for new associations in amnesic subjects. Journal of Experimental Psychology: Learning, Memory, and Cognition, 11, 501-518

Graf, P., Shimamura, A.P., & Squire, L.R. (1985). Priming across modalities and priming across category levels: Extending the domain of preserved function in amnesia. Journal of Experimental Psychology: Learning, Memory & Cognition, 11, 386-396

Graf, P., Squire, L.R., & Mandler, G. (1984). The information that amnesic patients do not forget. Journal of Experimental Psychology: Learning, Memory & Cognition, 10, 164-178

Greene, R.L. (1986). Word stems as cues in recall and completion tasks. Quarterly Journal of Experimental Psychology, 38A, 663-673

Gregg, V.H., & Gardiner, J. M. (1991). Components of Conscious awareness in a long term modality effect. British Journal of Psychology, 82, 153-162

Hasher, L., & Zacks, R.T. (1979). Automatic and effortful processes in memory. Journal of Experimental Psychology: General, 108, 356-388.

Hasher, L., & Zacks, R.T. (1989). Working memory comprehension, and aging: a review and a new view. The Psychology of learning and motivation, 22, 193-225.

Hayman, C.A.G., & Tulving, E. (1989a). Contingent dissociation between recognition and fragment completion: The method of triangulation, Journal of Experimental Psychology: Learning, Memory & Cognition, 15, 228-240.

Hayman, C.A.G., & Tulving, E. (1989b). Is priming in fragment completion based on a "traceless memory system?" Journal of Experimental Psychology: Learning, Memory, and Cognition, 15, 941-956.

Howard, D.V. (1988). Implicit and explicit assessment of cognitive aging. In M.L. Howe & C.J. Brainerd (Eds.), Cognitive development in adulthood: Progress in cognitive development research. (pp. 3-37). New York.

Howard, D.V., Heisey, J.G., & Shaw, R.J. (1986). Aging and the priming of newly learned associations. Developmental Psychology, 22, 78-85.

Howard, D.V., McAndrews, M.P. & Lasaga, M.I. (1981). Semantic priming of lexical decisions in young and old adults. Journal of Gerontology, 36, 707-714.

Hultsch, D.F., Masson, M.E.J., & Small, B.J. (1991). Adult age differences in direct and indirect tests of memory. Journal of Gerontology, 46, 22-30.

Jablonski, E.M., & Mueller, J.H. (1972). Anagram solution as a function of instructions, priming and imagery. Journal of Experimental Psychology, 94, 84-89.

Jacoby, L.L. (1983). Remembering the data:Analysing interactive processes in reading. Journal of verbal learning & verbal Behavior, 22, 458-508.

Jacoby, L.L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. Journal of Experimental Psychology: General, 110, 306-340.

Jacoby, L.L., & Witherspoon, D. (1982). Remembering without awareness. Canadian Journal of Psychology, 36, 300-324.

Johnson, M.K., & Hasher, L. (1987). Human Learning and Memory. Annual Review of Psychology, 38, 631-668.

Johnson, M.K., Kim, J.K., & Risse, G. (1985). Do alcoholic Korsakoff Syndrome patients acquire affective reactions? Journal of Experimental Psychology: Learning, Memory & Cognition, 11, 22-36.

Johnson, M.M.S., Schmitt, F.A., & Pietrukowicz, M. (1989). The memory advantages of the generation effect: Age and process differences. Journal of Gerontology, 44, 91-94.

Kausler, D.H. (1982). Experimental psychology and human aging. New York: Wiley.

Kausler, D.H., & Puckett, J.M. (1980). Adult age differences in recognition memory for a nonsemantic attribute. Experimental Aging Research, 6, 349-355.

Kausler, D.H. & Puckett, J.M. (1981). Adult age differences in memory for sex of voice. Journal of Gerontology, 36, 44-50.

Light, L.L.,& Albertson, S.A. (1989). Direct and indirect tests of memory for category exemplars in young and older adults. Psychology and Aging, 4, 487-492.

Light , L.L., and Singh, A. (1987). Implicit and Explicit memory in young and older adults. Journal of Experimental Psychology: Learning, Memory & Cognition, 13, 531-541

Light, L.L., Singh, A., & Capps,J.L. (1986). The disscoiation of memory and awareness in young and older adults. Journal of Clinical and Experimental Neuropsychology, 8, 62 -74

Macken, W., & Hampson, P. (in press). Integration, elaboration and recollective experience. European Journal of Cognitive Psychology, xx

Mandler, G. (1986). Reminding, recalling, recognizing: Different memories? In F.Klix and H. Hagendorf (Eds.) Human Memory and Cognitive Capabilities, Mechanisms and Performances. Elsevier Science Publishers B.V. North Holland.

Mandler, G., Hampson, C.O., & Dorfman, J. (1990). Test of dual process theory: Word priming and recognition. The Quarterly Journal of Experimental Psychology, 42A, 713-739

Mason, S.E. (1979). Effects of orienting tasks on the recall and recognition performance of subjects differing in age. Developmental Psychology, 15, 467-469

McClelland, A.G.R., & Pring, L (1991). An investigation of cross-modality effects in implicit and explicit memory. Quarterly Journal of Experimental Psychology, 43A, 19-33

McFarland, C.E., Jnr., Warren, L.R., & Crockard, J (1985). Memory for self generated stimuli in young and old adults. Journal of Gerontology, 40, 205-207

Milner, B., Corkin, & Teuber, H.L. (1968). Further analysis of the hippocampal amnesia syndrome. Neuropsychologia, 6, 215-234.

Mishkin, M., Malmut, B., & Bachevalier, J. (1984). Memories and habits:Two neural systems. in G. Lynch, J.L. Mcgaugh & N.M. Weinberger (Eds.), Neurobiology of learning and memory, New York: Guildford.

Mitchell, D.B. (1989). How many memory systems? Evidence from aging. Journal of Experimental Psychology: Learning, Memory & Cognition, 15, 31-49

Mitchell, D.B., Brown, A.S., & Murphy, D.R. (1990). Dissociation between procedural and episodic memory: Effects of time and aging. Psychology and Aging, 5, 264-276.

Mitchell, D.B., Reed-Hunt, R., & Schmitt, F.A. (1986). The generation effect and reality monitoring:Evidence from dementia and normal aging. Journal of Gerontology, 41, 79-84

Mogg, K., Gardiner, J.M., Stavrou, A., & Golombok, S. (1991). Recollective experience and recognition memory for threat in clinical anxiety states. Manuscript submitted for publication.

Morris, C.D., Bransford, J.D., & Franks, J.J (1977). Levels of processing versus transfer appropriate priocessing. Journal of Verbal Learning & Verbal Behavior, 16, 519-533

Moscovitch, M. (1982). A Neuropsychological approach to perception and memory in normal and pathalogical aging. In F.I.M. Craik and S.E. Trehub (Eds.) Aging and Cognitive Processes. New York: Plenum Press.

Moscovitch, M., Winocur, G., & McLachlan, D (1986). Memory as assessed by recognition and reading time in normal and memory impaired people with Alzheimer's disease and other neurological disorders. Journal of Experimental Psychology: General, 115, 331-347

O'Keefe, J., & Nadel, L. (1978). The hippocampus as a cognitive map. London: Oxford University.

Parkin, A.J., & Walter, B. (1991). Recollective experience, normal aging and frontal dysfunction. Manuscript submitted for publication.

Perlmutter, M. (1978). What is memory aging the aging of? Developmental Psychology, 14, 330-345

Perlmutter, M. (1979a). Age differences in adults' free, cued recall, and recognition. Journal of Gerontology, 34, 533-539.

Perlmutter, M. (1980). An apparent paradox about memory and aging. In New Directions in Memory and Aging: Proceedings of the George A.Talland Memorial Conference. (Eds.) L.W.Poon., J.L. Fozard,., L.S. Cermak., D Arenberg and L.W Thompson. Hillsdale,N.J.: Lawrence Erlbaum Associates

Perruchet, P., & Baveux, P. (1989). Correlational analyses of explicit and implicit memory performance. Memory and Cognition, 17, 77-86.

Rabinowitz, J.C. (1984). Aging and recognition failure. Journal of Gerontology, 39, 65-71

Rabinowitz, J.C. (1986). Priming in episodic memory. Journal of Gerontology, 41, 204-213

Rabinowitz, J.C. (1989). Judgements of origin and generation effects: Comparisons between young and elderly adults. Psychology and Aging, 4, 259-268

Rabinowitz, J.C., & Ackerman, B.P. (1982). General encoding of episodic events by elderly adults. In F.I.M. Craik & S. Trehub (Eds.), Aging and Cognitive Processes (pp145-154). New York:Plenum Press

Rabinowitz, J.C., & Ackerman, B.P. (1988). In F.I.M. Craik and S.E. Trehub (Eds.) Aging and Cognitive Processes. New York: Plenum Press.

Read, D.E. (1988). Age related change in performance on a visual closure task. Journal of Clinical and Experimental Neuropsychology, 10, 451-466

Richardson-Klavehn A., & Bjork, R.A. (1988). Measures of memory. Annual Review of Psychology, 39, 475-543

Roediger, H.L. 111. (1990). Implicit Memory: Retention without remembering. American Psychologist. 45. 1043-1056

Roediger, H.L. 11., & Blaxton, T.A. (1987b). Retrieval modes produce dissociations in memory for surface information. In D.S. Gorfein & R.R. Hoffman (Eds.) Memory and Learning: The Ebbinghaus Centennial Conference (pp. 349-379). Hillsdale,N.Y.: Erlbaum

Roediger, H.L.111., Weldon, M.S., & Challis, B.B. (1989). Explaining dissociations between implicit and explicit measures of retention: A processing account. In H.L. Roediger, 111., & F.I.M. Craik (Eds.) Varieties of Memory and Consciousness: Essays in Honor of Endel Tulving. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Rose, T.L., Yesavage, J.A., Hill, R.D., & Bower, G.H. (1986). Priming effects and recognition memory in young and elderly adults. Experimental Aging Research. 12. 31-37.

Salthouse, T.A. (1980). Age and memory: strategies for localizing the loss. In L.W. Poon, J.L. Fozard, L. Cermak, D. Arenberg & L.W. Thompson (Eds.) New directions in memory and aging: Proceedings of the George Talland Memorial Conference. Hillsdale, N.J: Erlbaum.

Schacter, D.L., Bowers, J., & Booker, J. (1990). Intention, awareness and implicit memory: The retrieval Intentionality Criterion. In S.Lewendowsky, J.Dunn, & K. Kirsner (Eds.) Implicit Memory: Theoretical Issues. Hillsdale, N.J.: Erlbaum Associates

Shimamura, A.P. (1986). Priming effects in amnesia: Evidence for a dissociable memory function. The Quarterly Journal of Experimental Psychology, 38a, 93-118.

Shimamura, A.P., & Squire, L.R. (1984). Paired associate learning and priming effects in amnesia: A neuropsychological study. Journal of Experimental Psychology: General, 113, 556-570.

Slamecka, N.J. & Graf, P. (1978). The generation effect; Delineation of a phenomenon. Journal of Experimental Psychology: Human Learning and Memory, 4, 592-604.

Smith, A.D., & Winograd, E. (1978). Adult age differences in remembering faces, Developmental Psychology, 14, 443-444.

Squire, L.R. (1982a). The neuropsychology of human memory. Annual review of neuroscience, 5, 241-273.

Squire, L.R., & Cohen, N.J. (1984). Human memory and amnesia. in G. Lynch, J.L. Mcgaugh & N.M. Weinberger (Eds.), Neurobiology of learning and memory, New York: Guildford.

Srinivas, K., & Roediger, H.L.111. (1990). Classifying implicit memory tests: Category and Anagram Solution. Journal of Memory & Language, 29, 389-412.

Thomson, D.M., & Tulving, E. (1970). Associative encoding and retrieval: weak and strong cues. Journal of Experimental Psychology, 86, 255-266

Tulving, E (1983) Elements of Episodic Memory. Oxford: O.U.P

Tulving, E (1985a). How many memory systems are there ? American Psychologist, 40, 385-398.

Tulving, E (1985b) Memory and Consciousness. Canadian Psychology, 26, 1-12.

Tulving, E., & Schacter, D.L. (1990). Priming and Human Memory Systems, Science, 247, 301-306

Tulving, E., Schacter, D.L., & Stark, H.A. (1982). Priming effects in word-fragment completion are independent of recognition memory. Journal of Experimental Psychology: Learning, Memory, and Cognition, 8, 336-342

Warrington, E.K., & Weiskrantz, L. (1968). A new method of testing long-term retention with special reference to amnesic patients, Nature, 217, 972-974

Warrington, E.K., & Weiskrantz, L. (1970) Amnesic Syndrome: Consolidation or retrieval. Nature, 228, 628-630

Warrington, E.K., & Weiskrantz, L. (1974). The effect of prior learning on subsequent retention in amnesic patients. Neuropsychologia, 12, 419-428

Warrington, E.K., & Weiskrantz, L. (1978). Further analysis of the prior learning effect in amnesic patients. Neuropsychologia, 16, 169-176.

Warrington, E.K., & Weiskrantz, L. (1982). Amnesia: A disconnection syndrome? Neuropsychologia, 20, 233-248.

Winocur, G., & Moscovitch, M. (1983). Paired associate learning in institutionalized old people: an analysis of interference and context effects. Journal of Gerontology, 38, 455-464.

Zelinski, E.M., Walsh, D.A., & Thompson, L.W. (1978). Orienting task effects on EDR and free recall in three age groups. Journal of Gerontology, 33, 239-245.

