SERIAL POSITION EFFECTS IN

IMPLICIT AND EXPLICIT MEMORY TESTS

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ABSTRACT

This thesis explored the properties of perceptual and conceptual priming by examining serial position effects and levels of processing effects in matched implicit and explicit memory tests. The experimental work used one perceptual implicit memory test, word stem completion, and two conceptual implicit memory tests, free association and name generation.

The main findings were that primacy effects were only found in the implicit memory tests when associative connections between stimulus pairs were strengthened during encoding. Short-term recency effects were not found in the implicit memory tests, but there was forgetting throughout the course of most of the conceptual implicit memory tests for all but primacy items. Neither name generation nor free association using weakly related word pairs, which were mainly common idioms, produced levels of processing effects. There was a levels of processing effect in free association using strongly related word pairs but not when baseline completion was subtracted prior to the analysis. In comparison, primacy effects, forgetting and levels of processing effects occurred in all the explicit tests and short-term recency effects appeared to be dependent on the degree of cognitive effort involved in recall from test cues.

The findings are discussed in relation to the multiple memory systems theory, that there are structurally and functionally distinct memory systems, and the transfer appropriate processing theory, that there is a unitary memory system which is susceptible to the degree of overlap between encoding and test processes.

An amendment to the multiple memory systems theory was suggested to explain the experimental results. It was proposed that all priming may be based on the perceptual representation system but that interactions between the perceptual representation system and the episodic and semantic memory systems occur during encoding.

INTRODUCTION

In their review of implicit memory, Roediger and McDermott (1993) stated that "Although examination of serial position effects has guided research about other issues in the study of memory, work on implicit memory is a clear exception at this point in time." (p.115). Referring specifically to primacy effects, they noted that "the voluminous implicit memory literature is almost mute on the issue as to whether a primacy effect exists on any implicit memory test" (p.115). The work that follows rectifies this omission by examining serial position effects in matched implicit and explicit memory tests. Examples of perceptual and conceptual implicit memory tests are included in this examination. The results of these studies provide detailed information about the properties of perceptual and conceptual priming and produce unique comparisons between perceptual and conceptual implicit and explicit memory tests.

In Chapter 1, studies comparing explicit memory tests with perceptual and conceptual implicit memory tests are described and reviewed. Two theoretical explanations for dissociations between the results of explicit and implicit memory tests are discussed: the multiple memory systems view that explicit and implicit memory tests reflect functionally and anatomically different underlying memory systems (e.g. Cohen, 1984; Hayman & Tulving, 1989; Schacter, 1990; 1992; 1994; Schacter & Tulving, 1994; Squire, 1987; 1992a; Tulving, 1985; Tulving & Schacter, 1990), and the transfer appropriate processing view that there is a unitary memory system in which dissociations between explicit and implicit test performance occur because there are different degrees of processing overlap between encoding and test (e.g. Blaxton, 1989; Graf & Mandler, 1984; Jacoby, 1983a; Mandler, 1988; Roediger, 1990a, 1990b; Roediger & Blaxton, 1987a; 1987b; Roediger & McDermott, 1993: Roediger, Weldon & Challis, 1989).

Chapter 2 describes studies relating to serial position effects in explicit memory tests to determine what is known about the reasons for these effects. In addition, the few previous studies which have investigated serial position effects in implicit memory tests, the most relevant to the current experimental studies, are reviewed and discussed.

Chapters 3 - 6 are experimental chapters. Chapter 3 describes three experiments comparing serial position effects in the perceptual implicit memory test of word stem completion with the explicit memory test of word stem cued recall. Chapter 4 describes three experiments comparing serial position effects in the conceptual implicit memory test of free association with the explicit test of word cued recall. Chapter 5 describes two experiments comparing serial position effects in the conceptual implicit memory test of name generation with the explicit memory test of name cued recall. Chapter 6 describes two further experiments which investigated levels of processing effects in free association and name generation compared with word cued recall and name cued recall.

In Chapter 7, the results of all these studies are discussed in the light of previous findings and in relation to the multiple memory systems and transfer appropriate processing theories.

The main aims of the thesis are threefold: to examine serial position effects in perceptual and conceptual implicit memory tests and to include explicit memory tests which are identical to the implicit memory tests, except for the test instructions, in accordance with the retrieval intentionality criterion (Schacter, Bowers & Booker, 1989); to ensure that the studies are methodologically sound so that the results that emerge are valid; and to relate the results of the studies to the multiple memory systems theory and the transfer appropriate processing theory, the two current theoretical explanations for dissociations between implicit and explicit memory tests.

CHAPTER 1

IMPLICIT AND EXPLICIT MEMORY

1.1 Introduction

During the past few years a number of dissociations have been found between the results of implicit and explicit memory tests (see Richardson-Klavehn & Bjork, 1988; Roediger & McDermott, 1993; and Schacter, Chiu, & Ochsner, 1993, for reviews). In implicit memory tests (e.g. word stem completion, perceptual identification, word association and category generation) subjects typically perform the test without reference to the study episode. In explicit memory tests (e.g. free recall, cued recall and recognition) subjects are instructed to try to retrieve information from the study episode. Dissociations between the results of implicit and explicit memory tests occur, even when the tests conform to the retrieval intentionality criterion of Schacter, *et al.* (1989), which proposed that all aspects of the explicit and implicit tests being compared should be the same except for the instructions at test.

A distinction has recently been made between perceptual and conceptual tests of implicit memory (see e.g. Blaxton, 1989; Tulving & Schacter, 1990). In perceptual implicit memory tests (e.g. word stem completion, word fragment completion, perceptual identification and lexical decision) a perceptually degraded version of the study item is presented at test. Such tests are usually sensitive to perceptual similarity and modality shifts between study and test. Studies comparing perceptual implicit and explicit memory tests are described and discussed in Section 1.2 of this chapter. In conceptual implicit memory tests (e.g. word association and category instance generation) there is often no perceptual overlap between study and test and there is less sensitivity to modality shifts. Supporting this distinction, dissociations have been found between perceptual and conceptual implicit memory tests (see Roediger & McDermott, 1993; Roediger, Srinivas & Weldon, 1989, for reviews). Studies comparing conceptual implicit and explicit memory tests are described and discussed in Section 1.3. The relationship between perceptual and conceptual implicit memory tests is discussed in Section 1.4.

A current debate in cognitive psychology is whether dissociations between implicit and explicit tests arise from different underlying structures or from differences in the match between encoding and test processes. On one side of the debate, the multiple memory systems approach proposes that implicit and explicit memory are mediated by functionally and anatomically different memory systems (e.g. Cohen, 1984; Hayman & Tulving, 1989; Schacter, 1990; 1992; Schacter et al. 1993; Schacter & Tulving, 1994; Squire, 1987; 1992a; Tulving, 1985; Tulving & Schacter, 1990). On the opposing side, the transfer appropriate processing theory proposes that implicit and explicit memory are dependent on the match between the type of processing required at encoding and at test within a unitary memory system (e.g. Blaxton, 1989; Graf & Mandler, 1984; Jacoby, 1983a; Mandler, 1988; Roediger, 1990a; 1990b; Roediger & Srinivas, 1993). These theories are described and discussed in Section 1.5 of this chapter.

1.2 Perceptual Implicit Memory Tests

1.2.1 Introduction

According to Schacter, *et al.* (1993), four main perceptual implicit memory tests are used to assess visual word priming: word stem completion; word fragment completion; perceptual identification and lexical decision. In word stem completion, subjects are typically exposed to words at study, often without being informed that they are performing a memory test. At test, three letter word stems of studied words are presented, e.g. *SPI....... (SPIDER),* and subjects are required to complete each word stem with the first word that comes to mind. The test is usually introduced as an unrelated task with target word stems interspersed among filler word stems. Completion of non-studied word stems provides a between-subjects measure of baseline completion. In order that baseline completion is not too high, each word stem has a number of possible completions. Priming occurs when subjects complete word stems with studied words more often than non-studied words. In word fragment completion, subjects are presented with fragments of studied words, e.g. *_P__D_R (SPIDER)*. Again this test is usually presented as an unrelated task with target word fragments interspersed among filler word fragments and with a between-subjects measure of baseline word fragment completion. Priming occurs when target word fragments are completed more often than non-studied word fragments. Perceptual identification involves subjects endeavouring to identify studied and non-studied words after very brief presentations. Priming occurs when subjects identify more studied than non-studied words. Lexical decision entails reaction time speeded decisions as to whether strings of letters are words or nonwords. Evidence of priming is shown when subjects are quicker to respond to previously studied words than non-studied words. Another commonly used test of perceptual implicit memory is the anagram completion test. Typically, anagrams are presented to subjects, e.g. *PDIERS*, and priming is shown if more anagrams of previously studied than unstudied words are completed.

During the last few years many dissociations have been found between performance in perceptual implicit and explicit memory tests. Variables which have been found to produce these dissociations include amnesia, age, levels of processing, the generation effect, modality, retention interval and interference. Dissociations associated with each of these variables are described and discussed below. Particular attention has been paid to levels of processing and retention interval as these variables are the most relevant to the research to be described in this thesis.

1.2.2 Amnesia

Perhaps the most notable dissociations have been found with amnesic patients who have difficulty recalling information explicitly but perform relatively normally in tests of implicit memory. Some of the first studies to discover this preserved memorial ability in amnesic patients were performed by Warrington and Weiskrantz (1968; 1970). In their studies, amnesic subjects were instructed to try to memorise lists of words. Their subsequent performance in recall or recognition tests was severely impaired compared to non-amnesic control subjects. However, if they were required to identify degraded words or guess completions of three letter word stems, they showed similar levels of priming to controls. Further research with amnesic patients has shown this same pattern of results using implicit memory tests of word stem completion (Diamond & Rozin, 1984; Graf, Squire & Mandler. 1984; Squire, Shimamura & Graf, 1987); word fragment completion (Tulving, Hayman & MacDonald, 1991); perceptual identification (Warrington & Weiskrantz, 1974; Cermak, Chandler & Wolbarst, 1985; Cermak, Verfaellie, Milberg, Letourneau, & Blackford, 1991); and lexical decision (Glass & Butters, 1985; Gordon, 1988; Moscovitch 1982; 1985; Verfaellie, Cermak, Letourneau & Zuffante, 1991).

1.2.3 Age

It has generally been found that elderly subjects perform as well as young subjects on tests of word stem completion, word fragment completion, perceptual identification and lexical decision tests (e.g. Light & Singh, 1987; Mitchell, Brown & Murphy, 1990). The elderly's performance in perceptual implicit memory tests therefore differs from their performance in explicit memory tests of free recall, cued recall and recognition, which is usually impaired compared to young subjects (for recent reviews see Mitchell, 1993; Naito & Komatsu, 1993; Parkin, 1993).

This dissociation between implicit and explicit memory test performance also occurs at the lower end of the age scale. Whereas older children perform better than younger children in explicit memory tests, no age-related difference in children's implicit memory test performance has yet been found (Carroll, Byrne & Kirsner, 1985; Greenbaum & Graf, 1989; Naito, 1990; Parkin & Streete, 1988). For example, Naito (1990) compared performance of first to sixth grade school children and adults in word fragment completion and free recall. There was no age-related difference in performance in the perceptual implicit test compared to a significant age-related difference in the explicit test. Indeed, Parkin and Streete (1988) found that children as young as three years showed picture completion priming.

1.2.4 Levels of Processing

Another interesting dissociation between the results of perceptual implicit and explicit memory tests is that explicit memory tests typically show levels of processing effects (Craik & Lockhart, 1972; Craik & Tulving, 1975) but perceptual implicit memory tests do not. This dissociation was first discovered by Jacoby and Dallas (1981, Experiment 1). In their experiment, subjects were sequentially presented with a list of words, each of which was accompanied by a question. Some of these questions related to the physical properties of the word, e.g. *whether the word contained an E?*, whereas other questions related to the semantic meaning of the word, e.g. *whether it would fit into a particular sentence?* Half the subjects then performed a recognition test and half performed a perceptual identification test. In the recognition test there was the usual levels of processing effect with subjects recognising significantly more of the semantically encoded words than the physically encoded words. A different pattern of results occurred in the perceptual identification test - there was no significant difference in the identification of semantically and physically encoded words, with both types of encoding producing similar levels of priming above a baseline level of word identification. Similar results were found by Graf and Ryan (1990) and Hashtroudi, Ferguson, Rappold and Chrosniak (1988).

Unfortunately the results of the above levels of processing studies are confounded by methodological differences between the implicit and explicit tests. For example, different retrieval cues used in the implicit and explicit tests may have contributed to the dissociations. In this respect, dissociations have been found between different explicit memory tests such as free recall and recognition which differ in the cues presented at test (e.g. Tulving, 1983). To counteract this problem, the retrieval intentionality criterion was proposed by Schacter, *et al.* (1989). It was based on advice by Neely and Payne (1983) and Neely (1989) that any extraneous variables that might affect test performance should be held as constant as possible when comparing implicit and explicit memory tests. All features of the implicit and explicit tests being compared should therefore be as similar as possible, with only the test instructions differing between the tests.

A study which fulfilled the retrieval intentionality criterion when comparing levels of processing in implicit and explicit memory tests was performed by Graf and Mandler (1984). In this study, all the subjects received the same test sheet of three letter word stems. One group performed an explicit cued-recall test whereas the other group performed an implicit word stem completion test. The results showed a levels of processing effect in the explicit test (41 per cent recall following semantic processing compared to 8 per cent recall following non-semantic processing) but no levels of processing effect in the implicit test (23 per cent following semantic processing compared to 21 per cent following non-semantic processing). The results of this study showed that a levels of processing dissociation between the results of the implicit and explicit memory tests still occurred, even when all other features of the tests were held as similar as possible. Another study by Roediger, Weldon, Stadler and Reigler (1992) conformed to the retrieval intentional criterion and showed that explicit recall of words from fragmented cues showed the normal levels of processing effect but implicit word fragment completion did not.

However, recent reviews of the perceptual implicit memory literature have shown that many experiments show a slight, but often non-significant, levels of processing effect (Brown & Mitchell, 1994; Challis & Brodbeck, 1992). For example, Challis and Brodbeck reviewed the results of 35 experiments, including data from amnesic patients, together with results of their own studies. They concluded that small but ubiquitous levels of processing effects do occur in perceptual implicit memory tests. Their own experiments revealed that significant levels of processing effects in word fragment completion were more likely to occur with between-subjects designs, or when orienting tasks were performed on blocks of items in within-subjects designs.

A possible explanation for this slight levels of processing effect in perceptual implicit memory tests is that it reflects a small amount of contamination from explicit retrievel processes. Another explanation is that subjects may curtail their perceptual analysis of a word if they are continually performing a graphemic orienting task such as checking whether the word contains an E. The effect of this curtailment would be more apparent when the graphemic orienting task was performed on a block of words as found by Challis and Brodbeck. An experiment by Hayman and Jacoby (1989) tested this hypothesis by instigating an encoding manipulation to test whether the perceptual analysis of words was being curtailed during a graphemic orienting task. In a letter search task, subjects were informed of the target letter before or after an 83 msecs. presentation of the word. Their results supported the hypothesis as word identification priming was higher when the target letter was not known until after presentation of the word.

1.2.5 The Generation Effect

A variation of the levels of processing effect is the generation effect - that generating a word at study, e.g. HOT - C...., leads to better recall or recognition than simply reading the word (Slamecka & Graf, 1978). Jacoby and Dallas (1981, Experiment 2) investigated whether the generation effect also occurred in an implicit memory test. Subjects were either required to read words or to generate words from simple anagrams, e.g. the generated solution to the anagram *OHUES* is *HOUSE*. Half the subjects performed a recognition test and half performed a perceptual identification test. There was the usual generation effect in the recognition test with significantly more generated than read words recognised. Conversely, there was a reversed generation effect in the perceptual identification test with significantly more priming of read than generated words. This experiment therefore produced a double dissociation with the study manipulation of generating or reading words producing opposite effects in the implicit and explicit tests. This double dissociation was replicated by Jacoby (1983a). A further study by Java (1994) employed a read or generate study manipulation similar to that used by Jacoby and Dallas. In addition, her study conformed to the retrieval intentionality criterion by using the same test sheet of three letter word stems for the implicit and explicit tests. She too found a double dissociation with a normal generation effect in the explicit test and a reversed generation effect in the implicit test.

Although the above pattern usually occurs, it has been found that, under certain circumstances, perceptual priming is higher for generated than read words (Masson & MacLeod, 1992; Toth & Hunt, 1990). For example, Gardiner (1988) found higher word fragment completion priming for generated words than for read words, but only when the same fragments were used at study and at test. When different fragments were used, priming was equal for read and generated words (see also Gardiner, 1989; Gardiner, Dawson & Sutton, 1989).

1.2.6 Modality

The results of Gardiner's (1988) study suggest that perceptual priming is sensitive to the perceptual form of target items. Indeed a further dissociation between implicit and explicit memory tests is that perceptual priming has been found to be sensitive to modality changes whereas explicit memory is relatively unaffected by switching modalities between study and test. For example, auditory encoding has been found to reduce or eliminate priming in tests of stem completion (Graf, Shimamura & Squire, 1985), fragment completion (Donnelly, 1988; reported in Roediger & McDermott, 1993; Roediger & Blaxton, 1987a), perceptual identification (Hashtroudi *et al.*, 1988; Jacoby & Dallas, 1981), and lexical decision (Scarborough, Cortese & Scarborough, 1977). In addition, little or no perceptual priming occurs in bilingual studies in which subjects study words in one language and are tested with the same words in a different language (Durgunoglu & Roediger, 1987; Gerard & Scarborough, 1989; Kirsner, Smith, Lockhart, King & Jain, 1984; Watkins & Peynircioglu, 1983).

However, perceptual priming is not entirely modality specific since data-driven tests usually produce some priming, even when there is no perceptual overlap between encoding and test. For example, pictures, auditory word encoding and words generated conceptually have all produced word fragment completion priming and have sometimes produced priming on perceptual identification (Bassili, Smith & MacLeod, 1989; Blaxton, 1989; Jacoby & Dallas, 1981; Masson & MacLeod, 1992; Weldon 1991; Weldon & Roediger, 1987).

There is also some controversy about the degree of hyperspecificity of perceptual priming. Some studies have found reduced priming when words are switched from upper to lower case between study and test (Roediger & Blaxton, 1987a, Scarborough *et al.* 1977) and even when the type font is altered (Jacoby & Hayman, 1987; Masson, 1986) but other studies have failed to find any effect of change in the surface features of stimulus words (e.g. Carr, Brown & Charalambous, 1989; Clarke & Morton, 1983; Feustel, Shriffrin & Salasoo, 1983; Tardif & Craik, 1989). An explanation for these differing results was proposed by Graf and Ryan (1990). They found that priming was reduced when the type font of words was altered between study and test, but only when the words were rated for readability, not when they were rated for pleasantness at encoding. They concluded that surface feature encoding was sensitive to perceptual priming hyperspecificity but semantic encoding was not. A further explanation was proposed by Marsolek, Kosslyn & Squire (1992). They found that changing the case of words between study and test reduced priming when test stems were presented to the left visual field but not when they were presented to the right visual field. This result indicates that the left and right visual fields both contribute to priming but that the contribution of the left visual field is more hyperspecific than that of the right.

1.2.7 Retention Interval

Another variable that has been found to produce dissociations between explicit and perceptual implicit memory tests is that of retention interval. Interest in the durability of perceptual priming was first aroused when Jacoby and Dallas (1981, Experiment 5) found that priming in word identification did not drop significantly over a 24 hour time interval. (The proportion correct fell from .73 in an immediate test, to .72 after 15 minutes, to .67 after 24 hours.) In comparison, recognition memory dropped significantly over these same retention intervals. This finding was replicated and extended by Tulving, Schacter and Stark (1982) who found only a 3 per cent drop in word fragment completion over a one week interval compared to a sharp drop in recognition memory. However, since the level of priming, after subtraction of baseline completion, is usually low, a small overall drop in priming represents a relatively high proportional drop. For example, the drop of 3 per cent found by Tulving *et al.* (1982) represents a proportional drop of 17 per cent. Irrespective of whether absolute or proportional priming levels are compared, a high proportion of more recent research has shown significant losses in word fragment completion over time (e.g. Chandler, 1983; reported in Sloman, Hayman, Ohta, Law & Tulving, 1988; Light, Singh & Capps, 1986; Roediger & Blaxton, 1987a; Sloman *et al.*, 1988).

In the study by Sloman *et al.* (Experiment 2), although word fragment completion was found to decrease over time, significant priming was still found 16 months after encoding. However, this effect might have been attributable to an effortful component of the task, since subjects were informed of the relationship between study and test and were not instructed to refrain from explicitly trying to remember. In addition, they had been tested in the same manner on five previous occasions, at intervals of 18 mins, 1 week, 5 weeks, 12 weeks and 23 weeks, using word fragments relating to other words from the study phase. Target words from the study phase could have been explicitly retrieved, but disregarded, during any or all these sessions, especially as subjects in the final (16 month) test were encouraged to imagine themselves back in the classroom situation in which they had taken the previous tests to try to reinstate the contextual elements of those tests.

Priming in word stem completion was thought to be less long-lasting than priming in word fragment completion. Graf and Mandler (1984), for example, found word stem completion priming disappeared after a two hour retention interval. However, it has since transpired that different test materials may be responsible for the time differences in priming retention between word stem and word fragment completion. Typically, word stem completion tests use short, familiar words whereas word fragment completion tests use long, less familiar words. When word length and familiarity were controlled by using the same test materials, the time course of loss of priming was similar for word fragment and word stem completion (Roediger *et al.*, 1992).

Further evidence that the time course of priming in word stem and word fragment completion is comparable was provided by Squire, Shimamura and Graf (1987). They found that amnesic and control subjects performed similarly in word stem completion, with priming dissipating within two hours, but differently in word fragment completion with amnesic subjects again showing no priming after two hours but control subjects still showing priming after four days. In addition, control subjects showed longer lasting priming effects in word fragment completion after semantic encoding than after non-semantic encoding. These results led Squire *et al.* to propose that any long-lasting priming effects found in word fragment completion are attributable to contamination by explicit retrieval.

1.2.8 Interference

Another possible source of a dissociation between perceptual implicit and explicit memory tests is the effect of interference. Proactive and retroactive interference have been found to decrease performance in many explicit memory tests (e.g. Barnes & Underwood, 1959; Postman & Stark, 1969). Contrarily, Jacoby (1983b, Experiment 4) found no evidence for either type of interference when he tested subjects on the perceptual implicit memory test of word identification using five different word lists on five successive days. However, there was no explicit control test in this study. An experiment which did include an explicit control test when studying retroactive interference in a word fragment completion test was performed by Sloman *et al.* (1988, Experiment 5). Subjects studied 25 words and then performed a verbal or non-verbal interpolated task before performing a word fragment completion test or a recognition test. Unfortunately, the results of this study were inconclusive as there was little evidence of retroactive interference in the word fragment completion test or in the forced-choice recognition test. Two more experiments which included explicit control tasks when studying retroactive interference were performed by Nelson, Keelean and Negrao (1989; Experiments 2 and 3). They found similar levels of retroactive interference in implicit word ending completion and explicit word ending cued recall. Interestingly, only interfering words which were visually or phonologically similar to target words produced retroactive interference; semantic similarity had no effect in either the implicit or explicit tests.

The situation as to whether perceptual implicit memory tests are susceptible to the same interference effects as explicit memory tests is therefore uncertain at the present time.

1.3 Conceptual Implicit Memory Tests

1.3.1 Introduction

According to Roediger and McDermott (1993), the main conceptual implicit memory tests are category instance generation, word association, and answering general knowledge questions. In category instance generation, subjects are required to generate a number of examples of a category, e.g.

ANIMALS - ?. Priming occurs when previously seen words are produced as examples of the category more often than unseen words. In word association, subjects are required to produce the first word that comes into their heads to cue words, e.g. *TUSK - ?*. Priming occurs when previously seen words are produced more often than unseen words. Similarly, when answering general knowledge questions, e.g. *What animal did Hannibal use to help him cross the Alps in his attack on Rome?*, priming occurs if correct responses are higher when the answers are words which have been seen previously.

In addition to these three types of conceptual implicit memory test, there are other implicit tests which involve conceptual processing. For example, in a modification of the word stem completion test, Graf and Schacter (1985) devised an implicit memory test that measured newly acquired associations. During the study phase subjects were presented with unrelated word pairs, e.g. *SHIP - CASTLE*. In a subsequent word stem completion test, word stems were presented in the same context, e.g. *SHIP - CAS.....*, or in a different context, e.g. *OFFICE - CAS......* Priming occurred when more same context than different context word stems were completed with target words. Another implicit memory test which involves conceptual processing is free association to single words from previously studied associated word pairs, e.g. *BEE - WASP*. Free association priming occurs when subjects associate with previously studied words more often than with unstudied words.

There is some disagreement in the literature as to whether or not dissociations occur between performance in conceptual implicit and explicit memory tests. To investigate this controversy, the following sections examine whether or not dissociations occur in those variables shown to have produced dissociations between perceptual implicit and explicit memory tests in Section 1.2. Again, more attention has been paid to levels of processing and retention interval as these variables are the most relevant to the research to be described in the thesis.

1.3.2 Amnesia

Many studies have found that amnesic patients show intact conceptual priming compared to impaired performance when their memory is tested explicitly (Gardner, Boller, Moreines & Butters, 1973; Graf, Shimamura & Squire, 1985, Experiment 2; Schacter, 1985; Shimamura & Squire, 1984). For example, Graf *et al.* found amnesic patients showed normal priming in a conceptual implicit memory test of category instance generation, even though they were severely deficient in a free recall test; and Shimamura and Squire, Experiment 4, found that amnesic patients showed normal priming in a word association test when they were required to free associate to words that were semantically related to previously studied words.

In Experiment 3 of the same study, Shimamura and Squire found amnesic patients showed normal priming when asked to free associate to the first word of previously seen word pairs, e.g. *TABLE - CHAIR*, despite these same patients being severely impaired at learning unrelated word pairs in Experiment 1. This finding was similar to the results of paired-associate learning experiments in which amnesic Korsakoff patients showed normal or close to normal learning for pairs of highly associated words (Cutting, 1978; Winocur & Kinsbourne, 1978; Winocur & Weiskrantz, 1976), despite patients with this syndrome being severely impaired at learning pairs of unrelated words (Jones, 1974). Cutting (1978) qualified this difference by showing that amnesic patients only showed normal learning when response words were the most common associates to stimulus words and when highly related word pairs were encoded in blocked trials. When response words were related, but not the most common associates to stimulus words, then amnesic subjects were impaired. They were also impaired in mixed trials of highly-related and less well related word pairs.

Also in accordance with this research, amnesic patients have been found to be impaired relative to normal controls on priming of newly acquired associations. For example, Schacter and Graf (1986a) found that severely amnesic patients did not exhibit priming of new associations; Cermak, Bleich and Blackford (1988) found that Korsakoff patients did not show any evidence of priming of new associations; and Mayes and Gooding (1989) showed that a group of seventeen mixed aetiology amnesic patients failed to show evidence of priming of new associations, even though some subjects within the group showed priming within the normal range.

1.3.3 Age

Few studies have examined whether elderly subjects show preserved priming in conceptual implicit memory tests. A study by Light and Albertson (1989), found comparable priming effects for young and elderly subjects in a category instance generation test. Contrary to this finding, a study, by Grober, Gitlin, Bang and Buschke (1992), found that elderly subjects produced less priming than young subjects in a category association test in which the category names were presented with the target words at encoding and also used to cue the previously associated word at test. These differential results may be attributable to differences in the test procedures. In the first study, subjects were required to generate eight category instances whereas only one category instance was required in the second study. In addition, the implicit test was always performed after the explicit test in the second study. These differences may have rendered the second study more susceptible than the first to explicit contamination.

The results of two further studies agreed with those of Light and Albertson. Isingrini, Vazou and Leroy (1995) found that young and elderly subjects showed similar levels of priming in category instance generation whereas elderly subjects were impaired in a cued recall test which used the same test cues as the implicit test. In addition, the cued recall test, but not the category instance generation test, was detrimentally affected by dividing attention at encoding. Java (1996) found no effect of age in a conceptual implicit word association test compared to a significant effect in a comparable explicit test. However, she did find an effect of age when subjects were required to specify which of their own implicitly completed responses they recognised from the study list. The young subjects failed to recognise 36% of their own responses whereas the older subjects failed to recognise 91%.

An interesting set of experiments by Howard, Fry and Brune (1991) found age differences in implicit memory for newly acquired associations (see e.g. Graf & Schacter, 1985) but only when elderly subjects encoded the new associations under less than optimal study conditions (Experiments 1 and 3). However, in Experiment 2, implicit age differences disappeared when elderly subjects encoded the pairs of words by creating their own sentences, and were given as much time as they wanted for this task. Explicit age differences occurred in all three experiments, irrespective of the study conditions used.

To date, no known studies have investigated whether age-related differences occur in children's performance in conceptual implicit memory tests.

1.3.4 Levels of Processing

The preceding two sections have demonstrated that amnesic and elderly subjects generally show normal priming in conceptual implicit tests. Their performance in conceptual implicit memory tests is therefore similar to their performance in perceptual implicit memory tests. Contrary to these findings, the effects of levels of processing appear to differ between perceptual and conceptual implicit memory tests. Whereas significant levels of processing effects do not usually occur in perceptual priming (see Section 1.2.4) it is generally accepted that they do occur in conceptual priming. For example, Hamann (1990; Experiment 1) found levels of processing effects in two conceptual implicit memory tests - answering general knowledge questions and category instance generation. In Experiment 2, Hamann again found a levels of processing effect in category instance generation.

In both these studies, two thirds of the test items related to target words. With such a high proportion of studied items at test, it is doubtful whether subjects remained unaware of the relationship between study and test items. It is therefore possible that intentional retrieval contributed to the levels of processing effects found by Hamann. It is also possible that word analysis was curtailed in the graphemic orienting task which involved comparing vowels from successive study list words using a blocked within-subjects design (see Challis and Brodbeck, 1992; Hayman and Jacoby, 1989; Section 1.2.4 of this thesis). Although Graf and Mandler (1984) had not found a levels of processing effect in word stem completion using this graphemic orienting task, curtailment of word analysis would have more effect on conceptual than perceptual implicit memory tests because conceptual implicit tests require the meaning of the word to be processed to a greater extent than perceptual implicit tests.

A further study which found a levels of processing effect in a category association task was performed by Srinivas and Roediger (1990; Experiment 2). In this experiment, similar to Hamann's experiments, approximately two thirds of the test items related to target words. Also, curtailment of word processing could have occurred in the blocked graphemic orienting task in which subjects were required to specify how many consonants each word contained. Supporting this explanation, a levels of processing effect occurred for target items encoded visually, but not for target items encoded auditorily. The reason for this difference may be that it is necessary for auditorily presented words to be heard before performance of either the semantic or the graphemic task, whereas there is no necessity for visually presented words to be read before performance of the graphemic task. For this reason, curtailment of processing would only occur in visually presented words.

Thapar and Greene (1994) investigated the explanation that curtailment of processing in graphemic tasks may be responsible for levels of processing effects in implicit tests. They measured levels of processing effects in a perceptual implicit memory test (perceptual identification) and a conceptual implicit memory test (answering general knowledge questions) using lists in which graphemic and semantic orienting tasks were either blocked or mixed. Their results were surprisingly similar for the two types of implicit memory test as both showed interactions between list design and levels of processing; each task showed significant levels of processing effects with blocked lists but not with mixed lists. These results differed from the results of perceptual and conceptual explicit memory tests which consistently showed significant levels of processing effects, irrespective of list design.

Further evidence for a levels of processing dissociation between conceptual implicit and explicit memory tests was found by Schacter and McGlynn (1989, Experiment 3). Performance in a conceptual implicit memory test involving free association to the first word of strongly related paired associates (e.g. *TABLE - CHAIR*), was independent of a levels of processing manipulation which significantly affected explicit cued recall. These stimuli are assumed to have a "unitised" memory representation because they function as integrated units. It has been proposed that activation of unitised stimuli occurs automatically during the study phase and priming of unitised stimuli is not therefore susceptible to levels of processing effects (Diamond & Rozin, 1984; Graf & Mandler, 1984). In Experiment 1, Schacter and McGlynn found that common idioms (e.g *SOUR - GRAPES*) were susceptible to a levels of processing manipulation. Subjects who were presented with the common idioms within a definition, (e.g. *"Complaints about failure by an ungracious loser are SOUR GRAPES"*) showed significantly higher priming in a free association test than subjects who were required to count vowels and consonants in the common idioms. However, this levels of processing difference may have been produced by subjects not being familiar with the meaning of all the common idioms because two other study tasks - reading the common idioms within non-explanatory sentences and generating synonyms to the common idioms - which both entailed semantic processing but did not provide subjects with the meaning of the common idioms - did not produce priming significantly above the vowel and consonant counting task.

In Experiment 4 in the same study, Schacter and McGlynn found that implicit memory for non-unitised word pairs (e.g. *TABLE - KEY*) was susceptible to a levels of processing study manipulation. Levels of processing effects were also found by Graf and Schacter (1985; 1989) and Schacter and Graf (1986b; 1989) when they investigated implicit memory for newly acquired associations of previously unrelated words. In these experiments subjects only showed priming when the two words had been semantically linked together at encoding. If the words were semantically encoded separately, or graphemically encoded together, no priming occurred. It would therefore appear that priming of new associations is susceptible to levels of processing effects. This is substantiated by the previously reported finding that amnesic patients are impaired relative to controls in priming of new associations (Cermak, Bleich & Blackford, 1988; Mayes & Gooding, 1989; Schacter & Graf, 1986a).

1.3.5 Generation Effect

Similar to levels of processing effects, it is generally accepted that perceptual and conceptual implicit memory tests differ in their susceptibility to the generation effect since a number of studies have found a generation effect in conceptual priming even though the effect does not usually occur in perceptual priming (see Section 1.2.5). For example, Blaxton (1989, Experiment 1) found a generation effect in the conceptual implicit memory test of answering general knowledge questions. Subjects answered more questions when they had previously generated the target word than when they had read the word, either in context or without context. However, a close scrutiny of the experimental procedure throws some doubt on the validity of this finding for two reasons.

First, subjects were initially instructed that they would be performing a memory test. Since all the encoded words featured as answers to the general knowledge questions, it is doubtful that any subjects remained unaware of the relationship between study and test. When they were unsure of the answer to a question, it would have been advantageous for them to think back to the study phase to try to recall the answer. Such explicit retrieval would explain why a generation effect occurred in this study. Second, only 12 subjects answered general knowledge questions. Half of these subjects encoded one list of 63 target words and half of them encoded a second list. In addition, each subject encoded 21 target words by generating the answer, 21 by reading the word in context and 21 by reading the word without any context. Blaxton states that the target words were fully counterbalanced across each condition, but this would only result in two subjects per cell. The power of such an analysis must be suspect.

Nevertheless, Tajika and Newmann (1992; Experiment 1) replicated Blaxton's results and found the same generation effect in the conceptual implicit memory test of answering general knowledge questions. However, in Experiment 2, they reduced ambiguity in the test instructions by asking subjects to "produce the first words to come to mind and write them down on the sheets of paper, even if they were words they had studied earlier" (p.80). In this experiment the generation effect disappeared. They argued that the generation effect in answering general knowledge questions resulted from ambiguity in the test instructions. This explanation is in accordance with the explanation that the generation effect occurred because subjects were using explicit strategies to perform the test.

Using similarly ambiguous test instructions, Blaxton (1992, Experiments 1 and 2) again found control subjects showed that generation produced more priming than reading when answering general knowledge questions. However, she did not find this generation advantage for epileptic memory-impaired patients in Experiment 1; nor for epileptic memory-impaired patients with left temporal lobe foci in Experiment 2. Her failure to find a generate advantage in the memory-impaired patients may indicate that the generate advantage is attributable to contamination of the test by intentional retrieval.

A generation effect was also found by Srinivas and Roediger (1990, Experiment 1) in a conceptual implicit category generation task. Again, subjects were initially instructed that they might be performing a memory test. Since categories relating to all thirty encoded target words appeared at test, it is again doubtful whether subjects remained unaware of the relationship between study and test. When seeking examples of a category they may have thought back to the study phase for inspiration. Such explicit retrieval would explain why a generation effect occurred. In the same experiment, anagram completion did not show a significant read superiority effect. (Anagram completion is usually classified as a data driven perceptual implicit memory task in which a read superiority effect would have been expected to occur.) It is possible that explicit retrieval may have offset the expected read superiority effect in this task also. Another possible reason why a generation effect may have occurred in the category generation test in the above study is that there was a ten minute delay between study and test spent performing intervening tasks. Generating a word at study may produce longer lasting activation than reading the word. This longer lasting activation might have produced a generation effect in the implicit test.

1.3.6 Modality

Although relatively few studies have investigated modality effects in conceptual implicit memory tests, those studies that have been performed have not found any modality effects. For example, neither Blaxton (1989) nor Challis & Sidhu (1993) found differences in priming between visual and auditory encoding of stimulus items using the conceptual implicit memory test of answering general knowledge questions. In addition, Srinivas and Roediger (1990, Experiment 2) did not find modality effects in category instance generation priming. These results are not surprising since there is no perceptual overlap between study and test in either of these tasks.

Interestingly, in the same experiment, Srinivas and Roediger did not find modality effects in anagram solution or word fragment completion priming following blocked graphemic encoding, although there were modality effects in both these tasks following blocked semantic encoding with visually encoded stimuli producing more priming than auditorily encoded stimuli. The lack of modality effects following graphemic encoding in these perceptual implicit memory tasks in which there were perceptual overlaps between study and test may be more manifestations of curtailed processing during graphemic encoding. Such curtailed processing would be more apparent during visual encoding, because reading stimulus words would not be necessary. During auditory encoding, irrespective of the encoding manipulation, stimulus words would be heard.

1.3.7 Retention Interval

Only three known studies have included retention interval as a variable in tasks of conceptual implicit memory. The first, by Shimamura and Squire (1984, Experiment 4) found amnesic patients and alcoholic controls showed similar levels of priming in an immediate word association test. Within two hours, priming for both groups had fallen to such an extent that it was not significantly different from baseline performance. In the same study, Experiments 2a and 2b were not specifically designed as conceptual implicit memory tests but it is probable that the amnesic patients performed them implicitly as their explicit memory was severely impaired. In Experiment 2a amnesic patients' performance in a paired-associate learning task fell sharply between 0 and 10 minutes retention interval and then more gradually until, after two hours, priming was not significantly different from baseline. Alcoholic control subjects' performance also fell sharply between 0 and 10 minutes but did not deteriorate further within the two hour interval. In Experiment 2b, performance of amnesic patients and alcoholic controls did not fall between 0 and 10 minutes, perhaps because subjects were given a word stem completion test before each paired-associate test, thereby delaying the immediate test. Nevertheless, Experiment 2b replicated Experiment 2a in that performance of amnesic patients fell to chance within two hours whereas alcoholic control subjects' performance remained high.

The second study, by Hamann (1990, Experiment 2), found category instance generation priming declined rapidly within a retention interval of 10 to 90 minutes. In addition, he found that category instance generation priming of graphemically encoded words had dropped to baseline within 30 minutes; priming of semantically encoded words endured longer but had also dropped to baseline within 90 minutes. This difference in retention interval between priming of graphemically and semantically encoded words may be attributable to contamination by intentional retrieval and/or curtailed word analysis in the graphemic task. (These were the explanations proposed in Section 1.3.4 above to account for the higher priming of semantically encoded than graphemically encoded words in his study.)

The third study, by Rappold and Hashtroudi (1991, Experiment 4), compared priming in category instance generation at retention intervals of 0 minutes, 45 minutes and 24 hours. Blocked or random encoding of category instances (36 items comprising six category instances from six different categories) was also included as a variable. The results of this experiment were interesting because blocked encoding produced more priming than random encoding in the immediate test but there was no significant difference between them after 45 minutes and 24 hours. It would therefore appear that organisation at encoding enhanced immediate priming only.

Since these are the only known studies which have measured the retention interval of priming in conceptual implicit memory tasks, there is clearly a need for more research in this area.

1.3.8 Interference

Another area in which more research is required concerns interference effects in conceptual implicit memory tasks. Graf and Schacter (1987, Experiment 1) found that implicit memory for newly acquired associations was unaffected by an A-B, A-C proactive or retroactive interference manipulation, whereas the explicit test of letter-cued recall was detrimentally affected. In Experiment 2 priming of newly acquired associations was unaffected by retroactive interference compared with a pair-matching recognition test which was. Conversely, Mayes, Pickering and Fairbairn (1987) showed that control subjects were more susceptible to an A-B, A-C proactive interference manipulation, when they free associated to the first word of previously studied word pairs than when they performed a comparable cued-recall test. In the same experiment amnesic subjects showed proactive interference in both the implicit and explicit tasks, indicating that they were using implicit memory for both tasks.

The difference between these studies may be explained by Warrington and Weiskrantz's (1974; 1978) proposal that interference in amnesic patients' priming only develops after more than one A-C trial. It is possible that this proviso also applies to non-amnesic subjects. In Graf and Schacter's study there was only one A-C trial whereas in Mayes *et al.*'s study there were five.

1.4 The Relationship between Perceptual and Conceptual Implicit Memory Tests

1.4.1 Introduction

Sections 1.2 and 1.3 summarised current research comparing the results of implicit and explicit memory tests in relation to amnesia, age, levels of processing, the generation effect, modality, retention interval and interference. For clarity's sake, studies relating to perceptual implicit memory tasks were reported separately from studies relating to conceptual implicit memory tasks. However, it is also useful to compare performance between perceptual and conceptual implicit memory tests. Hence there follows a brief comparison of perceptual and conceptual implicit memory test performance, based on a summary of the findings of the above studies.

1.4.2 Amnesia

Amnesic patients generally demonstrated preserved priming in both perceptual and conceptual implicit memory tests. A notable exception, however, was that they were impaired in conceptual implicit memory tests involving priming of newly acquired associations (see e.g. Cermak, Bleich & Blackford, 1988; Schacter & Graf, 1986a).

1.4.3 Age

Most studies showed that elderly people demonstrated intact priming in both perceptual and conceptual memory tasks. The one exception was in a conceptual implicit test (Grober, Gitlin, Bang & Buschke, 1992) in which explicit strategies may have contributed to different priming between young and elderly subjects.

It is not possible to compare children's performance in perceptual and conceptual implicit memory tests as no known studies have investigated children's conceptual implicit memory.

1.4.4 Levels of Processing

The situation with respect to levels of processing is complicated. In perceptual implicit memory tests, although it was once thought that there was no levels of processing effect, more recent research has shown that a slight, non-significant effect usually occurs. Conversely, in conceptual implicit memory tests, it is generally agreed that there is a significant levels of processing effect (Hamann, 1990; Srinivas & Roediger, 1990). This effect may well be genuine. However, contamination by explicit retrieval has been proposed as one explanation for the trend towards a levels of processing effect in perceptual implicit tests and significant levels of processing effects in conceptual implicit tests. Another explanation is that curtailment of processing in the graphemic orienting task is responsible (Challis & Brodbeck, 1992; Hayman & Jacoby, 1989; Thapar & Greene, 1994).

Notwithstanding, there appears to be a genuine levels of processing effect in implicit memory tasks involving newly acquired associations. The acquisition of newly-acquired associations has resulted in increased word stem completion, (see e.g. Graf & Schacter, 1985) and increased word association (Schacter & McGlynn, 1989, Experiment 4). Since word stem completion is usually classified as a perceptual implicit memory task and word association as a conceptual implicit memory task, a significant levels of processing effect involving newly acquired associations does not necessarily differentiate between the two types of test. Newly-acquired associations appear to be a necessary prerequisite for a levels of processing effect as, in the latter study, there was no levels of processing effect in word association when unitised word pairs were used as stimuli.

1.4.5 Generation Effect

There also appears to be a difference between perceptual and conceptual implicit memory tests with respect to generation effects. Whereas reading usually produces more perceptual priming, generating usually produces more conceptual priming. It has even been suggested by Blaxton (1989), Roediger and Blaxton (1987b) and Roediger, Weldon and Challis (1989) that the generate/read manipulation may be used as a criterion to determine whether a test is perceptually or conceptually driven. Since perceptually driven tests are thought to rely on bottom-up processing they should benefit more from reading the target words at encoding than from generating the words. Conversely, conceptually driven tests would be expected to benefit more from generating the target words from conceptual cues than from simply reading the words. It is also possible that longer lasting activation may produce a generation effect in conceptual implicit memory tests. However, there are comparatively few studies investigating the generation effect in conceptual implicit memory tasks and some of the generate superiority found in these studies may be explained by explicit contamination.

1.4.6 Modality

It has generally been found that perceptual implicit memory tests are sensitive to modality switches between study and test (e.g. Donnelly, 1988; Graf, Shimamura & Squire, 1985) whereas conceptual implicit memory tests are not (Blaxton, 1989; Challis & Sidhu, 1993; Srinivas & Roediger, 1990). However, this difference should be qualified by adding that perceptual implicit memory tests usually show some cross-modality priming (see e.g. Weldon & Barrett, 1993). Since there is no perceptual overlap between study and test in most conceptual memory tasks, it is not surprising that no modality effects occur. In this connection, it would be interesting to investigate whether modality effects occur when there is some perceptual overlap between study and test, e.g. priming of newly acquired associations.

1.4.7 Retention Interval

It is difficult to compare the time course of priming in perceptual and conceptual implicit memory tests for two reasons: first, because the results of studies investigating the duration of priming in perceptual implicit memory tests differ widely in their results; and second, because there are only three known studies investigating the duration of priming in conceptual implicit memory tests. From the best analysis of the results, priming in perceptual implicit tasks appears to last longer than priming in conceptual implicit tasks. However, this is only a tentative conclusion and more research is required to clarify this issue.

1.4.8 Interference

The situation with respect to interference effects in perceptual and conceptual implicit memory tests is also confusing. In perceptual implicit memory tests, there is a lack of agreement between the studies as to whether interference effects occur. Studies which did not find interference effects either did not include explicit control tests (Jacoby, 1983b, Experiment 4), or failed to find interference effects in the explicit control test (Sloman *et al.* 1988, Experiment 5). Two experiments which found interference (Nelson, Keelean & Negrao, 1989, Experiments 2 and 3) found similar levels and type of interference in a comparable explicit test. In each test, perceptual or phonological similarity caused interference, not semantic similarity.

There are also divergent results in conceptual implicit memory tests. Graf and Schacter (1987, Experiments 1 and 2) found that implicit memory for newly acquired associations was unaffected by interference whereas the results of comparable explicit tests were. Conversely, Mayes, *et al.* (1987) showed that control subjects were more susceptible to interference in a word association test than they were in a cued-recall test. Since current research is unclear as to whether interference affects either perceptual or conceptual implicit memory tests, the only conclusion that may be drawn is that both types of test are similar in the variability of the findings.

1.5 Theoretical explanations for dissociations between explicit and implicit memory tests

Sections 1.2 and 1.3 examined dissociations and similarities between implicit and explicit memory tests and Section 1.4 examined dissociations and similarities between perceptual and conceptual implicit memory tests. Current theoretical explanations for these findings fall into two main groups: those which are based on a "systems" standpoint that dissociations between implicit and explicit memory tests reflect retrieval from different memory systems (see e.g. Schacter & Tulving, 1994; Squire, 1992a; Tulving, 1985); or those which are based on a "processing" standpoint that these dissociations reflect different degrees of overlap between encoding and test processes within a unitary memory system (see e.g. Graf & Mandler, 1984; Jacoby, 1983a; Roediger & Srinivas, 1994). Theories relating to each of these standpoints are described below.

1.5.1 Multiple Memory Systems

Theoretical explanations which are based on a "systems" standpoint include dual systems theories such as the distinction between "procedural" vs.

"declarative" memory systems (e.g. Squire, 1992a). According to this theory, procedural memory is concerned with task performance and functions at a nonconscious level whereas declarative memory is concerned with memory for facts and events and is available to consciousness. A simple way of classifying the difference between these systems is that "knowing how" relates to procedural memory whereas "knowing that" relates to declarative memory.

This theory is able to explain why amnesic patients, who have difficulty recalling information explicitly, are able to perform relatively normally in implicit memory tests (see e.g. Warrington & Weiskrantz, 1968; 1970; Sections 1.2.2 and 1.3.2), and why elderly subjects, who are impaired compared to young subjects on explicit memory tests, also perform relatively normally in implicit memory tests (see e.g. Light & Singh, 1987; Sections 1.2.3, 1.3.3.). According to this theory, implicit memory test performance is attributable to the procedural memory system, which is spared in amnesia and old age, whereas recalling information explicitly is attributable to the declarative memory system, which is impaired. However, the theory does not adequately explain why amnesic patients are impaired compared to controls in implicit memory tasks which involve learning new associations (see e.g. Mayes & Gooding, 1989; Schacter & Graf. 1986a); nor why perceptual and conceptual implicit memory tasks respond differently to the levels of processing effect (see e.g. Graf & Mandler, 1984; Hamann, 1990; but see Section 1.3.4), the generation effect (see e.g. Blaxton, 1989; Jacoby & Dallas, 1981; but see

Section 1.3.5) and the modality effect (see e.g. Graf, Shimamura & Squire, 1985; Srinivas & Roediger, 1990).

To account for all these factors, it has been found necessary to propose more than two memory systems. According to Schacter and Tulving (1994) "... a memory system is defined in terms of its brain mechanisms, the kind of information it processes, and the principles of its operation" (p.13). In the multiple memory systems theory, they have initially proposed five different systems: procedural memory, perceptual representation memory, working memory, semantic memory and episodic memory.

Procedural memory is described as a vast, mainly unexplored memory system responsible for motor and cognitive skills, simple conditioning and simple associative learning. These skills and associations are mainly acquired by gradual, incremental learning and are performed automatically. Evidence that procedural memory operates in a non-cognitive manner is provided by converging dissociations between procedural and other memory systems in amnesic patients (e.g. Cohen & Squire, 1980; Moscovitch, 1982), demented patients (Butters, Heindel & Salmon, 1990), and normal subjects (e.g. Schwartz & Hashtroudi, 1991). With reference to the brain mechanisms involved in the procedural memory system, research with patients suffering from Huntington's disease has found that the learning of motor skills is dependent upon unimpaired basal ganglia (Butters, Heindel & Salmon, 1990). This conclusion is complimentary to the animal research finding that habit learning involves a corticostriatal circuit (Mishkin, Malamut & Bachevalier, 1984; Packard, Hirsh & White, 1989).

The perceptual representation system (PRS) is hypothesised to contain four sub-systems - visual and auditory word forms, structural descriptions and face recognition units. These sub-systems are influential in identifying words, objects and faces. They operate pre-semantically and are involved in the non-conscious priming effects found in perceptual implicit memory tests. In addition, according to Schacter (1994), "the outputs of PRS sub-systems can serve as inputs to episodic memory..... Whether or not the outputs of particular PRS sub-systems are "selected" for representation in the episodic trace likely depends on a variety of factors that guide encoding processes at any particular moment." (p.257). Evidence for the PRS comes from two sources: dissociations between perceptual implicit and explicit memory tests, examples of which are described in Section 1.2; and neuropsychological research on patients with lexical and object processing impairments showing relatively intact access to perceptual and structural knowledge compared to severely impaired semantic knowledge (Schacter, 1990).

Information as to the brain structures involved in the PRS is obtained from three main sources. First, by examining patients with agnosia, dyslexia and dementia, to determine the location of the perceptual deficits associated with these conditions. This research has shown that various structures in the posterior neocortex are implicated. For example, visual word form deficits appear to be associated with left extrastriate, occipital cortex lesions (Warrington & Shallice, 1980); whereas auditory word form deficits have been found to be associated with left, superior posterior temporal lesions (Kohn & Friedman, 1986; Saffran & Marin, 1977). Second, by determining the brain structures which are not integral to the PRS by examining patient groups suffering from various medical conditions which show intact perceptually based priming but impaired explicit memory. For example, amnesic patients with damage to the hippocampus, medial temporal lobes and related limbic structures show normal perceptually based priming (Moscovitch, Vriezen & Goshen-Gottstein, 1993; Shimamura, 1986; Squire, 1992b). Similarly, patients suffering from Parkinson's and Huntington's disease, which affect basal ganglia and the frontal cortex, show preserved perceptually based priming (Butters, Heindel, & Salmon, 1990; Heindel, Salmon, Shults, Walicke & Butters, 1989). Third, by using positron emission tomography (PET) studies. Findings have shown evidence of a visual word form system in the left extrastriate, occipital cortex (Petersen, Fox, Synder & Raichle, 1990). However, a PET study using the subtraction technique to investigate word stem completion priming found reduced activation in the right, not the left, extrastriate, occipital cortex (Petersen, Fox, Posner, Mintun & Raichle, 1989).

Working memory is described by Baddeley (1981) as consisting of three sub-systems - a central executive, a visuo-spatial sketchpad and a phonological loop. It is concerned with maintaining information for brief periods and has links with long-term memory systems. Although evidence supporting a central executive and visuo-spatial scratchpad is scarce, there is considerable evidence that there is a phonological or auditory loop which is separate from other long-term memory systems. For example, Warrington and Shallice have published a number of detailed studies of their subject, KF, who had a selective impairment in his ability to repeat auditorily presented words (Warrington & Shallice, 1969; Shallice & Warrington, 1970; 1977). The brain structure implicated in KF's impairment, and in similar impairments of JB and WH, was the left inferior parietal lobe (Warrington, Logue & Pratt, 1971).

Semantic memory is thought to contain a person's factual knowledge about the world whereas episodic memory is concerned with personally experienced events. There is some dispute as to whether semantic and episodic memory are separate systems since they have often been found to be similarly impaired in amnesia. For example, Squire (1994) proposed that they are both part of the declarative memory system. However, Schacter cites research that amnesic patients can acquire new semantic information despite being unable to remember any past personal experiences (e.g. Hayman, Macdonald & Tulving, 1993; Tulving, Hayman & Macdonald, 1991). With reference to the brain structures associated with semantic and episodic memory, Schacter and Tulving (1994) suggested that semantic memory depends on medial-temporal regions whereas episodic memory depends on prefrontal-cortical areas.

The multiple memory systems theory is able to account for the finding that amnesic patients have difficulty recalling information explicitly but perform relatively normally in tests of perceptual implicit memory (see e.g. Warrington & Weiskrantz, 1968; 1970) by suggesting that perceptual implicit memory is associated with the PRS whereas explicit memory is associated with the episodic memory system.

With regard to perceptually and conceptually based priming, Schacter (1994) suggested that they are based on different underlying systems. He proposed that perceptually based priming is associated with the PRS whereas conceptually based priming occurs outside the PRS, at an unspecified location, but possibly the semantic system. To support his suggestion, he cited research by Hamann (1990) that conceptually based priming was susceptible to a levels of processing effect and Blaxton (1989) that perceptually and conceptually based priming can be dissociated. However, it has been shown in Sections 1.3.4 and 1.3.5, that these results may be attributable to other factors and do not provide categorical evidence that perceptually and conceptually based priming reflect different underlying systems. In addition, the slight, but often non-significant, levels of processing effects usually found in perceptually based priming (Challis & Brodbeck, 1992) would not be predicted from this hypothesis. The significant levels of processing effect found by Thapar and Greene (1994) in perceptually based priming from blocked stimuli encoding would also not be predicted; nor would the converse result from the same experiment - no levels of processing effect in conceptually based priming from randomised stimuli (see Section 1.3.4). The lack of significant levels of processing effects found in conceptually based priming of unitised word pairs (Schacter & McGlynn, 1989, Experiment 3) is also counter to Schacter's proposal.

With reference to priming of new associations, Schacter suggested that this phenomenon shares processes with conceptually based priming of individual words and they may both depend on the semantic system. However, the finding that amnesic patients are impaired relative to controls in priming of new associations (Cermak, Bleich & Blackford, 1988; Mayes & Gooding, 1989; Schacter & Graf, 1986a) but usually show intact conceptual priming when new associations are not involved (Gardner, Boller, Moreines & Butters, 1973; Graf, Shimamura & Squire, 1985, Experiment 2; Schacter, 1985; Shimamura & Squire, 1984) indicates that additional processes are evoked in priming of new associations relative to conceptually based priming of single words or unitised word pairs.

Schacter (1994) does agree that "Some perceptual-specificity effects in priming may involve an interaction or collaboration between the PRS and episodic (or semantic) memory system." (p.252). However, he only envisages this interaction to be related to the relatively rare phenomenon of binding voice specific information to auditory word priming. He was lead to this conclusion by experimental results which failed to find voice-specific auditory priming effects in amnesic subjects compared to control subjects (Schacter, Church & Bolton, 1995), even though previous experiments had shown comparable auditory priming levels between amnesics and controls (Schacter, Church & Treadwell, 1994).

1.5.2 Transfer Appropriate Processing

Theoretical explanations which are based on a "processing" standpoint relate to the transfer appropriate processing principle that memory test performance depends on the degree of overlap between encoding and test processes; the greater the degree of overlap the better memory test performance will be (Morris, Brandsford & Franks, 1977). This principle formed the basis of Tulving's (1983) encoding specificity principle which stressed the match in relational information between encoding and test.

One such theoretical explanation is Graf and Mandler's (1984) dual process theory which proposes two different memory organising processes, integration and elaboration. According to Graf and Ryan (1990), "Integration results from processing that bonds the features of a target into a coordinated whole or unitized representation" (p.989) whereas "Elaboration results from processing that associates a target with other mental contents ....(e.g. other targets, situational cues, and relevant prior knowledge)" (p.990). Study processes involve both integration and elaboration but implicit tests mainly access integrative processing while explicit tests mainly access elaborative processing. Dissociations between implicit and explicit tests therefore occur because implicit tests reflect study-test overlaps in integrative processing whereas explicit tests reflect study-test overlaps in elaborative processing.

Perhaps the best known 'processing' explanation, the transfer appropriate processing theory, was suggested by Roediger and his colleagues (Roediger, 1990a; 1990b; Roediger & Blaxton, 1987a and Roediger, Weldon & Challis, 1989). As a starting point, the theory used Jacoby's (1983a) proposal that implicit memory tests, such as perceptual identification, word stem completion and word fragment completion, appear to be data-driven because they are susceptible to study-test changes in surface features. Conversely, most explicit memory tests may be classified as conceptually-driven because they are sensitive to the meaning of stimuli. According to this theory, each study episode involves a combination of data-driven and conceptually-driven processing. Dissociations between implicit and explicit tests occur because implicit tests are more likely to access data-driven processes whereas explicit tests are more likely to access conceptually-driven processes. However, Roediger, Srinivas and Weldon (1989) have qualified this distinction by stating that "there is no necessary correlation between explicit memory tests and conceptually-driven processing, or between implicit memory tests and data-driven processing" (p.69). It is possible for an explicit memory test to access data-driven processes or for an implicit test to access conceptually-driven processes. Underlying this qualification was a study by Blaxton (1989) in which she found that performance on implicit and explicit conceptually driven tasks (answering general knowledge questions, free recall and semantic cued recall) was better when items were generated at study whereas performance on implicit and explicit data driven tasks (word fragment completion and recall using graphemic cues) was better when items were read at study.