APPENDIX

Table A1: Experiment 1

Summary of Analysis of Variance for Word Stem Completion, Age and Orientation Task

Source	df	SS	MS	F	p
Age (A)	1	1.531	1.531	.264	.6113
Error	30	174.188	5.806		
Orientation (O)	1	.781	.781	.527	.4733
Age x Orientation (AO)	1	.781	.781	.527	.4733
Error	30	44.438	1.481		
Item type (S)	1	101.531	101.531	60.995	.0000
Age x Item type (AS)	1	1.531	1.531	.920	.3452
Error	30	49.938	1.665		
Orientation x Item type (OS)	1	.281	.281	.217	.6449
Age x Orientation x Item type (AOS)	1	.781	.781	.602	.4439
Error	30	38.938	1.298		

Table A2: Experiment 1

Summary of Analysis of Variance for

Cued Recall, Age and Orientation Task

Source	df	SS	MS	F	p
Age (A)	1	30.250	30.250	5.386	.0273
Error	30	168.500	5.617		
Orientation (O)	1	60.063	60.063	22.701	.0000
Age x Orientation (AO)	1	7.563	7.563	2.858	.1013
Error	30	79.375	2.646		

Table A3: Experiment 2

Summary of Analysis of Variance for Anagram Solution, Age and Presentation

Source	df	SS	MS	F	p
Age (A)	1	4.133	4.133	.982	.3297
Error	30	126.297	4.210		
Item type (S)	1	27.195	27.195	11.018	.0024
Age x Item type (AS)	1	.008	.008	.003	.9555
Error	30	74.047	2.468		
Presentation (P)	1	.195	.195	.084	.7738
Age x Presentation (AP)	1	.383	.383	.165	.6876
Error	30	69.672	2.322		
Item type x Presentation (SP)	1	.633	.633	.485	.4917
Age x Item type x Presentation (ASP)	1	3.445	3.445	2.639	.1148
Error	30	39.172	1.306		

Table A4: Experiment 2

Summary of Analysis of Variance for

Recognition, Age and Presentation

Source	df	SS	MS	F	p
Age (A)	1	64.695	64.695	18.454	.0002
Error	30	105.172	3.506		
Item type (S)	1	765.383	765.383	330.158	.0000
Age x Item type (AS)	1	53.820	53.820	23.216	.0000
Error	30	69.547	2.318		
Presentation (P)	1	233.820	233.820	176.260	.0000
Age x Presentation (AP)	1	13.133	13.133	9.900	.0037
Error	30	39.797	1.327		
Item type x Presentation (SP)	1	233.820	233.820	100.142	.0000
Age x Item type x Presentation (ASP)	1	4.883	4.883	2.091	.1585
Error	30	70.047	2.335		

Table A5: Experiment 3

Summary of Analysis of Variance for
Word Stem Completions, Age and Presentation

Source	df	SS	MS	F	p
Age (A)	1	7.031	7.031	2.462	.1271
Error	30	85.688	2.856		
Presentation (P)	1	.781	.781	.172	.6815
Age x Presentation (AP)	1	.281	.281	.062	.8053
Error	30	136.438	4.548		
Item type (S)	1	166.531	166.531	105.316	.0000
Age x Item type (AS)	1	2.531	2.531	1.601	.2155
Error	30	47.438	1.581		
Presentation x Item type (PS)	1	7.031	7.031	5.249	.0292
Age x Item type x Presentation (ASP)	1	.281	.281	.210	.6501
Error	30	40.188	1.340		

Table A6: Experiment 3

Summary of Analysis of Variance for
Free Recall, Age and Presentation

Source	df	SS	MS	F	p
Age (A)	1	49.000	40.000	15.243	.0005
Error	30	96.438	3.215		
Presentation (P)	1	42.250	42.250	11.716	.0018
Age x Presentation (AP)	1	7.563	7.563	2.097	.1580
Error	30	108.188	3.606		

Table A7: Experiment 4

Summary of Analysis of Variance for Embedded Word Stem Completion, Age and Presentation

Source	df	SS	MS	F	p
Age (A)	1	.195	.195	.044	.8359
Error	30	134.234	4.474		
Item type (S)	1	53.820	53.820	28.428	.0000
Age x Item type (AS)	1	.633	.633	.334	.5675
Error	30	56.798	1.893		
Presentation (P)	1	9.570	9.570	3.868	.5850
Age x Presentation (AP)	1	3.445	3.445	1.392	.2473
Error	30	74.234	2.474		
Item type x Presentation (SP)	1	.008	.008	.005	.9431
Age x Item type x Presentation (ASP)	1	.945	.945	.626	.4350
Error	30	45.297	1.510		

Table A8: Experiment 4

Summary of Analysis of Variance for

Free Recall, Age and Presentation

Source	df	SS	MS	F	p
Age (A)	1	8.266	8.266	2.185	.1498
Error	30	113.469	3.782		
Presentation (P)	1	28.891	28.891	17.975	.0002
Age x Presentation (AP)	1	11.391	11.391	7.087	.0124
Error	30	48.219	1.607		

Table A9: Experiment 5

Summary of Analysis of Variance for Non-Embedded Word Stem Completion, Age and Presentation

Source	df	SS	MS	F	p
Age (A)	1	.781	.781	.336	.5664
Error	30	69.719	2.324		
Item type (S)	1	81.281	81.281	36.824	.0000
Age x Item type (AS)	1	.500	.500	.227	.6376
Error	30	66.219	2.207		
Presentation (P)	1	4.500	4.500	1.731	.1982
Age x Presentation (AP)	1	2.531	2.531	.974	.3316
Error	30	77.969	2.599		
Item type x Presentation (SP)	1	5.281	5.281	3.005	.0933
Age x Item type x Presentation (ASP)	1	2.000	2.000	1.138	.2946
Error	30	52.719	1.757		

Table A10: Experiment 5

Summary of Analysis of Variance for Embedded Word Stem Completion, Age and Presentation

Source	df	SS	MS	F	p
Age (A)	1	15.125	15.125	6.747	.0144
Error	30	67.250	2.242		
Item type (S)	1	69.031	69.031	58.030	.0000
Age x Item type (AS)	1	3.781	3.781	3.179	.0847
Error	30	35.688	1.190		
Presentation (P)	1	2.000	2.000	1.215	.2791
Age x Presentation (AP)	1	.125	.125	.076	.7848
Error	30	49.375	1.646		
Item type x Presentation (SP)	1	.781	.781	.170	.6834
Age x Item type x Presentation (ASP)	1	2.531	2.531	.550	.4643
Error	30	138.188	4.606		

Table A11: Experiment 5

Summary of Analysis of Variance for Embedded Word Stem Completion and Order for the Young Group Only

Source	df	SS	MS	F	p
Order (O)	1	.563	.563	.241	.6311
Error	14	32.688	2.335		
Item type (S)	1	52.563	52.563	46.173	.0000
Order x Item type (OS)	1	1.000	1.000	.878	.3645
Error	14	15.938	1.138		
Presentation (P)	1	1.563	1.563	.964	.3428
Order x Presentation (OP)	1	2.250	2.250	1.388	.2583
Error	14	22.688	1.621		
Item type x Presentation (SP)	1	.250	.250	.068	.7965
Order x Item type x Presentation (OSP)	1	33.063	33.063	9.043	.0094
Error	14	51.188	3.656		

Table A12: Experiment 6

Summary of Analysis of Variance for

Word Association, Age and Presentation

Source	df	SS	MS	F	p
Age (A)	1	2.258	2.258	2.774	.1062
Error	30	24.422	.814		
Item type (S)	1	18.758	18.758	12.527	.0013
Age x Item type (AS)	1	.070	.070	.047	.8299
Error	30	44.922	1.497		
Presentation (P)	1	2.258	2.258	2.988	.0942
Age x Presentation (AP)	1	2.820	2.820	3.732	.0629
Error	30	22.672	.756		
Item type x Presentation (SP)	1	2.820	2.820	3.904	.0574
Age x Item type x Presentation (ASP)	1	2.258	2.258	3.125	.0872
Error	30	21.672	.722		

Table A13: Experiment 6

Summary of Analysis of Variance

for Free Recall, Age and Presentation

Source	df	SS	MS	F	p
Age (A)	1	22.563	22.563	10.074	.0035
Error	30	67.188	2.240		
Presentation (P)	1	36.000	36.000	18.170	.0002
Age x Presentation (AP)	1	.563	.563	.284	.5981
Error	30	59.438	1.981		

Table A14: Experiment 6

Summary of Analysis of Variance for Word Association, Age, Presentation and Order

Source	df	SS	MS	F	p
Age (A)	1	2.258	2.258	2.651	.1147
Order (O)	1	.383	.383	.450	.5080
Age x Order (AO)	1	.195	.195	.229	.6357
Error	28	23.844	.852		
Item type (S)	1	18.758	18.758	11.811	.0019
Age x Item type (AS)	1	.070	.070	.044	.8349
Order x Item type (OS)	1	.383	.383	.241	.6273
Age x Order x Item type (AOS)	1	.070	.070	.044	.8349
Error	28	44.469	1.588		
Presentation (P)	1	2.258	2.258	3.186	.0851
Age x Presentation (AP)	1	2.820	2.820	3.980	.0559
Order x Presentation (OP)	1	.008	.008	.011	.9171
Age x Order x Presentation (AOP)	1	2.820	2.820	3.980	.0559
Error	28	19.844	.709		
Item type x Presentation (SP)	1	2.820	2.820	4.869	.0357
Age x Item type x Presentation (ASP)	1	2.258	2.258	3.898	.0583
Order x Item type x Presentation (OSP)	1	4.133	4.133	7.135	.0125
Age x Order x Item Type x Presentation (AOSP)	1	1.320	1.320	2.279	.1423
Error	28	16.219	.579		

Table A14: Experiment 6

Summary of Analysis of Variance for Word Association, Age, Presentation and Order

Source	df	SS	MS	F	p
Age (A)	1	2.258	2.258	2.651	.1147
Order (O)	1	.383	.383	.450	.5080
Age x Order (AO)	1	.195	.195	.229	.6357
Error	28	23.844	.852		
Item type (S)	1	18.758	18.758	11.811	.0019
Age x Item type (AS)	1	.070	.070	.044	.8349
Order x Item type (OS)	1	.383	.383	.241	.6273
Age x Order x Item type (AOS)	1	.070	.070	.044	.8349
Error	28	44.469	1.588		
Presentation (P)	1	2.258	2.258	3.186	.0851
Age x Presentation (AP)	1	2.820	2.820	3.980	.0559
Order x Presentation (OP)	1	.008	.008	.011	.9171
Age x Order x Presentation (AOP)	1	2.820	2.820	3.980	.0559
Error	28	19.844	.709		
Item type x Presentation (SP)	1	2.820	2.820	4.869	.0357
Age x Item type x Presentation (ASP)	1	2.258	2.258	3.898	.0583
Order x Item type x Presentation (OSP)	1	4.133	4.133	7.135	.0125
Age x Order x Item Type x Presentation (AOSP)	1	1.320	1.320	2.279	.1423
Error	28	16.219	.579		

Table A15: Experiment 7

Summary of Analysis of Variance

for Word Stem Completion and Age

Source	df	SS	MS	F	p
Age (A)	1	.029	.029	2.521	.1229
Error	30	.350	.012		
Item type (S)	2	.266	.133	8.897	.0004
Age x Item type (AS)	2	.049	.024	1.628	.2048
Error	60	.896	.015		

Table A16: Experiment 7

Summary of Analysis of Variance for Cued Recall and Age

Source	df	SS	MS	F	p
Age (A)	1	40.641	40.641	4.880	.0349
Error	30	249.844	8.328		
Item type (S)	1	1113.891	1113.891	171.285	.0000
Age x Item type (AS)	1	34.516	34.516	5.308	.0283
Error	30	195.094	6.503		

Table A17: Experiment 7

t Test to compare "Remember" Responses and Age on Cued Recall

Cued Recall			
Young		Old	
X_1	X_1^2	X_2	X_2^2
6	36	6	36
15	225	3	9
11	121	0	0
9	81	10	100
11	121	7	49
15	225	5	25
9	81	5	25
4	16	4	16
3	9	7	49
0	0	2	4
6	36	2	4
3	9	5	25
15	225	1	1
7	49	13	169
15	225	10	100
6	36	5	25

$\Sigma X_1 = 135 \quad \Sigma X_1^2 = 1495 \quad \Sigma X_2 = 85 \quad \Sigma X_2^2 = 637$

$\bar{X}_1 = 8.4 \qquad \bar{X}_2 = 5.3$

$S_1^2 = \frac{1495}{16} - 70.56 \qquad S_2^2 = \frac{637}{16} - 28.09$

$= 22.88 \qquad = 11.72$

$$t_{30} = \frac{(8.4 - 5.3)\sqrt{(16 + 16 - 2)\ 16 \times 16}}{\sqrt{16 \times 22.88 + 16 \times 11.72\ (16 + 16)}}$$

$= 2.10$

Memory & Cognition
1990, 18 (1), 23-30

Recollective experience in word and nonword recognition

JOHN M. GARDINER and ROSALIND I. JAVA
City University, London, England

The functional relationship between memory and consciousness was investigated in two experiments in which subjects indicated when recognizing an item whether they could consciously recollect its prior occurrence in the study list or recognized it on some other basis, in the absence of conscious recollection. Low-frequency words, relative to high-frequency words, enhanced recognition accompanied by conscious recollection but did not influence recognition in the absence of conscious recollection. By contrast, nonwords compared with words enhanced recognition in the absence of conscious recollection and reduced recognition accompanied by conscious recollection. A third experiment showed that confidence judgments in recognizing nonword targets corresponded with recognition performance, not with recollective experience. These measures of conscious awareness therefore tap qualitatively different components of memory, not some unitary dimension such as "trace strength." The findings are interpreted as providing further support for the distinction between episodic memory and other memory systems, and also as providing more qualified support for theories that assume that recognition memory entails two components, one of which may also give rise to priming effects in implicit memory.

The nature of consciousness in relation to memory performance has once again become of central importance in memory research. This importance is reflected by the contemporary interest in studies of amnesia, a disorder in which the loss of recollective experience is the main presenting symptom (see Shimamura, 1986, for a review). It is also reflected by the many recent studies in which performance in explicit memory tests, defined as those in which the person is directed consciously to recollect prior events or experiences, has been compared with performance in implicit memory tests, defined as those in which the person is not so directed (see Richardson-Klavehn & Bjork, 1988; Roediger, Weldon, & Challis, 1989; Schacter, 1987, for reviews). These two sets of studies are linked by repetition, or direct priming, effects in implicit memory tests. In amnesic patients, such priming effects are typically found to be quite comparable with those found in memory-unimpaired adults. And, in memory-unimpaired adults, priming measures are typically uninfluenced, or influenced in different ways, by variables that influence performance in explicit memory tests. Furthermore, it has become increasingly clear from a number of other recent studies that memory in the absence of recollective experience influences the performance of memory-unimpaired adults in a wide variety of perceptual, judgmental, and estimation tasks (Jacoby, 1988; Jacoby, Kelley, & Dywan, 1989).

Despite this concern with the nature of consciousness in memory, there have been scarcely any attempts to directly *measure* conscious experience in relation to memory performance. Hitherto, the general strategy has been to manipulate consciousness, as in comparisons between implicit and explicit tests, to assess its influence indirectly, and to make various assumptions about the kinds of consciousness and the forms of memory involved. This situation may partly reflect what Tulving (1989) has called the doctrine of concordance of behavior, cognition, and experience. In general form, this doctrine holds that performance, knowledge, and experience are closely correlated. Acceptance of this doctrine implies that the relationship between memory performance and conscious experience is more a matter of rational analysis than empirical inquiry. The situation may also reflect what Watkins (in press) has called the doctrine of mediationism, that is, the prevailing theoretical emphasis on hypothetical mental constructs such as memory traces, mechanisms, processing modes, and the like. This emphasis on hypothetical mental entities leads all too readily to the exclusion of any concern with actual mental experience.

In this article, we describe two experiments in which the relationship between memory performance and conscious experience was measured empirically, adopting a procedure for doing this that was suggested by Tulving (1985b). In these experiments, subjects were required, when recognizing an item from a study list, to indicate whether they could consciously recollect its prior occurrence in the study list (in which case they responded "R" for "remember") or recognized it on some other basis, in the absence of any recollective experience (in which case they responded "K" for "know"). Richardson-Klavehn and Bjork (1988) prefer to reserve the terms ex-

We are grateful to Francesca Ahmed for collecting the data in Experiment 3. Requests for reprints should be addressed to John Gardiner, Memory & Cognition Research Group, City University, Northampton Square, London EC1V OHB, England.

—Accepted by previous editor, Alice F. Healy

plicit and implicit memory for memory expressed with and without awareness of remembering, instead of using those terms to classify memory tests. According to their usage, therefore, these two measures correspond exactly with measures of explicit and implicit memory.

In a previous article in which these measures were used, it was found that they gave rise to dissociations between a person's conscious experience and his or her performance on recognition-memory tasks (Gardiner, 1988a). This research showed that levels of processing, generate versus read-study conditions, and retention interval—all variables whose influence on recognition-memory performance is well known—influenced only items whose recognition was accompanied by conscious recollection. Recognition performance in the absence of any recollective experience was quite uninfluenced by these variables.

These findings are important theoretically for Tulving's (1983, 1985a, 1985b) distinction between episodic memory and other memory systems. Because recollective experience (or "autonoetic consciousness") is a defining property of the episodic system, that distinction is materially strengthened by evidence that staple episodic memory phenomena such as levels-of-processing effects are indeed truly episodic as defined and measured by conscious awareness. The findings are also interesting because the form of dissociation observed resembles that which had been previously observed in comparisons of the effects of these independent variables on performance in explicit and implicit memory tests (e.g., Gardiner, 1988b; Jacoby & Dallas, 1981; Tulving, Schacter, & Stark, 1982). This parallel is consistent with theories that assume that recognition performance entails two different components, one of which may also give rise to priming effects in implicit tests. This second component has been thought of as increased familiarity (Mandler, 1980, 1988) or as relative perceptual fluency (Jacoby, 1988; Jacoby & Dallas, 1981), and to reflect data-driven rather than conceptually driven processing (Jacoby, 1983; Roediger et al., 1989). Thus, as Gardiner (1988a) suggested, "remember" and "know" measures of conscious awareness may respectively correspond with conceptually driven and data-driven processes.

However, in the experiments described by Gardiner (1988a), recognition performance in the absence of conscious recollection was not only uninfluenced by the independent variables, it was also much lower than when recognition was accompanied by conscious recollection. This low level of performance makes it difficult to entirely discount the possibility that recognition in the absence of recollective experience might reflect only relatively weak "trace strength," rather than some qualitatively different component of memory—even though the form of dissociation obtained itself argues against this possibility, on the grounds that weak as well as strong memory traces should have been influenced by those variables, albeit to a lesser extent.

The main purpose of the present research was to provide further tests of the "dual-component hypothesis," that is, the hypothesis that these measures of consciousness reflect qualitatively distinct components of memory performance, rather than some unitary dimension such as trace strength. The dual-component hypothesis would prove hard to sustain if recognition in the absence of recollective experience is always found to be associated with low levels of performance, and is always found to be uninfluenced by independent variables. On the other hand, the hypothesis would be supported by evidence that recognition in the absence of recollective experience is sometimes associated with relatively high levels of performance and is systematically influenced by some independent variable.

EXPERIMENT 1

The purpose of Experiment 1 was to compare "remember" and "know" measures of conscious awareness in recognition memory for low-frequency and high-frequency words. The point of this comparison was to see whether recognition of the low-frequency words might be associated with an increase in the incidence of "know" responses. This possibility is suggested by the finding that low-frequency words, relative to high-frequency words, give rise to enhanced priming in perceptual identification (Jacoby & Dallas, 1981), as well as enhanced performance in recognition memory (see Duchek & Neely, 1989; Glanzer & Adams, 1985; Gregg, 1976, for reviews), and by the view that both of these word-frequency effects are due to increased familiarity (Mandler, 1980) or perceptual fluency (Jacoby & Dallas, 1981).

Method

Subjects. The subjects were 24 undergraduate students who were paid for their participation in the experiment and were tested individually.

Design and Materials. A set of 96 words, 48 low-frequency and 48 high-frequency, were selected from the Medical Research Council (MRC) psycholinguistic database described by Coltheart (1981). These low- and high-frequency words had mean frequency counts of 2 and 160, respectively, in Kučera and Francis's (1967) norms, and they each had the same mean imagery value of 609, as calculated in the MRC database by merging three sets of norms to form a scale ranging from 100–700. There were equal numbers of one-, two-, and three-syllable words of each frequency. Examples of the low-frequency words are: KILT, BLOSSOM, TORNADO, ATHLETE, and HARP. Examples of the high-frequency words are: MONEY, RIVER, HOSPITAL, CAR, and PRESIDENT.

There were two alternate study lists, each consisting of 24 low-frequency and 24 high-frequency words selected so that words of each syllabic length were assigned to each frequency level in each study list in equal proportions. Half of the subjects received one study list; half received the other study list. The recognition test consisted of all 96 words from the complete set; hence, target words for half the subjects were lure words for the other half. In this test, for each word the subjects recognized, they were asked to indicate whether they could or could not consciously recollect its prior occurrence in the study list.

Procedure. Study-list words were handprinted on a deck of cards and presented at the rate of 2 sec/word in an order randomized separately for each subject. The subjects were told simply to memorize the words for a test to be given on the following day. The 24-h retention interval was intended to reduce the risk of ceiling effects in recognition performance. For the test, all 96 words in the complete set appeared, in a single constant order, typewritten in 4 columns of 24 words each. The subjects were given the following instructions to read:

> In this test there are four columns of words; some of these words are from the cards you studied in the first part of the experiment, others are not.
>
> Please work carefully down each column, indicating for each successive word whether you recognize it from the study cards or not. If you recognize a word, please encircle it.
>
> *Additionally*, as you make your decision about recognizing a word, I would like you to bear in mind the following:
>
> Often, when *remembering* a previous event or occurence, we consciously recollect and become aware of aspects of the previous experience. At other times, we simply *know* that something has occurred before, but without being able consciously to recollect anything about its occurrence or what we experienced at the time.
>
> Thus in addition to your indicating your recognition of a word from the original study set, I would like you to write either the letter "R" after the encircled item, to show that you recollect the word consciously, or "K" if you feel you simply know that the word was in the previous study set.
>
> So, for each word that you recognize, please write "R" next to it if you recollect its occurrence, or "K" if you simply know that it was shown on the cards.

After the subjects had read these instructions, the experimenter gave further, oral instructions. Conscious recollection was described as the ability to become consciously aware again of some aspects of what happened and what was experienced at the time the word was presented—such as something to do with the physical appearance of the word, the way it was presented, something one was thinking of or did during the word's presentation, or something else one noticed in the laboratory at that time. Recognition on some other basis was described as recognizing that the word was from the study list but being unable consciously to recollect anything about the actual occurrence of the word, or what happened and was experienced at the time it was presented. This distinction between R and K judgments was further illustrated by more everyday examples. The subjects were told that their memory for the name of the last movie they watched would almost certainly be accompanied by conscious awareness of aspects of that particular event and experience, but that their memory for their own name would almost certainly not normally be accompanied by conscious awareness of any particular event or experience. This particular illustration was deliberately chosen to make it clear that the absence of recollective experience was not necessarily associated with poor memory. The subjects' understanding of these instructions was monitored and, after they had completed the test, the experimenter checked that the instructions had been followed properly.[1]

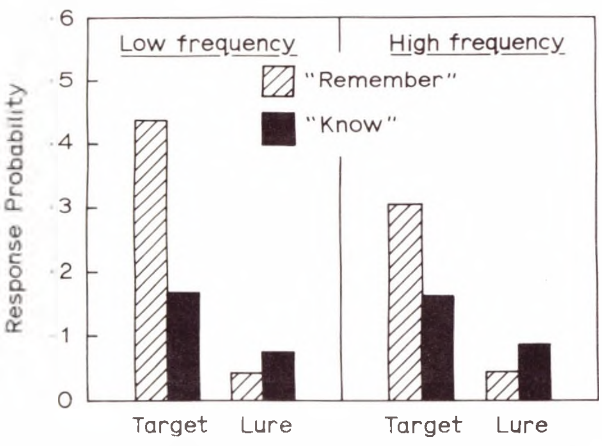


Figure 1. Response probability in the recognition of low-frequency versus high-frequency words.

Results and Discussion

Figure 1 summarizes the principal results, which are the mean probabilities of R and K responses for recognition targets and lures. Overall hit rates and false positive rates are given by the sum of these two types of response. The figure shows that in target recognition, word frequency influenced R responses but had no discernible effect upon K responses. The figure also shows little effect of word frequency on false positive rates, but there is some indication that false positive rates were higher for K than for R responses.

A separate analysis of variance (ANOVA) was carried out on individual subject responses to recognition targets and to lures. Following a precedent set by Gardiner (1988a), in these analyses, response type—R versus K—was treated as an independent variable, on the grounds that it may be regarded as an instructional manipulation. This assumption is, of course, questionable, but it does have the advantage that interactions involving response type can be directly evaluated. For target words, the results of the ANOVA showed that both the main effect of response type [$F(1,23) = 41.76$, $MS_e = 14.37$, $p < .001$] and that of word frequency [$F(1,23) = 19.68$, $MS_e = 3.06$, $p < .001$] were significant, and so too was the interaction between them [$F(1,23) = 6.67$, $MS_e = 7.23$, $p < .025$]. For lures, the results of the ANOVA showed that neither the main effect of word frequency nor the interaction between word frequency and response type were significant ($F < 1$ in each case); however, the main effect of response type was significant—but just barely [$F(1,23) = 4.28$, $MS_e = 5.15$, $p = .05$]. A greater proportion of K than R responses to lure words was not found in Gardiner's (1988a) experiments, probably because false positive rates tended to be lower there than here.

Further analyses were undertaken to confirm that the proportion of K responses to target words reliably exceeded the proportion of K responses to lures. It was indeed found to be so, both for low-frequency [$t(23) = 3.36$, $SE = 0.03$, $p < .001$] and for high-frequency [$t(23) = 3.38$, $SE = 0.03$, $p < .001$] words.

These findings therefore provide no evidence that the incidence of K responses was greater for low-frequency than for high-frequency words. Instead, the word-frequency effect, like the levels-of-processing effect and the generation effect (Gardiner, 1988a), occurs only for recognition accompanied by recollective experience. This result is not consistent with the view that the word-frequency effect is attributable to increased familiarity (Mandler, 1980) or perceptual fluency (Jacoby & Dallas, 1981).

EXPERIMENT 2

The purpose of Experiment 2 was to compare "remember" and "know" measures of conscious awareness in recognition memory for nonwords and words. The point of this comparison was to see whether the recognition of nonwords might be associated with an increase in the incidence of "know" responses, a possibility suggested by evidence of enhanced perceptual fluency in nonword recognition (Johnston, Dark, & Jacoby, 1985). The rationale was similar to that of Experiment 1. If perceptual fluency is enhanced for nonwords, relative to words, then there should be more "know" responses for nonwords than for words.

Method

Subjects. The subjects were a further 20 undergraduate students who were paid for their participation in the experiment and were tested individually.

Design and Materials. A set of 60 items—30 nonwords and 30 words—were chosen such that all items were of four-letter, one-syllable length. The nonwords were all readily pronounceable; items that obviously sounded like or looked like real words were avoided. The words were all chosen to be highly familiar. Examples of the nonwords are: JOSP, LORT, KLIB, ABST, and SOTE. Examples of the words are: WASH, GATE, SALT, YEAR, and MALE.

There were two alternate study lists, each consisting of 15 nonwords and 15 words. Half of the subjects received one study list; half received the other study list. The recognition test consisted of all 60 items from the complete set; hence, target items for half of the subjects were lure items for the other half. In this test, for each item the subjects recognized, they were asked to indicate whether they could or could not consciously recollect its prior occurrence in the study list.

Procedure. The procedure was similar to that of Experiment 1. Study lists were handprinted on a deck of cards and presented at the rate of 2 sec/item in an order randomized separately for each subject. The subjects were told to memorize the items for a test to be given on the following day. The 24-h retention interval was again intended to reduce the risk of ceiling effects. For the test, all 60 items in the complete set appeared, in a single constant order, handprinted in 3 columns of 20 items each. The subjects were given test instructions similar to those given in Experiment 1.

Results and Discussion

Figure 2 summarizes the principal results, which are the mean probabilities of R and K responses for recognition targets and lures. The figure shows a quite different pattern of results for nonwords and words. Target recognition of nonwords, compared with words, was associated with a marked increase in the incidence of K responses and a decrease in the incidence of R responses. False positive rates did not differ much for nonwords and words, but false positive rates were higher for K than for R responses.

These findings were analyzed in a similar way to those of Experiment 1. For target items, the results of the ANOVA showed that neither the main effect of response type nor that of nonwords versus words were significant ($F < 1$ in each case), but the interaction between them was highly significant [$F(1,19) = 18.66$, $MS_e = 4.08$, $p < .001$]. For lures, the results of the ANOVA showed that neither the main effect of nonwords versus words nor the interaction with response type were significant ($F < 1$ in each case); however, the main effect of response type was significant—this time, highly significant [$F(1,19) = 16.99$, $MS_e = 1.70$, $p < .001$]. The proportion of K responses to target items reliably exceeded the proportion of K responses to lures, both for nonwords [$t(19) = 3.66$, $SE = 0.06$, $p < .001$] and for words [$t(19) = 2.48$, $SE = 0.02$, $p < .025$].

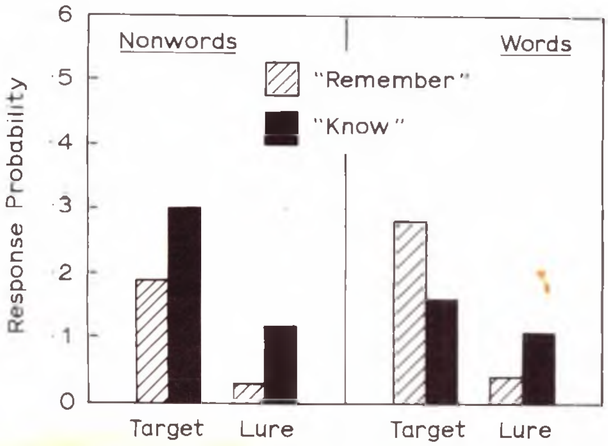


Figure 2. Response probability in the recognition of nonwords versus words.

These findings demonstrate that the recognition of nonwords, compared with that of words, was reflected more in K responses than in R responses. Recollective experience was reduced in nonword recognition, and recognition was accomplished to a much greater extent in the absence of conscious recollection. This result is completely consistent with the view that perceptual fluency contributes more to nonword than to word recognition (Johnston et al., 1985). It therefore supports the hypothesis that "remember" and "know" measures reflect qualitatively distinct components of memory, rather than simple differences in trace strength.

The results of Experiment 2 also confirm the finding from Experiment 1 of higher false positive rates for recognition decisions made in the absence of recollective experience.

EXPERIMENT 3

A high level of recognition performance for "know" responses means that these responses cannot be equated with weak trace strength. But one might argue that if one were to take confidence, rather than performance, as an index of trace strength, then one might find that a high level of performance reflects an increase in the proportion of responses about which subjects are not very confident. For these reasons, Experiment 3 was designed to see whether the pattern of results obtained in Experiment 2 would also be obtained with confidence ratings. Specifically, the crucial question was whether nonword recognition, relative to word recognition, is associated with an increase in the proportion of decisions about which subjects are unsure.

Tulving (1985b) described a study in which subjects gave both "remember" versus "know" responses and confidence ratings in their recognition performance, and he found the two measures to be correlated quite highly. One would, of course, expect that recollective experience normally provides one basis for confidence in performance. But Tulving's procedure of having subjects give both confidence ratings and "remember" versus "know" responses at the same time might inflate the correlation between the two measures by encouraging subjects to base their confidence ratings on their recollective experience. For this reason, we decided to replicate Experiment 2 in all respects except that we had subjects give confidence ratings instead of "remember" versus "know" responses.

Method

Subjects. The subjects were a further 22 undergraduate students who were paid for their participation in the experiment and were tested individually.

Design, Materials, and Procedure. The design, materials, and procedure were identical to those of Experiment 2 except with respect to the recognition-test instructions. These instructions directed the subjects to give confidence ratings instead of measures of conscious awareness. To match the two measures as closely as possible, the subjects rated their confidence in each recognition decision using only a 2-point rating scale labeled "sure" and "unsure."

Results and Discussion

Figure 3 summarizes the principal results of this experiment. It is obvious from this figure that nonword target recognition was not associated with any increase in the proportion of decisions about which subjects were unsure, and that confidence ratings in target-item recognition do not show a similar interaction to that observed previously with measures of conscious awareness. The implication is that measures of conscious awareness are not simply equivalent to confidence ratings, even though, in general, it is probably true that subjects' confidence is correlated with their recollective experience. In this connection, it is worth noting that the confidence ratings of false positive responses did correspond with measures of conscious awareness, in that, for both words and nonwords, a greater proportion of false positive responses was associated with the "unsure" confidence rating.