This qualification enables dissociations between perceptual and conceptual implicit memory tests to be explained. Indeed, Weldon (1993) suggested that all implicit memory tests may be classified on a continuum representing their susceptibility to conceptual processing. She came to this conclusion when she found that a word fragment completion test was affected by the encoded meaning of words but a perceptual identification test was not (Weldon, 1991). In addition, when examining the time course of priming in word fragment completion, she found that visual word encoding produced priming at briefer exposures than auditory encoding which, in turn, was faster than picture encoding (Weldon, 1993, Experiment 1). According to Weldon, perceptual identification would feature at one end of the continuum as it appears relatively impervious to different degrees of semantic processing but is detrimentally affected by perceptual changes between study and test. Word fragment completion would be further along the continuum because it is more affected by semantic processing manipulations but less detrimentally affected by perceptual changes between study and test.

The main criticism of the transfer appropriate processing theory is that it does not adequately explain the preserved perceptually and conceptually based priming in amnesic patients who show severely impaired explicit memory.

1.6 Summary

Sections 1.2, 1.3 and 1.4 reviewed studies concerned with the effects of amnesia, age, levels of processing, the generation effect, modality, retention interval and interference on priming. Dissociations and similarities between perceptually and conceptually based priming and explicit memory test performance resulting from these variables have been useful in formulating and testing the two current theoretical explanations of the systems or processes underlying human memory, the multiple memory systems theory and the transfer appropriate processing theory, described in Section 1.5. During recent years, considerable progress has been made, but there is still much to be learned. A different perspective might prove useful in this respect. The studies in this thesis have therefore used a another variable with which to compare perceptual and conceptual implicit and explicit memory test performance - serial position effects.

The next chapter reviews studies which have investigated serial position effects in explicit memory tests in order that informed theoretical predictions as to the presence or absence of these effects in implicit memory tests may be made. It also critically reviews the few studies which have so far investigated serial position effects in implicit memory tests in order that any methodological problems encountered by these studies may be addressed in the studies in this thesis.

CHAPTER 2

SERIAL POSITION EFFECTS

2.1 Introduction

This chapter has been included to present a summary of current knowledge about serial position effects in explicit memory tests. Such an overview will be beneficial in forming theoretical predictions as to whether or not these effects would occur in implicit memory tests and in interpreting the relevance of the presence or absence of these effects. In addition, the few previous studies which have investigated serial position effects in implicit memory tests are reviewed and discussed.

2.2 Serial Position Effects in Explicit Memory Tests

Serial position effects were probably the first memory phenomenon to be studied experimentally as they were initially discovered by Nipher in 1878. He reported that the position of an item in a list influences its subsequent retention, with more items remembered from the beginning and end of a list and less items remembered from middle serial positions. The curve produced when these effects are plotted on a graph has since been named the "serial position curve". Enhanced memory for the first few items is referred to as the "primacy effect"; enhanced memory for the last few items is referred to as the "recency effect"; and inferior memory for the middle items is referred to as the "asymptote".

During the 1960s and 1970s many studies were conducted investigating serial position effects in free recall (see e.g. Murdoch, 1962; Glanzer & Cunitz, 1966). The results of these studies mainly agreed with Nipher's original discovery but some interesting variations between primacy and recency effects were found. For example, recall of primacy and asymptote items was higher when stimulus words were presented at 9 sec. intervals compared to 3 sec. intervals, but recall of recency items was unaffected by this change in presentation rate (Glanzer & Cunitz, 1966). If anything, faster presentation rates have since been found to raise recency effects (Craik, 1969; Murdock & Walker, 1969). Other variables which have been found to have significant effects on primacy and asymptote but not recency items include variations in word frequency (Raymond, 1969; Sumby, 1963); inter-item semantic similarity (Craik & Levy, 1970); and list length (Lewis-Smith, 1975; Murdoch, 1962; Postman & Phillips, 1965). In addition, amnesic patients with impaired long-term memory typically show preserved memory for recency items but impaired memory for primacy and asymptote items compared to control subjects (Baddeley & Warrington, 1970). Other patients with impaired short-term memory show impaired memory for recency items (Shallice & Warrington, 1970).

The above dissociations have contributed to the generally held view that different processes are responsible for primacy and recency effects. The foremost explanations for primacy and recency effects are described below.

2.2.1 Primacy Effects

The consensus of opinion is that primacy effects are attributable to long-term memory (named episodic memory in the multiple memory systems theory, see Section 1.5.1) and arise from more rehearsal (elaborative or rote), or greater attention devoted to the first few items in a to-be-remembered list than to the remaining items (Atkinson & Shriffrin, 1968; Craik & Lockhart, 1972; Glenberg, Bradley, Stevenson, Kraus, Tkachuk, Gretz, Fish & Turpin, 1980; Rundus, 1971; Welch & Burnett, 1924).

Welch and Burnett (1924) tested the hypothesis that rehearsal was responsible for the primacy effect by instructing subjects to rehearse only the most recently presented item and not to continue to rehearse previously presented items. Under these instructions the primacy effect disappeared. In a later experiment, Rundus (1971) required subjects to rehearse aloud so that the number of rehearsals devoted to each item could be assessed. It was found that early list items were rehearsed far more often than later items. In addition to the greater degree of rehearsal attributed to early list items, Craik and Lockhart (1972) proposed that such rehearsal would be more elaborative since the first few list items received subjects' undivided attention compared to later items. In their opinion, the more elaborative rehearsal contributed towards primacy effects.

Another source of evidence that primacy effects arise from more rehearsal of early list items is that they are not usually found in incidental memory tests in which subjects are unaware that they are performing a memory test and therefore do not bother to rehearse items (Baddeley & Hitch, 1977; Glenberg *et al.*, 1980; Marshall & Werder, 1972; Seamon & Murray, 1976).

The absence of primacy effects in incidental memory tests, and when rehearsal is controlled, is contrary to the theory that individuals intentionally use the beginning and end of a sequence of events as "anchors" or "benchmarks" from which they try to retrieve the relevant information (see Fitzgerald, 1988; Pillemer, Goldsmith, Panter & White, 1988; Roediger & Crowder, 1976).

2.2.2 Recency Effects

There is less consensus about the explanation for recency effects. The standard theory is that recency effects in free recall occur because subjects off-load the contents of their short-term memory (named working memory in the multiple memory systems theory, see Section 1.5.1) prior to retrieving items from long-term memory (Glanzer & Cunitz, 1966; Craik, 1970). In support of this theory, the recency effect disappears if a subject is asked to count backwards for 20 seconds before recalling a list of words (Glanzer & Cunitz, 1966). Further support for this theory was provided by a negative recency effect found by Craik (1970). In this study, Craik initially gave subjects a series of immediate free recall tests in which he found both primacy and recency effects. Finally, he asked subjects to recall items from all the previously seen lists. Primacy effects still occurred in this test but not recency effects. In fact, significantly less recency than asymptote items were recalled. According to Craik, this negative recency effect occurred because recency items had previously been recalled from short-term memory and there was less incentive or opportunity for them to be encoded into long-term memory. When rehearsal of the last few items was ensured, the negative recency effect was reduced or eliminated (Watkins & Watkins, 1974).

Doubts about this explanation arose when Bjork & Whitten (1974) reported a long-term recency effect which occurred when 12 seconds of distractor task preceded the presentation of each study item. This long-term recency effect survived a 20 seconds retention interval in which the same distractor task was performed. (This procedure has been named the continuous distractor paradigm.) Presumably any items in short-term memory would have been displaced during this period. This finding has been replicated and has been found to occur using different stimuli and distractor tasks (see e.g. Glenberg, Bradley, Stevenson, Kraus, Tkachuk, Gretz, Fish & Turpin, 1980; Glenberg & Kraus, 1981; Whitten, 1978).

Some variables which have different effects on recency and pre-recency items in immediate free recall have been shown to behave similarly in the continuous distractor paradigm. For example, word frequency, which affects pre-recency but not recency items in immediate free recall (Raymond, 1969; Sumby, 1963), has been found to show the same pattern in the continuous distractor paradigm (Greene, 1986). In Greene's study, subjects were presented with six lists of commonly used English words and six lists of rare words using the continuous distractor paradigm. It was found that word frequency had a large effect on recall of items at all serial positions except the last; the last list items were unaffected by word frequency. Another variable which has been found to influence pre-recency but not recency items is inter-item semantic similarity. This effect occurs in immediate free recall (Craik & Levy, 1970) and in the continuous distractor paradigm (Greene & Crowder, 1984). Similarly, list length influences pre-recency but not recency items in immediate free recall (Lewis-Smith, 1975; Murdock, 1962; Postman & Phillips, 1965) and in the continuous distractor paradigm (Greene 1986). A variable which has found to enhance recency but not pre-recency items is the modality effect - the finding that auditory encoding enhances the recency effect more than visual encoding in immediate free recall. This effect also occurs using the continuous distractor paradigm (Gardiner & Gregg, 1979).

Another experiment which casts doubt on the theory that the recency effect is attributable to subjects off-loading the contents of their short-term memory was conducted by Watkins and Peynircioglu (1983). Subjects were presented with a 45 item list comprising 15 items from three sub-lists of different categories of items, e.g. riddles, objects and sounds. Items from each sub-list were presented alternatively. Subjects were then cued to free recall items from one category. Irrespective of which category was recalled, results showed marked recency effects. It should be noted, however, that the categories in this study were very different from each other. It is not possible to produce three different recency effects by simply using three different semantic categories (Rejman, 1979).

A number of explanations for the long-term recency effects found in the continuous distractor paradigm and in multi-category lists have been proposed. One explanation is that they are attributable to the strategic use of short-term memory (Koppenaal & Glanzer, 1990; Poltrock & MacLeod, 1977). Koppenaal and Glanzer proposed that subjects in the continuous distractor paradigm have much more practice at the distractor task than subjects who perform the distractor task only at the end of a list. They are therefore more likely to habituate to the task, and are able to strategically use short-term memory to produce a long-term recency effect. To support this explanation, they cited the finding that the long-term recency effect in the continuous distractor paradigm disappears if a different distractor task is presented after the last list item (Koppenhaal & Glanzer, 1990; Nakajima & Sato, 1989). However, Glenberg, Bradley, Kraus & Renzaglia (1983) had previously shown that no recency effect occurred in a delayed free recall test involving a well-practised distractor task. According to Koppenhaal & Glanzer, a recency effect would have been expected in this situation as subjects would already have habituated to the distractor task and should therefore have been able to strategically use short-term memory in the same manner as in the continuous distractor paradigm. In addition, manipulations of task difficulty in the continuous distractor paradigm have been found to affect recall of early and middle list items but not recency items (Glenberg, *et al.* 1980). If the strategic use of short-term memory was responsible for the long-term recency effect, task difficulty would be expected to have a deleterious effect on recency items.

A further problem with the proposal that the long-term recency effect is attributable to the strategic use of short-term memory is that long-term recency effects have been found outside the laboratory in real-life situations. For example, Baddeley and Hitch (1977) asked rugby players to recall the teams they had played against that season. Results showed a significant recency effect as players were most likely to recall the last team they had played against. The most important factor in determining whether a team would be recalled was the number of interpolated games, not the time element. In another real life study, Pinto and Baddeley (1991) found recency effects when regular car park users were asked to remember the locations in which they had parked their cars during the previous week. In the same study, infrequent car park users were able to remember their parking spot one month later.

Other explanations of the long-term recency effect also assume that short and long-term recency effects stem from the same source but they do not consider that short-term memory is responsible. For example, Baddeley (1986) suggested that recency effects occur because the most recent memory representations have a higher level of activation than previous inputs and are therefore more easily recalled. He compared representations in memory to a bank of lights which are illuminated when a current is passed through them. These lights stay warm for a short period of time after they have been illuminated, and are more easily re-illuminated when they are warm. According to this analogy, sequential presentation of a series of items is comparable to illuminating one light at a time. In an immediate test, lights corresponding to the last few items presented are still warm and are therefore more easily re-illuminated than lights corresponding to earlier items. Baddeley and Hitch (1993) extended this explanation to propose that recency effects are attributable to a combination of implicit learning and a particular retrieval strategy which may or may not be explicit.

Another such explanation proposed that recency effects are attributable to the temporal distinctiveness of the most recent items in a well-ordered series (Bjork & Whitten, 1974). This explanation is encapsulated by Crowder's (1976) suggestion that free recall is analogous to looking back at telegraph poles along a railway line. The most recent poles are the most distinctive, so long as there is a reasonable space between the poles. According to Bjork and Whitten, two factors contribute to the discriminability of items in memory: the time span of inter-item intervals; and the time elapsed since presentation of the last item. They noted that, other factors being equal, recency effects in free recall may be calculated from the constant ratio rule - that the probability of recall equals the presentation interval between items divided by the time elapsed since presentation of the last item. Positive recency effects occur if the ratio between these two time spans approaches 1.0.

Sato (1990) tested this hypothesis in two experiments. In Experiment 1, he compared word recency effects with word position and order recency effects in immediate and delayed free recall and in the continuous distractor paradigm. As expected, he found that word recency effects were present in immediate free recall, disappeared in delayed free recall, and re-appeared in the continuous distractor paradigm. However, word position and order recency effects showed different patterns of results. Recency effects for position information occurred in free recall, disappeared in the delayed free recall test, but did not re-appear in the continuous distractor paradigm whereas recency effects for order information remained constant in all three tests. In Experiment 2, he found that temporal distinctiveness, measured by varying the congruence of digit-word pairs, did not affect short-term recency effects in free recall. From these results he concluded that temporal distinctiveness did not adequately explain short-term and long-term recency effects.

Glenberg *et al.* (1980; 1983) proposed a similar explanation to that of Bjork & Whitten, but they stressed the contextual rather than the temporal aspects of discriminability. According to Glenberg's explanation, each list item is associated in memory with particular elements of the psychological context in which the list was studied. Since contextual elements change over time, the most recently encoded items would be more similar to the test context than earlier items. By incorporating long inter-item intervals, the continuous distractor paradigm would exacerbate these contextual differences for all but the final list item. The test context would therefore more effectively cue the most recently encoded list items. In addition, the last items would be more discriminable from earlier items and less likely to be affected by interference or cue overload (Watkins & Watkins, 1975).

Bjork and Whitten and Glenberg *et al.* agreed that other factors, such as inter-item semantic similarity, word frequency and list length, contribute to the probability of recalling items. They suggested that ordinal or contextual information is more effective at recalling recency items because they are more distinctive, whereas other retrieval cues are more effective at recalling earlier list items because they have had more opportunity for rehearsal. In this way, they were able to explain why word frequency, inter-item semantic similarity and list length affect only pre-recency items in both immediate free recall and the continuous distractor paradigm. They were also able to offer an explanation for the negative recency effect (Craik, 1970). According to this explanation, in immediate free recall tests, recency items are mainly cued by ordinal or contextual information whereas pre-recency items are cued by other cues. However, in a final recall test for all the items from a number of prior lists, ordinal or contextual cues would not effectively cue list recency items whereas cues for pre-recency items would remain effective.

Bjork and Whitten and Glenberg *et al.* therefore attribute recall to a number of different sources, even though it would be more parsimonious to propose a single source. It may also be necessary to attribute short-term and long-term recency effects to different sources. To quote Sato (1990), "A theory which can account for a variety of recency effects in many paradigms with a common principle is very attractive. However, parsimony never guarantees validity of the theory." (p.1350)

There are some findings that support the proposal that different processes are responsible for short and long-term recency effects. For example, contrary to the constant ratio rule, faster presentation rates have been found to raise recency effects in immediate free recall (Craik, 1969; Murdock & Walker, 1969). Another finding is that short-term recency effects are dependent on subjects recalling the last items first (Dalezman, 1976) but long-term recency effects in the continuous distractor paradigm are independent of whether items are recalled from the beginning, middle or end of the list first (Whitten, 1978).

An important source of evidence that the recency effect is attributable to off-loading the contents of short-term memory is that amnesic patients with impaired long-term memory show preserved recency in immediate free recall despite being severely impaired at recalling earlier list items (Baddeley & Warrington, 1970). Conversely, some amnesic patients with impaired short-term memory show disrupted recency (Shallice & Warrington, 1970). Vallar and Papagno (1986) found a patient, PV, with left-hemisphere damage resulting in a severely reduced immediate auditory memory span, which they attributed to a defective short-term phonological store. PV showed no recency effect in free recall of auditorily presented words. Even when she was instructed to recall the last words first, she still showed impaired recency. However, under this instruction, her recall of visually presented words showed a normal recency effect. They interpreted these results as showing that a short-term phonological store was usually the basis of short-term recency effects. In PV's case, only a short-term visual store was effective. Despite PV's impaired short-term recency, she showed marked long-term recency in recalling anagram solutions (Vallar, Papagno & Baddeley, 1991), providing further evidence that short and long-term recency effects stem from different sources.

Finally, recent research by Hodges, Greene and Baddeley (1996) found that Alzheimer's patients showed more forgetting than controls from immediate to delayed recall of a 10-item word list. Further analysis showed that the differential forgetting rates were attributable to loss of short-term recency effects in delayed recall. This loss affected Alzheimer's patients to a greater extent than controls because their immediate recall contained a higher proportion of words off-loaded from short-term memory which is relatively unimpaired in Alzheimer's.

2.3 Theoretical Predictions

In this thesis, it will be assumed that short and long-term recency effects stem from different sources and that short-term recency effects are attributable to subjects off-loading the contents of their short-term memory prior to recalling items from long-term memory (Glanzer & Cunitz, 1966). If this is the correct explanation, a short-term recency effect would be less likely to occur in cued recall tests which involve effortful retrieval from associated cues because this would interfere with the off-loading process. The results of a study by Tulving and Arbuckle (1963) might be considered to be against this hypothesis. In this study, digit-word pairs were encoded and the digits were used to cue the words in a cued recall test. It was found that cued recall performance was 100% when the first test cue related to the last digit-word pair studied. However, very little cognitive effort would be required to immediately retrieve a word from a digit cue which had only just been presented and the slight cognitive effort involved would be unlikely to interfere with the off-loading process.

If the short-term recency effect is less likely to occur in cued recall tests using associated cues than in free recall tests, but still occurs when little cognitive effort is required to recall a word from a cue, it might be possible to predict an inverse relationship between positive short-term recency effects and the degree of cognitive effort involved in recall from the cues provided. It follows from this prediction that word stem cued recall would be more likely to produce a short-term recency effect than cued recall of associated words because word stem cued recall probably involves less cognitive effort. For the same reason, cued recall of unitised words would be more likely to produce a short-term recency effect than cued recall of weakly related words.

Since primacy effects are assumed to be attributable to more elaborative or rote rehearsal or to greater attention devoted to the first few list items (Atkinson & Shriffrin, 1968; Craik & Lockhart, 1972; Glenberg *et al.,* 1980; Rundus, 1971; Welch & Burnett, 1924; see Section 2.2.1), it is unlikely that these effects will be susceptible to the degree of cognitive effort involved in cued recall to the same extent as short-term recency effects.

Neither the multiple memory systems theory, nor the transfer appropriate processing theory has anything specific to say about serial position effects in explicit memory tests. However, it is probable that the multiple memory systems theory would propose that primacy effects are based on the episodic memory system and short-term recency effects are based on the working memory system. The transfer appropriate processing theory might propose that primacy effects are attributable to deeper processing of the first few list items, resulting in more overlap of conceptual processes between encoding these items and performance in explicit memory tests, whereas short-term recency effects are attributable to intentional retrieval processes.

2.4 Serial Position Effects in Implicit Memory Tests

Only four known studies have so far been performed to examine whether primacy or recency effects occur in implicit memory tests. The first such study, by Sloman, Hayman, Ohta, Law & Tulving (1988, Experiment 1), investigated primed word-fragment completion. Subjects were initially shown 16 words and were immediately required to complete 16 unique word fragments of these words, presented in reverse order. Results indicated the existence of a recency effect and a single item primacy effect. However, a closer examination of the experimental procedure in this study reveals that the word fragment completion test was contaminated by intentional retrieval. Instructions to subjects stated that "they were to try to complete each fragment with a study-list word" (p. 227). It is therefore possible that the explicit component of the task was responsible for the serial position effects obtained. Subjects also had the opportunity to practise encoding and retrieval strategies since each subject performed eight similar tests using different target words.

Another study, by McKenzie & Humphreys (1991, Experiments 1 - 3), found significant recency effects in implicit word stem and ending completion but not in implicit extralist associate production. For the word stem completion test in Experiment 1, two lists of 20 words were compiled, L1 and L2. The same three letter word stems appeared on each list, but words in L1 were more likely to be produced than words in L2. For example, L1 contained the word "shoe", a more common completion to the three letter word stem "sho" than the L2 word, "show". Similar test lists were compiled for the word ending completion test but with word endings, instead of word stems, shared between

L1 and L2. For example, the word "wrench" in L1 was a more common completion to the word ending "ench" than the word "stench" in L2. In each test, four groups of subjects were sequentially presented with L1 and then L2 words with instructions to rate each L1 word according to how frequently they thought it occurred in the English language and to rate each L2 word according to how pleasant they thought it was. Two of these groups of subjects were tested immediately, one group performing a word stem or word ending completion test and the other group performing a word stem or word ending cued recall test with instructions to recall words from L1 only. The remaining two groups of subjects performed the same tests but after a delay of 3-minutes in which they executed a distractor task. There were positive recency effects in both the implicit and explicit versions of the tests with more stems and endings completed in the immediate tests than in the delayed tests. In addition, there were further indications of recency in the implicit tests with more L2 than L1 words completed in the immediate tests but no differences between L2 and L1 words in the delayed tests.

In the extralist associate production test, extralist associates were shared between two lists of 20 words with more common associates in L1 than in L2. For example, to the extralist associate cue "animal", L1 contained the word "dog" whereas L2 contained the word "cat". The design and procedure of the extralist associate production test was otherwise the same as for the word stem and word ending completion tests. However, contrary to the word stem and word ending completion tests, there was no sign of a recency effect in the extralist associate production tests in any of the three experiments. Conversely, there were indications of a recency effect in the explicit version of this test in Experiments 2 and 3, even though such an effect was counter to instructions as subjects were asked to recall words from L1 only.

The results from this study therefore failed to show a recency effect in the conceptual implicit memory test of extralist associate production but did show recency effects in the perceptual implicit memory tests of word stem and word ending completion. However, the recency effect found in these tests is different to the short-lived recency component of the serial position curve which disappears if a subject is asked to count backwards for 30 seconds before recalling a list of words (Glanzer & Cunitz, 1966). It is more likely that this recency effect is attributable to decay or to interference. It is also possible that no similar effect occurred in the conceptual implicit test because priming had already fallen to baseline. Unfortunately, there is no way of checking that any priming occurred in the conceptual implicit test since there was no baseline measurement included in the design.

Rybash and Osborne (1991) did include a form of baseline measurement in their study which investigated primacy and recency effects in free recall, implicit word stem completion and explicit word stem cued recall. The study used 48 words, 5 - 7 letters long, selected from the pool developed by Kuçera and Francis (1967). Each word began with a unique three letter word stem which had at least three alternative completions. Half of these words were randomly allocated to be used as target words and the other half were used to provide an estimate of baseline performance in the word stem completion test or as lures in the word stem cued recall test. Since no details about presentation orders were included in the methodology, it is assumed that all target words were presented in the same order. Subjects performed an incidental learning task in which they were required to rate each word for pleasantness. They were tested immediately on one of the three tests. In the word stem completion and word stem cued recall tests all subjects received the same test sheet on which the word stems of all 48 words were printed.

All three tests produced a significant recency effect but only free recall produced a significant primacy effect. However, the first few words may have been less memorable or less easily completed than the remaining words, negating any possible primacy effects in all but the free recall test. Similarly, the last few words may have been more memorable or more easily completed, producing a spurious recency effect in the word stem completion and cued recall tests. The significant recency effect in the word stem completion and cued recall tests was surprising because the test sheet contained 48 word stems and any recency effects would presumably have disappeared before the relevant word stems were completed.

Furthermore, subjects who performed the implicit word stem completion test might have used explicit strategies to complete the word stems. They were not informed of the connection between the study and test episode even though they were tested immediately. Since word stems from all the previously studied words were represented at test, it is unlikely that many subjects remained ignorant of this connection.

The latest study to investigate serial position effects in implicit word stem completion, word stem cued recall and free recall, was performed by Gershberg and Shimamura (1994, Experiments 1-3). In Experiment 1, two study lists of 12 words, matched for frequency in Kuçera and Francis (1967), were used. In each list, eight words represented non-living things (e.g. tractor) and four words represented living things (e.g. lion). Every word began with a unique two or three letter word stem which could be completed by at least 10 common English words. Two different orders of the words in each study list were used. Equal numbers of subjects were presented with one of the resulting four lists of words and performed an incidental learning task in which they were required to state whether each word represented a living or a non-living thing. Subjects were tested immediately on one of the three tests. In the word stem completion and word stem cued recall tests, all 24 word stems were presented sequentially and subjects' responses were recorded by the experimenter. The word stems were presented in six different orders with equal numbers of subjects in each test assigned to 12 different study list/test order combinations. The word stem completion test was introduced as a different task and subjects were asked to respond to each word stem with the first word that came to mind. In the word stem cued recall test, subjects were required to try to complete stems with words from the study episode but, if they could not recall a word, they were asked to guess completions. This test was not, therefore, a true test of cued recall but a mixture of explicit and implicit processes. Experiment 2 was similar to Experiment 1 but a filler task of word stem completion was performed between the study and test. Experiment 3 was also similar to Experiment 1 but the study list was increased to 24 items (with the inclusion of 12 filler items) and the presentation rate was increased from 2 secs. to 1 sec. per word.

The results of the word stem completion and word stem cued recall tests were collapsed across four consecutive data points resulting in three data points, primacy, asymptote and recency. Analyses showed the results of the word stem completion test to be variable. According to Gershberg and Shimamura, "The most striking finding was the transient nature of the primacy effect in the implicit word stem completion test. That is, the primacy effect that was present in the first half of testing was eliminated in the second half of testing" (p.1376). The transient primacy effects referred to above, occurred in Experiments 1 and 3 but not in Experiment 2. There was also a transient serial position recency effect in Experiment 1, but this effect was not replicated in Experiment 3. (A serial position recency effect would not have been expected in Experiment 2 because a filler task was performed between study and test.) Unfortunately, the results of the explicit tests were also variable. In word stem cued recall, the only significant primacy effect occurred in the second half of testing in Experiment 3. (In the first half of testing the primacy effect was only approaching significance.) In addition, there were no significant serial position recency effects in word stem cued recall in any of the experiments. In Experiment 3, even the immediate free recall test failed to show a recency effect.

The surprising failure to obtain reliable serial position effects in these explicit tests, especially in the immediate free recall test, may be attributable to inadequate counterbalancing of word position at encoding. Only two orders of two study lists were used for 86 subjects in Experiment 1; for 84 subjects in Experiment 2; and for 88 subjects in Experiment 3. If inadequate counterbalancing was responsible for the lack of reliable serial position effects in the explicit tests, it might also have produced the transient serial position effects in the implicit tests. Adequate counterbalancing is particularly important in word stem completion as it is impossible to control for both word frequency and ease of completion simultaneously.

2.5 Summary

Section 2.2 reviewed studies which have investigated serial position effects in explicit memory tests. Whilst it is generally agreed that primacy effects are attributable to more rehearsal or greater attention devoted to the first few items presented at study (Atkinson & Shriffrin, 1968; Craik & Lockhart, 1972; see Section 2.2.1), the situation with respect to recency effects is still being debated. From the many possible theoretical explanations discussed in Section 2.2.2, the explanation favoured in this thesis is that subjects intentionally off-load recency items from short-term memory prior to retrieving items from long-term memory (Glanzer & Cunitz, 1966; Craik, 1970; see Section 2.3). (Such effects will hitherto be referred to as "short-term recency effects" in this thesis to distinguish them from the longer lasting recency effects, such as those found by McKenzie & Humphreys (1991), which are probably attributable to decay or interference and which will simply be referred to as "forgetting".) It was also suggested in Section 2.3, that cued recall tests involving little cognitive effort would be less likely to interfere with subjects off-loading items from short-term memory and would therefore be more likely to produce a short-term recency effect than cued recall tests involving more cognitive effort. The degree of cognitive effort involved in the test cue was not expected to influence primacy effects to the same extent. In Section 2.4, the four previous studies investigating whether or not serial position effects occur in implicit memory tests were critically reviewed. The results of these studies varied widely. Possible reasons for the variability of the results are - contamination by intentional retrieval processes, methodological short-comings, and measurement of delayed, instead of immediate, recall.

2.6 Preface to Experimental Chapters

There is obviously a need to investigate whether or not serial position effects occur in implicit memory tests which are performed immediately, and which are methodologically sound and uncontaminated by intentional retrieval processes. Only then may informed conclusions be drawn from the results obtained. Investigating serial position effects in implicit and explicit memory tests will provide another perspective from which to test the multiple memory systems theory and the transfer appropriate processing theory. Although neither of these theoretical explanations have predicted whether or not serial position effects would occur in implicit memory tests, it is possible to speculate according to each theory.

The multiple memory systems theory would not predict a primacy effect in a perceptual implicit memory test since the theory states that perceptually based priming is dependent on the PRS which operates pre-semantically. A perceptual representation would be unlikely to be enhanced by increased rote or elaborate rehearsal, or greater attention, thought to be responsible for the primacy effect (Glanzer & Cunitz, 1966; Craik & Lockhart, 1972). However, the multiple memory systems theory might predict a primacy effect in a conceptual implicit memory test since it proposes that conceptual priming occurs outside the PRS, and is possibly based on the semantic memory system (Schacter, 1994). According to the transfer appropriate processing theory, each study episode involves a combination of data-driven and conceptually-driven processing and perceptual implicit tests are more likely to access data-driven processing. The first few list items would involve more conceptually-driven processing than the remaining items because more rote or elaborative rehearsal, or greater attention, is devoted to them. If this is the case, a perceptual implicit memory test would not be expected to access primacy items better than non-primacy items because there is no greater overlap of conceptually-driven processes between primacy items and the data-driven test than between non-primacy items and the test. There might even be expected to be a greater overlap of data-driven processes between non-primacy items and the test, resulting in a negative primacy effect. However, the transfer appropriate processing theory would be unlikely to predict a negative primacy effect because perceptual priming has not been found to show a reversed levels of processing effect. In a conceptual implicit memory test, there would be more overlap of conceptually-driven processes between primacy items and the test than between non-primacy items and the test. The transfer appropriate processing theory might therefore predict a primacy effect in conceptual priming but not in perceptual priming. Neither theory would predict a short-term recency effect in any implicit memory tests since this effect has been found to be dependent on intentional retrieval which should not be involved in implicit memory test performance.

Even though subjects performing implicit memory tests are not required to intentionally retrieve items from the study phase, they are not necessarily unaware of the connection between study and test. Bowers and Schacter (1990) categorised subjects as test-aware and test-unaware according to their responses to a structured interview which they were given after they had completed a word stem completion test. Analysis of their data using this distinction revealed that the test-aware subjects showed a levels of processing effect in their target word stem completions, indicating that their performance was contaminated by intentional retrieval processes; the test-unaware subjects did not show a levels of processing effect. However, Richardson-Klavehn, Gardiner and Java (1994) did not find a similar levels of processing effect in word stem completion priming, even though all their subjects were test-aware. They proposed that previous descriptions of retrieval intentionality as a simple dichotomy, e.g. *conscious memory* and *unconscious memory* (Jacoby, 1991) were not able to account for the finding that involuntary retrieval can occur independently of subjects' conscious awareness of the connection between study and test items. Instead, they suggested that the terms *"voluntary retrieval"* and *"involuntary retrieval"* were better able to describe test performance. Confirming the preceding finding, Richardson-Klavehn, Lee, Joubran & Bjork (1994) found a crossed double dissociations between direct and indirect memory tests, even though most of the subjects reported themselves to be test-aware. In three experiments, a deep level of auditory encoding produced better recognition memory than a shallow level of visual encoding whereas the shallow level of visual encoding produced significant priming in a perceptual identification test but the deep level of auditory encoding did not. They concluded that "... test-awareness, in the global sense, occurs frequently in indirect test subjects but does not always prompt intentional retrieval strategies. The exact conditions under which global test-awareness in indirect tests does and does not prompt an intentional retrieval strategy remain to be delineated." (p.311). To overcome this problem, they recommended informing subjects of the connection between study and test but requesting them not to specifically try to recollect study items. Bowers and Schacter ran such a condition in the study reported above. When subjects were informed of the study-test relationship but were asked to respond with the first word that came to mind, there was no levels of processing effect, indicating that explicit contamination did not occur. In the experiments in this thesis, subjects performing the implicit test were therefore informed of the connection between study and test items but were asked to ignore this connection and to respond with the first item that came into their heads.

The first experimental chapter describes three experiments which investigated whether serial position effects occur in the perceptual implicit memory test of word stem completion.

CHAPTER 3

SERIAL POSITION EFFECTS IN THE PERCEPTUAL IMPLICIT MEMORY TEST OF WORD STEM COMPLETION

3.1 Introduction

Three experiments investigating serial position effects in the perceptual implicit memory test of word stem completion are described in this first experimental chapter. Experiment 1 investigated primacy effects, but not short-term recency effects, because the test sheet used was not designed to test the last items presented first. Experiments 2 and 3 used test sheets which were designed to test items in the reverse to study order and therefore investigated both primacy and short-term recency effects. Experiments 1 and 2 used identical stimulus words, whereas Experiment 3 was a replication of Experiment 2 using different stimulus words. It was considered necessary to try to replicate the results of Experiment 2 using different stimuli because previous experiments investigating serial position effects in implicit memory tests had produced such varied results (see Section 2.4).

Each experiment included an explicit test of word stem cued recall in which the stimuli, test sheet, and study instructions were identical to the implicit test and only the test instructions differed. The results of the implicit and explicit tests therefore fulfilled the retrieval intentionality criterion of Schacter, *et al.* (1989) and could be directly compared. Any dissociations found between the serial position effects in the implicit and explicit tests would be attributable to the test instructions and not to methodological differences between the tests.

3.2 EXPERIMENT 1

Experiment 1 was devised to investigate whether a primacy effect exists in a perceptual implicit word stem completion test. A word stem cued recall test was included as an explicit control test. Word stems were completed under implicit or explicit test instructions but all other aspects of the study were the same. Because word stems of all the studied words were seen at test, and because the test was performed immediately, it is unlikely that subjects were unaware of the relationship between study and test items. Implicit instructions therefore informed subjects of this relationship but asked them to try not to think back to the study episode and to complete each word stem with the first word that came to mind. This instruction was given to discourage subjects from using intentional retrieval in the implicit test. The order of presentation of words was rotated so that any significant results would not be contaminated by differences in word memorability or ease of completion.

Primacy effects are predicted to occur in the explicit word stem cued recall test which requires intentional retrieval of studied items. However, they are not predicted in the perceptual implicit word stem completion test which assesses indirect memory for the study episode without requiring subjects to intentionally refer back to that episode. With regard to possible theoretical speculations, the multiple memory systems theory would be unlikely to predict a primacy effect in the perceptual implicit memory test because, according to this theory, perceptually based priming is based on the PRS and a perceptual representation of the word would not be susceptible to the increased rehearsal, or greater attention, thought to underlie primacy effects. According to the transfer appropriate processing theory there might be a greater overlap of data-driven processes between non-primacy items and the test than between primacy items and the test resulting in a negative primacy effect. However, the transfer appropriate processing would be unlikely to predict a negative primacy effect because perceptual priming has not been found to show a reversed levels of processing effect which would be consistent with such a prediction.

This experiment was not designed to capture short-term recency effects as they would have disappeared during the time it took subjects to complete intervening items on the test sheet.

Method

Subjects. Thirty-six students from City University, London, and Goldsmiths College, University of London, age range 18 - 36 years, participated in the experiment. They were randomly allocated to two groups of 18 subjects and tested individually or in pairs.

Design and Materials. The design factors were Test (implicit vs. explicit) and Serial Position, with Test conducted between-subjects and Serial Position within-subjects.

Stimulus material comprised 36 cards. On each card was printed a six letter word in capital letters. These words were selected from materials prepared by Java (1991; Java & Gardiner, 1991). The first three letters of each word formed the initial word stem of at least six words found in the Concise Oxford Dictionary. (A list of these words is shown in Appendix A.) The 36 cards were randomly allocated to two sets of 18 cards. During the course of the experiment the two card sets were counterbalanced such that when one set was presented as target words the other set formed the lure words. Cards within each set were sequentially numbered from 1 - 18. The sequential order of each set of cards was kept constant during the course of the experiment but the positional order varied. Each set of cards was advanced by two numbers after it had been presented once in the implicit test and once in the explicit test. This procedure resulted in each word appearing once in every other serial position.

The test order was held constant in the form of one test sheet of 40 three-letter word stems printed in capital letters in two columns. The first four word stems on the test sheet were filler items followed by word stems from both sets of words, listed in a pseudo-random order with not more than three consecutive word stems from one set.

Procedure. Subjects were randomly assigned to the implicit or explicit test group and were tested either individually or in pairs. Both groups received the same preliminary instructions - to try to memorise the words they were about to see. One set of 18 words was then shown to them on cards, one card at a time for two seconds. After one subject from each group had been presented with the cards in an identical order, the positional order of the cards was advanced by two words (whilst keeping the sequential order the same) before the cards were presented again. In addition, alternate subjects in each group received a different set of words.

Subjects were tested immediately. In the implicit test, subjects were asked to complete every word stem with the first word that came to mind - if a word did not immediately come to mind they were to leave it blank. They were advised that word stems from some study words would be included in the list, but they should only complete word stems with these words if they were the first words that came to mind. In the explicit test, subjects were instructed to write completions to the word stems of any words they could remember from the study cards. They were informed of the presence of some lure word stems and were instructed to leave these blank. They were also asked not to guess completions. Three minutes were allowed for these tests.

On completion, subjects in the implicit test were asked whether they had actually completed word stems with the first word that came to mind or whether they had deliberately tried to remember words from the study episode. All the subjects reported that they had completed the word stems with the first word that came to mind.

Results and Discussion

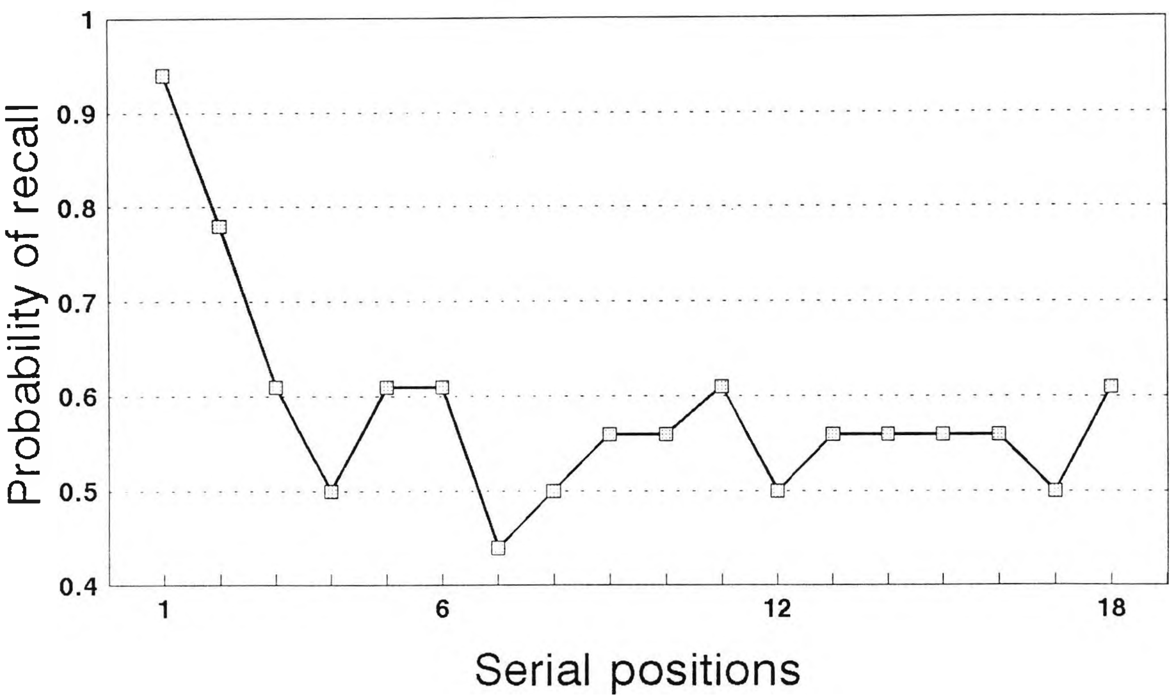
In all the statistical analyses reported in this thesis the alpha level was set at 0.05. There was significant priming in the implicit memory test (target word stem completion prob. = 0.55; lure word stem completion prob. = 0.20) [$t(17) = 9.94$]. Since the level of completion of lure word stems was relatively low, baseline completion should not affect any possible serial position effects. Similarly, incorrect completions in the explicit test were very low (target word stem completion prob. = 0.59; wrong completion prob. = 0.03) [$t(17) = 13.42$] indicating that guessing should not affect serial position effects in the explicit test.

Graphs of the results of the implicit and explicit tests in Experiment 1 are shown in Figure 1. A further graph of these results, collapsed across three consecutive serial positions to reduce noise and with baseline completion (prob. = 0.20) subtracted in the implicit test, is shown in Figure 1a. It appears from these graphs that explicit word stem cued recall produced a primacy effect but implicit word stem completion did not. (Percentages of target words completed and recalled as a function of serial position and test are shown in Table 1, Appendix B.)

To investigate this interpretation of the data a 2 x 2 analysis of variance (ANOVA) was performed with one between-subjects factor, Test (implicit vs. explicit), and one within-subjects factor, Serial Position (probability of recall

Experiment 1

Explicit Test - Word Stem Cued Recall



Implicit Test - Word Stem Completion

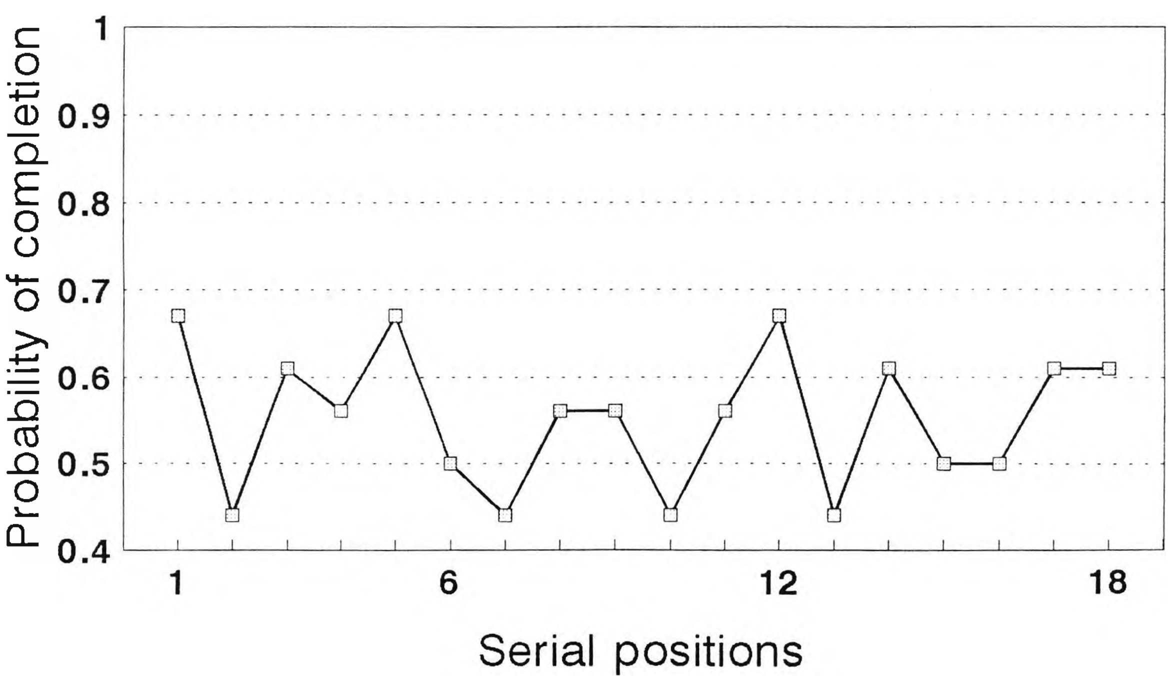


Figure 1

Experiment 1

Word Stem Completion/Cued Recall

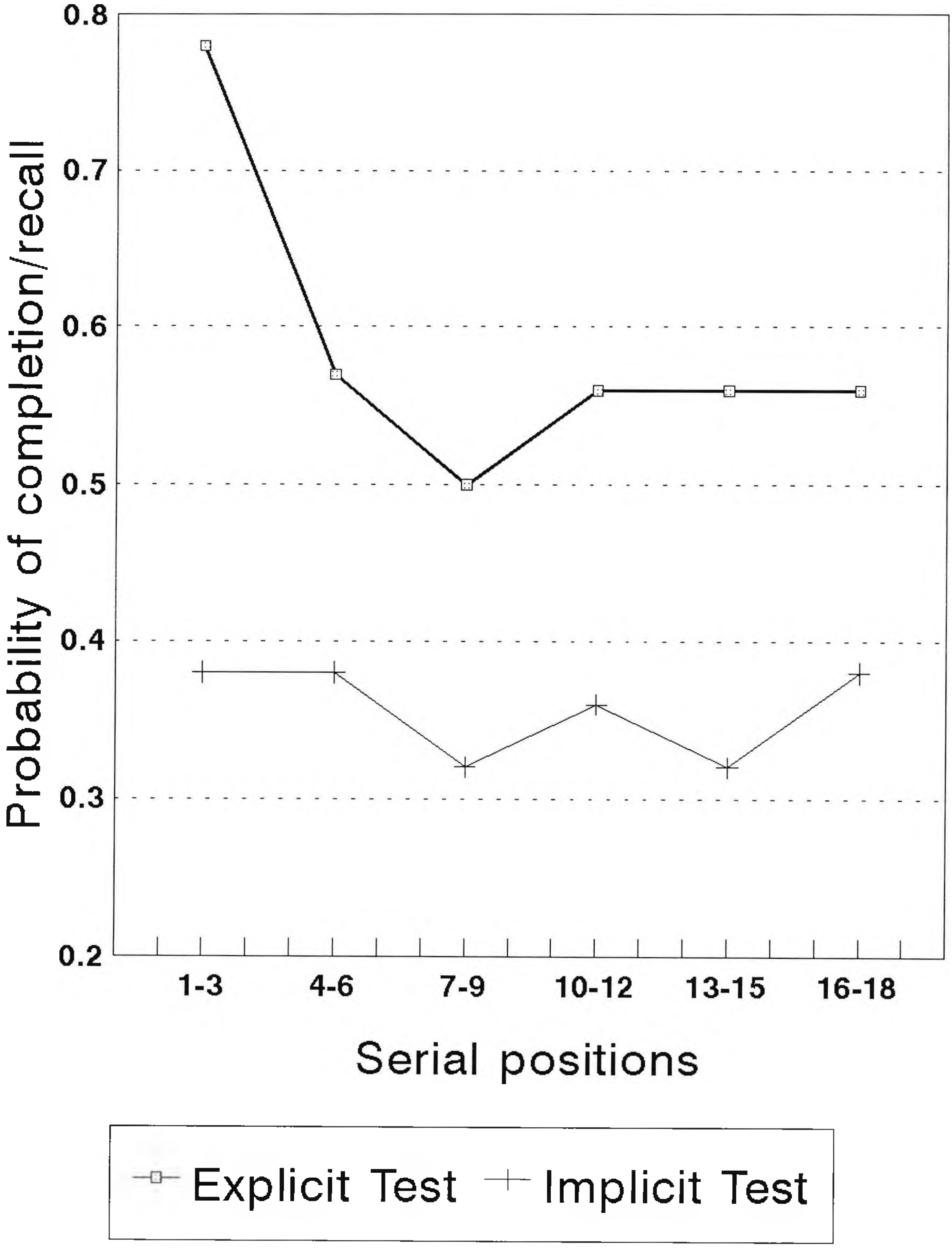


Figure 1a

from primacy serial positions 1-3 vs. probability of recall from asymptote serial positions 7-12). (The choice of these serial positions as indicators of primacy effects and asymptote levels was arbitrary and did not influence the results obtained.) The ANOVA was performed on the data for studied items, without subtracting baselines (i.e. the data shown in Figure 1).

The main effect of Test was not significant [$F(1,34) = 1.78$, $MSe = 0.86$] but that of Serial Position was [$F(1,34) = 8.59$, $MSe = 0.39$] and there was a significant interaction between Test and Serial Position [$F(1,34) = 4.73$, $MSe = 0.39$]. Separate t-tests were performed between the primacy and asymptote serial positions from each test to find the reason for this interaction. In the implicit test, the difference between these serial positions was not significant [$t(17) = 0.29$] but in the explicit test it was [$t(17) = 13.11$].

These results show a primacy effect in explicit cued recall but not in implicit word stem completion. This difference could not be attributed to greater variability in the implicit test since both tests had identical mean square error terms. This dissociation provides evidence that the implicit test was not contaminated by explicit strategies and that subjects were performing according to instructions. Informing subjects of the relationship between study and test items, but asking them to try not to think back to the study episode and complete word stems with the first word that came to mind, therefore appears to be a worthwhile procedure to adopt to discourage explicit contamination (Richardson-Klavehn et al., 1994; see Section 2.6).

The results of this study are consistent with the multiple memory systems theory in which perceptually based priming is assumed to depend on the PRS and perceptual representations would be unlikely to be enhanced by increased rehearsal, or greater attention, believed to be responsible for the primacy effect (Glanzer & Cunitz, 1966; Craik & Lockhart, 1972). The results are less consistent with the transfer appropriate processing theory because encoding primacy items probably involves more conceptually-driven processes than encoding non-primacy items resulting in less overlap of data-driven processes between encoding primacy items and the data-driven test than encoding non-primacy items and the test. However, it is unlikely that the transfer appropriate processing theory would have predicted a negative primacy effect because perceptual priming has not been found to produce a reversed levels of processing effect.

The design of the test sheet in this experiment made it unlikely that a short-term recency effect would occur in either test - any possible short-term recency effects would have disappeared during the time it took subjects to work through the four filler word stems and intervening word stems. It was therefore necessary to alter the test sheet so that the most recently seen words were presented first to capture any possible short-term recency effects. Neither the multiple memory systems theory, nor the transfer appropriate processing theory would be likely to predict a short-term recency effect in implicit memory tests since this effect has been found to be dependent on intentional retrieval which should not occur in implicit memory tests.

3.3 EXPERIMENT 2

Because short-term recency effects are short-lived when words are encoded without an interpolated task (Glanzer & Cunitz, 1966; Craik, 1970), it was necessary to design a new test sheet which would provide an optimal test for short-term recency. It was also necessary for the test sheet to accommodate the rotation of the order of presentation of stimuli words. A circular test sheet was devised on which word stems of the two sets of stimuli words appeared alternately. A mask, which allowed one word stem to be viewed at a time, was placed over the test sheet and secured at the centre. When the mask was rotated in a clockwise direction, subjects saw word stems from the words they had seen previously, in reverse order, alternated by word stems from the other study list which they had not seen. This test sheet design provided an optimal test for short-term recency since it enabled subjects to complete word stems in the reverse to studied order. It also allowed for full rotation of the studied items across subjects and incorporated lures/baseline items.

Short-term recency effects, like primacy effects, are assumed to reflect intentional retrieval of studied items. They are not therefore predicted in the implicit word stem completion test which does not involve intentional retrieval processes. However, they are predicted in the explicit word stem cued recall test in which intentional retrieval processes are involved. It is anticipated that the cognitive effort required to retrieve a word from a word stem cue will lower the short-term recency effect compared to free recall but subjects should still be able to off-load words from short-term memory to a limited extent (see Section 2.3).

In addition to testing for short-term recency effects, Experiment 2 provided an opportunity to replicate the results of Experiment 1 in which a primacy effect was found in explicit word stem cued recall but not in implicit word stem completion.

Method

Subjects. Seventy-two students and staff from City University, London, and Goldsmiths College, University of London, age range 18 - 42, participated in the experiment. They were randomly allocated to two groups of 36 subjects and tested individually.

Design and Materials. The experimental design was similar to Experiment 1 but the positional order of the cards was advanced by one word, instead of two words, after presentation in the implicit and explicit tests. This procedure allowed full counterbalancing of serial positions since every word appeared once in every serial position for each test.

The stimuli were also identical to Experiment 1, but the test sheet was designed to capture any possible short-term recency effects. It contained 36 three-letter word stems printed in capital letters and equally spaced around the circumference of a circle with word stems from each set appearing alternately. The test sheet was covered by a cardboard circular mask, fixed at the centre, with a three-sided cut-out on the circumference which allowed one word stem to be viewed at a time. When the mask was rotated in a clockwise direction, subjects saw word stems from the study words, in reverse order, alternated with lure word stems.

Procedure. The procedure was also similar to Experiment 1 but with the following differences. In Experiment 2, subjects were all tested individually. Immediately after seeing the study words, they were given a test sheet with the mask open at the word stem of the lure word immediately preceding the word stem of the last study word they had seen. Additional instructions were given to move the mask clockwise for each word stem. Subjects were only allowed to view each word stem once.

On completion, subjects in the implicit test were asked whether they had completed word stems with the first word that came to mind or whether they had deliberately tried to remember words from the study episode. One subject was replaced because she had misunderstood the test instructions.

Results and Discussion

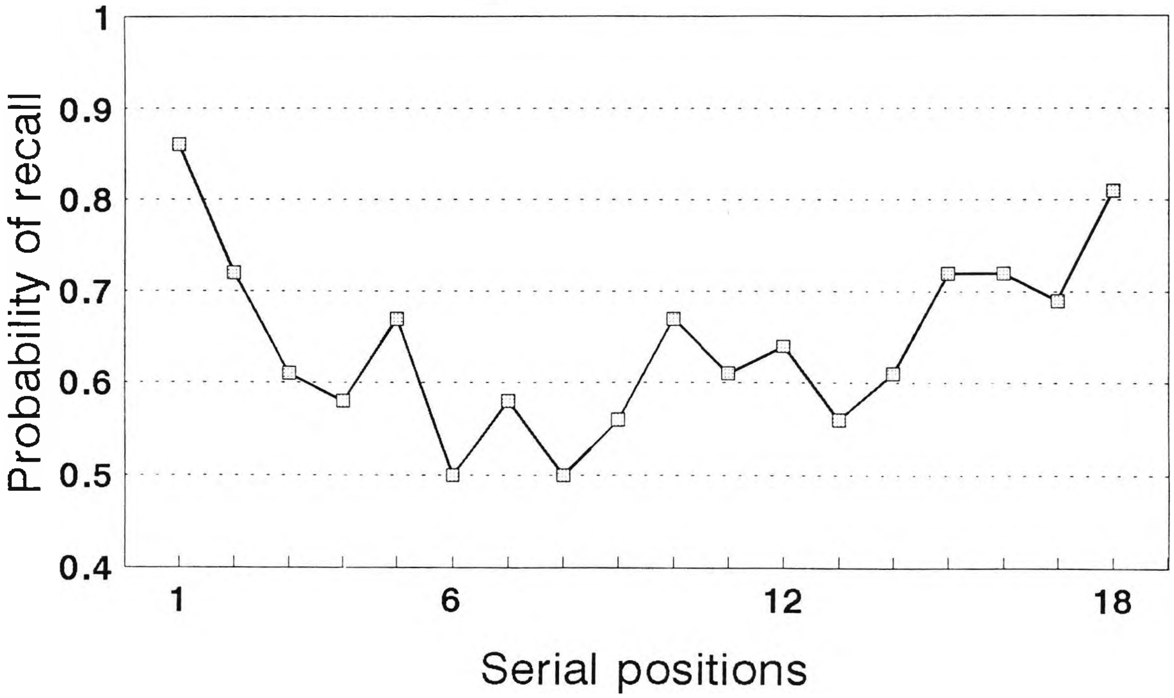
In the implicit test, baseline word stem completion was again relatively low (prob. = 0.21) compared with target word stem completion (prob. 0.65) [t(35) = 14.16]. Similarly, incorrect completions in the explicit test were low (prob. = 0.07) compared with target completions (prob. = 0.65) [t(35) = 18.44].

Graphs of the results of the implicit and explicit tests in Experiment 2 are shown in Figure 2. A further graph of these results, collapsed across three consecutive serial positions to reduce noise and with baseline completion (prob. = 0.21) subtracted in the implicit test, is shown in Figure 2a. It appears from these graphs that explicit word stem cued recall produced primacy and short-term recency effects but implicit word stem completion did not. (Percentages of target words completed and recalled as a function of serial position and test are shown in Table 1, Appendix B.)

To calculate whether there were significant serial position effects in the implicit test compared with the implicit test, a 2 x 3 ANOVA was performed with one between-subjects factor, Test (implicit vs. explicit), and one within-subjects factor, Serial Position (probability of recall from primacy serial positions 1-3 vs. asymptote serial positions 7-12 vs. short-term recency serial positions 16-18). (The choice of these serial positions as indicators of primacy, asymptote and short-term recency was arbitrary and did not influence the results obtained.) The ANOVA was performed on the data for studied items, without subtracting baselines.