For comparison purposes, we shall report analyses of these data similar to those reported for Experiments 1 and 2, treating positive "sure" and "unsure" judgments in the same way as "remember" and "know" responses. For target items, the results of the ANOVA showed that there was a main effect of response type [$F(1,21) = 5.03$, $MS_e = 9.26$, $p < .05$], but neither the main effect of nonwords versus words [$F(1,21) = 1.34$, $MS_e = 3.40$] nor the interaction between them [$F(1,21) = 1.42$, $MS_e = 2.59$] was significant. For lures, the results of the ANOVA showed that the main effect of response type was highly significant [$F(1,21) = 26.22$, $MS_e = 2.64$, $p < .0001$], but neither the main effect of nonwords versus words [$F(1,22) = 2.10$, $MS_e = 2.62$] nor the interaction between them ($F < 1$) was significant. The proportion of "unsure" responses to target items reliably exceeded the

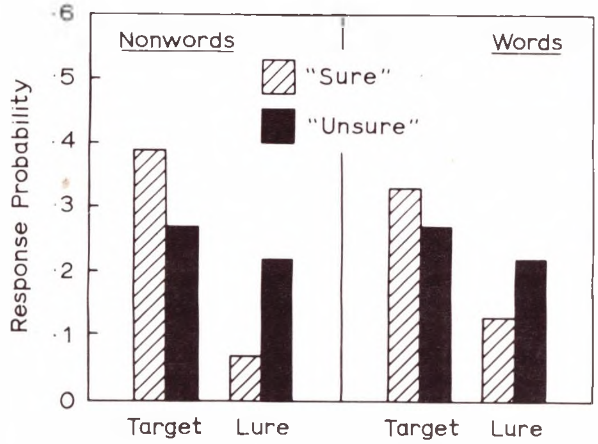


Figure 3. Confidence judgments in the recognition of nonwords versus words.

proportion of "unsure" responses to lures for nonwords [$t(21) = 2.07$, $SE = 0.01$, $p < .05$], but not for words [$t(21) = 1.48$, $SE = 0.01$, $p < .10$].

GENERAL DISCUSSION

Recognition memory involves two measurable states of conscious awareness, one characterized by some specific recollective experience, one characterized by the absence of any such experience (Gardiner, 1988a; Tulving, 1985b). The goal of the present research was to provide further evidence about whether these two states of conscious awareness reflect qualitatively distinct components of recognition performance, rather than some unitary dimension such as trace strength. This dual-component hypothesis was suggested by the clear-cut dissociations previously observed with levels-of-processing and generation effects; neither of these effects occurred for words recognized in the absence of any recollective experience (Gardiner, 1988a). However, in those previous studies, recognition in the absence of recollective experience was not only uninfluenced by the independent variables, it was also associated with low levels of performance. This low level of performance makes it hard to completely discount the possibility that this state of conscious awareness simply reflects weak trace strength.

Three findings from the present experiments provide good support for the dual-component hypothesis: (1) recognition in the absence of recollective experience is not always associated with low levels of performance, (2) recognition in the absence of recollective experience responds systematically to some experimental manipulation, and (3) recognition in the absence of recollective experience is not merely equivalent to judgments about which subjects are relatively unsure.

The functional dissociations observed here and in previous, similar studies (Gardiner, 1988a) support the dual-component hypothesis, but we concede that they do not compel it. In particular, they do not provide evidence of *reversed association*, a form of dissociation that Dunn and Kirsner (1988) have argued is a sounder basis for making such claims than other, more common dissociations, including double dissociations. In addition, the acceptability of our conclusion depends on accepting the validity of the measures used. But the validity of these measures is attested by the patterns of results they produce: the data are highly principled. Also important in this connection is the finding that irrespective of differences in responses to recognition targets, false positives in both Experiments 1 and 2 included far more "know" than "remember" responses.

The argument that these two measures reflect something other than trace strength is not to deny that, as a general rule, stronger memories will be positively correlated with sharper recollective experiences and higher levels of confidence (Tulving, 1985b). The point is that strong memories are not invariably those that invoke some recollective experience, as, for example, when recognizing a very familiar person out of his or her normal context, and being quite unable to place the context or bring anything else to mind. In such circumstances, feelings of embarrassment are directly proportional to feelings of confidence about knowing who the person is. In a similar way, one might be confident about recognizing a nonword from a previous study list, and yet quite unable to bring back to mind anything about the occurrence of that nonword. With words, rather than nonwords, it is presumably much easier to encode specific aspects of the original context, and so to bring these back to mind in the recognition test. Thus, there is no real inconsistency between the relationships observed here among performance, confidence, and recollective experience and the relationships observed in Tulving's (1985b) study.

The present findings and conclusions are theoretically important for Tulving's (1983, 1985a, 1985b) distinction between episodic memory and other memory systems, and for dual-component theories of recognition memory, particularly those that assume that one of these components corresponds with familiarity (Mandler, 1980) or perceptual fluency (Jacoby & Dallas, 1981) and gives rise also to priming effects in implicit memory.

In Tulving's (1983, 1985a, 1985b) scheme, recollective experience is a defining property of the episodic system, so "remember" responses may be thought to provide a relatively "pure" measure of output from this system. This position is strengthened by evidence that the word-frequency effect, like the levels-of-processing effect and the generation effect (Gardiner, 1988a), occurs only for recognition accompanied by recollective experience. The state of conscious awareness characterized by "know" responses is a defining property of the semantic memory system. Semantic knowledge is typically retrieved in the absence of any specific recollective experience. However, because nonwords have no semantic representation, the present findings indicate that this state of conscious awareness may also reflect some other form of memory. A plausible conjecture is that this other form of memory may be the *quasimemory* (QM) system that Hayman and Tulving (1989, in press) have proposed to account for priming effects in implicit memory. This is a "traceless" memory system that may be more closely related to procedural than to semantic memory. Its functional properties are assumed to include the major characteristics of implicit memory performance as summarized in Roediger et al.'s (1989) account of the transfer-appropriate processing approach (see also Richardson-Klavehn & Bjork, 1988). Among these characteristics are a lack of sensitivity to conceptual factors and a greater dependence on data-driven factors. Moreover, information in the QM system is known to be highly resistant to forgetting (e.g., Sloman, Hayman, Ohta, Law, & Tulving, 1988). In line with this conjecture, recognition memory in the absence of recollective experience has also been found to be quite resistant to forgetting. Over retention intervals ranging from 10 min to 1 week, "know" responses have been found to remain essentially unchanged, and virtually all the forgetting occurred only in "remember" responses (Gardiner, 1988a; Gardiner & Java, 1989). Perhaps "know" responses in recognition memory provide a relatively "pure" measure of output from the QM system.

This conjecture is not problem-free, particularly because of the confused situation with respect to nonword priming effects (see Richardson-Klavehn & Bjork, 1988, for a review; see also Duchek & Neely, 1989). Especially problematic is evidence that amnesic patients do not show nonword priming either in perceptual identification (Cermak, Talbot, Chandler, & Wolbarst, 1985) or in a nonword stem-completion task (Diamond & Rozin, 1984). These results suggest that nonword priming effects in memory-unimpaired adults must be episodic in origin. On the other hand, there is more recent evidence that amnesic patients may show priming effects for nonwords, and that whether or not they do so depends on the etiology of the amnesia, not its severity (Cermak, Blackford, O'Connor, & Bleich, 1988; Gordon, 1988). This evidence is important because it directly implicates some system other than episodic or semantic memory.

From the standpoint of two-component theories of recognition memory, "know" responses presumably correspond with familiarity (Mandler, 1980) or perceptual fluency (Jacoby & Dallas, 1981), and "remember" responses reflect more elaborative, conceptually driven processing. These theories, too, are generally well supported by the present results and those of Gardiner (1988a). However, the finding that the word-frequency effect depends on conscious recollection, like levels-of-processing and generation effects, is not consistent with the view that increased familiarity or perceptual fluency accounts both for this word-frequency effect and for the enhanced priming of low-frequency words in perceptual identification. No comparable problem exists with respect to our comparison of nonword with word recognition, which directly supports the view that perceptual fluency is enhanced in nonword recognition (Johnston et al., 1985). We do not know how this apparent discrepancy in the perceptual fluency interpretation is to be resolved. But we suspect that its resolution may turn out to be connected with the finding that there is greater dependence between nonword recognition and perceptual identification than between word recognition and perceptual identification (Jacoby & Witherspoon, 1982; Johnston et al., 1985).

Finally, it should be borne in mind that the distinction between the two states of conscious awareness measured by "remember" and "know" responses applies to individual items, not to the general experimental context. When giving a "know" response, it is only at the level of the individual item that subjects have no recollective experience; they can perfectly well recollect the presentation of the study list as a whole. This point is significant because it means that this kind of recognition memory may not be equivalent to *source amnesia*—that is, the finding that people may know some newly learned facts but not remember that these facts were acquired earlier in the experiment (e.g., McIntyre & Craik, 1987; Schacter, Harbluk, & McLachlan, 1984)—and because amnesics lack recollective experience at this global level, not just at the level of individual items.

Nevertheless, as Richardson-Klavehn and Bjork (1988) pointed out, memory-unimpaired adults may quite commonly have recollective experiences in implicit memory tests. Indeed, this was a major reason for Richardson-Klavehn and Bjork's preference for using the terms explicit and implicit memory to define states of conscious awareness rather than types of memory test. Furthermore, independence between explicit and implicit measures of retention does not seem to depend on subjects always being unaware, or uninformed, that the implicit test relates to a previously presented study list. For example, levels-of-processing effects occur in recognition memory but not in primed fragment completion, and recognition memory and primed fragment completion are stochastically independent, even though subjects are told that some fragments in the completion test are fragments of study-list words (see Gardiner, 1988b; Gardiner, Dawson, & Sutton, 1989, for more discussion of this point). The independence arises simply from directing subjects to complete the fragments irrespective of what they remember from the study list. At least for memory-unimpaired subjects, the crucial difference between explicit and implicit memory performance seems to stem mainly from the *set* provided by the retrieval instructions. An explicit set directly engages conscious recollection. An implicit set attempts to disengage conscious recollection; it does not necessarily prevent it from occurring. And both sets can operate at the level of the individual list items with subjects being fully informed about the relationship between study and test lists.

One can define events at microlevel, as individual list items, or at macrolevel, as the entire experimental episode. This difference in the environmental nature of events may or may not correspond with some fundamental difference in the nature of mental experience and the relationship between mental experience and memory performance.

REFERENCES

Cermak, L. S., Blackford, S. P., O'Connor, M., & Bleich, R. P. (1988). The implicit memory ability of a patient with amnesia due to encephalitis. *Brain & Cognition*, **7**, 312-323.

Cermak, L. S., Talbot, N., Chandler, K., & Wolbarst, L. R. (1985). The perceptual priming phenomenon in amnesia. *Neuropsychologia*, **23**, 615-622.

Coltheart, M. (1981). The MRC psycholinguistic database. *Quarterly Journal of Experimental Psychology*, **33A**, 497-508.

Diamond, R., & Rozin, P. (1984). Activation of existing memories in anterograde amnesia. *Journal of Abnormal Psychology*, **93**, 98-105.

Duchek, J. M., & Neely, J. H. (1989). A dissociative word-frequency × levels-of-processing interaction in episodic recognition and lexical decision tasks. *Memory & Cognition*, **17**, 148-162.

Dunn, J. C., & Kirsner, K. (1988). Discovering functionally independent mental processes: The principle of reversed association. *Psychological Review*, **95**, 91-101.

Gardiner, J. M. (1988a). Functional aspects of recollective experience. *Memory & Cognition*, **16**, 309-313.

Gardiner, J. M. (1988b). Generation and priming effects in word-fragment completion. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **14**, 495-501.

Gardiner, J. M., Dawson, A. J., & Sutton, E. A. (1989). Specificity and generality of enhanced priming effects for self-generated study items. *American Journal of Psychology*, **102**, 295-305.

Gardiner, J. M., & Java, R. I. (1989). [Temporal aspects of conscious awareness in recognition memory]. Unpublished raw data.

Glanzer, M., & Adams, J. K. (1985). The mirror effect in recognition memory. *Memory & Cognition*, **13**, 8-20.

Gordon, B. (1988). Preserved learning of novel information in amnesia: Evidence for multiple memory systems. *Brain & Cognition*, **7**, 257-282.

Gregg, V. H. (1976). Word frequency, recognition, and recall. In J. Brown (Ed.), *Recall and recognition* (pp. 183-216). London: Wiley.

Hayman, C. A. G., & Tulving, E. (1989). Contingent dissociation between recognition and fragment completion: The method of triangulation. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **15**, 228-240.

Hayman, C. A. G., & Tulving, E. (in press). Is priming in fragment completion based on a "traceless" memory system? *Journal of Experimental Psychology: Learning, Memory, & Cognition.*

Jacoby, L. L. (1983). Remembering the data: Analyzing interactive processes in reading. *Journal of Verbal Learning & Verbal Behavior*, **22**, 485-508.

Jacoby, L. L. (1988). Memory observed and memory unobserved. In U. Neisser & E. Winograd (Eds.), *Remembering reconsidered: Ecological and traditional approaches to the study of memory* (pp. 145-177). New York: Cambridge University Press.

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General*, **3**, 306-340.

Jacoby, L. L., Kelley, C. M., & Dywan, J. (1989). Memory attributions. In H. L. Roediger III & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honor of Endel Tulving* (pp. 391-422). Hillsdale, NJ: Erlbaum.

Jacoby, L. L., & Witherspoon, D. (1982). Remembering without awareness. *Canadian Journal of Psychology*, **36**, 300-324.

Johnston, W. A., Dark, V. J., & Jacoby, L. L. (1985). Perceptual fluency and recognition judgments. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **11**, 3-11.

Kucera, H., & Francis, W. N. (1967). *Computational analysis of present-day American English*. Providence, RI: Brown University Press.

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review*, **87**, 252-271.

Mandler, G. (1988). Memory: Conscious and unconscious. In P. R. Solomon, G. R. Goethals, C. M. Kelley, & B. R. Stephens (Eds.), *Memory: Interdisciplinary approaches* (pp. 84-106). New York: Springer-Verlag.

McIntyre, J. A., & Craik, F. I. M. (1987). Age differences in memory for item and source information. *Canadian Journal of Psychology*, **41**, 175-192.

Richardson-Klavehn, A., & Bjork, R. A. (1988). Measures of memory. *Annual Review of Psychology*, **39**, 475-543.

Roediger, H. L., III, Weldon, M. S., & Challis, B. H. (1989). Explaining dissociations between implicit and explicit measures of retention: A processing account. In H. L. Roediger III & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honor of Endel Tulving* (pp. 3-41). Hillsdale, NJ: Erlbaum.

Schacter, D. L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **13**, 501-518.

Schacter, D. L., Harbluck, J. L., & McLachlan, D. R. (1984). Retrieval without recollection: An experimental analysis of source amnesia. *Journal of Verbal Learning & Verbal Behavior*, **23**, 593-611.

Shimamura, A. P. (1986). Priming effects in amnesia: Evidence for a dissociable memory function. *Quarterly Journal of Experimental Psychology*, **38A**, 619-644.

Sloman, S. A., Hayman, C. A. G., Ohta, N., Law, J., & Tulving, E. (1988). Forgetting in primed fragment completion. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **14**, 223-239.

Tulving, E. (1983). *Elements of episodic memory*. New York: Oxford University Press.

Tulving, E. (1985a). How many memory systems are there? *American Psychologist*, **40**, 385-398.

Tulving, E. (1985b). Memory and consciousness. *Canadian Psychologist*, **26**, 1-12.

Tulving, E. (1989). Memory: Performance, knowledge, and experience. *European Journal of Cognitive Psychology*, **1**, 3-26.