Experiment 2

Explicit Test - Word Stem Cued Recall



Implicit Test - Word Stem Completion

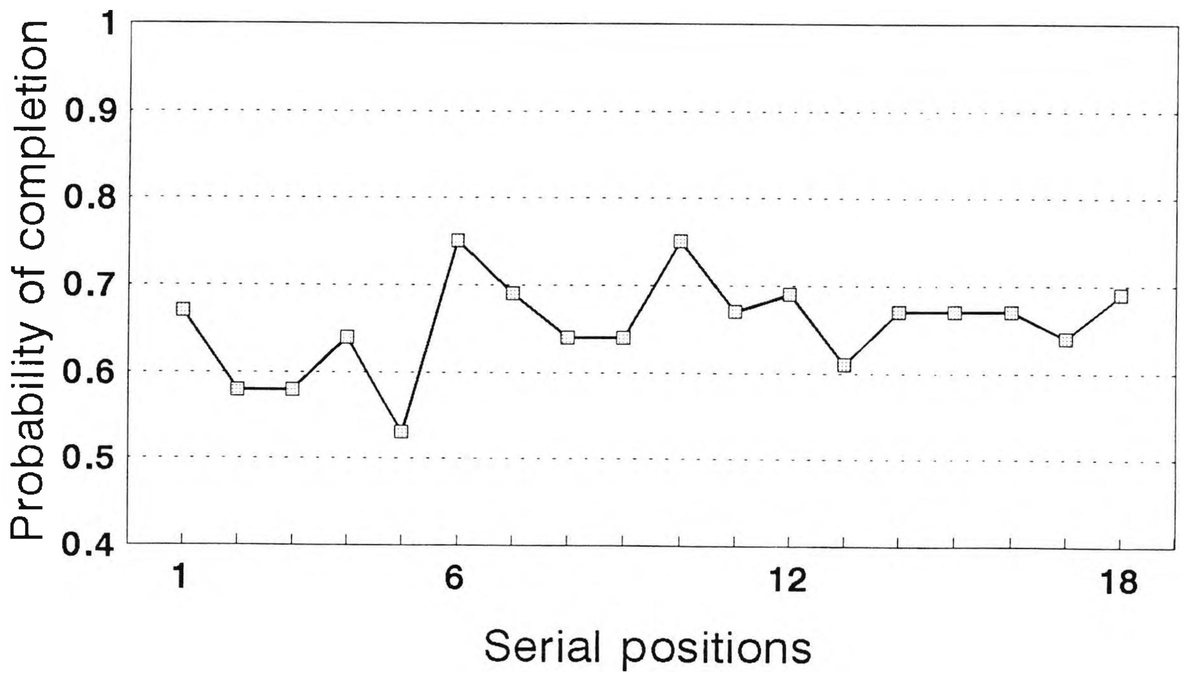


Figure 2

Experiment 2

Word Stem Completion/Cued Recall

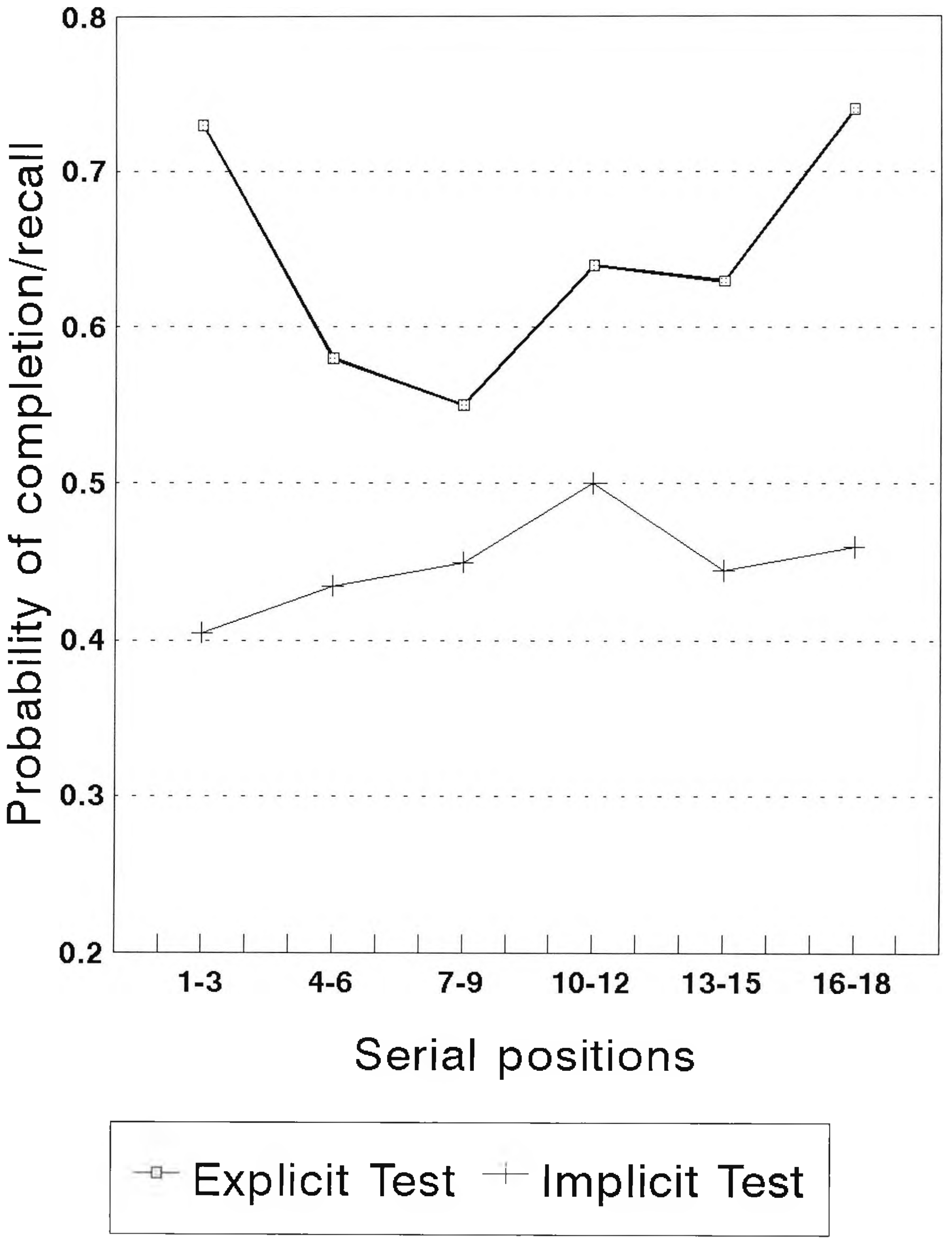


Figure 2a

Neither the main effect of Test [F(1,70) = 0.63, MSe = 0.97] nor the main effect of Serial Position [F(2,140) = 1.44, MSe = 0.51] was significant, but there was a significant interaction between Test and Serial Position [F(2,140) = 3.81, MSe = 0.51]. One-way ANOVAS were performed on each test to investigate the reason for this interaction. In the implicit test the main effect of Serial Position was not significant [F(2,70) = 0.97, MSe = 0.45] but in the explicit test it was [F(2,70) = 3.95, MSe = 0.57]. In the explicit test, a paired t-test between the primacy and asymptote probabilities was significant [t(35) = 2.51] as was a paired t-test between the asymptote and short-term recency probabilities [t(17) = 2.60].

Primacy and short-term recency effects were therefore found in explicit word stem cued recall but not in implicit word stem completion. However, an examination of Figure 2a shows forgetting occurred throughout the course of the explicit test for non-primacy items. Indeed, a polynomial test of order of Non-primacy Serial Positions 4-6, 7-9, 10-12, 13-15 and 16-18 confirmed this interpretation of the data as it showed a significant linear trend [F(1,35) = 5.59, MSe = 0.92] in the explicit test. This forgetting which occurred during the explicit test would have contributed to the short-term recency effect. It is not therefore possible to be sure that the short-term recency effect in the explicit test was all produced by subjects off-loading the contents of their short term memory prior to retrieving items from long-term memory. According to Figure 2A, there also appeared to be slight forgetting throughout the course of the implicit test but this trend was not significant [F(1,35) = 0.87, MSe = 0.56].

The results of this experiment provide a replication of the results of Experiment 1 with a significant primacy effect in the explicit test but not in the implicit test. However, a comparison of the graphs of the two explicit tests indicates that the primacy effect was higher in Experiment 1 than in Experiment 2. This difference may be because word stems of studied words appeared in the reverse order on the test sheet in Experiment 2. The first words encoded (from which the primacy effect is measured) were therefore the last word stems completed, resulting in a lower primacy effect.

When the results of Experiments 1 and 2 are compared, it is apparent that target word stem completion rates in the implicit tests differed (Expt. 1 prob. = 0.55; Expt. 2 prob. = 0.65). Since the stimuli and study conditions were identical, it is probable that this difference was located in the different test sheets. The absence of four filler word stems in Experiment 2 may be one contributory factor, but a further factor might be that test word stems were presented one at a time in Experiment 2 which was more similar to the manner in which they were encoded. The increased similarity between encoding and test conditions may have provided more optimal conditions for implicit test performance.

Experiments 1 and 2 were performed using the same set of stimulus words. To further replicate and test the generality of the results, it was considered necessary to repeat the procedure used in Experiment 2 with different stimulus words. In addition, to further investigate involuntary retrieval (see Section 2.6), a procedure first used by Java (1994) was adapted for use in the implicit test. In her study, she asked subjects to re-examine their responses after an implicit word stem completion test and to "pick out" those which they recognised as study items. In the following study, subjects were also requested to re-examine their responses immediately they had completed the word stem completion test and to tick those which they recognised as study items. If subjects were unable to explicitly recognise their implicitly completed responses as target words, this would indicate a further dissociation between implicit and explicit memory test performance as subjects would obviously be able to recognise target words which they had just explicitly recalled.

3.4 EXPERIMENT 3

Experiment 3 was performed to try to replicate the results of Experiment 2 using a different set of stimulus words. Each of these words had a unique three letter word stem which was different to the words used in Experiments 1 and 2. Again each word stem could be completed by at least six words found in the Concise Oxford Dictionary. The use of different stimulus words was considered necessary because previous studies investigating serial position effects in implicit memory tests have shown such variable results (see Section 2.4).

Immediately after the implicit test, subjects were asked to specify which of their implicitly completed words they could remember from the study phase. If they were unable to explicitly recognise a high proportion of their completions, this would indicate a further dissociation between the results of implicit and explicit memory tests as subjects in the explicit test would obviously be able to recognise the word stems that they had just recalled.

Method

Subjects. Seventy-two students and staff from Goldsmiths College, University of London, age range 18 - 44, participated in the experiment. They were randomly allocated to two groups of 36 subjects and tested individually.

Design, Materials and Procedure. The experimental design was identical to Experiment 2, but 36 different stimulus words, selected from materials prepared by Java (1991), were used. (A list of these words is shown in Appendix A.) Three-letter word stems of the new stimulus words appeared on the test sheet in the same format as Experiment 2. The procedure was also similar to Experiment 2 but with one additional feature. In the implicit test, immediately after subjects had completed the word stem completion test, they were required to look back over the words they had completed and to tick any words which they remembered from the study cards.

On completion, subjects in the implicit test were asked whether they had completed word stems with the first word that came to mind or whether they had deliberately tried to remember words from the study episode. Two subjects were replaced because they had misunderstood the test instructions.

Results and Discussion

In the implicit test, baseline word stem completion was again low (prob. = 0.17) compared with target word stem completion (prob. 0.61) [$t(35) = 16.24$]. Similarly, incorrect completions in the explicit test were low (prob. = 0.03) compared with target completions (prob. = 0.65) [$t(35) = 22.30$].

Almost a quarter of the implicitly completed target words were not explicitly recognised (prob. = 0.22). This figure was not the result of subjects being too stringent as incorrect recognition of implicitly completed words was relatively high (prob. = .12). Even though explicit cued recall performance was high (prob. = 0.65) with a low error rate (prob. = 0.03), subjects failed to recognise a high proportion of their own implicitly completed words. However, this proportion was not as high as was found by Java (1996). She found young subjects failed to recognise 36% and older subjects failed to recognise 91% of their own implicitly completed words. The difference between the results of this experiment and those of Java may be because this implicit test was performed immediately and there was a high implicit completion rate (61%) whereas, in Java's experiment, the implicit test was performed after an interim task and the implicit completion rate was lower (35%).

Graphs of the results of the implicit and explicit tests in Experiment 3 are shown in Figure 3. A further graph of these results, collapsed across three consecutive serial positions to reduce noise and with baseline completion (prob. = 0.17) subtracted in the implicit test, is shown in Figure 3a. It appears from these graphs that cued recall again produced primacy and short-term recency effects but implicit word stem completion did not. However, the short-term recency effect in the explicit test, shown in Figure 3, appears less pronounced than the short-term recency effect in the explicit test in Experiment 2, shown in

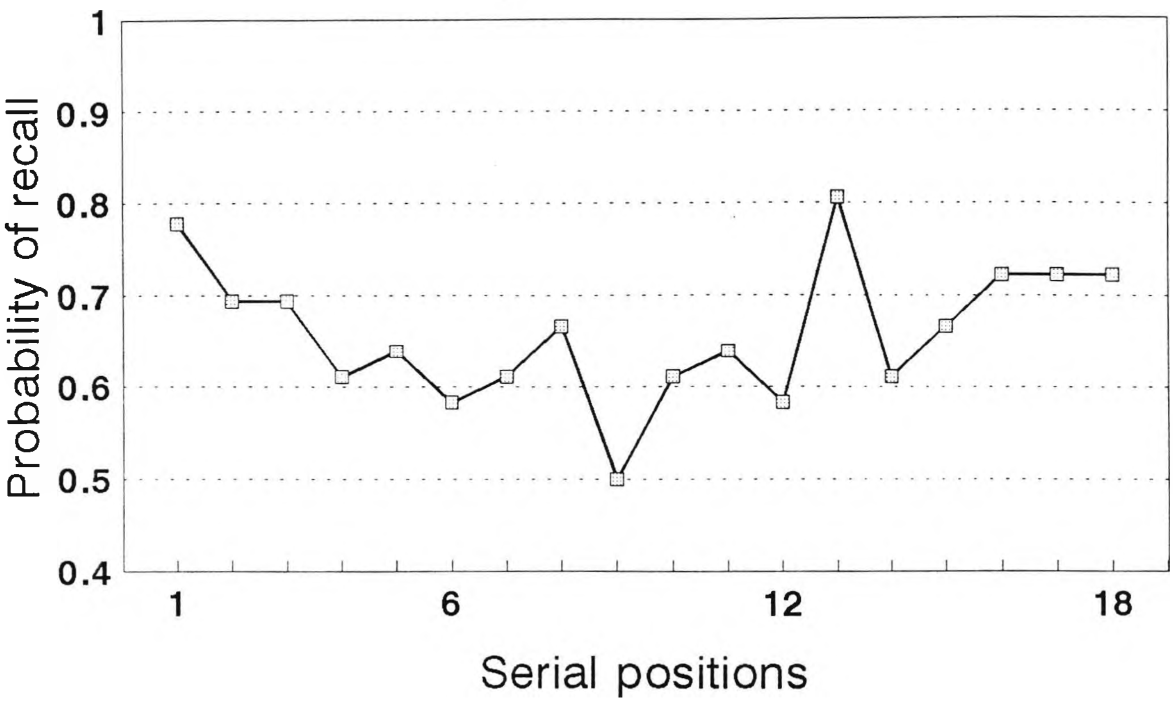
Figure 2. In addition, Figure 3a indicates a higher level of asymptote in the implicit test than Figure 2a. (Percentages of target words completed andrecalled as a function of serial position and test are shown in Table 1, Appendix B.)

To calculate whether there were significant serial position effects in the explicit test compared with the implicit test, a 2 x 3 ANOVA was performed with one between-subjects factor, Test (implicit vs. explicit), and one within-subjects factor, Serial Position (probability of recall from primacy serial positions 1-3 vs. asymptote serial positions 7-12 vs. short-term recency serial positions 16-18). (The choice of these serial positions as indicators of primacy, asymptote and short-term recency was arbitrary and did not influence the results obtained). The ANOVA was performed on the data for studied items, without subtracting baselines.

Neither the main effect of Test [$F(1,70) = 1.65$, $MSe = 0.81$] nor the main effect of Serial Position [$F(2,140) = 0.16$, $MSe = 0.45$] was significant but there was a significant interaction between Test and Serial Position [$F(2,140) = 5.42$, $MSe = 0.45$]. One-way ANOVAS were performed on each test to investigate the reason for this interaction. In the explicit test the main effect of Serial Position was significant (one-tailed) [$F(2,70) = 2.92$, $MSe = 0.47$]. The main effect of Serial Position was also approaching significance in the implicit test [$F(2,70) = 2.66$, $MSe = 0.44$], but Figure 3a shows that this

Experiment 3

Explicit Test - Word Stem Cued Recall



Implicit Test - Word Stem Completion

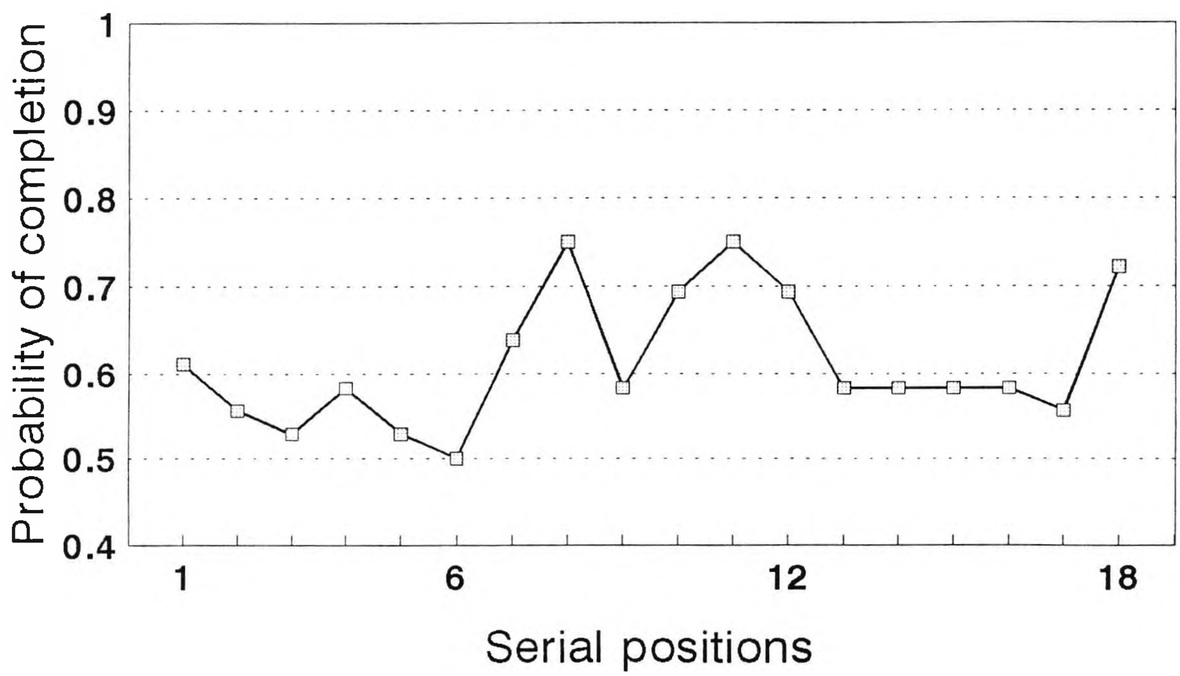


Figure 3

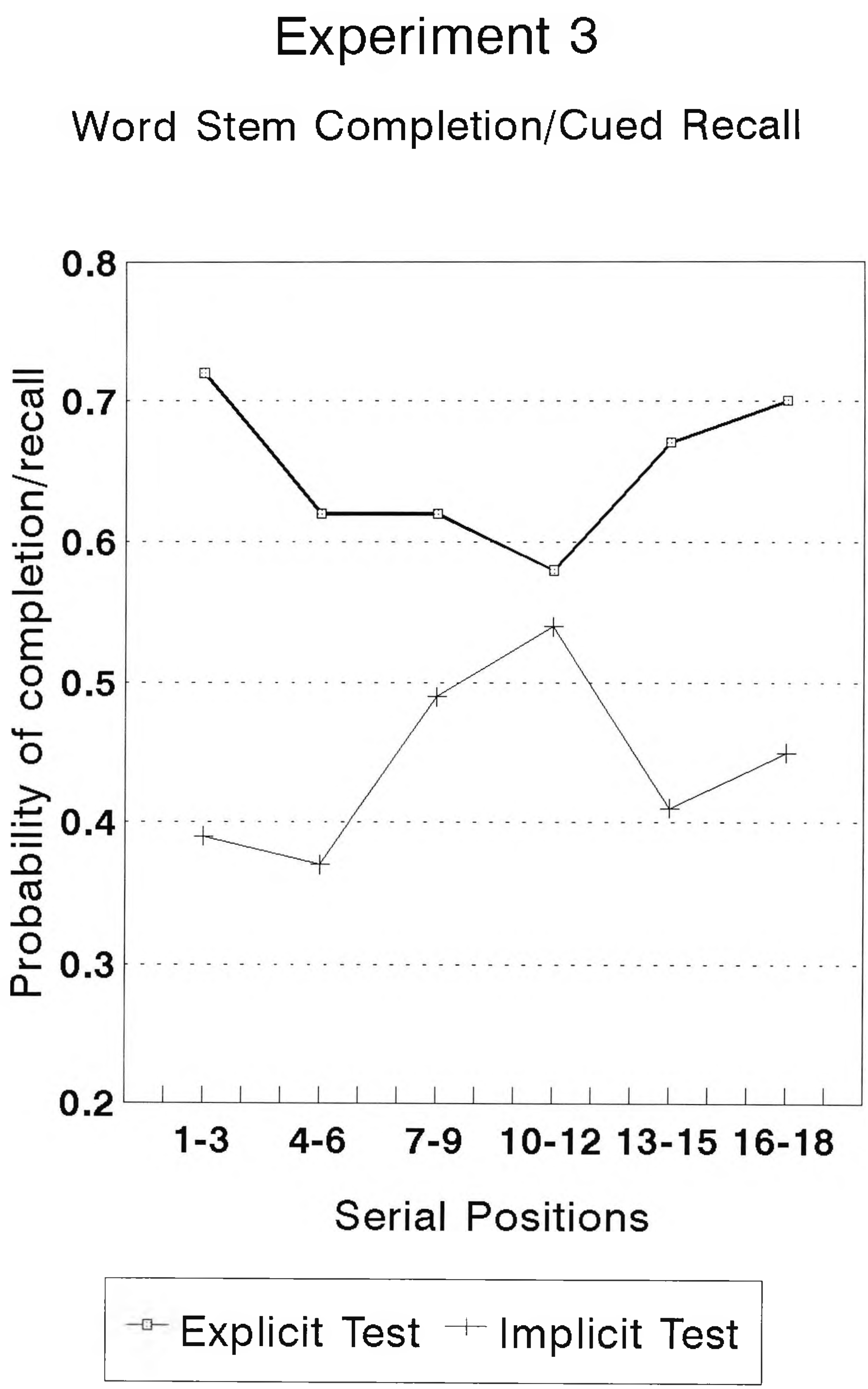

Experiment 3
Word Stem Completion/Cued Recall
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Probability of completion/recall
1-3
4-6
7-9
10-12
13-15
16-18
Serial Positions
Explicit Test
Implicit Test

Figure 3a

was in the opposite direction to the explicit test. In the explicit test a paired t-test between the primacy and asymptote probabilities was significant [t(35) = 2.35] and a further paired t-test between the asymptote and short-term recency probabilities was significant (one-tailed) [t(35) = 1.98].

These results show that primacy and short-term recency effects were again found in explicit word stem cued recall but not in implicit word stem completion. Similar to Experiment 2, the significant short-term recency effect in the explicit test may have been attributable to forgetting during the course of the test. However, a polynomial test of order of Non-primacy Serial Positions 4-6, 7-9, 10-12. 13-15 and 16-18 in the explicit test did not show a significant linear trend in the explicit test. Instead, it showed a significant quadratic trend [F(1,35 = 5.66, MSe = 0.51], perhaps because the primacy effect was longer in this experiment than in Experiment 2.

Apart from the longer primacy effect in the explicit test, and the higher asymptote level in the implicit test, the results of Experiment 3 were in general agreement with those of Experiment 2. The results of Experiment 1 and 2 therefore generalised to different stimulus words.

General Discussion

There was no indication of serial position effects in the implicit tests in these three experiments whereas the explicit tests, which were identical to the implicit tests in every aspect except the test instructions, showed primacy effects in all three experiments and recency effects in Experiments 2 and 3. It should be noted, however, that it is uncertain to what extent these recency effects were attributable to subjects off-loading the contents of their short-term memory or to forgetting that occurred during the test.

The lack of serial position effects in the implicit tests differed from all the four previous studies investigating serial position effects in implicit memory tests which were discussed in Section 2.4. The most probable reason for the difference between the results of this study and those of Sloman *et al.* (1988; Experiment 1) was the use of intentional retrieval in Sloman *et al.*'s study. With reference to the study by McKenzie and Humphreys (1991, Experiments 1-3), the most probably reason for the difference between their results and the results of this study was because their experiments measured forgetting which occurred throughout the course of the experiment, not short-term recency effects. The main difference between the results of this study and those of Rybash and Osborne (1991) and Gershberg and Shimamura (1994) was the different procedures used. For example, the order in which target words were presented to subjects differed between the studies. In Rybash and Osborne's study, all the subjects studied the same list of target words in the same order. In Gershberg and Shimamura's study, each subject studied one of two target word lists in one of two different orders. In this study, the subjects also studied one of two target word lists, but each list was presented in nine different orders in Experiment 1 and in 18 different orders in Experiments 2 and 3. Only by such an extensive rotation of words at encoding can differences in word frequency and ease of completion of word stems be adequately controlled.

As well as providing evidence for the lack of serial position effects in implicit memory, these results provide tangible evidence that test-aware subjects performed according to instructions in the implicit test. If they had been using explicit strategies, it is probable that serial position effects in the implicit test would have been similar to those in the explicit test. There was also evidence of a difference in conscious awareness between performance in implicit and explicit memory tests as subjects were unable to recognise almost a quarter of the words they had implicitly completed, whereas they were obviously aware of words they had recalled.

The finding that the perceptual implicit memory test of word stem completion does not show serial position effects, compared with the explicit memory test of word stem cued recall which does, reveals another dissociation between tests of implicit and explicit memory and provides further evidence that intentional retrieval processes were not involved in this implicit memory test. The absence of a primacy effect in the perceptual implicit memory test is consistent with the multiple memory systems theory which states that perceptual priming is based on the PRS and a perceptual representation would not be susceptible to deeper conceptual processing. It is less consistent with the transfer appropriate processing theory which might have predicted a negative primacy effect in a perceptual implicit memory test except that a reversed levels of processing effect has not been found in perceptual priming. The absence of a short-term recency effect in perceptual priming is consistent with possible predictions from both theories.

Since primacy effects are assumed to arise from more elaborative or rote rehearsal or from greater attention devoted to the first few items than later items in a to-be-remembered list (see e.g. Atkinson & Shriffrin, 1968, Craik & Lockhart, 1972), their presence or absence may be consistent with the presence or absence of levels of processing effects. If this supposition is correct, the absence of a primacy effect in word stem completion is in agreement with previous implicit memory literature which has generally found no significant levels of processing effects in perceptual implicit memory tests (see e.g. Graf & Mandler, 1984; but see Challis & Brodbeck, 1992; see Section 1.2.4). Levels of processing have generally been found in conceptual implicit memory tests but there is some disagreement as to why they occur. The multiple memory system theory's explanation is that conceptual implicit memory is based on a different underlying system to perceptual implicit memory, a system which is susceptible to deeper semantic processing. The transfer appropriate processing theory's explanation is that conceptual implicit test processes overlap better with deeper encoding processes (Hamann, 1990; Srinivas & Roediger, 1990). Alternatively, it has been suggested that curtailment of processing in the shallow encoding task is responsible for the levels of processing effect (Challis & Brodbeck, 1992; Hayman & Jacoby, 1989; Thapar & Greene, 1994); or that contamination by intentional retrieval strategies has contributed to the effect (see Section 1.3.4).

If the presence or absence of primacy effects is consistent with the presence or absence of levels of processing effects, an investigation into whether or not primacy effects occur in conceptual priming would cast some light on this debate from a different perspective. Curtailment of processing would not be an issue when investigating primacy effects, as the same encoding task would be performed on all the stimulus words. In addition, as there was no evidence of the use of intentional retrieval strategies in the implicit tests in Experiments 1 - 3, it is unlikely that intentional retrieval strategies would be used to retrieve primacy items in a conceptual implicit memory test. Primacy effects are therefore relatively independent of two of the proposed reasons for levels of processing effects in conceptual implicit memory tests described above. The occurrence of primacy effects would therefore indicate that conceptual implicit memory tests are susceptible to different encoding processes independently of curtailment or shallow graphemic encoding or contamination by intentional retrieval.

To investigate this issue, the next chapter examined whether or not primacy effects occurred in a conceptual implicit memory test. The test chosen was that of free association to single words from previously studied associated word pairs. This test was selected because it is concise (single word cues elicit single word responses) and it has previously been found to produce a relatively high level of conceptual priming (see e.g. Shimamura & Squire, 1984, Experiment 3).

CHAPTER 4

SERIAL POSITION EFFECTS IN THE CONCEPTUAL IMPLICIT MEMORY TEST OF FREE ASSOCIATION

4.1 Introduction

In this chapter three experiments are described, all of which investigated serial position effects in the conceptual implicit memory test of free association. Experiments 4 and 5 used moderately and weakly related word pairs respectively and Experiment 6 used both strongly and weakly related word pairs. As in Experiments 1 - 3, each experiment included an explicit test. In accordance with the retrieval intentionality criterion (Schacter, *et al.*, 1989), all aspects of the implicit and explicit tests, except the test instructions, were identical to enable the results of the two tests to be directly compared.

According to the multiple memory systems theory, conceptual priming is based on a system outside the PRS, possibly the semantic system, which is susceptible to deeper conceptual processing (Schacter, 1994; see Section 1.5.1). Schacter (1994) states that "... priming can be observed on tasks that involve semantic processing, such as answering general knowledge questions or producing category instances in response to a category label. The magnitude of such tasks is increased by semantic study relative to nonsemantic study (Hamann, 1990) and can be dissociated from perceptually based priming." (p.253). Consistent with levels of processing effects, the multiple memory systems theory might predict a primacy effect in a conceptual implicit memory test. The transfer appropriate processing theory might also predict a primacy effect in a conceptual implicit memory test since encoding primacy items would involve more conceptually-based processing which would overlap better with conceptually-based priming. However, because primacy effects are assumed to reflect intentional retrieval processes, they would not be predicted in a conceptual implicit memory test which assesses indirect memory for a study episode without requiring subjects to intentionally refer back to that episode. But neither would levels of processing effects.

As with perceptual implicit memory tests, neither the multiple memory systems theory nor the transfer appropriate processing theory would be likely to predict a short-term recency effect in conceptual implicit memory tests since this effect has been found to be dependent on intentional retrieval which should not occur in implicit memory tests.

4.2 EXPERIMENT 4

Since primacy effects are assumed to reflect a greater opportunity to process the first few items compared to the remaining items in a to-be-remembered list, they may be construed as evidence of deeper processing of the first few list items compared to latter items. Consistent with this assumption, tests which show primacy effects might be expected to be susceptible to levels of processing effects. If this is the case, empirical data as to whether or not primacy effects occur in conceptual implicit memory tests might help resolve the disagreement as to why levels of processing effects occur in these tests (see Section 1.3.4 and the General Discussion at the end of Chapter 3).

Experiment 4 therefore investigated whether a primacy effect would occur in a conceptual implicit memory test of free association compared to a comparable explicit test of cued recall. In both tests, subjects were presented with eighteen semantically related word pairs, printed on cards, e.g. *YELLOW SUN, FRUIT ORANGE,* with instructions to try to memorise them. Immediately they had seen all the word pairs, they performed a free association test or a cued recall test. The same test sheet design as Experiments 2 and 3 was retained in this experiment so that the results of this conceptual implicit memory test are comparable with those of the perceptual implicit memory tests. In addition, as there appeared to be slight forgetting during the implicit test in

Experiment 2, the proposed test sheet would capture any forgetting which might occur during the conceptual implicit memory test. It would also capture any short-term recency effects which might occur in the explicit test.

A significant primacy effect in this conceptual implicit test would be consistent with both the multiple memory systems theory and the transfer appropriate processing theory. However, a primacy effect would not be predicted if the levels of processing effects which have previously been found in conceptual implicit memory tests are attributable to curtailment of processing in the shallow encoding task (see e.g. Thapar & Greene, 1994), or to contamination by intentional retrieval strategies (see Section 1.3.4). A primacy effect is predicted in the explicit control test.

The occurrence of a short-term recency effect in the explicit control test may depend on the difficulty of the cued recall test. Unitised word pairs (e.g. *BLACK WHITE, MAN WOMAN*) might be more likely to produce short-term recency effects because retrieval of the second word, given the first, is relatively automatic and would be less likely to interfere with off-loading items from short-term memory. Retrieval of the second word, given the first, in non-unitised word pairs involves more cognitive effort and might therefore be less likely to produce short-term recency effects (see Section 2.3). In Experiment 4, the stimulus word pairs were only moderately well related and were not therefore predicted to produce a short-term recency effect in the explicit test. A short-term recency effect is not predicted in the implicit test.

Method

Subjects. One hundred and forty-four students and staff from Goldsmiths College, University of London, age range 19 - 36, participated in the experiment. They were randomly allocated to two groups of 72 subjects and tested individually.

Design and Materials. The design factors were Test (implicit vs. explicit) and Serial Position, with Test manipulated between-subjects and Serial Position manipulated within-subjects.

Stimulus material comprised 36 cards. Two semantically related words were printed on each card, e.g. *HOUSE GARDEN*, *FRUIT ORANGE*. These word pairs were taken from the Minnesota Word Association Norms (Jenkins, 1970). Word pairs in which the second word of the pair was produced to the first word an average of 75 times in 1000 and in which the second word was never the most common response to the first were used. (A list of these word pairs is shown in Appendix A.) The 36 cards were randomly allocated to two sets of 18 cards. These two sets of stimuli were counterbalanced such that when one set was presented as targets the other set formed the lures. Cards within each set were sequentially numbered from 1 - 18. During the course of the experiment, the sequential order of each set of cards was kept constant but the positional order varied; each set of cards was advanced by one number after it had been presented once in the implicit test and once in the explicit test. This procedure allowed full counterbalancing of stimuli since every word pair appeared twice in every serial position for each test.

The first words from each word pair formed the test cues, e.g. *HOUSE* ....., *FRUIT* ...... These words were printed in capital letters and equally spaced around the circumference of a circle with words from each stimulus set appearing alternately. The test sheet was covered by a cardboard circular mask, fixed at the centre, with a three-sided cut-out on the circumference which allowed one word to be viewed at a time. When the mask was rotated in a clockwise direction, subjects saw the first word from each pair of words they had previously studied, in reverse order, interspersed by lure words.

<u>Procedure</u>. Subjects were randomly assigned to the implicit or the explicit test group. Both groups received the same preliminary instructions - to try to memorise the pairs of words they were about to see. Eighteen word pairs were then shown to them on cards, one word pair every three seconds. After one subject from each group had seen the stimuli in an identical order, the positional order of the cards was advanced by one (whilst keeping the sequential order the same) before they were presented again. In addition, alternate subjects in each group saw a different set of stimuli.

Subjects were tested immediately. Each subject received an identical test sheet with the mask open at the word immediately preceding the cue word from the last studied word pair and was instructed to move the mask in a clockwise direction. In the implicit test, subjects were asked to write word associations to each of the words on the test sheet. They were asked not to try to think back to the study cards and only to write words from the study cards if they were the first words that came to mind. In the explicit test, subjects were asked to study each word on the test sheet. If they remembered that the word had appeared on the study cards, they were instructed to try to recall and write the other member of the word pair. They were informed of the presence of some lure words and were instructed not to guess associations. On completion, subjects in the implicit test were asked whether they had actually written the first words that came to mind or whether they had deliberately tried to recall words from the study episode. Two subjects were replaced because they had misunderstood the test instructions and had deliberately tried to recall words in the free association test.

Results and Discussion

There was significant priming in the implicit test (target word association prob. = 0.55, lure word association prob. = 0.09) [$t(71) = 24.51$]. Since the level of lure word association was low, baseline association should not have masked any possible serial position effects in the implicit test. Similarly, incorrect recall in the explicit test was very low (target word recall prob. = 0.67, incorrect recall prob. = 0.04) [t(71) = 26.13] indicating that guessing should not have masked serial position effects in the explicit test.

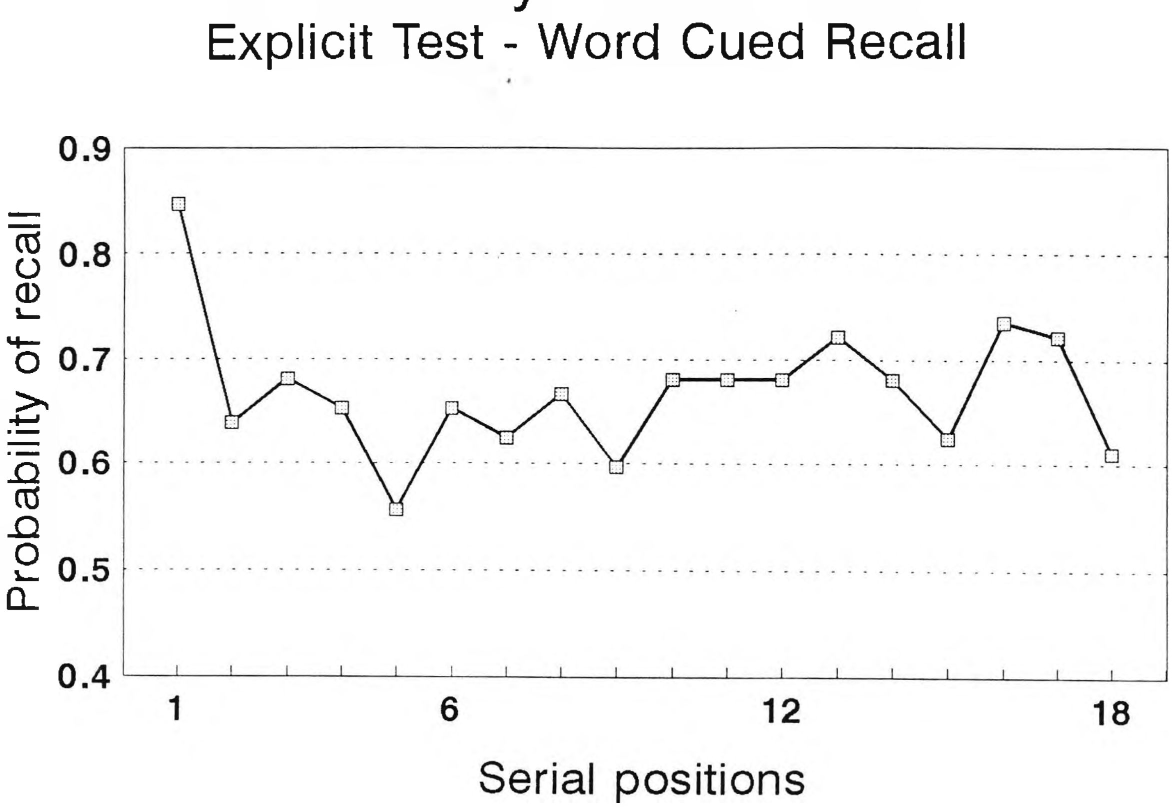
Graphs of the results of the implicit and explicit tests in Experiment 4 are shown in Figure 4. To reduce noise in the graphs, data were collapsed across three consecutive serial positions in each test. In addition, baseline association (prob. = 0.09) was subtracted from each data point in the implicit test. A graph of these results is shown in Figure 4a. (Percentages of target words associated and recalled as a function of serial position and test are shown in Table 2, Appendix B.) It appears from Figures 4 and 4a that both the implicit and explicit tests produced primacy effects. In Figure 4a there appear to be forgetting functions in both tests but there are no apparent short-term recency effects in either test in Figure 4. Instead, performance tails off in both tests for the most recently presented items. The following statistical analyses were executed to investigate these interpretations of the data.

A 2 x 6 ANOVA was performed with one between-subjects factor, Test (implicit vs. explicit) and one within-subjects factor, Serial Position (probability of recall from serial positions 1-3 vs. 4-6 vs. 7-9 vs. 10-12, vs. 12-15 vs. 16-18) to calculate whether there was a significant difference between serial positions in the explicit test compared with the implicit test. The ANOVA was performed on the data for studied items, without subtracting baselines. The main effects of Test [$F(1,142) = 15.39$, $MSe = 1.76$] and Serial Position [$F(5,710) = 3.44$, $MSe = 0.66$] were significant but there was no interaction between Test and Serial Position [$F(5,710) = 0.58$, $MSe = 0.66$].

Planned comparisons between serial positions 1-3 and 4-6 in each test to investigate possible primacy effects showed a significant difference in the explicit test [$t(71) = 2.31$] but not in the implicit test [$t(71) = 1.25$]. (The test of primacy was performed on these two sets of adjacent serial positions because of the apparent forgetting functions in both tests. Because of these forgetting functions, it was not feasible to compare primacy items with asymptote items as in Experiments 1 - 3.) The explicit test therefore showed a significant primacy effect and the implicit test showed a tendency towards a primacy effect. Although this tendency towards a primacy effect in the conceptual implicit test was not conclusive, it differed from the results of the perceptual implicit tests in Experiments 1. 2 and 3 in which no indications of primacy effects were found.

Further planned comparisons between serial positions 13-15 and 16-18 to investigate possible short-term recency effects were not significantly different in the explicit test [$t(71 = 0.35$] nor in the implicit test [$t(71) = 0.69$]. (The test of short-term recency was performed on these two sets of adjacent serial positions because of the forgetting functions in both tests shown in Figure 4a). Nevertheless, a 2 x 5 Polynomial Test of Order between Test and Non-Primacy

Experiment 4
Moderately Related Cues



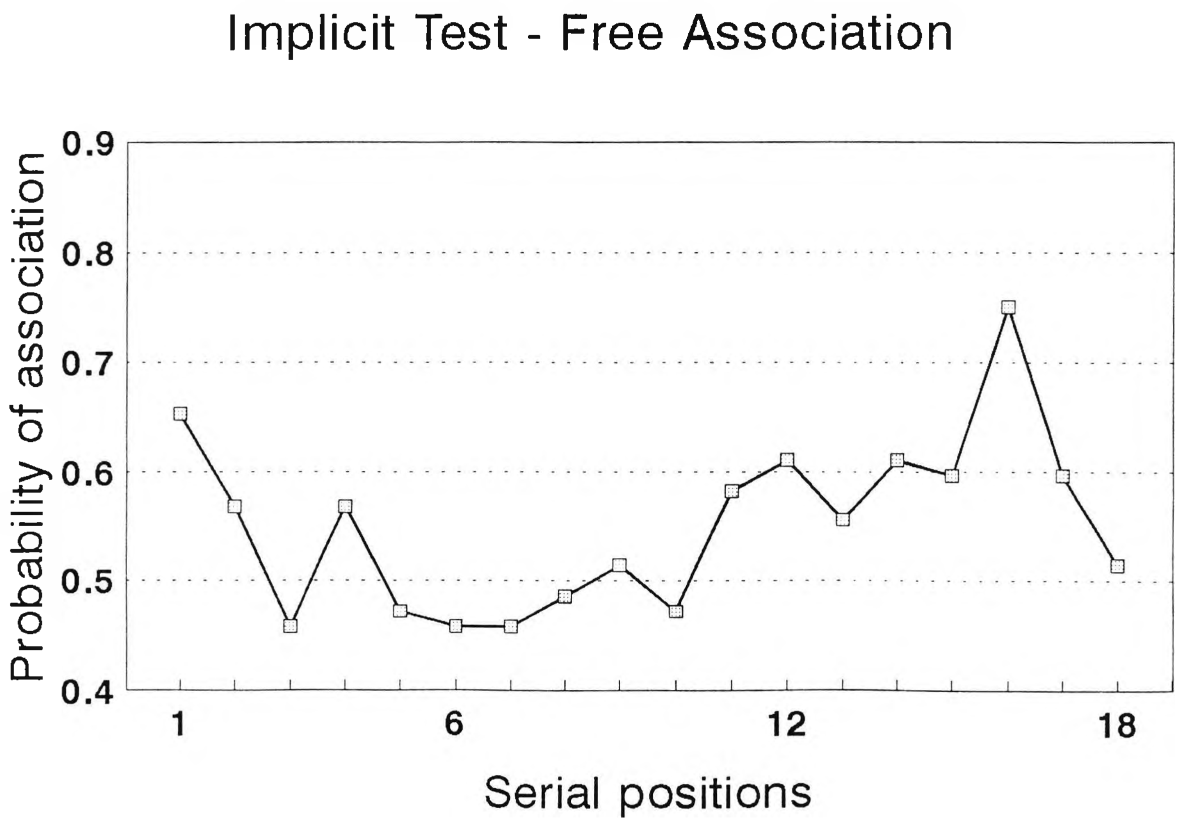
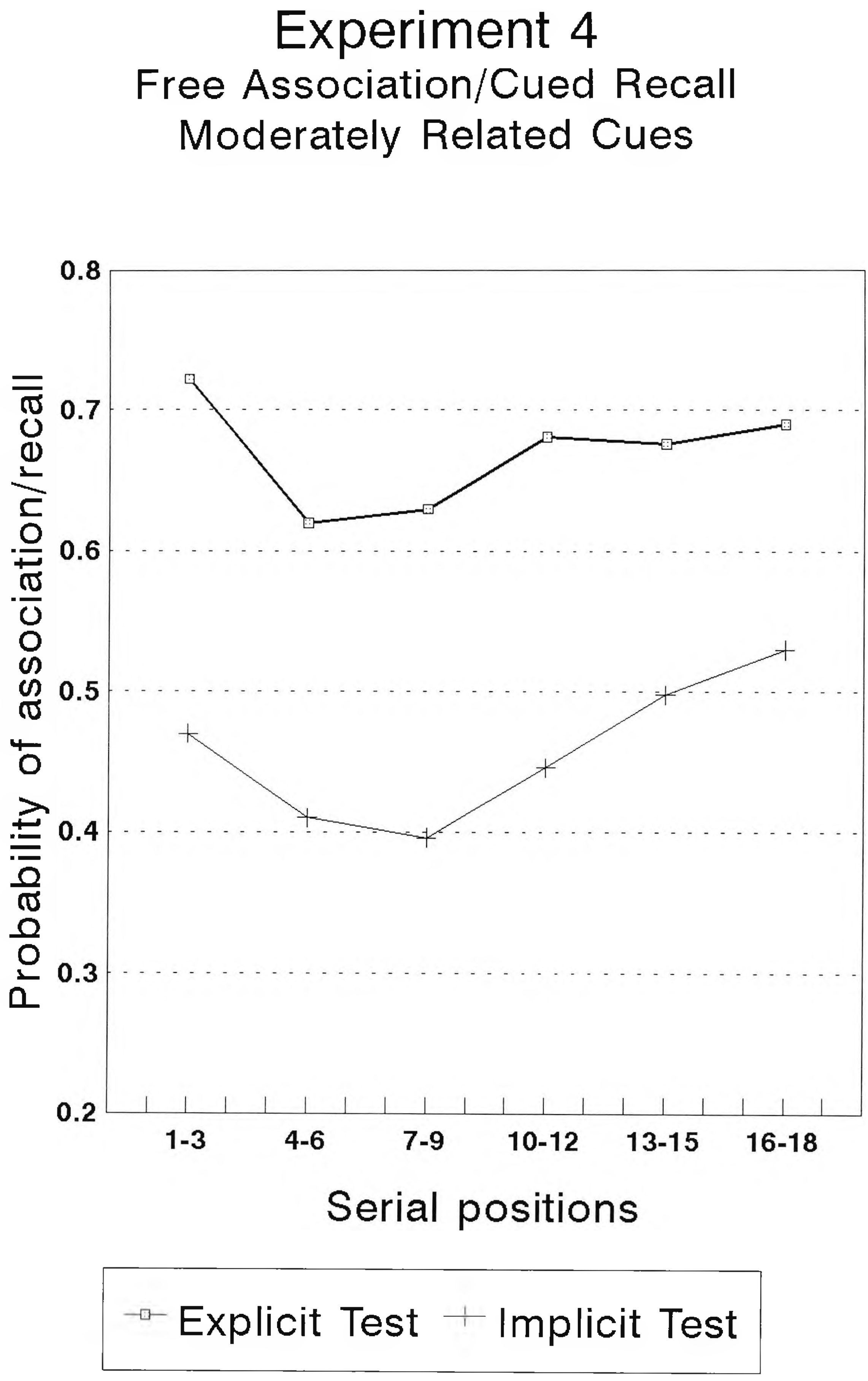


Figure 4



Experiment 4
Free Association/Cued Recall
Moderately Related Cues
Probability of association/recall
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1-3
4-6
7-9
10-12
13-15
16-18
Serial positions
Explicit Test
Implicit Test

Figure 4a

Serial Positions (4-6, 7-9, 10-12, 13-15 and 16-19), showed a significant linear forgetting trend [F(142) = 11.89, MSe = 0.76] with no interaction between Test and Non-Primacy Serial Positions [F(1,142) = 1.06, MSe = 0.76].

Whilst neither test appeared to show a short-term recency effect, both tests showed forgetting throughout the course of the tests when primacy items were excluded. This degree of forgetting did not occur in the perceptual implicit memory tests in Experiments 2 and 3. Because of this forgetting, it is difficult to be sure whether or not short-term recency effects did occur but, since Figure 4 shows that performance tailed off for the last two items in both tests, this is unlikely to be the case.

There were two main differences between this experiment and Experiments 2 and 3. First, different stimuli were used (this experiment used moderately related word pairs whereas Experiments 2 and 3 used single words) and second, different implicit tests were performed (this experiment used a free association test whereas Experiments 2 and 3 used a word stem completion test). It therefore follows that the tendency towards a primacy effect and the rapid forgetting, found in the implicit test in this experiment but not in Experiments 2 and 3, were produced, either by the different stimuli, or by the different test instructions. In Experiment 5, the first of these assumptions was tested - that the tendency towards a primacy effect and the forgetting function in the conceptual implicit test in Experiment 4 was attributable to the word pairs which were used as stimuli. The tendency towards a primacy effect and the rapid forgetting found in the conceptual implicit test may be related to stronger associative connections made between the word pair stimuli during encoding.

4.3 EXPERIMENT 5

It is possible that the tendency towards a primacy effect in the conceptual implicit test in Experiment 4 was produced because the relationship between the two stimulus words in the first one or two word pairs was encoded better than the relationship between the two stimulus words in the remaining word pairs. The forgetting functions in both the implicit and explicit tests may have resulted from interference or decay to the encoded relationship between the pairs of stimulus words. If these two assumptions are correct, then word pairs that are less well related might reflect these effects more. They would benefit more from the better opportunity for encoding the relationship between the first one or two word-pairs resulting in higher primacy effects. The relationship between the word pairs would also be more susceptible to interference or decay, producing steeper forgetting functions.

Experiment 5 was therefore devised to examine serial position effects in conceptual implicit and explicit memory tests using a different stimulus list of more weakly related word pairs. This difference is predicted to produce a more pronounced primacy effect and forgetting function in the conceptual implicit test than was found in Experiment 4. In addition, in the same manner as Experiment 3, conscious awareness in the implicit test was measured by requiring subjects to specify which of their implicit associations had been studied previously.

Method

Subjects. One hundred and forty-four students and staff from Goldsmiths College, University of London, age range 18 - 52, participated in the experiment. They were randomly allocated to two groups of 72 subjects and tested individually.

Design and Materials and Procedure. There were two methodological differences from Experiment 4. First, word pairs in which the second word of the pair was produced to the first an average of 12 times in 1000, according to the Minnesota Word Association Norms (Jenkins, 1970), were used as stimuli. These word pairs were thus less well related than the word pairs in Experiment 4. (A list of these word pairs is shown in Appendix A.) Second, in the implicit test, immediately after subjects had completed the free association test, they were required to look back over the words they had associated and to tick any word pairs which they remembered from the study cards.

All the subjects in the implicit test responded that they had written the first word that came to mind and had not intentionally tried to retrieve words from the study phase.

Results and Discussion

There was significant priming in the implicit test (target word association prob. = 0.48, lure word association prob. = 0.03) [$t(71) = 24.23$].

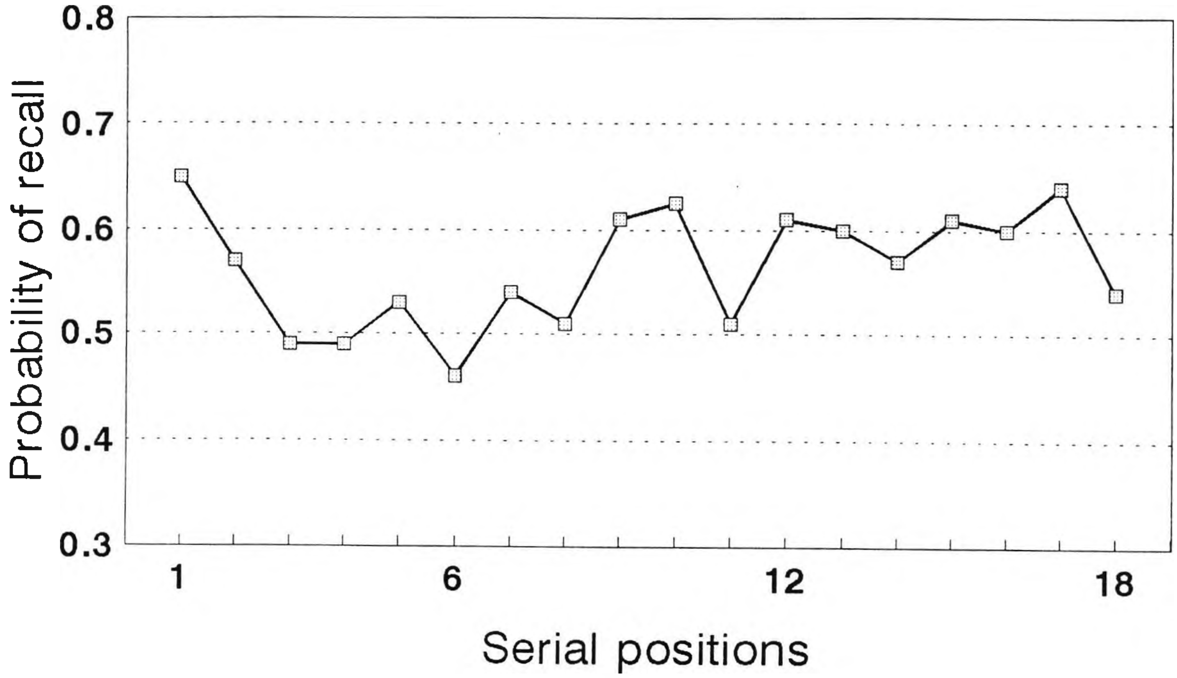
Since the level of association of lure words was very low, baseline association should not have masked any possible serial position effects in the implicit test. Similarly, incorrect recall in the explicit test was very low (target word recall prob. = 0.56, incorrect recall prob. = 0.05) [$t(71) = 22.53$] indicating that guessing should not have masked serial position effects in the explicit test. A relatively high proportion of the target word pairs, which had been implicitly associated, were not explicitly recognised (prob. = 0.18). This figure was lower than was found in Experiment 3 in which the same manipulation was performed (prob. = 0.22), perhaps because subjects in this experiment were more stringent than subjects in Experiment 3 with lower incorrect recognition of their implicit completions (Expt. 3 prob. = 0.12 vs. Expt. 5 prob. = 0.03). Nevertheless, explicit cued recall performance was high (prob. = 0.56), and the error rate was low (prob. = 0.05), but subjects failed to recognise nearly a fifth of their own implicitly associated words.

Graphs of the results of the implicit and explicit tests in Experiment 5 are shown in Figure 5. To reduce noise in the serial position graphs, data were collapsed across three consecutive serial positions in each test. In addition, baseline association (prob. = 0.03) was subtracted from each data point in the implicit test. A graph of these results is shown in Figure 5a. (Percentages of target words associated and recalled as a function of serial position and test are shown in Table 2, Appendix B.) It appears from Figures 5 and 5a that both tests produced a primacy effect. Both tests again showed rapid forgetting

Experiment 5

Weakly Related Cues

Explicit Test - Word Cued Recall



Implicit Test - Free Association

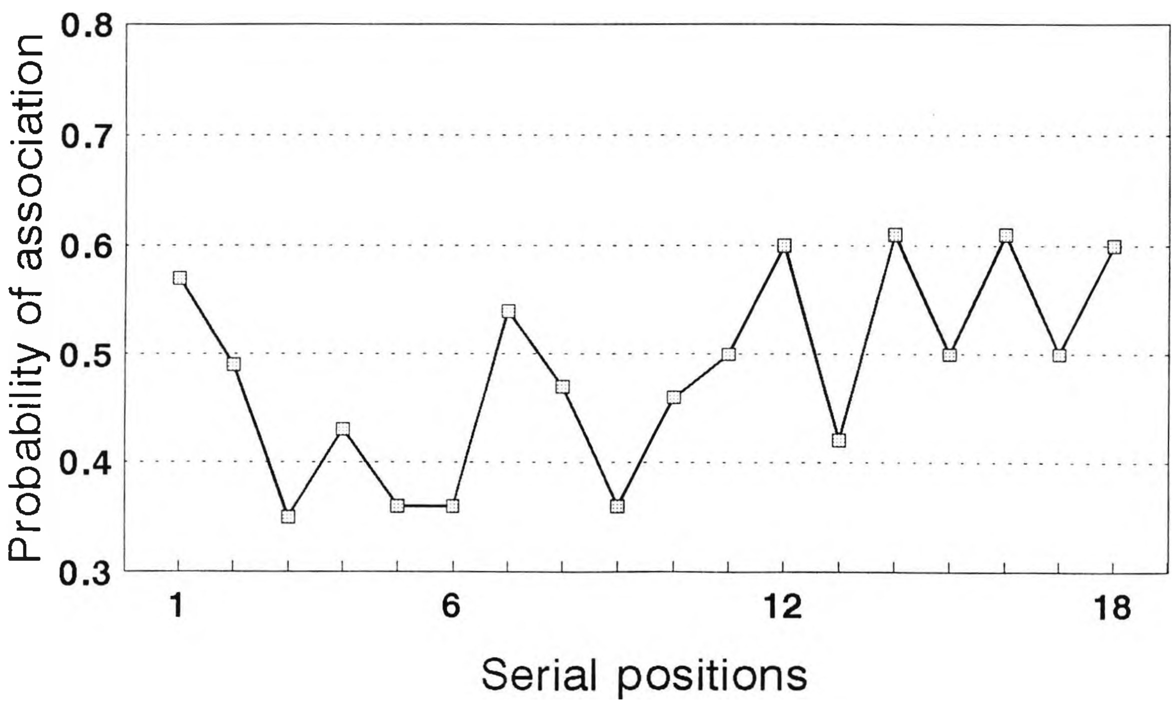


Figure 5

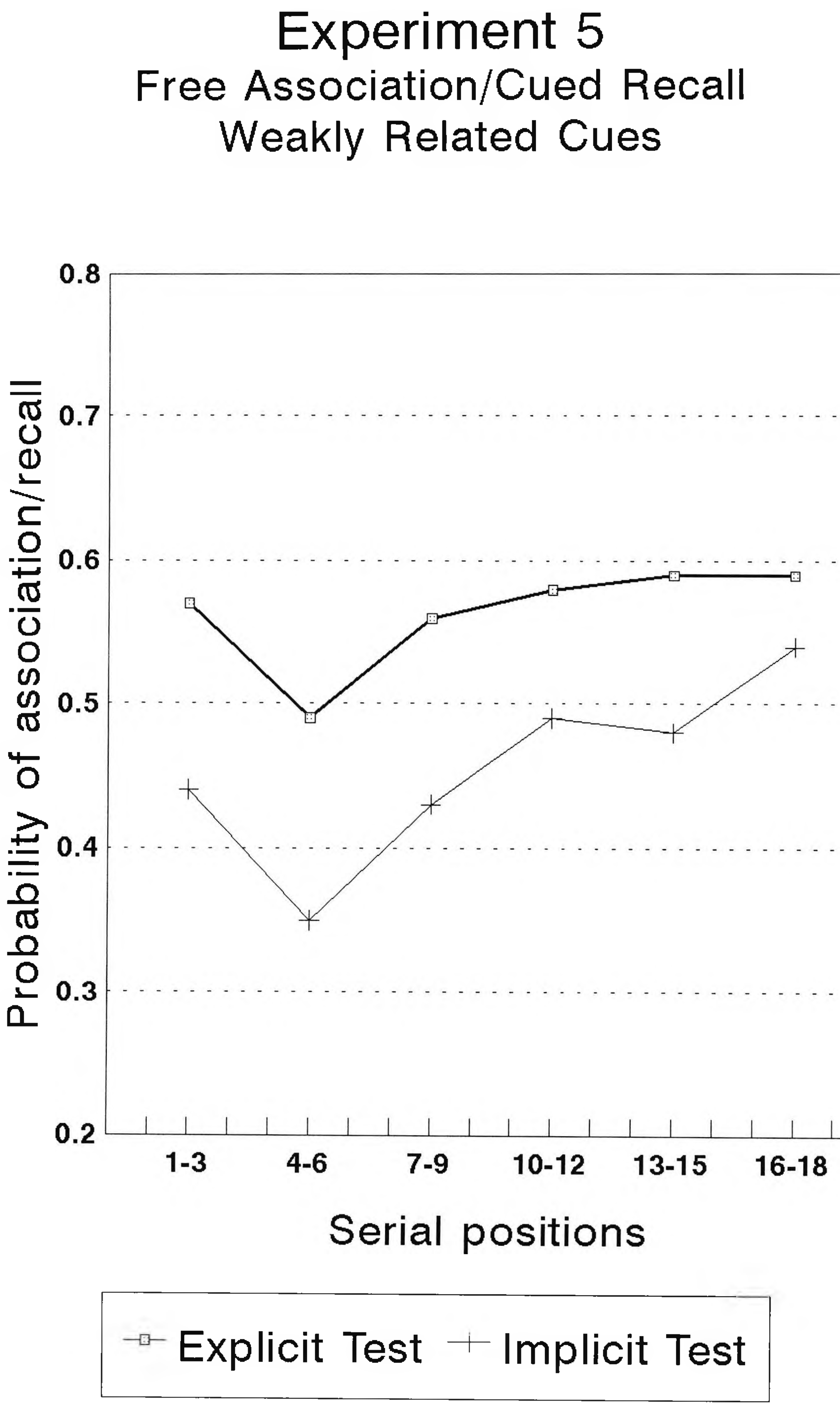

Experiment 5
Free Association/Cued Recall
Weakly Related Cues
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Probability of association/recall
1-3
4-6
7-9
10-12
13-15
16-18
Serial positions
Explicit Test
Implicit Test

Figure 5a

throughout the course of testing, except for primacy items, but neither test appeared to show short-term recency effects.