Tulving, E., Schacter, D. L., & Stark, H. A. (1982). Priming effects in word-fragment completion are independent of recognition memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **8**, 336-342.

Watkins, M. J. (in press). Mediationism and the obfuscation of memory. *American Psychologist*.

NOTE

1. In some studies in which we have measured "remember" and "know" responses, though not those reported here, a few subjects have clearly failed to understand or act upon this distinction. In nearly every case, these subjects responded as if "know" meant "certain." Such cases are indicated by an exceptionally high preponderance of "know" responses, and they can be confirmed by going through a subject's responses with that subject after the testing session. The present instructions were designed to ensure that the subjects did not interpret a "know" response to mean the same thing as poor memory, by giving the example of knowing one's own name. The general aim of the instructions was to prevent "remember" and "know" responses from being interpreted in terms of "goodness of memory," and to pin the distinction entirely to the mental experience that accompanies the memory.

(Manuscript received December 14, 1988;
revision accepted for publication June 5, 1989.)

Memory & Cognition
1990, 18 (6), 632-637

The Tulving-Wiseman law and the recognition of recallable music

JOHN M. GARDINER, ZOFIA KAMINSKA, ROSALIND I. JAVA,
ERIC F. CLARKE, and PETER MAYER
City University, London, England

Memory & Cognition
1990, 18 (6), 632-637

The Tulving-Wiseman law and the recognition of recallable music

JOHN M. GARDINER, ZOFIA KAMINSKA, ROSALIND I. JAVA,
ERIC F. CLARKE, and PETER MAYER
City University, London, England

Memory for well-known musical phrases was tested first for recognition in the absence of any specific musical context and then for recall given the preceding musical phrase as a contextual cue. Recognition and recall were found to be largely, but not completely, independent. Moreover, there was no evidence of any greater dependency between recognition and recall than that previously observed in the relation between word recognition and recall, as summarized by the Tulving-Wiseman law. These findings significantly extend the range of applicability of this law.

It has been claimed that there is an empirical law in the relation between recognition and recall. This law has come to be known as the *Tulving-Wiseman law*, after those who discovered the regularity that it embodies (Tulving & Wiseman, 1975). Tulving and Wiseman proposed that this regularity could be summarized mathematically by the following equation:

$$p(Rn/Rc) = p(Rn) + c[p(Rn) - p(Rn)^2], \quad (1)$$

where the constant $c = .5$. In this equation, the relation between recognition and recall is assessed by the conditional probability of recognition *(Rn)* given recall *(Rc)*, and the relation is one in which recognition and recall are largely, but not completely, independent.

The claim that this relation between recognition and recall is lawful has been recently discussed by Gardiner (1988, 1989), Jones and Gardiner (1990), Nilsson, Dinniwell, and Tulving (1987), and Nilsson, Law, and Tulving (1988). But the fullest review has been provided by Gardiner and Nilsson (1990), who state the law as follows:

> Recognition of a set of to-be-remembered items in the absence of any item-specific context is largely independent of their subsequent recall given item-specific contextual cues—provided these cues are functionally related to, but not equivalent to, the target items themselves.

Gardiner and Nilsson reviewed results from 78 relevant experiments from 42 published articles. These experiments yielded a total of 272 different observations of the probability of recognition given recall, and—with few exceptions—these observations all corresponded approximately with the probability of recognition given recall that would be expected, on the basis of Equation 1, from the probability of recognition. The experiments naturally differed with respect to a great many variables that separately influenced recognition and recall performance. The lawfulness arises from the fact that the relation between recognition and recall remains relatively intact, despite this variability.

All those experiments, however, conform to a particular experimental situation that was worked out by Tulving and Thomson (1973) and Watkins and Tulving (1975). Typically, subjects study a list of target words, each of which is accompanied by a contextual word that they are told will be presented as a recall cue in a later test. Subjects are then given successive tests for the recognition of target words in the absence of the contextual cues and for the recall of target words given those cues. As is well known, the finding that subjects often fail to recognize words that they can recall was used initially to argue against generate-recognize theories of recall, which predict a relation of dependency between recognition and recall. According to these theories, any item in a recallable state is also in a recognizable state, because recall entails an implicit recognize stage, as well as a generate stage (for reviews, see Tulving, 1983; Watkins & Gardiner, 1979). Thus, according to generate-recognize theories, the probability of recognition given recall should always approximate 1.00.

Although the Tulving-Wiseman law holds generally in this experimental situation, a few exceptions have been observed. These exceptions are cases in which the observed probability of recognition given recall is appreciably greater than expected.

There are two kinds of exception. One occurs when the contextual cues are not encoded in relation to their targets. In this case, the cues provide no additional contextual information and so they do not function as effective cues. In these circumstances, a nominally cued-recall test is functionally like free recall. Exceptions of this kind have been reported by Begg (1979) and by Gardiner and Tulving (1980), among others.

The second kind of exception occurs when the contextual cues are functionally equivalent to the targets in the

We thank Ian Cross for help in computer programming and James Hampton and Paul Williams for help in recording the music. Requests for reprints should be addressed to John Gardiner, Memory & Cognition Research Group, City University, Northampton Square, London EC1V OHB, England.

sense that the contextual information provided by the cue is largely inherent in the target. In these circumstances, a nominally uncued-recognition test is functionally like a cued-recognition test, because the contextual information in the cue can be retrieved from the target. Contextual cues will therefore again be ineffective, but now in comparison with recognition rather than with free recall. Exceptions of this kind have been reported by Jones and Gardiner (1990), Muter (1984), and Nilsson and Shaps (1980).

Gardiner and Nilsson (1990) argue that these exceptions constitute the only known, principled, systematic deviations from Equation 1. These exceptions therefore define the *specific* boundary conditions of the Tulving-Wiseman law, and it was for this reason that Gardiner and Nilsson referred to these exceptions in their statement of the law.

An empirical law of this kind formulates what will happen in a particular situation under given conditions. Any such law therefore has a set of boundary conditions that restrict its range. The most important theoretical issue concerning this kind of empirical law is its range of applicability. This is the issue addressed in the present article. The research we describe was motivated by the fact that the Tulving-Wiseman law is based entirely on the results of word-list experiments. Our purpose was to determine whether the law is necessarily restricted to verbal materials or whether it extends to some nonverbal domain. Therefore, we decided to investigate the relation between the recognition and recall of music.

EXPERIMENT 1

We report two experiments, each of which was modeled on Muter's (1984) study. Muter's study was a semantic memory version of the basic procedure. There was no study list. Subjects were given a recognition test for names of famous people, some of whom had unique names (e.g., *Ataturk*) and some of whom had common names (e.g., *Cooper*). Subjects had to indicate which names they recognized were names of famous people. There was then a cued-recall test in which the cues were descriptive phrases embodying the main reason for each person's fame (e.g., "First president of the republic of Turkey, Kemal: __________"; "Author of *The Last of the Mohicans*, James Fennimore: __________"). Muter found that for a common name such as Cooper, the probability of recognition given recall was much as expected from Equation 1, but that for a unique name the probability of recognition given recall was virtually 1.00. He interpreted this result as supporting a version of generate-recognize theory according to which recognition is dependent on recall only for words of single meaning (see, e.g., Reder, Anderson, & Bjork, 1974). In this version of the theory, words of single meaning are assumed to have only one representation in semantic memory, and access to that one representation is assumed not to be influenced by contextual differences between recognition and recall.

However, in recognizing Ataturk as the name of a famous person, subjects presumably retrieved information about the reasons for his fame, and so retrieved much of the information subsequently provided by the cue. Evidence suggesting that Muter's (1984) results were due not to any representational properties of the names as assumed by generate-recognize theory but to overlap in the contextual information provided by the target and the cue was reported by Nilsson et al. (1988), who showed that, when the contextual cues were less predictable from the targets, the relation between the recognition and recall of unique famous names was much as expected from Equation 1.

In our experiments, the subjects were first given a recognition test for musical phrases taken from well-known tunes or themes, and they had to indicate which phrases they recognized. They were then given a recall test in which each contextual cue was the immediately preceding musical phrase from the particular tune or theme. Target phrases for recognition and recall were selected so as to avoid using phrases that were repetitious or otherwise directly predictable from the preceding contextual phrase. These phrases were also selected so as to be not only recognizable, but recognizably unique in the sense that each one appears in only one well-known tune or theme. For example, phrases taken from "Rule Brittannia" or from the first movement of Mozart's Symphony No. 40 in G Minor do not figure in any other well-known piece of music.

What little is known about memory for music, in particular memory for melodies, largely involves short-term memory for novel or unfamiliar melodies (e.g., Balch, 1984; Dewitt & Crowder, 1986; Dowling, 1986; Jones, Sumereall, & Marshburn, 1987; Roberts, 1986; Serafine, Davidson, Crowder, & Repp, 1986). How does one gain access to phrases from well-known tunes or themes represented in semantic memory? One possibility, suggested by generate-recognize theory, is that such musical phrases are represented in such a way that one gains direct access to each phrase on hearing it. If this is so, recognition should be highly dependent on recall, and the recognition of recallable music should be essentially perfect. This outcome would provide good support for a generate-recognize theory account of the relation between the recognition and recall of music, and it would indicate that the Tulving-Wiseman law may be restricted to the verbal domain. Alternatively, of course, the relation between the recognition and recall of musical phrases may be much the same as that between the recognition and recall of words. If this is so, the probability of recognition given recall should be much as expected from Equation 1.

Method

Subjects. The subjects were 18 undergraduate students at City University, London. They were paid for their help and were tested individually.

Design and Materials. A set of 18 melodies was selected on the basis of pilot work indicating that these melodies were highly familiar to the population of subjects tested. These melodies were from well-known folk songs, carols, hymns, and nursery rhymes. Their titles are listed in full in the Appendix. The first major section of each melody was divided into "A" and "B" phrases, not arbitrarily, but according to music criteria, that is, between rather than within larger phrase boundaries. The B phrases served as target phrases for recognition and recall; the A phrases served as recall cues. The recognizability of each target phrase and its recallability given the cue were also independently confirmed in pilot work. The target phrases were on average 6.8 notes in length (range = 5–12 notes). In the recognition test, these phrases were randomly mixed together with 18 comparable phrases taken from Polish folk songs and carols that, though well known in Poland, are not well known in England. These lure phrases were on average 7.2 notes in length (range = 4–10 notes). Target and lure phrases were recorded in two unique random orders; half of the subjects received one presentation order and half received the other. The subjects were told to listen to each phrase and judge whether they recognized it as a phrase from a well-known tune. For the recall test, the 18 A phrases were recorded in two unique random orders; half of the subjects received one presentation order and half received the other. The cue phrases were on average 8.3 notes in length (range = 6–16 notes). The subjects were told to use each phrase as a cue to recalling the next phrase from the tune.

Procedure. All musical phrases were single-line melodies played on a Casio synthesizer and recorded on a Sony cassette, from which they were played back to the subject through a set of headphones. The subjects' responses in the recall test were recorded on another Sony cassette.

In the recognition test, the subjects were told that they were going to hear a series of excerpts from tunes that either were fairly well known and familiar or were unfamiliar. Immediately after hearing each phrase, the subjects indicated whether they recognized the phrase using a 6-point rating scale ranging from +3 (*highly familiar*) to −3 (*very unfamiliar*). Familiar phrases (rated +1, +2, or +3) were defined as those which the subjects recognized, in the sense that they knew the piece of music in which the phrase appears; for unfamiliar phrases (rated −1, −2, or −3), the converse definition applied. In the recall test, which followed directly, the subjects were told that each phrase was taken from the beginning of a well-known tune featured in the earlier part of the experiment and that, after listening to each phrase, they were to recall the next phrase from the tune. They were given the option of recalling the phrases by singing, humming, whistling, or "la-la"ing. It was emphasized that the accuracy of their performance was more important than its musical qualities. The subjects sat in front of a microphone for recording their responses.

Results and Discussion

It was obvious from the subjects' recall performance whether or not they could recall the appropriate phrase, and so scoring recall presented no difficulty. The subjects were not penalized for minor errors, such as omitting one particular note or drifting somewhat off key. The principal results, collapsed over the midpoint of the rating scale, are summarized in Table 1 (upper half) and Table 2 (left-hand columns). Table 1 shows the overall response frequencies; Table 2 shows the probabilities of recognition, of recall, and of recognition given recall—the observed value and the value expected from Equation 1. All entries in Tables 1 and 2 reflect the fates of individual items. The mean values in Table 2 are based on values calculated separately for each individual subject, not on the aggregate data summarized in Table 1. The average false-positive rate in the recognition test, which is not shown in these tables, was .35; all subjects scored considerably more hits than false positives.

Table 1
Overall Response Frequency

	Recalled	Not Recalled	Total
	Experiment 1		
Recognized	199	51	250
Not Recognized	45	29	74
Total	244	80	324
	Experiment 2		
Recognized	120	21	141
Not Recognized	82	47	129
Total	202	68	270

Table 2
Probability of Recognition, Recall, and Recognition Given Recall

	Experiment 1		Experiment 2	
	M	*SEM*	*M*	*SEM*
Recognition (Rn)	.76	.03	.52	.05
Recall (Rc)	.75	.03	.74	.03
Expected Rn/Rc	.85	.02	.64	.05
Observed Rn/Rc	.81	.02	.59	.05

The results summarized in Tables 1 and 2 show that the subjects were able to recall much the same proportion of phrases that they were able to recognize, but that these were not all the same actual phrases. That is, the subjects successfully recalled quite a few phrases that they failed to recognize. Moreover, the observed probability of recognition given recall corresponds fairly closely with the expected value. Importantly, these measures of recognition given recall provide no evidence of any greater dependency between recognition and recall than that which has previously been found in the relation between word recognition and recall. This outcome provides no support for the possibility that generate–recognize theory might be able to account for the recognition and recall of music. Instead, it extends the range of applicability of the Tulving–Wiseman law from verbal to musical items.

EXPERIMENT 2

Although presented in purely musical form, the melodies used in Experiment 1 have associated texts or lyrics. In recognizing phrases from these melodies, the subjects may well have implicitly retrieved some of this verbal information. It is known that memory for melody and text is integrated, at least in recognizing unfamiliar folk songs (see, e.g., Serafine et al., 1986). So it seems possible that, to some extent, the relation between the recognition and recall of the music may have been mediated by knowledge of the associated text or lyrics. Accordingly, Experiment 2 was designed to test the replicability of Experiment 1 when the melodies used had no text or lyrics. These melodies all consisted of well-known themes from classical music.

Method

Subjects. The subjects were 18 undergraduate students at City University, London. They were paid for their help and were tested individually. None of the subjects in Experiment 2 had participated in Experiment 1.

Design and Materials. The design was essentially the same as that in Experiment 1, but the materials were different. A set of 15 melodies was selected on the basis of pilot work indicating that these melodies were quite familiar to the population of students tested. This was a set of slightly fewer melodies than that used in Experiment 1, because it proved to be more difficult here to find melodies that were sufficiently well known to be used. These melodies were all themes from pieces of classical music, as cited by Barlow and Morgenstern (1983). They are listed in full in the Appendix. Each of these themes was divided into A and B phrases, as in Experiment 1, for use as recall cues and recognition and recall targets. As in Experiment 1, the recognizability of each target phrase and its recallability given the cue were confirmed in pilot work. The target phrases were on average 12.1 notes in length (range = 8-24 notes). In the recognition test, these target phrases were randomly mixed together with 15 comparable lures. The lure phrases were other themes cited by Barlow and Morgenstern from relatively unknown pieces of music by the same composers whose music provided the target phrases. The lure phrases were on average 12.7 notes in length (range = 9-28 notes). The cue phrases in the recall test were on average 11.5 notes in length (range = 7-20 notes).

Procedure. The procedure was also essentially the same as in Experiment 1, except for the instructions in the recognition test. A preliminary version of the experiment revealed that subjects were occasionally prone to say that they "recognized" a phrase when they meant only that they recognized the musical style or period rather than the specific phrase and the theme in which it occurs. So the subjects were instructed that it was not sufficient just to recognize the composer's style or the period in which the music was probably composed. They were told: "You must recognize the specific theme from which the excerpt is taken. This does not mean knowing the number of the opus or symphony or its name. You may, for example, recognize that the excerpt is from one of Elgar's best-known orchestral works, but not remember which one it is. The important thing is to be sure you do recognize the *particular* excerpt from a familiar piece of music." The subjects were also told that all the excerpts they were to hear in this test were from pieces by well-known composers, some of which were their best-known compositions and some of which were their least known compositions.

The recall test was conducted in the same manner as before. One subject turned out to be incapable of rendering any kind of musically intelligible performance. This subject quit and was replaced. There were also a few occasions on which the subjects did not produce the complete phrase as designated and stopped after producing only part of it or merely repeated the cue. On these occasions, the subjects were required to continue until they had produced the complete target phrase.

Results and Discussion

Scoring recall performance presented no difficulty in deciding whether the subjects had recalled the appropriate phrase and, as in Experiment 1, the subjects were not penalized for slight errors, such as omitting an occasional note or deviating somewhat from the correct rhythm. The principal results are summarized in Table 1 (lower half) and Table 2 (right-hand columns). The average false-positive rate in the recognition test was .17, appreciably less than that in Experiment 1. All but 1 subject scored more hits than false positives; this subject scored an equal number of each.

The results show that recognition, but not recall, was lower in Experiment 2 than in Experiment 1; however, in other respects, the findings are similar. The subjects again successfully recalled quite a few phrases that they had failed to recognize. The observed probability of recognition given recall again corresponds fairly closely with the expected value. There is again no evidence of any greater dependency between recognition and recall than that predicted by the Tulving-Wiseman law. The relation between the recognition and recall of these musical phrases was essentially the same as that in Experiment 1. It may be concluded that this relation also obtains when the music has no associated text or lyrics.

GENERAL DISCUSSION

The purpose of the experiments described in this article was to test the generality of the Tulving-Wiseman law. Hitherto, this law has been observed only in experiments using word lists. This fact raises the question of whether the law is necessarily restricted to the verbal domain or whether it applies to other domains. The results of the experiments demonstrate that the law extends to the recognition and recall of musical phrases. This extension of the generality of the Tulving-Wiseman law significantly increases its theoretical importance.

It is of interest to compare our results more directly with results from some of the experiments that have used verbal materials.[1] Figure 1 reproduces results from 40 different conditions in the first 12 such experiments, as

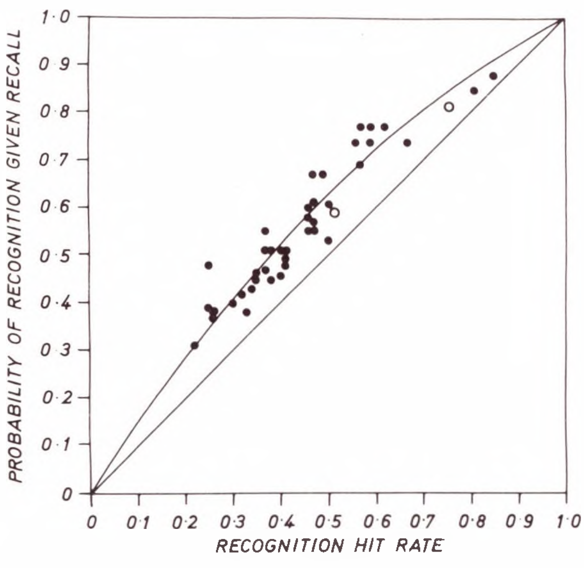


Figure 1. Probability of recognition given recall as a function of recognition hit rate. Based on Tulving and Wiseman's (1975) Figure 1.

summarized by Tulving and Wiseman (1975). To this, we have added our results, which are shown by the open, unfilled data points.

An empirical law summarizes a considerable, coherent set of observations. But, insofar as it is predictive and it gives understanding, it also has explanatory value. The explanation lies simply in the statement or description of the law. In this case, one can say that successive recognition and recall of the same set of items will always be largely independent—approximately to the extent predicted by Equation 1—whenever the recall environment includes effective contextual cues that were not present in the recognition environment.

Although empirical laws may be regarded as an alternative form of explanation (see Watkins, 1990), they are, of course, also open to explanations of a more familiar and conventional sort. For example, Flexser and Tulving (1978) proposed a computer simulation model of the function that is embodied in the Tulving-Wiseman law. In this model, one assumption is that of *retrieval independence* in recognition and recall. That is, knowing what critical features are encoded from the target in the recognition test does not predict what critical features will be encoded from the cue in the recall test. On its own, this assumption produces complete independence between the tests. But the relation observed is one of slight or moderate dependency. Another assumption accounts for this degree of dependency, which is the assumption that retrieval in each test is directed at the same memory trace. Also, success at retrieval in each test is assumed to depend on the encoding specificity principle. This model proved remarkably successful in mimicking the observed relation between recognition and recall. Furthermore, in other tests of their model, Flexser and Tulving showed that when the assumption of retrieval independence is relaxed, so that features encoded from the recall cue become predictable from features encoded from the recognition target, then the relation between recognition and recall becomes much more dependent. This corresponds with the situation in which the recall cue is functionally equivalent to the recognition target. Interestingly, the Flexser-Tulving model may also be used as a more general theoretical framework for understanding the relation between performance in any two successive tests. For example, the model can be used to interpret observations of complete independence between successive tests as evidence for a "traceless" memory system (see Hayman & Tulving, 1989).

Despite the achievement of the Flexser-Tulving model, other models can also account for the Tulving-Wiseman law. Jones (1978, 1983), for example, has developed a dual-mechanism model of recall that provides an alternative account (see also Jones & Gardiner, 1990). And the law can be readily accommodated by quite a few other, general models of memory—albeit with somewhat varying degrees of success—as Ratcliff and McKoon (1989) have recently shown. So the existence of this empirical law is consistent with many current theoretical ideas about memory function.

The theoretical rationale for the experiments described in this article, however, did not stem from theorizing of this sort. These experiments were motivated by the importance of determining the range of applicability of the Tulving-Wiseman law. And, in demonstrating that the law holds not just for the recognition and recall of words but also for the recognition and recall of music, our findings suggest that, provided the specific conditions of the law are met, it may hold true for any kind of to-be-remembered item whatsoever.

REFERENCES

Balch, W. R. (1984). The effects of auditory and visual interference on the immediate recall of melody. *Memory & Cognition*, **12**, 581-589.

Barlow, H., & Morgenstern, R. (1983). *A dictionary of musical themes*. London: Faber & Faber.

Begg, I. (1979). Trace loss and the recognition failure of unrecalled words. *Memory & Cognition*, **7**, 113-123.

Dewitt, L. A., & Crowder, R. G. (1986). Recognition of novel melodies after brief delays. *Music Perception*, **3**, 259-274.

Dowling, W. J. (1986). Context effects on melody representation: Scale-step versus interval representations. *Music Perception*, **3**, 281-296.

Flexser, A. J., & Tulving, E. (1978). Retrieval independence in recognition and recall. *Psychological Review*, **85**, 153-171.

Gardiner, J. M. (1988). Recognition failures and free-recall failures: Implications for the relation between recall and recognition. *Memory & Cognition*, **16**, 446-451.

Gardiner, J. M. (1989). The Tulving-Wiseman law and exceptions to it. In A. F. Bennett & K. M. McConkey (Eds.), *Cognition in individual and social contexts* (pp. 253-260). Amsterdam: North-Holland.

Gardiner, J. M., & Nilsson, L. G. (1990). *Relation between recognition and recall: The Tulving-Wiseman law*. Manuscript submitted for publication.

Gardiner, J. M., & Tulving, E. (1980). Exceptions to recognition failure of recallable words. *Journal of Verbal Learning & Verbal Behavior*, **19**, 194-209.

Hayman, C. A. G., & Tulving, E. (1989). Is priming in fragment completion based on a "traceless" memory system? *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **15**, 941-956.

Jones, G. V. (1978). Recognition failure and dual mechanisms in recall. *Psychological Review*, **85**, 464-469.

Jones, G. V. (1983). Structure of the recall process. *Philosophical Transactions of the Royal Society, London B*, **302**, 373-385.

Jones, G. V., & Gardiner, J. M. (1990). Recognition failure when recognition targets and recall cues are identical. *Bulletin of the Psychonomic Society*, **28**, 105-108.

Jones, M. R., Sumereall, L., & Marshburn, E. (1987). Recognizing melodies: A dynamic interpretation. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, **39**, 89-121.

Muter, P. (1984). Recognition and recall of words with a single meaning. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **10**, 198-202.

Nilsson, L.-G., Dinniwell, M., & Tulving, E. (1987). Recognition failure of categorized words. *Memory & Cognition*, **15**, 389-396.

Nilsson, L.-G., Law, J., & Tulving, E. (1988). Recognition failure of recallable unique names: Evidence for an empirical law of memory and learning. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **14**, 266-277.

Nilsson, L.-G., & Shaps, L. (1980). A functional view of memory. In F. Klix & J. Hoffman (Eds.), *Interdisciplinary research of human memory*. Berlin: DVW.

Ratcliff, R., & McKoon, G. (1989). Memory models, text processing, and cue-dependent retrieval. In H. L. Roediger, III, & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honour of Endel Tulving*. Hillsdale, NJ: Erlbaum.

Reder, L. M., Anderson, J. R., & Bjork, R. A. (1974). A semantic interpretation of encoding specificity. *Journal of Experimental Psychology*, **102**, 648-656.

Roberts, L. A. (1986). Modality and suffix effects in memory for melodic and harmonic musical materials. *Cognitive Psychology*, **18**, 123-157.

Serafine, M. L., Davidson, J., Crowder, R. G., & Repp, B. H. (1986). On the nature of melody-text integration in memory for songs. *Journal of Memory & Language*, **25**, 123-135.

Tulving, E. (1983). *Elements of episodic memory*. Oxford: Clarendon.

Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, **80**, 352-373.

Tulving, E., & Wiseman, S. (1975). Relation between recognition and recognition failure of recallable words. *Bulletin of the Psychonomic Society*, **6**, 79-82.

Watkins, M. J. (1990). Mediationism and the obfuscation of memory. *American Psychologist*, **45**, 328-335.

Watkins, M. J., & Gardiner, J. M. (1979). An appreciation of generate-recognize theory of recall. *Journal of Verbal Learning & Verbal Behavior*, **17**, 621-633.

Watkins, M. J., & Tulving, E. (1975). Episodic memory: When recognition fails. *Journal of Experimental Psychology: General*, **1**, 5-29.

NOTE

1. We are indebted to Endel Tulving for this suggestion.

APPENDIX

Experiment 1: Materials

"All Things Bright and Beautiful"
"Au Clair de la Lune"
"Clementine"
"Ding Dong Merrily on High"
"Frère Jacques"
"Good King Wenceslas"
"Green Grow the Rushes-O"
"Greensleeves"
"In the Bleak Midwinter"
"London's Burning"
"My Bonnie Lies over the Ocean"
"O Little Town of Bethlehem"
"Onward Christian Soldiers"
"Pop Goes the Weasel"
"Rule Britannia"
"Sing a Song of Sixpence"
"The Happy Wanderer"
"While Shepherds Watched"

Experiment 2: Materials

Bach:	*Jesu Joy of Man's Desiring*; 1st Movement, 1st Theme.
Beethoven:	*Für Elise*; Opening Theme.
Bizet:	*L'Arlesienne*, Suite No. 1; Overture, 1st Theme.
Bizet:	*Carmen*; Prelude to Act 1, 1st Theme.
Grieg:	*Peer Gynt*, Suite No. 1; 1st Movement, Morning Mood.
Grieg:	*Peer Gynt*, Suite No. 1; 4th Movement, In the Hall of the Mountain King.
Mozart:	Symphony No. 40; 1st Movement, 1st Theme.
Offenbach:	*Orpheus in Hades*; Galop, 2nd theme.
Prokofiev:	*Lieutenant Kije*; 4th Movement, Troika.
Prokofiev:	*Peter and the Wolf*; 1st Theme, Peter.
Ravel:	*Bolero*; Theme A.
Strauss:	*Waltzes from Die Fledermaus*; No. 1, 1st Theme.
Suppe:	*Light Cavalry Overture*; 3rd Theme.
Tschaikovsky:	*1812 Festival Overture*; 2nd Theme.
Tschaikovsky:	*Swan Lake*, Suite from the Ballet; 3rd Movement, Dance of the Swans.

(Manuscript received September 11, 1989; revision accepted for publication May 9, 1990.)

Please PROOF Carefully
and RESPOND to all
comments and questions

PLEASE PLACE IN R
MAILWITHIN 48

Forgetting in recognition memory with and without recollective experience

JOHN M. GARDINER and ROSALIND I. JAVA
City University, London, England

Retention interval was manipulated in two recognition-memory experiments in which subjects indicated when recognizing a word whether its recognition was accompanied by some recollective experience ("remember") or whether it was recognized on the basis of familiarity without any recollective experience ("know"). Experiment 1 showed that between 10 min and 1 week, "remember" responses declined sharply from an initially higher level, whereas "know" responses remained relatively unchanged. Experiment 2 showed that between 1 week and 6 months, both kinds of responses declined at a similar, gradual rate and that despite quite low levels of performance after 6 months, both kinds of responses still gave rise to accurate discrimination between target words and lures. These findings are discussed in relationship to current ideas about multiple memory systems and processing accounts of explicit and implicit measures of retention.

Memory links time present with time past. In recognition memory, the phenomenal experience of the link between the present and the past can take at least two distinct forms. Recognition can be accompanied by either conscious recollection of some specific experience or feelings of familiarity without any recollective experience. Recognition memory with and without recollective experience can be measured by "remember" and "know" responses (Tulving, 1985b). A "remember" response indicates that seeing the word in the test list brings back to mind some specific recollection of what was experienced when the word appeared in the study list. A "know" response indicates that seeing the word in the test list brings to mind feelings of familiarity, without any recollective experience.

Recent studies have shown that these measures of recognition with and without recollective experience produce principled outcomes. Quite a few independent variables have been found to influence "remember" responses but not "know" responses. These variables include levels of processing and generate-versus-read study conditions (Gardiner, 1988a), word frequency (Gardiner & Java, 1990), divided-versus-undivided attention (Gardiner & Parkin, 1990), intentional-versus-incidental learning and number of rehearsals (Macken & Hampson, in press), presentation mode (Gregg & Gardiner, in press), and threatening-versus-nonthreatening words (Mogg, Gardiner, Stavrou, & Golombok, 1991).

But some variables have also been found to influence "know" responses. Compared with words, nonwords gave rise to more "know" responses and fewer "remember" responses (Gardiner & Java, 1990). Compared with young adults, elderly adults produced more "know" responses and fewer "remember" responses (Parkin & Walter, 1991). And Blaxton (1991) found a similar pattern of results after comparing data-driven with conceptually driven processing tasks at study and also after comparisons of epileptic patients who had left-temporal-lobe lesions with epileptic patients who had right-temporal-lobe lesions.