Replicating the statistical analyses performed in Experiment 4, a 2 x 6 ANOVA was performed with one between-subjects factor, Test and one within-subjects factor, Serial Position. The ANOVA was performed on the data for studied items, without subtracting baselines. The main effects of Test [$F(1,142) = 8.45$, $MSe = 1.45$] and Serial Position [$F(5,710) = 4.29$ $MSe = 0.76$] were again significant, with no interaction between Test and Serial Position [$F(5,710) = 0.42$, $MSe = 0.76$]. Planned comparisons between serial positions 1-3 and 4-6 showed significant (one-tailed) differences in the implicit test [$t(71) = 1.71$] and in the explicit test [$t(71) = 1.83$]. Referring back to Figure 5, both tests appeared to show primacy effects for the first two serial positions only. Unfortunately, these effects were attenuated by collapsing across three consecutive serial positions. When the probability of association/recall from serial positions 1-2 was compared with the probability of association/recall from serial positions 3-6, there were more pronounced primacy effects in the implicit test [$t(71) = 3.14$] and in the explicit test [$t(71) = 2.25$]

Further planned comparisons between serial positions 13-15 and 16-18 to investigate possible short-term recency effects were not significantly different in the implicit test [$t(71) = 1.44$] nor in the explicit test [t(71 = 0.00]. However, a 2 x 5 Polynomial Test of Order between Test and Non-Primacy Serial

Positions showed a significant linear forgetting trend [$F(142) = 17.41$, $MSe = 0.82$] with no interaction between Test and Non-Primacy Serial Positions [$F(1,142) = 1.30$, $MSe = 0.82$]. Whilst neither test appeared to show a short-term recency effect, both tests again showed rapid forgetting. The F value was higher in this polynomial Test of Order than the comparable F value in Experiment 5, but both were highly significant.

In accordance with the experimental hypothesis, the weakly related word pairs in Experiment 5 increased the tendency towards a primacy effect, produced by moderately related word pairs in Experiment 4, to a significant two-item primacy effect in the implicit test. In addition, the rapid forgetting found in Experiment 4 was replicated in Experiment 5. The only methodological difference between Experiments 4 and 5 was the different stimuli used; in Experiment 4, baseline response of the second word, when cued with the first word, was 0.09 whereas in Experiment 5, it was 0.03. However, since it is unwise to compare results across experiments, it was proposed to investigate the effect of word pair relatedness within a single experiment.

4.4 EXPERIMENT 6

It appears from the results of Experiments 4 and 5 that the strength of the relationship between word pairs is related to whether or not a primacy effect occurs in the conceptual implicit memory test of free association. In Experiment 4, moderately related word pairs produced a tendency towards a primacy effect whereas, in Experiment 5, weakly related word pairs produced a two item primacy effect. The enhanced encoded relationship between word pairs of primacy items was reflected in implicit test performance. This enhanced encoded relationship was more apparent with weakly related word pairs, which require more associations to be made at encoding, than moderately related word pairs.

This finding is in agreement with studies investigating levels of processing effects in conceptual implicit memory tests. Unitised stimuli pairs did not produce a levels of processing effect (Schacter & McGlynn, 1989, Experiment 3) but non-unitised stimuli, in which new associations were required to be made, did produce a levels of processing effect (Graf & Schacter, 1985; 1989; Schacter & Graf, 1986b; 1989; Schacter & McGlynn, 1989, Experiments 2 and 4; see Section 1.3.4).

If differences between strongly and weakly related word pairs were found in a single experiment, this would provide better evidence that word pair relatedness contributes to a primacy effect and to rapid forgetting in this test. Experiment 6 was therefore devised to extend the main findings of Experiments 4 and 5 - that the degree of relatedness of stimulus word pairs produces differences in primacy effects in the conceptual implicit memory test of free association, and that forgetting is also associated with stimulus word pair relatedness.

Sets of weakly related and strongly related word pairs were used in the experiment. Half the subjects were presented with weakly related word pairs and half were presented with strongly related word pairs. Of the subjects who had studied weakly related word pairs, a further half performed a free association test and half performed a cued recall test. Similarly, of the subjects who had studied strongly related word pairs, half performed a free association test and half performed a cued recall test. In addition, two sets of each of the weakly and strongly related word pairs stimuli were fully counterbalanced such that when one set was presented as targets, the other set formed the lures.

Performance in the conceptual implicit memory test of free association and in the explicit memory test of cued recall was therefore compared using strongly or weakly related word pairs as stimuli. In order that the same test sheet could be used for all conditions, strongly and weakly related word pairs shared the same initial cue words. It was predicted that weakly related word pairs would produce a higher primacy effect and a faster forgetting rate than strongly related word pairs in the implicit test.

Method

Subjects. One hundred and forty-four students and staff from Goldsmiths College, University of London, and the University of East London, age range 18 - 40 years, participated in the experiment. They were randomly allocated to four groups of 36 subjects and tested individually.

Design and Materials. The design factors were Test (implicit vs. explicit), Word Relatedness (strong vs. weakly related word pairs) and Serial Position, with Test and Word Relatedness manipulated between-subjects and Serial Position manipulated within-subjects.

Stimulus material comprised 72 cards. Two semantically related words were printed on each card in capital letters, e.g. *SQUARE CIRCLE, SQUARE HOLE, GREEN GRASS, GREEN GIANT*. As can be seen from the examples, each initial cue word was followed by either a strongly related word or a weakly related word. Two sets of 36 of these word pairs, were selected from the Minnesota Word Association Norms (Jenkins, 1970). One set comprised word pairs in which the second word of the pair was produced to the first an average of 192 times in 1000 and the second set comprised word pairs in which the second word was produced to the first an average of twice in 1000. Each set of 36 cards was randomly allocated to two further sets of 18 cards. (Lists of these stimuli are shown in Appendix A.) These two sets of stimuli were counterbalanced such that when one set was presented as targets the other set formed the lures. Cards within each set were sequentially numbered from 1 - 18. During the course of the experiment, the sequential order of each set of cards was kept constant but the positional order varied; each set of cards was advanced by one number after it had been presented once in the implicit and once in the explicit memory test. This procedure allowed full counterbalancing of stimuli since every word pair appeared once in every serial position for each test.

The same test sheet was used for every test. On the test sheet, the shared first words from the word pairs formed the test cues, e.g. *SQUARE*......, *GREEN*....... These words were printed in capital letters and equally spaced around the circumference of a circle with words from each stimulus set appearing alternately. In the same manner as Experiments 2 - 5, the test sheet was covered by a cardboard circular mask, fixed at the centre, with a three-sided cut-out on the circumference which allowed one word to be viewed at a time. When the mask was rotated in a clockwise direction, subjects saw the first word from each pair of words they had previously studied, in reverse order, interspersed by lure words.

Procedure. The only difference in the procedure from Experiment 5 was that subjects were randomly allocated to four experimental groups rather than two. The additional experimental groups were necessary so that subjects performed implicit or explicit tests using either strongly or weakly related word pairs. One subject was misplaced because she had misunderstood the instructions in the explicit test.

Results and Discussion

There was significant priming in the two implicit tests (strongly related words - target word association prob. = 0.61, lure word association prob. = 0.17 [t(35) = 11.15]; weakly related words - target word association prob. = 0.42, lure word association prob. = 0.01 [t(35) = 11.15]). Since lure word association in the two implicit tests was low, baseline association should not have masked any possible serial position. However, baseline completion of strongly related words was obviously higher than baseline completion of weakly related words, (prob. = 0.17 vs. prob. = 0.01). Incorrect recall in the two explicit tests was very low (strongly related words - target word recall prob. = 0.67, incorrect recall prob. = 0.05 [t(35) = 16.85]; weakly related words - target word recall prob. = .61, incorrect recall prob. = 0.04 [t(35) = 15.47]), indicating that guessing should not have masked serial position effects in the explicit tests.

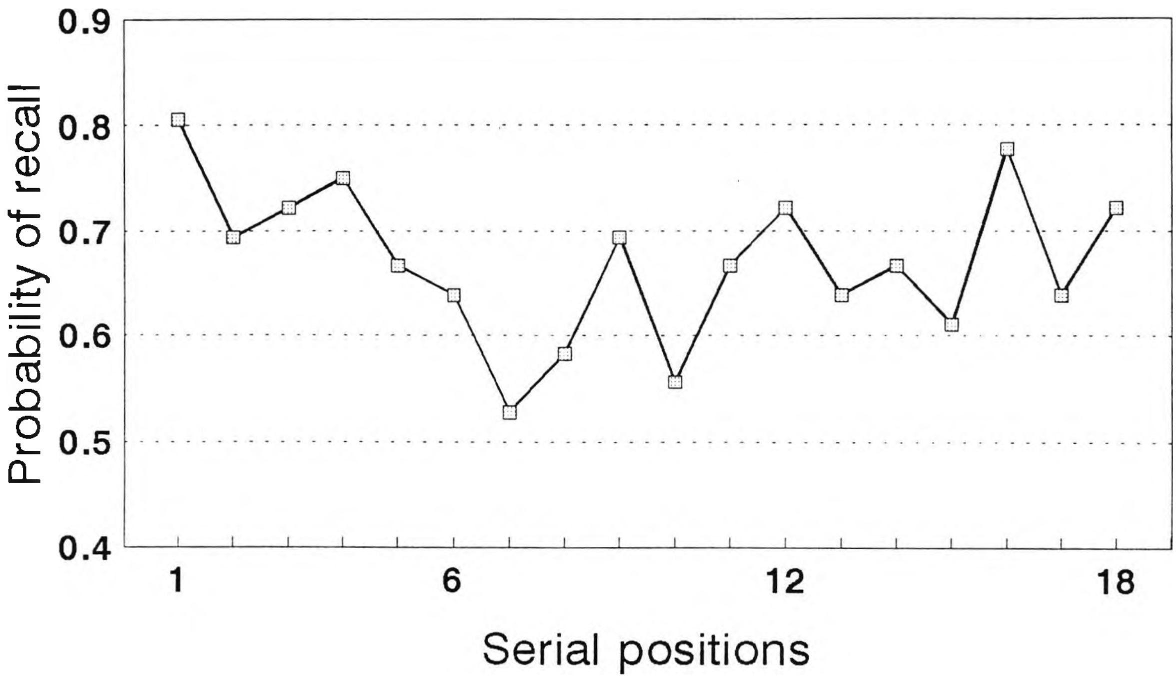
There was relatively high non-recognition of implicity associated strongly related word pairs (prob. = 0.18), even though incorrect recognition of implicit associations was high (prob. = 0.13). In comparison, non-recognition of implicitly associated weakly related word pairs was lower (prob. = 0.08), and incorrect recognition was also lower (prob. = 0.05). These different results may be because the weakly related word pairs were generally more distinctive than the strongly related word pairs and therefore more easily recognised (Gregg, 1976). As in Experiments 3 and 5, explicit cued recall performance was high (strongly related words - prob. = 0.67; weakly related words - prob. = .61) and the error rate was low (strongly related words - prob. = 0.05; weakly related words - prob. = 0.04), but subjects failed to recognise a relatively high proportion of their own implicitly associated word pairs.

Graphs of the results of the implicit and explicit tests for strongly and weakly related words in Experiment 6 are shown in Figures 6(S) and 6(W). To reduce noise in the serial position graphs, data were collapsed across three consecutive serial positions in each test. In addition, the probability of baseline association (strongly related words prob. = 0.17; weakly related words prob. = 0.01) was subtracted from each data point in the implicit tests. Graphs of these results are shown in Figures 6(S)a and 6(W)a. (Percentages of target words associated and recalled as a function of serial position, word relatedness and test are shown in Table 3, Appendix B.) It appears from Figures 6(S) and 6(S)a that strongly related word pairs produced a primacy effect in the explicit test but not in the implicit test. Conversely, Figure 6(W) indicates that weakly related word pairs produced primacy effects in both the implicit and explicit tests. It should be noted, however, that the apparent single item primacy effect in the implicit test in Figure 6(W) is not evident in Figure 6(W)a when three consecutive serial positions are collapsed into one. A comparison of Figures

Experiment 6

Strongly Related Cues

Explicit Test - Word Cued Recall



Implicit Test - Free Association

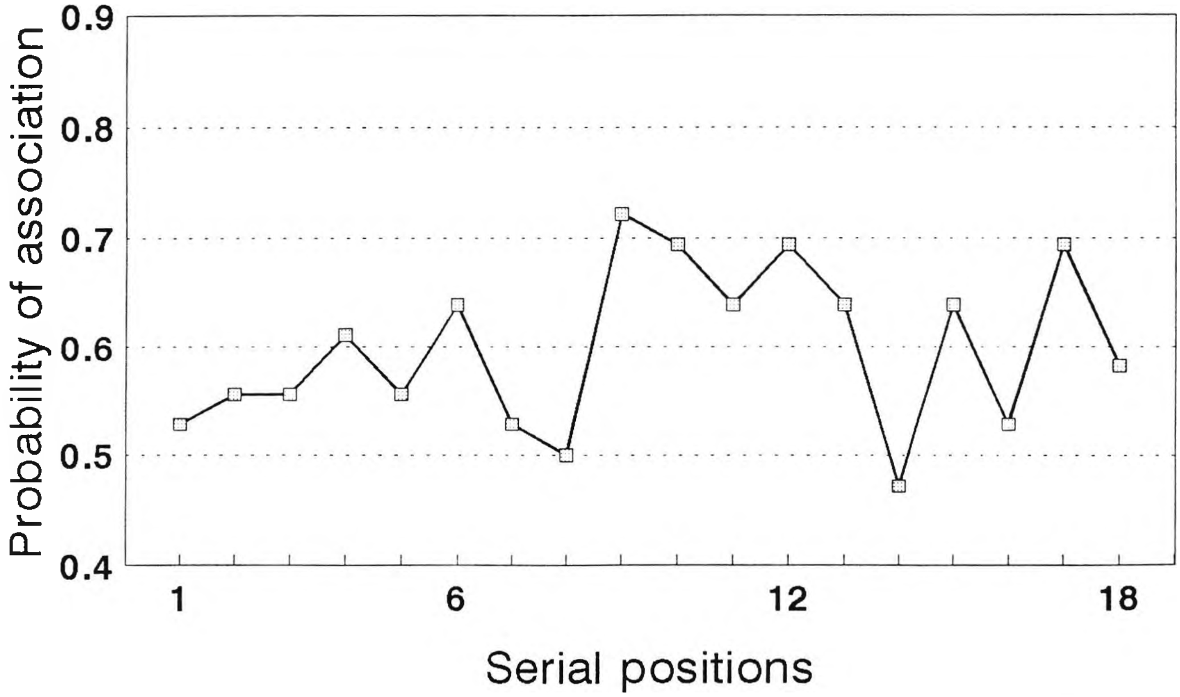


Figure 6(S)

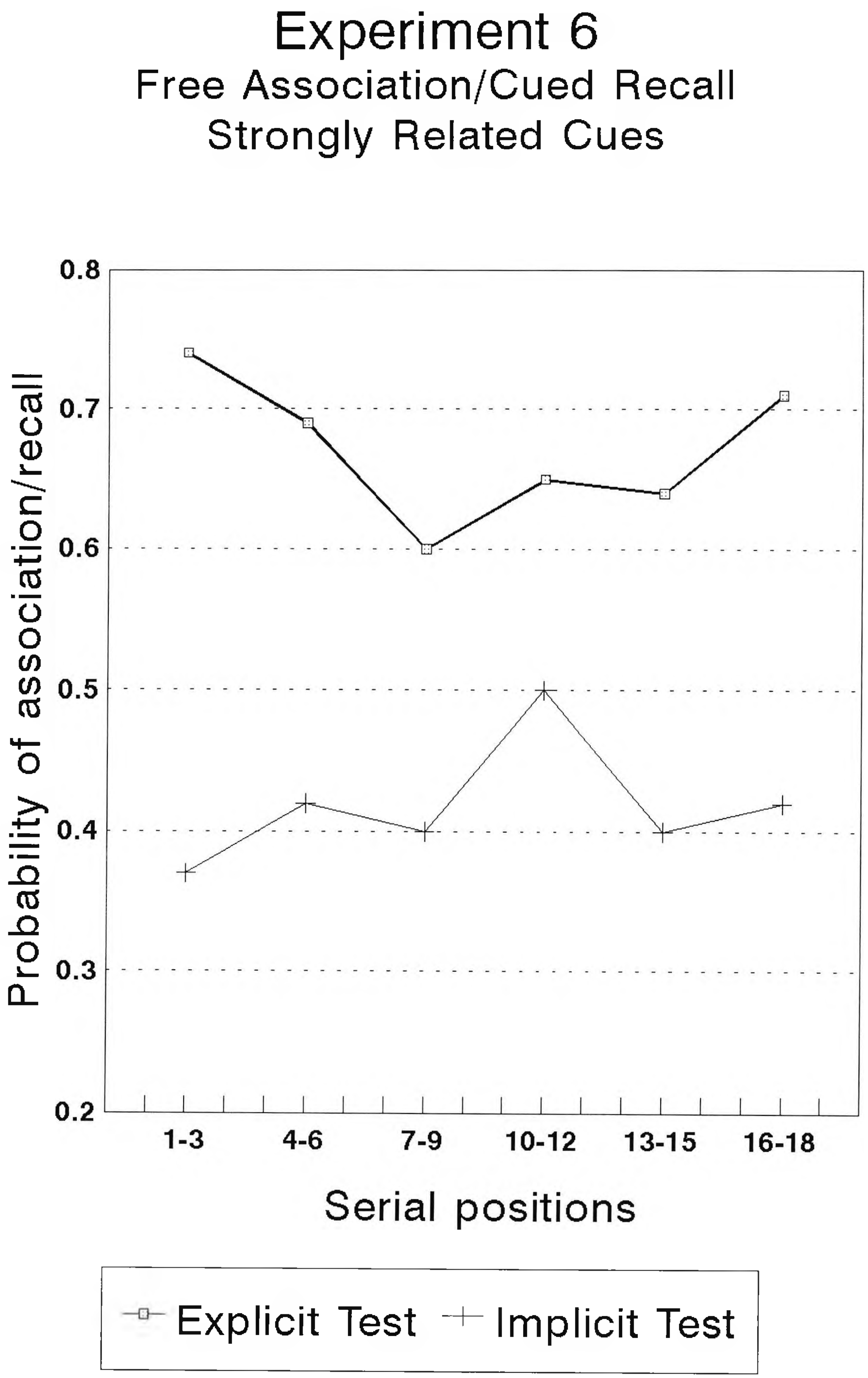
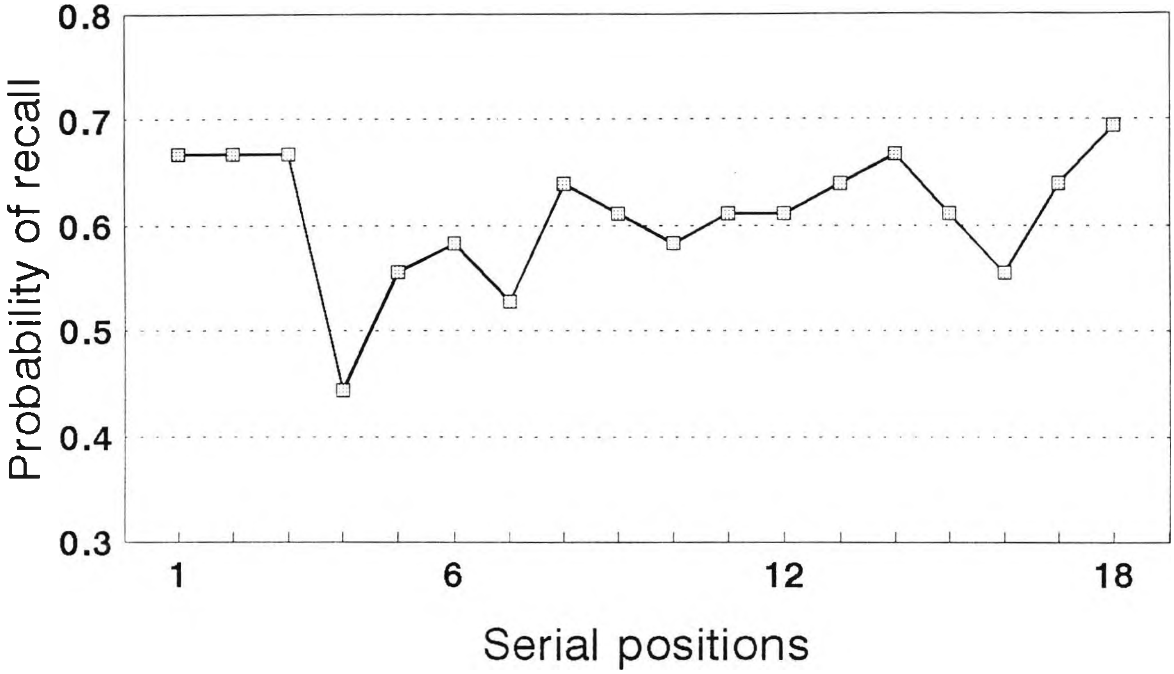

Experiment 6
Free Association/Cued Recall
Strongly Related Cues
Probability of association/recall
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1-3
4-6
7-9
10-12
13-15
16-18
Serial positions
Explicit Test
Implicit Test

Figure 6(S)a

Experiment 6

Weakly Related Cues

Explicit Test - Word Cued Recall



Implicit Test - Free Association

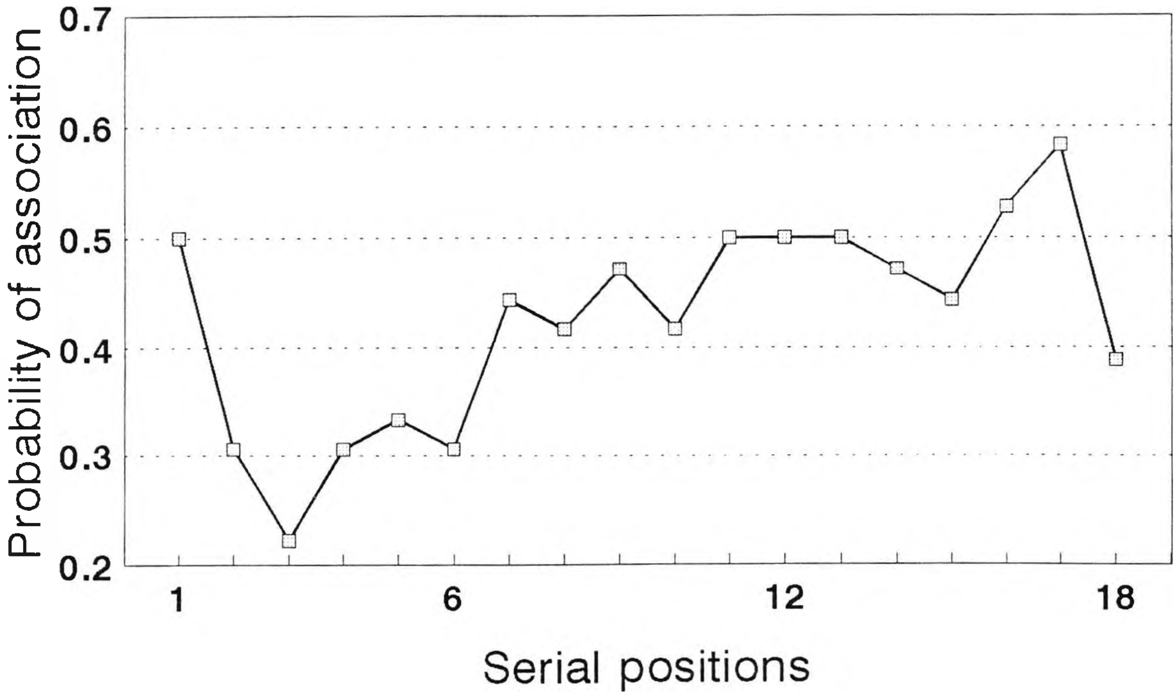


Figure 6(W)

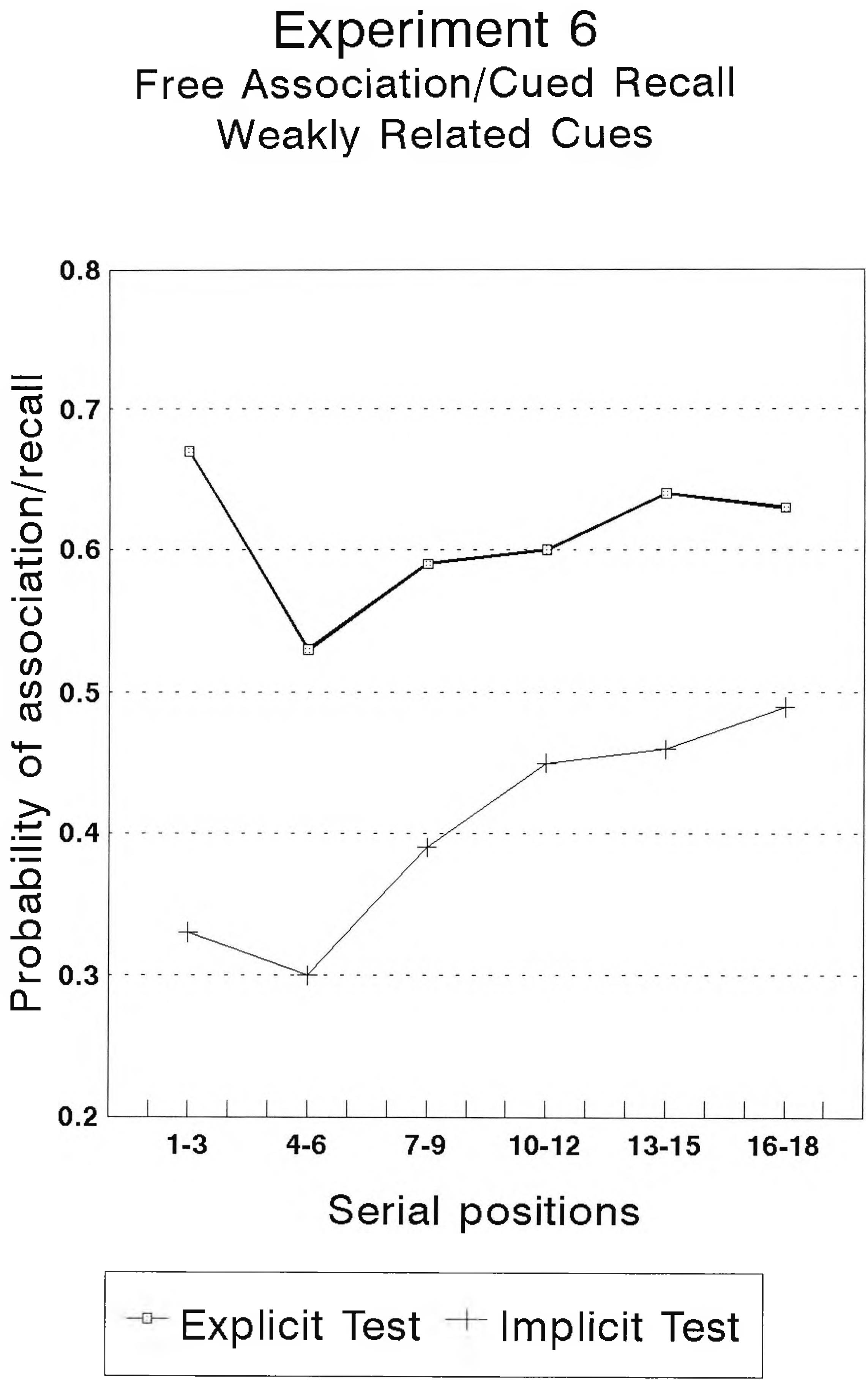

Experiment 6
Free Association/Cued Recall
Weakly Related Cues
Probability of association/recall
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1-3
4-6
7-9
10-12
13-15
16-18
Serial positions
Explicit Test
Implicit Test

Figure 6(W)a

6(S)a and 6(W)a shows the forgetting rate in the implicit tests appears to be steeper for weakly related than strongly related word pairs. The following statistical analyses were performed to investigate these interpretations of the data. Because of the differences in baseline completion, strongly and weakly related word pairs were analysed separately.