In many cases, these results bear a striking resemblance to the results found in comparisons between performance in explicit and implicit memory tests (for reviews, see Richardson-Klavehn & Bjork, 1988; Schacter, 1987). For example, levels of processing have been found to influence performance in explicit but not implicit tests (Graf & Mandler, 1984; Jacoby & Dallas, 1981); similar results have been found for generate-versus-read study conditions (Gardiner, 1988b), for divided-versus-undivided attention (Parkin, Reid, & Russo, 1990), and for intentional-versus-incidental learning and number of rehearsals (Greene, 1986).

The theories most directly implicated by "remember" and "know" measures are Tulving's (1983, 1985a, 1985b) distinction between episodic memory and other memory systems and Mandler's (1980, 1988) distinction between the elaboration and the activation or integration of information. In Tulving's theory, a "remember" response reflects episodic memory, because recollective experience (or autonoetic consciousness) is a defining characteristic of that system. A "know" response (or noetic consciousness) is characteristic of semantic memory, because knowledge retrieved from semantic memory is not normally accompanied by recollective experience. In Mandler's theory, a "know" response is characteristic of the activation or integration of information, because it is activation or integration that gives rise to feelings of familiarity; recollective experience is based on elaboration.

It has also been suggested (Gardiner, 1988a; Gardiner & Java, 1990; Gardiner & Parkin, 1990) that "remem-

Correspondence about this article should be addressed to John Gardiner, Memory & Cognition Research Group, Department of Social Sciences, City University, Northampton Square, London EC1V 0HB, England.

ber" and "know" responses can be interpreted within a theoretical framework that combines Tulving's (1983, 1985a, 1985b) theory with the transfer-appropriate processing account of differences between explicit and implicit measures of retention (Roediger & Blaxton, 1987; Roediger, Weldon, & Challis, 1989). This suggestion accords with a theoretical rapprochement recently discussed by Hayman and Tulving (1989), Schacter (in press), and Tulving and Schacter (1990; see also Richardson-Klavehn & Bjork, 1988; Roediger et al., 1989). By this account, "remember" responses depend on conceptual processing in episodic memory, and "know" responses reflect data-driven processing, or "perceptual fluency" (Jacoby, 1983; Jacoby & Dallas, 1981), perhaps arising from the perceptual representation systems Tulving and Schacter (1990; see also Schacter, in press) have recently discussed in relation to priming.

This suggestion is well supported by the results of the study by Blaxton (1991) on recognition memory for abstract visuospatial designs. Blaxton showed that memory-unimpaired adults made more "remember" than "know" responses following a conceptually driven study task and more "know" than "remember" responses following a data-driven study task. Moreover, she showed that regardless of study task, epileptic patients with left-temporal-lobe lesions and impaired verbal memory made more "know" than "remember" responses, and epileptic patients with right-temporal-lobe lesions and impaired visuospatial memory made more "remember" than "know" responses.

Dissociations of the kind found by Blaxton (1991) are difficult to reconcile with another theoretical possibility, which is that "know" responses might merely reflect weak trace strength. There is other evidence against this possibility in the studies by Gardiner and Java (1990) and Parkin and Walter (1991). Gardiner and Java not only found more "know" than "remember" responses for nonwords, compared with more "remember" than "know" responses for words, but also that the higher level of "know" responses for nonwords corresponded with high confidence ratings. In a post hoc analysis, Parkin and Walter showed that their finding of more "know" and fewer "remember" responses in elderly adults compared with young adults held good even when the overall levels of performance in the two age groups were equated.

The present research was expected to further clarify these theoretical issues, especially concerning the interpretation of "know" responses, but the research had a straightforward empirical goal—the need for further evidence about the forgetting characteristics of recognition memory as measured by "remember" and "know" responses. In each case, the aim was to obtain good evidence about the persistence of recognition memory and about the rate of forgetting.

In one previous study with "remember" and "know" measures that manipulated retention interval (Gardiner, 1988a, Experiment 2), there were two retention intervals of 1 h and 1 week. The proportion of correct "remember" responses declined sharply after a week, but the proportion of correct "know" responses changed little. However, the proportion of "know" responses to lure words rose sharply after a week and was not reliably lower than the proportion of correct "know" responses. The longest retention interval over which there is evidence of accurate discrimination with "know" responses is 24 h, a retention interval used by Gardiner and Java (1990) to avoid ceiling effects. Thus, it is possible that accurate "know" responses may not persist for much longer than a 24-h period.

So far as forgetting rate is concerned, the general finding since the classic study by Ebbinghaus (1885/1964), both in laboratory studies (e.g., Wicklegren, 1972) and in autobiographical memory (e.g., Rubin, 1982), is that forgetting occurs rapidly at first and then slows down—although in very long-term memory, there is some conflicting evidence about whether there is any forgetting at all (Bahrick, 1984; Bahrick, Bahrick, & Wittlinger, 1975; Squire, 1989). The rate of forgetting is remarkably immune to the effects of most independent variables (Underwood, 1964, 1969). It is important to note that, as Slamecka and McElree (1983) have more recently confirmed, these variables include original degree of learning and item difficulty (see Baddeley, 1990, for a brief review).

We describe two similar experiments, in each of which a different group of subjects was assigned to each different retention interval. In Experiment 1, the retention intervals were 10 min, 1 h, 1 day, and 1 week.

EXPERIMENT 1

Method

Subjects. The subjects were 64 undergraduate students at City University, London, who were paid for their participation in the experiment. They were allocated arbitrarily to one of four separate groups of 16 subjects. All subjects were tested individually. Three subjects, all in the 10-min group, evidently failed to comprehend or act upon the instructions. These subjects were replaced.

Design and Materials. The experiment involved a single-factor independent groups design, with retention interval as the factor. The four retention intervals were 10 min, 1 h, 1 day, and 1 week. Subjects were allocated to each group partly by order of arrival at the laboratory, partly by availability for testing.

The stimulus materials were a set of 72 words selected randomly from the materials used by Tulving, Schacter, and Stark (1982), subject to the exclusion of a few words likely to have been unknown to some of the subjects. The recognition test lists consisted of all 72 words. There were four different study lists, derived from two random divisions of all 72 words into equal subsets of 36 words. The four different study lists resulted from counterbalancing target words and lures within each such division. Within each group, each study list was used equally often.

At study, the subjects were told simply to memorize the words for a subsequent test, the nature of which was not specified at the time. At test, the subjects were required to give "remember" or "know" judgments for each word they recognized.

Procedure. The study-list words were printed on a deck of cards and presented at the rate of 2 sec/word, in an order randomized separately for every subject. The subjects were told to memorize the words for a subsequent memory test, about which they were given no further information until the test began. The subjects allocated to the 10-min retention interval were during that time engaged in winsome conversation with the experimenter. The subjects allocated to the other retention intervals were dismissed and told to return to the laboratory at test time but, in the meantime, not to think about the words.

For the recognition test, all 72 words were printed, in a single constant order, in three columns of 24 words each. The subjects were instructed to work down each column carefully in turn, drawing a circle around any word that they recognized from the study list. In addition, they were told to put an "R," for "remember," or a "K," for "know," alongside each word they recognized. As in previous similar studies (e.g., Gardiner & Parkin, 1990), the subjects were given a typewritten set of instructions describing these two kinds of responses, supplemented by oral instructions for further clarification as necessary. A "remember" response was described as some specific recollection of what was experienced the moment the word appeared in the study list. Examples included an association with another list word, an image that came to mind, something about the physical appearance or position of the word, or something of personal significance in autobiographical memory. A "know" response was described as recognition that is without any such item-specific recollective experience but that is accomplished on some other basis, particularly feelings of familiarity (see Gardiner & Java, 1990, and Gardiner & Parkin, 1990, for a more detailed account of the instructions).

The recognition test was self-paced, though backtracking was discouraged and the subjects were also discouraged from guessing.

Results and Discussion

The principal results from this experiment are summarized in Table 1, which shows the mean proportion of "remember" and "know" responses to target words and lures at each retention interval. The table shows that whereas the mean proportion of correct "remember" responses declined sharply over retention interval, there was little change in the mean proportion of correct "know" responses. False-positive rates were quite low and tended to increase slightly at the longer retention intervals.

Previous studies using "remember" and "know" measures have tended to report one or the other of two alternative ways in which the data may be analyzed. In one, the analysis of variance (ANOVA) includes response type as a factor on the questionable grounds that it can be regarded as an instructional manipulation. In the other, a separate ANOVA is carried out on "remember" and on "know" responses. The latter approach precludes the evaluation of interactions involving response type but is less questionable statistically. For the experiments described here, we report the results from both kinds of analyses. We also report the results of separate analyses of individual subject hit rates and of individual subject scores corrected by subtracting each person's false-alarm rate from the corresponding hit rate. The alpha level was set at .05 throughout.

The results of an ANOVA with response type as a factor on uncorrected scores showed that the main effects of retention interval [$F(3,60) = 10.82$, $MS_e = 12.83$] and of response type [$F(1,60) = 15.45$, $MS_e = 34.72$] were both reliable. The interaction between retention interval and response type was significant [$F(3,60) = 4.39$, $MS_e = 34.72$]. The results of a similar ANOVA on corrected scores also showed significant main effects of retention interval [$F(3,60) = 12.70$, $MS_e = 15.87$] and of response type [$F(1,60) = 27.35$, $MS_e = 27.98$]. Their interaction was also significant [$F(3,60) = 5.10$, $MS_e = 27.98$].[1]

Separate ANOVAs on uncorrected "remember" and "know" scores revealed a significant effect for "remember" responses [$F(3,60) = 9.47$, $MS_e = 30.28$] but not for "know" responses ($F < 1$). For the corrected scores, there was again a significant effect for "remember" responses [$F(3,60) = 12.46$, $MS_e = 26.46$] but not for "know" responses ($F < 1$).

No ANOVA was carried out on individual subject responses to lures because too few responses were made. It is clear, however, that "know" responses to lures exceeded "remember" responses to lures, as has been found in previous similar studies (e.g., Gardiner & Java, 1990), and that both kinds of lure responses increased with longer retention intervals. At each retention interval, for each kind of response, the hit rate significantly exceeded the false-alarm rate by sign test.

Although it is well established that the rate of forgetting does not depend either on the degree of original learning or on whether retention is measured for easy or difficult items (Baddeley, Baddeley, & Nimmo-Smith, cited in Baddeley, 1990; Slamecka & McElree, 1983; Underwood, 1964), it is nonetheless possible that the initial differences that were observed in forgetting rates for "remember" and "know" measures over the first three retention intervals might reflect scaling problems associated with differences in the initial levels of performance. This possibility can be checked by examining the data at each of these three retention intervals for the 8 subjects whose hit rates for "know" responses were above the median (cf. Gardiner & Parkin, 1990). These 8 subjects had average hit rates across the three retention intervals of .36, .34, and .35. In contrast, the average "remember" hit rates for the 8 subjects whose hit rates fell below the median were .19, .14, and .09. These data provide no evidence that scaling problems underlie the absence of any sharp drop in "know" responses over the earlier retention intervals.

The main conclusions from Experiment 1 are that recognition memory without recollective experience persists for at least as long as 1 week (cf. Gardiner, 1988a) and,

Table 1
Response Probability as a Function of Retention Interval in Experiment 1

Retention Interval	Target Words "Remember"	Target Words "Know"	Lures "Remember"	Lures "Know"
10 min	.49	.26	.00	.05
1 h	.42	.24	.01	.06
1 day	.27	.27	.03	.06
1 week	.25	.23	.05	.08

Au! "cf." (compare) or "see"

during this period, shows relatively little evidence of forgetting. In contrast, over the same period, recognition memory with recollective experience declines sharply.

EXPERIMENT 2

Experiment 2 had two main aims: first, to replicate the finding that recognition memory measured by "know" responses persists for at least 1 week and, second, to extend "remember" and "know" measures of recognition memory to much longer retention intervals. Accordingly, in Experiment 2, there were three retention intervals: 1 week, 4 weeks, and 6 months.

Method

Subjects. The subjects were another group of 48 undergraduate students at City University, London, who were paid for their participation in the experiment. They were allocated arbitrarily to one of three separate groups of 16 subjects. All subjects were tested individually. One subject, in the 4-week group, was replaced for failing to carry out the instructions properly.

Design, Materials, and Procedure. The design, materials, and procedure were essentially the same as in Experiment 1, except that the retention intervals were 1 week, 4 weeks, and 6 months.

Results and Discussion

The principal results from this experiment are summarized in Table 2, which shows the mean proportion of "remember" and "know" responses to target words and lures at each retention interval. In contrast to the results of Experiment 1, the results here show a broadly similar pattern for "remember" and "know" responses to target words, both of which declined gradually as the retention intervals increased. At the 1-week retention interval, the results from this experiment correspond quite closely with those from Experiment 1. And although performance generally declined to quite low levels by 6 months, both "remember" and "know" responses to target words exceeded those made to lures.

The results of an ANOVA that had response type as a factor and that was carried out on uncorrected hit rates showed that there was a significant main effect of retention interval [$F(2,45) = 12.05$, $MS_e = 6.36$] but that neither the main effect of response type nor the interaction between retention interval and response type was significant ($F < 1$, in each case). The results of a similar ANOVA on corrected scores also showed a significant main effect of retention interval [$F(2,45) = 10.72$, $MS_e = 5.71$]; neither the main effect of response type [$F(1,45) = 2.75$, $MS_e = 19.10$] nor the interaction ($F < 1$) was significant.

Table 2
Response Probability as a Function of Retention Interval in Experiment 2

Retention Interval	Target Words "Remember"	Target Words "Know"	Lures "Remember"	Lures "Know"
1 week	.24	.25	.05	.10
4 weeks	.19	.21	.02	.09
6 months	.15	.17	.05	.09

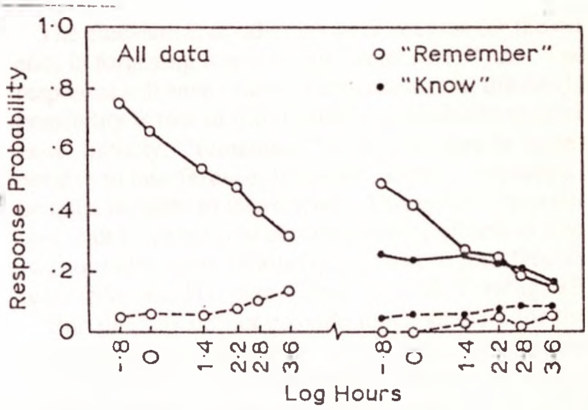


Figure 1. Response probability as a function of log hours.

Separate ANOVAs on uncorrected "remember" and "know" scores revealed a significant effect both for "remember" responses [$F(2,45) = 4.73$, $MS_e = 8.72$] and for "know" responses [$F(2,45) = 4.99$, $MS_e = 7.23$]. For the corrected scores, the effect was not quite significant either for "remember" responses [$F(2,45) = 2.81$, $MS_e = 13.47$] or for "know" responses [$F(2,45) = 2.20$, $MS_e = 11.23$].

As in Experiment 1, the proportion of "know" responses to lure words exceeded the proportion of "remember" responses to lure words, but at these longer retention intervals, there was little sign of any tendency for false-positive rates to systematically increase. No ANOVA was carried out on individual subject responses to lures, again because of the generally low number of responses. At the longer retention intervals, the differences between "know" responses to target words and to lures were quite small, but they were very consistent across subjects. A t test carried out on individual subject "know" responses to targets versus lures at the 6-month interval was highly significant [$t(15) = 4.37$, $SE = .02$], and so, too, was a similar test at the 4-week interval [$t(15) = 5.78$, $SE = .02$]. For both kinds of responses at all other retention intervals, hit rates significantly exceeded the corresponding false-claim rates by sign test.

The results of Experiment 2 therefore provide evidence that both recognition memory with recollective experience and recognition memory without recollective experience persist for at least 6 months. They also show that over these longer retention intervals, both forms of recognition memory decline gradually at a similar rate.

For illustrative purposes, the results of Experiments 1 and 2 may be combined to show forgetting curves over the full range of retention intervals tested. To this end, it was arbitrarily decided to include the 1-week data from Experiment 1 and to omit the 1-week data from Experiment 2. There were, therefore, six sets of data, for retention intervals of 10 min, 1 h, 1 day, 1 week, 4 weeks, and 6 months. Figure 1 summarizes these data as a function of log hours, with "remember" and "know" responses combined to give conventional hit-rate and false-alarm-rate measures in the left-hand panel and shown separately in the right-hand panel.

The left-hand panel of Figure 1 shows that, considered overall, these data conform with classic forgetting functions which, when plotted logarithmically, usually appear linear. The right-hand panel shows that both forms of recognition memory have quite different forgetting rates over shorter retention intervals of up to 24 h.

GENERAL DISCUSSION

This research had two straightforward empirical goals. The first was to discover the persistence of recognition memory with and without recollective experience, as measured by "remember" and "know" responses. The second was to obtain evidence about forgetting rates with each of these two measures. The results seem relatively clear-cut. Recognition without recollective experience persists for at least 6 months, as does recognition with recollective experience. Also, both forms of recognition memory have different forgetting rates. Recognition accompanied by recollective experience is initially higher but declines sharply over a 24-h period. In contrast, recognition without recollective experience shows little forgetting over the first 24 h. Thereafter, both kinds of recognition memory decline gradually, at about the same rate, from 24 h up to at least 6 months. The difference in forgetting rates provides further evidence against the idea that "remember" and "know" responses correspond with strong and weak memory traces, because it has been established that forgetting rates for strong and weak items do not differ.[2]

Of course, it is possible that over time, "remember" responses become "know" responses as specific contextual information is lost, contrary to the suggestion that the relationship between "remember" and "know" responses is one of exclusivity (see Gardiner & Parkin, 1990). But we suspect that it would require quite a complicated set of assumptions to fully account for the two forgetting functions in this way. Furthermore, in an additional experiment in which we used a test–retest procedure, we found no evidence that "know" responses in the second of the two tests (which took place a week later) included a relatively high proportion of items to which a "remember" response had been given in the first test. "Know" responses in the second test included only a small proportion of "remember" responses from the first test, and "remember" responses in the second test included a similarly small proportion of "know" responses from the first test. Finally, in thinking about the relationship between "remember" and "know" responses, it should be borne in mind that previous studies have provided good evidence that "remember" and "know" responses reflect qualitatively distinct components of recognition memory, not some unitary quantitative dimension such as trace strength (Blaxton, 1991; Gardiner & Java, 1990; Parkin & Walter, 1991).

The elucidation of other possible reasons for the difference in forgetting functions for "remember" and "know" responses will have to await further research. But one likely possibility is that of differential susceptibility to interference. Initially, "remember" responses may be quite vulnerable to interference, whereas "know" responses may be quite resistant to interference. This possibility is consistent with evidence that certain priming effects in implicit memory also seem relatively immune to interference effects (Sloman, Hayman, Ohta, Law, & Tulving, 1988).

Our findings do not provide much support for the account provided by Mandler's (1980, 1988) distinction between elaboration and activation or integration. The persistence of recognition memory, as measured by "know" responses, for as long as 6 months is not consistent with an interpretation of these responses with respect to temporary activation or integration. There are at least four other pieces of evidence that are difficult to square with this activation view. Gardiner and Java (1990) found that the word-frequency effect in recognition memory, which, together with word-frequency effects in certain priming tasks, has been attributed to enhanced activation (e.g., Jacoby & Dallas, 1981; Mandler, 1980), did not give rise to more "know" responses. Rather, it gave rise to more "remember" responses. Gardiner and Java also found that the probability of "know" responses was greater for nonwords than for words, a result that cannot easily be explained by the activation of representations in semantic memory. Similarly, Blaxton's (1991) demonstration that "remember" responses were enhanced by conceptually driven processing and that "know" responses were enhanced by data-driven processing involved recognition memory for novel, abstract visuospatial designs. Finally, Mogg et al. (1990) found that although clinically anxious patients show more direct priming of threat than of nonthreat words in word-stem completion, a result that has been explained by enhanced activation of threatening stimuli (Williams, Watts, MacLoed, & Mathews, 1988), in recognition memory, clinically anxious patients gave no more "know" responses to threat words than did normal controls.

Thus Mandler's (1980, 1988) distinction between elaboration and activation or integration, and his assumption that activation or integration gives rise both to certain priming effects, such as those observed in word-stem completion, and to feelings of familiarity in recognition memory do not seem to provide a good account of results obtained from "remember" and "know" measures of recognition (cf. Macken & Hampson, in press). The problem, for this account, is that recognition measured by "know" responses does not seem to correspond with feelings of familiarity that can be attributed to activation or integration.

Blaxton (1991) argued that "remember" responses reflect conceptual processing and that "know" responses reflect data-driven processing. Although her evidence provides good support for this interpretation, this processing account is not necessarily incompatible with a memory-systems account, and there are advantages in a theoretical framework that combines the two approaches (Gardiner, 1988; Gardiner & Java, 1990; Gardiner & Parkin, 1990).

Within Tulving's (1983, 1985a, 1985b) distinction between episodic memory and other memory systems, "remember" responses tap autonoetic consciousness and reflect output from the episodic system, and "know" responses tap noetic consciousness, which characterizes the semantic system. However, the evidence that is problematic for an activation account of "know" responses is, by the same token, problematic for a semantic-memory account. That is why Gardiner and Parkin (1990; see also Gardiner, 1988a; Gardiner & Java, 1990; Mogg et al., 1990) suggested that in recognition memory, "know" responses may arise from the perceptual-representation systems that have been proposed to account for certain priming effects in implicit memory (Schacter, in press; Tulving & Schacter, 1990). Such perceptual systems are presumed to operate at a presemantic level and can, for example, represent structural descriptions either of unfamiliar objects (see Schacter, Delaney, & Cooper, 1990) or of the visual forms of words but not their meanings. Therefore, this account can readily accommodate evidence that "know" responses in recognition memory are generally not influenced by semantic factors and also occur for unfamiliar stimuli such as nonwords and abstract visuospatial designs.

An additional advantage of this account is that it can readily accommodate long-lasting effects, such as those found in the present experiments and others found with certain priming measures, for example, word-fragment completion (Sloman et al., 1988). A single, brief encounter with a stimulus can lead to fairly durable modification of the perceptual system (cf. Kolers & Roediger, 1984). Indeed, as Schacter et al. (1990; see also Sherry & Schacter, 1987) have pointed out, a fairly durable change is to be expected if the encounter is to have any real adaptive significance for the organism.

A systems approach makes good sense from an evolutionary standpoint. In evolutionary terms, recognition must be considered a relatively primitive form of memory. It is therefore not surprising that recognition is quite often accompanied by noetic rather than by autonoetic consciousness. Noetic and autonoetic consciousness must have evolved to meet very different adaptive needs, and one can only speculate about what those needs might be. Reaching a better understanding of the nature and adaptive significance of these two kinds of conscious awareness is one of the more important challenges that we face.

But attempts to explain consciousness with reference to hypothetical mental processes and memory systems do not capture the significance of personal experience from the person's point of view. Such explanations represent what Velmans (in press) called "third-person" accounts, rather than "first-person" accounts. Velmans argued that both third-person and first-person accounts are needed for a complete psychology of memory and that the two kinds of account should be regarded as complementary.

For the subject, the significance of recognition memory accompanied by recollective experience is that the act of recognition has a particular mental cause. A "remember" response involves mental causation in the sense that the subject can make statements such as "I recognize TABLE because I remember that when TABLE occurred in the study list it reminded me that last night at dinner I spilled some wine." A "know" response does not have a specific mental cause. The subject cannot make statements that explain the particular reasons for the act of recognition. Recognition is instead attributed to feelings of familiarity.[3]

From a first-person perspective, then, recognition memory with and without recollective experience corresponds to recognition memory with and without a particular mental cause. Studies in which these two mental states have been measured by "remember" and "know" responses converge on the unavoidable conclusion that recognition that has some specific mental cause and recognition that has no particular mental cause differ in systematic, fundamental ways.

REFERENCES

Baddeley, A. D. (1990). *Human memory: Theory and practice*. Hillsdale, NJ: Erlbaum.

Bahrick, H. P. (1984). Semantic memory content in permastore: "Fifty years of memory for Spanish learned in school." *Journal of Experimental Psychology: General*, **113**, 1-47.

Bahrick, H. P., Bahrick, P. O., & Wittlinger, R. P. (1975). Fifty years of memories for names and faces: A cross-sectional approach. *Journal of Experimental Psychology: General*, **104**, 54-75.

Blaxton, T. A. (1991). *The role of temporal lobes in memory function: Conceptual and data-driven transfer*. Manuscript submitted for publication.

Ebbinghaus, E. E. (1964). *Memory* (H. A. Ruger & C. E. Bussenius, Trans.). New York: Dover. (Original work published 1885)

Gardiner, J. M. (1988a). Functional aspects of recollective experience. *Memory & Cognition*, **16**, 309-313.

Gardiner, J. M. (1988b). Generation and priming effects in word-fragment completion. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **14**, 495-501.

Gardiner, J. M., & Java, R. I. (1990). Recollective experience in word and nonword recognition. *Memory & Cognition*, **18**, 23-30.

Gardiner, J. M., & Parkin, A. J. (1990). Attention and recollective experience in recognition memory. *Memory & Cognition*, **18**, 579-583.

Graf, P., & Mandler, G. (1984). Activation makes words more accessible, but not necessarily more retrievable. *Journal of Verbal Learning & Verbal Behavior*, **23**, 553-568.

Greene, R. L. (1986). Word stems as cues in recall and completion tasks. *Quarterly Journal of Psychology*, **38A**, 663-673.

Gregg, V. H., & Gardiner, J. M. (in press). Components of conscious awareness in a long-term modality effect. *British Journal of Psychology*.

Hayman, C. A. G., & Tulving, E. (1989). Is priming a fragment completion based on a "traceless" memory system? *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **15**, 941-956.

Jacoby, L. L. (1983). Remembering the data: Analysing interactive processes in reading. *Journal of Verbal Learning & Verbal Behavior*, **22**, 485-508.

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General*, **110**, 306-340.

Kolers, P. A., & Roediger, H. L., III (1984). Procedures of mind. *Journal of Verbal Learning & Verbal Behavior*, **23**, 425-449.

Loftus, G. R. (1985). Evaluating forgetting curves. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **11**, 397-406.

Macken, W., & Hampson, P. (in press). Integration, elaboration, and recollective experience. *European Journal of Cognitive Psychology*.

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review*, **87**, 252-271.

Mandler, G. (1988). Memory: Conscious and unconscious. In P. R. Solomon, G. R. Goethals, C. M. Kelley, & B. R. Stephens (Eds.), *Memory: Interdisciplinary approaches* (pp. 84-106). New York: Springer-Verlag.

Mogg, K., Gardiner, J. M., Stavrou, A., & Golombok, S. (1991). *Recollective experience and recognition memory for threat in clinical anxiety states*. Manuscript submitted for publication.

Parkin, A. J., Reid, T. K., & Russo, R. (1990). On the differential nature of implicit and explicit memory. *Memory & Cognition*, **18**, 507-514.

Parkin, A. J., & Walter, B. (1991). *Recollective experience, normal aging, and frontal dysfunction*. Manuscript submitted for publication.

Richardson-Klavehn, A., & Bjork, R. A. (1988). Measures of memory. *Annual Review of Psychology*, **39**, 475-543.

Roediger, H. L., III, & Blaxton, T. A. (1987). Retrieval modes produce dissociations in memory for surface information. In D. Gorfein & R. R. Hoffman (Eds.), *Memory and cognitive processes: The Ebbinghaus centennial conference* (pp. 349-379). Hillsdale, NJ: Erlbaum.

Roediger, H. L., III, Weldon, M. S., & Challis, B. H. (1989). Explaining dissociations between implicit and explicit measures of retention: A processing account. In H. L. Roediger III & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honour of Endel Tulving* (pp. 3-41). Hillsdale, NJ: Erlbaum.

Rubin, D. A. (1982). On the retention function for autobiographical memory. *Journal of Verbal Learning & Verbal Behavior*, **21**, 21-38.

Schacter, D. L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **13**, 501-518.

Schacter, D. L. (in press). Perceptual representation systems and implicit memory: Toward a resolution of the multiple memory systems debate. In A. Diamond (Ed.), *Development and neural bases of higher cognitive function*. Annals of the New York Academy of Sciences.

Schacter, D. L., Delaney, S. M., & Cooper, L. A. (1990). Implicit memory for unfamiliar objects depends on access to structural descriptions. *Journal of Experimental Psychology: General*, **119**, 5-24.

Sherry, D. F., & Schacter, D. L. (1987). The evolution of multiple memory systems. *Psychological Review*, **94**, 439-454.

Slamecka, N. J. (1985). On comparing rates of forgetting: Comment on Loftus (1985). *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **11**, 812-816.

Slamecka, N. J., & McElree, B. (1983). Normal forgetting of verbal lists as a function of their degree of learning. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **9**, 334-347.

Sloman, S. A., Hayman, C. A. G., Ohta, N., Law, J., & Tulving, E. (1988). Forgetting in primed fragment completion. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **14**, 223-239.

Squire, L. R. (1989). On the course of forgetting in very long-term memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **15**, 241-245.

Tulving, E. (1983). *Elements of episodic memory*. New York: Oxford University Press.

Tulving, E. (1985a). How many memory systems are there? *American Psychologist*, **40**, 385-398.

Tulving, E. (1985b). Memory and consciousness. *Canadian Psychologist*, **26**, 1-12.

Tulving, E., & Schacter, D. L. (1990). Priming and human memory systems. *Science*, **247**, 301-306.

Tulving, E., Schacter, D. L., & Stark, H. A. (1982). Priming effects in word-fragment completion are independent of recognition memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **8**, 336-342.

Underwood, B. J. (1964, ★★★★★★★). Forgetting. *Scientific American*, pp. ★★★-★★★.

Underwood, B. J. (1969). Are we overloading memory? In A. W. Melton & E. Martin (Eds.), *Coding processes in human memory*. Washington, DC: Winston.

Velmans, M. (in press). Is human information processing conscious? *Behavioral & Brain Sciences*.

Wickelgren, W. A. (1972). Trace resistance and the decay of long-term memory. *Journal of Mathematical Psychology*, **9**, 418-455.

Williams, J. M. G., Watts, F., MacLoed, C., & Mathews, A. (1988). *Cognitive psychology and emotion disorders*. Chichester, U.K.: Wiley.

NOTES

1. These analyses also assume that the use of an interaction test is an appropriate procedure for comparing rates of forgetting, a procedure that has been challenged by Loftus (1985), who put forward an alternative model for evaluating forgetting curves. In this matter, we are persuaded by the arguments made by Slamecka (1985; Slamecka & McElree, 1983) in favor of the more direct, less theoretically committed approach entailed by straightforward tests of interactions (for an endorsement, see Baddeley, 1990, pp. 254-255).

2. We are grateful to Douglas Nelson for drawing this point to our attention.

3. Unpublished data collected in collaboration with Vernon Gregg directly support these assertions. The data are from experiments in which subjects had to report not just "remember" and "know" judgments but, in addition, the actual mental experiences that gave rise to these judgments. "Know" responses were never accompanied by reports of recollective experiences. "Remember" responses were almost always accompanied by particular recollections from the study phase; these quite often concerned autobiographical incidents.

(Manuscript received September 24, 1990;
revision accepted for publication May 13, 1991.)

Au!
Spelling Co