Strongly related word pairs

A 2 x 6 ANOVA with one between-subjects factor, Test (implicit vs. explicit) and one within-subjects factor, Serial Position (probability of recall from serial positions 1-3 vs. 4-6 vs. 7-9 vs. 10-12, vs. 12-15 vs. 16-18) was performed to calculate whether there was a significant difference between serial positions in the explicit test compared with the implicit test when strongly related word pairs were the stimuli. The ANOVA was performed on the data for studied items, without subtracting baselines. Neither the main effect of Test [$F(1,70) = 1.17$, $MSe = 2.72$], nor the main effect of Serial Position [$F(5,350) = 1.19$, $MSe = 0.88$], was significant, but the interaction between Test and Serial Position was approaching significance [$F(5,350) = 2.05$, $MSe = 0.88$]. This interaction showed a significant quadratic trend in a polynomial test of order [$F(1,70) = 7.29$, $MSe = 0.85$].

There was therefore no difference in overall performance between the implicit and explicit tests (target word association prob. = 0.61 vs. target word recall prob. = 0.67). There was also no overall difference between the serial positions of target items associated and recalled but the implicit and explicit tests differed in the distribution of these serial positions. A re-examination of Figure 6(S)a shows that quadratic trends in the two tests went in opposite directions. There was no indication of a primacy effect in the implicit test but there was a significant difference between serial positions 1-3 and 7-9 [t(35) = 2.08] in the explicit test, perhaps indicating an extended primacy effect. The only indication of any recency effect was in the explicit test in which a comparison between serial positions 7-9 and 16-18 was significant [t(35) = 2.09].

Weakly related word pairs

A further 2 x 6 ANOVA with one between-subjects factor, Test (implicit vs. explicit) and one within-subjects factor, Serial Position (probability of recall from serial positions 1-3 vs. 4-6 vs. 7-9 vs. 10-12, vs. 12-15 vs. 16-18) was performed for weakly related word pairs. This ANOVA was also performed on the data for studied items, without subtracting baselines. Both the main effects of Test [F(1,70) = 16.78, MSe = 2.19] and Serial Position [F(5,350) = 2.40, MSe = 0.74] were significant but the interaction between Test and Serial Position was not [F(5,350) = 1.11, MSe = 0.74]. There was therefore a difference in overall performance between the implicit and explicit tests (target word association prob. = 0.42 vs. target word recall prob. = 0.61). There was also an overall difference between the serial positions of target items associated and recalled in the implicit and explicit tests with no difference between the tests in this respect.

Comparisons between serial positions 1-3 and 4-6 showed a significant difference in the explicit test [t(35) = 2] but not in the implicit test [t(35) = 0.39], indicating that only the explicit test showed a primacy effect. However, in Figure 6(W), the implicit test appears to show a single item primacy effect, and this was confirmed in a comparison between the probability of target word association between serial position 1 and serial positions 2-6 [t(1,35) = 2.64]. Further comparisons between serial positions 13-15 and 16-18 were not significant in the explicit test [t(35) = 0.14] nor in the implicit test [t(35) = 0.39]. Neither test therefore appeared to show a short-term recency effect. Nevertheless, in a 2 x 5 Polynomial Test of Order between Test and Non-Primacy Serial Positions (4-6, 7-9, 10-12, 13-15 and 16-19), Non-Primacy Serial Positions showed a significant linear trend [F(1,70) = 11.52, MSe = 0.68] with no interaction between Non-Primacy Serial Position and Test [F(1,70) = 0.9, MSe = 0.68]. When primacy items were excluded, there was forgetting throughout the course of both tests.

General Discussion

In the implicit tests, there was a trend towards a primacy effect with moderately related word pairs in Experiment 4; a significant two item primacy effect with weakly related word pairs in Experiment 5; a significant one item primacy effect with very weakly related word pairs; but no indication of a primacy effect with strongly related word pairs in Experiment 6. A pattern emerges from these results - primacy effects appear to be dependent on the strength of the relationship between the two stimulus words as follows: strongly related word pairs did not show any indication of a primacy effect; moderately related word pairs showed a tendency towards a primacy effect; weakly related word pairs produced a two item primacy effect; very weakly related word pairs produced a single item primacy effect. A higher, narrower, primacy effect was therefore inversely related to the strength of the prior relationship between stimulus pairs. This pattern of results was different to the comparable explicit tests which all showed significant primacy effects, implying that retrieval intentionality contributed to the primacy effects in the explicit tests but not in the implicit tests.

An explanation for this pattern may be that the stimulus words in strongly related word pairs have pre-existing strong associative connections which are not present to the same extent in weakly related word pairs. It is therefore necessary to strengthen the existing associative connections, or establish new associative connections, when encoding weakly related word pairs but not when encoding strongly related word pairs. In accordance with the currently accepted basis for primacy effects in explicit memory tests (e.g. Atkinson & Shriffrin, 1968; see Section 2.2.1) strengthening of existing associative connections or establishing new associative connections at encoding would be more effective for the first word pairs than for the remaining word pairs. These stronger associative connections of the first word pairs encoded would produce a primacy effect, even in an implicit memory test which does not require intentional retrieval of the study episode. Because strongly related word pairs would not require the pre-existing strong associative connections to be strengthened at encoding, they would not produce an implicit primacy effect. This explanation would concur with the absence of primacy effects in the perceptual implicit memory word stem completion tests in Experiments 1 - 3 as no associative connections were required to be made when encoding the single word stimuli. A further test would be to use unitised word pairs as stimuli, the relationship between which is already known prior to encoding. In this event, no primacy effect should occur in a conceptual implicit memory test.

This explanation might also provide a reason why levels of processing effects occur in conceptual implicit memory tests. Deeper processing would be more beneficial than shallow processing when new associations are required to be made, or existing associations are required to be strengthened, during the encoding phase of a conceptual implicit memory test. This would explain why unitised word pairs do not produce a levels of processing effect (Schacter & McGlynn, 1989, Experiment 3; see Section 1.3.4). It would also explain why amnesic patients have been found to show intact priming in conceptual implicit memory tests using highly associated words (e.g. Shimamura & Squire, 1984, Experiment 3) but are impaired in priming of newly acquired associations (e.g. Schacter & Graf, 1986; see Section 1.3.2). Amnesic patients may be impaired at strengthening existing associative connections or establishing new connections at encoding, a facility which would be required when encoding new associations but not when encoding highly associated words.

The results of these three experiments are not wholly consistent with the multiple memory systems theory. According to Schacter (1994), conceptual priming occurs outside the PRS, possibly in the semantic system, and is susceptible to levels of processing effects. Consistent with this prediction, conceptually based priming would be susceptible to a primacy effect, irrespective of any strengthening of associative connections required at encoding. An amendment to the multiple memory systems theory would be required to explain the results of Experiments 4 - 6. Such an amendment would specify that all priming is based on the PRS but that there are interactions between the PRS and the episodic (or semantic) memory system when associative connections are required to be made or strengthened during the encoding phase. Primacy effects would reflect the involvement of episodic (or semantic) memory; when this involvement occurred, primacy items would be encoded better. Schacter (1994) has already agreed that there may be some interaction between the PRS and the episodic (or semantic) memory system, but only with regard to perceptual-specificity effects. He came to this conclusion to explain results of a study that found amnesic patients failed to exhibit voice-specific priming. The amnesic patients showed equal priming in the same-voice and different-voice conditions in a perceptual identification test, whereas control subjects showed significantly more priming in the same-voice condition (Schacter, Church & Bolton, 1995; see Section 1.5.1). Presumably, the amnesic patients were unable to perform the necessary interaction with episodic (or semantic) memory during the encoding phase to enable them to exhibit voice-specific priming. If Schacter's suggestion of an interaction between the PRS and the episodic (or semantic) memory system was extended to incorporate all encoding episodes in which new or strengthened associative connections are required to be made, it might explain many of the differential effects between perceptual and conceptual priming.

Alternatively, the results of these three experiments are mainly consistent with the transfer appropriate processing theory which predicts that memory test performance corresponds to the overlap of conceptually-driven or data-driven processes between encoding and test. A greater overlap of conceptually-driven processes between encoding primacy items and the free association test than between encoding the remaining items and the test may have been responsible for the primacy effects with moderately related and weakly related word pairs. In addition, encoding weakly related word pairs would involve more conceptually-driven processes than encoding strongly related word pairs. This difference would explain why the primacy effect was higher with weakly related word pairs than with moderately related word pairs. However, even with strongly related word pairs, there would have been more overlap of conceptually-driven processes between encoding primacy items and the free association test, which should have resulted in a primacy effect. This was not the case in the free association test, but a primacy effect did occur in the explicit test. This difference between the results of the implicit and explicit tests is also not in line with the transfer appropriate processing theory, but might occur because the explicit test is more conceptually-driven than the implicit test.

None of the implicit or explicit tests appeared to show short-term recency effects, but it is difficult to be certain of this finding because significant forgetting trends occurred in many of the tests. With regard to these forgetting trends, the strength of the relationship between word pairs affected the forgetting rate in the implicit test in Experiment 6, with weakly related word pairs being forgotten quicker than strongly related word pairs. In addition, the forgetting trends found in the conceptual implicit free association tests in Experiments 4, 5 and 6 were more evident than in the perceptual implicit word stem completion tests in Experiments 2 and 3. Since the main difference between the word stem completion tests and the free association tests, was the stimulus items, it is probable that forgetting in the free association tests occurred because the associative connections which had been encoded between the stimulus words were breaking down, either through decay or interference. This explanation would also account for weakly related word pairs being forgotten faster than strongly related word pairs; encoded associative connections would be more tenuous with weakly related word pairs.

A new conceptual implicit memory test was used in the next chapter. This test used unitised word pairs as stimuli, the relationship between which was already known prior to encoding.

CHAPTER 5

SERIAL POSITION EFFECTS IN THE CONCEPTUAL IMPLICIT MEMORY TEST OF NAME GENERATION

5.1 Introduction

This chapter describes two experiments which investigated serial position effects in a new conceptual implicit memory test of name generation. In this test, subjects were presented with unique and easily recognisable surnames of famous people, all of whom have common forenames which were not seen at encoding. The common forenames were used as test cues in a conceptual implicit name generation test or in an explicit cued recall test. The name generation test conforms to the requirements of a conceptual implicit memory test as no perceptual elements of the study phase are re-instated at test.

If primacy effects in conceptual implicit memory tests are attributable to associations being made or strengthened during the encoding phase, no primacy effects should occur in this test because the relationship between the forename/surname pairs was known prior to the study. In addition, this new test might enable the two possible reasons for forgetting in conceptual implicit memory tests, decay and interference, to be teased apart.

In Experiment 7 subjects were tested immediately whereas, in Experiment 8, an interpolated task was inserted between study and test to eliminate any possible short-term recency effects.

5.2 EXPERIMENT 7

In this experiment distinctive and unique surnames of famous people were presented at study and their associated common forenames were used as test cues. The use of these forename/surname pairs enabled conceptual implicit memory to be measured without any perceptual overlap between study and test, and with relatively low baseline generation since the common forename cues could be completed with many different surnames.

If primacy effects in conceptual priming are attributable to associations being made or strengthened during encoding, no primacy effects should occur in this test because the relationship between the forename/surname pairs was known prior to study and could not be learned during the study phase. However, primacy effects are predicted in the explicit test, even though the relationship between the stimulus pairs was known prior to the study, because there were explicit primacy effects with single word stimuli in Experiments 1 - 3, and with strongly related word pairs in Experiment 6. Neither the implicit nor the explicit tests are predicted to show short-term recency effects because short-term recency effects were not found in Experiments 4 - 6, even with strongly related word pairs. However, the assessment of short-term recency effects in Experiments 4 - 6 was confounded by the rapid forgetting that occurred throughout most of the tests for non-primacy items.

The pre-existing knowledge of the relationship between the forename/surname pairs might also enable the two possible reasons for forgetting the relationship between stimulus pairs in conceptual priming, decay and interference, to be teased apart. As subjects already knew the relationship between a forename and surname at encoding, that knowledge was less likely to decay between study and test. (The activation of pre-existing relationships between word stems and completions in perceptual priming in Experiments 2 and 3, and between strongly related word pairs in conceptual priming in Experiment 6, was not found to decay to any appreciable extent.) Conversely, the relationship between the forename/surname pairs would be particularly susceptible to interference from other names. (Strongly related word pairs would offer less opportunity for decay or interference.) Experiment 7 might therefore be predicted to show a similar pattern of forgetting to that found with moderately and weakly related word pairs in Experiments 4 - 6 if interference to the relationship between stimulus word pairs was responsible, but not if decay was responsible.

Since forgetting occurred in the explicit tests in Experiments 2 and 3, even though the single word stimuli did not necessitate encoding any associative connections, and in Experiment 6 with strongly related word pairs, even though these stimuli would not be very susceptible to either decay or interference, forgetting was predicted in the explicit test irrespective of whether decay or interference was responsible for the breakdown in the relationship between stimulus pairs.

Method

Subjects. One hundred and forty-four students and staff from Goldsmiths College, University of London, age range 18 - 41, participated in the experiment. They were randomly allocated to two groups of 72 subjects and tested individually.

Design and Materials. The design factors were Test (implicit vs. explicit) and Serial Position, with Test manipulated between-subjects and Serial Position manipulated within-subjects. Stimulus material comprised 36 cards. On each card was printed a unique and easily identifiable surname of a famous person. All these famous people had different common forenames which were not present on the cards, e.g. *DARWIN (CHARLES), CAINE (MICHAEL)*. (See Appendix A for a full list of these names). The 36 cards were randomly allocated to two sets of 18 cards. During the course of the experiment the two sets of stimuli were counterbalanced such that when one set was presented as target names the other set formed the lure names. Cards within each set were sequentially numbered from 1 - 18. The sequential order of each set of cards was kept constant but the positional order varied; each set of cards was advanced by one number after it had been presented once in the implicit and once in the explicit memory test. This procedure allowed full counterbalancing of stimuli since every word appeared twice in every serial position for each test.

Because pilot studies indicated that performance in the explicit test was near ceiling, a further 12 cards, each printed with the surname of a unique and easily recognisable famous person, were used as fillers in both sets. The forenames of these famous people were all different from the forenames of the famous people whose surnames formed the target items. (These names are also listed in Appendix A.) Following a procedure used by Gershberg & Shimamura (1994), six of these filler names were inserted after the first six target names and the remaining six filler names were inserted after a further six target names. As the order of the target names was advanced, each block of filler names was adjusted so that the location and order of the filler names remained constant with three blocks of six target names always interspersed by two blocks of six filler names. Identical sets of filler names were used in each stimulus set. This procedure enabled ceiling effects to be lowered without increasing the number of test items, an important consideration as motivation might decline if the test was too long. It was particularly important that motivation remained constant because test items appeared in the reverse order to the order in which they were studied and primacy items therefore appeared at the end of the test.

The test sheet contained 36 forenames, printed in capital letters and equally spaced around the circumference of a circle with forenames of target surnames from each stimulus set appearing alternately. In the same manner as Experiments 2 - 6, the test sheet was covered by a cardboard circular mask, fixed at the centre, with a three-sided cut-out on the circumference which allowed one forename to be viewed at a time. When the mask was rotated in a clockwise direction, subjects saw forenames associated with target surnames from the study cards, in reverse order, interspersed by lure forenames.

Procedure. Subjects were randomly assigned to the implicit or explicit test group. Both groups received the same preliminary instructions - to try to memorise the names they were about to see. Thirty surnames were then shown to them on cards, one surname every three seconds. After one subject from each group had seen the names in an identical order, the positional order of the names was advanced by one (whilst keeping the sequential order and the location of filler names the same) before they were presented again. In addition, alternate subjects in each group saw a different set of names.

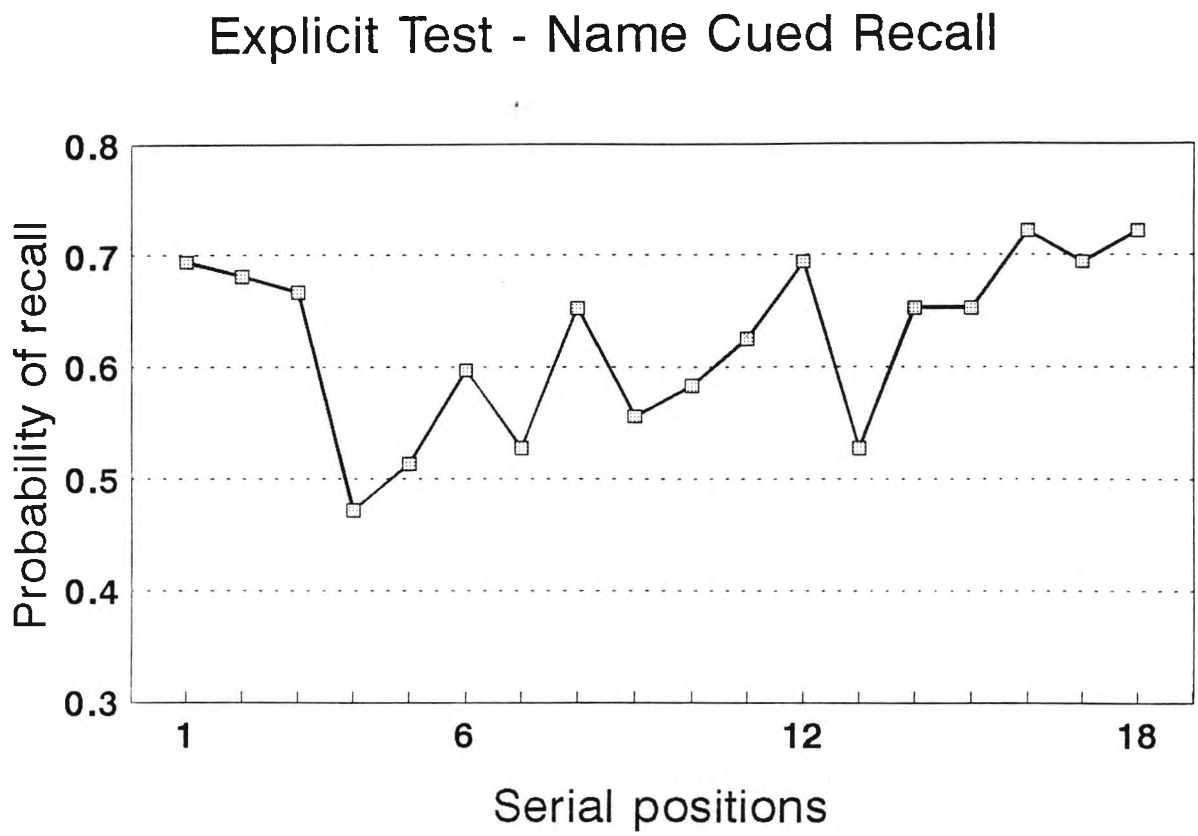
Subjects were tested immediately. In both tests, subjects were presented with identical test sheets with the mask open at the forename immediately preceding the forename of the last surname they had seen. They were instructed to move the mask in a clockwise direction. In the explicit test subjects were asked to write surnames to forenames only if they could remember the surname from the study cards. They were informed of the presence of some lure forenames and were instructed not to guess. In the implicit test, subjects were asked to complete every forename with the first surname that came to mind, either the name of a person they knew personally or a famous person. However, if a surname did not immediately come to mind, they were instructed to leave it blank. They were asked not to specifically try to think back to the study cards and only to complete forenames with studied surnames if they were the first names that came to mind. On completion, subjects in the implicit test were asked whether they had actually completed forenames with the first surname that came to mind or whether they had deliberately tried to remember names from the study episode. One subject was replaced because she had misunderstood the test instructions.

Results and Discussion

There was significant priming in the implicit test (target name generation prob. = 0.56, lure name generation prob. = 0.16) [t(71) = 20.35]. Since the level of generation of lure surnames was relatively low, baseline generation should not have masked any possible serial position effects in the implicit test. Similarly, incorrect recall in the explicit test was very low (target name recall prob. = 0.62, incorrect recall prob. = 0.04) [t(71) = 24.29] indicating that guessing should not have masked serial position effects in the explicit test.

Graphs of the results of the implicit and explicit tests in Experiment 7 are shown in Figure 7. To reduce noise in the graphs, data were collapsed across three consecutive serial positions in each test. In addition, baseline generation (prob. = 0.16) was subtracted from each data point in the implicit test. A graph of these results is shown in Figure 7a. (Percentages of target names generated and recalled as a function of serial position and test are shown in Table 4, Appendix B.) It appears from Figures 7 and 7a that only the explicit test produced a primacy effect whereas both tests produced short-term recency effects. However, there appear to be steep forgetting functions in both tests which may have contributed to these short-term recency effects.

Experiment 7



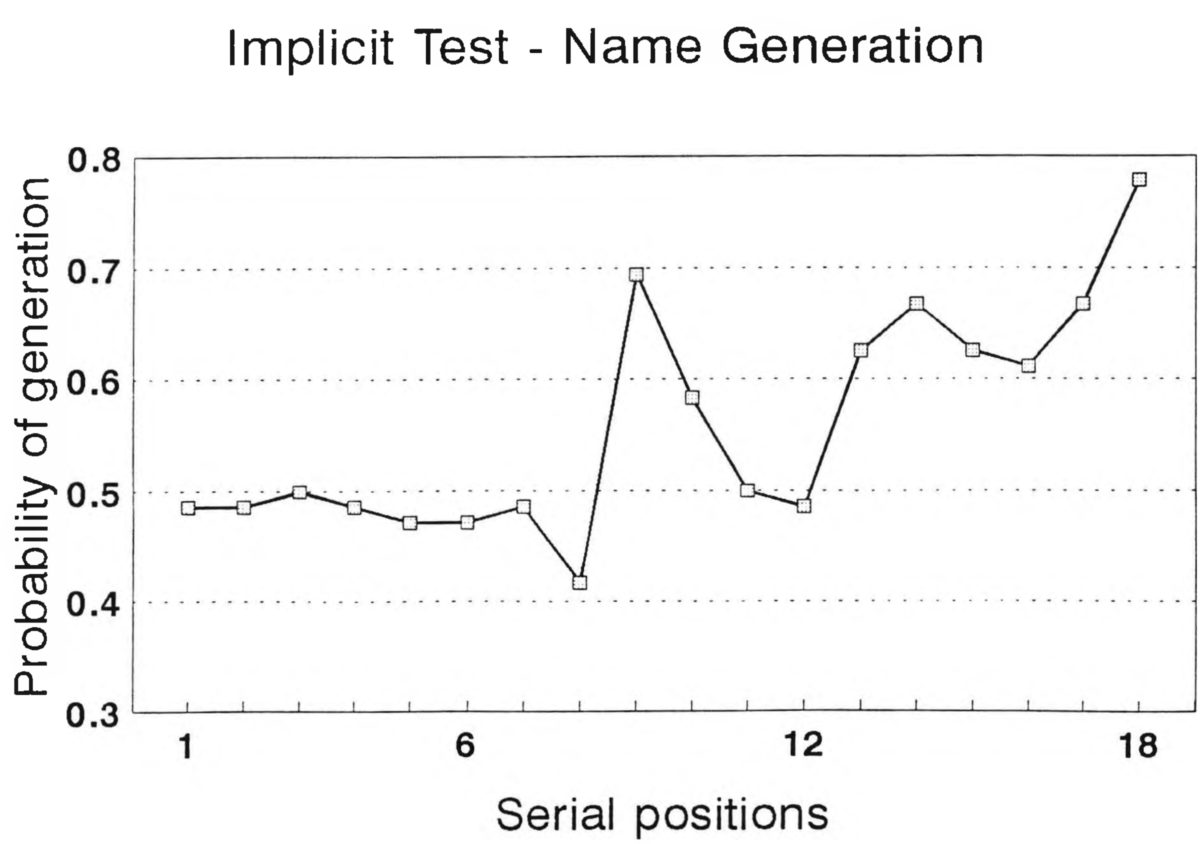
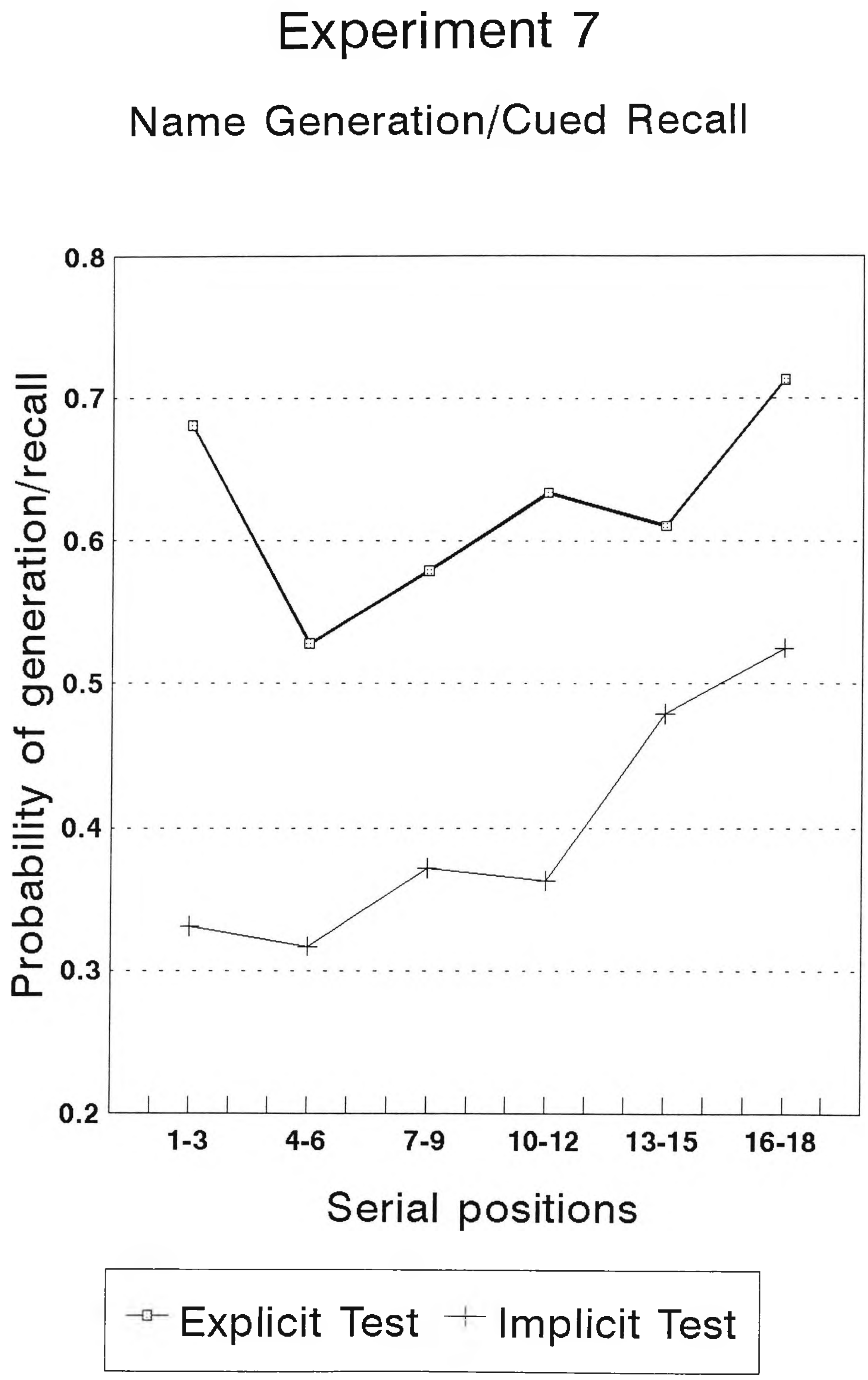


Figure 7



Experiment 7
Name Generation/Cued Recall
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Probability of generation/recall
1-3
4-6
7-9
10-12
13-15
16-18
Serial positions
Explicit Test
Implicit Test

Figure 7a

A 2 x 6 analysis of variance (ANOVA) was performed with one between-subjects factor, Test (implicit vs. explicit) and one within-subjects factor, Serial Position (probability of recall from serial positions 1-3 vs. 4-6 vs. 7-9 vs. 10-12, vs. 12-15 vs. 16-18) to calculate whether there was a significant difference between serial positions in the explicit test compared to the implicit test. The ANOVA was performed on the data for studied items, without subtracting baselines. The main effects of Test [F(1,142) = 6.67, MSe = 1.28] and Serial Position [F(5,710) = 7.94, MSe = 0.72] were significant and there was a significant interaction between Test and Serial Position [F(5,710) = 2.53, MSe = 0.72]. Planned comparisons between serial positions 1-3 and 4-6 in each test to investigate possible primacy effects showed a significant difference in the explicit test [t(71) = 3.19] but not in the implicit test [t(71) = 0.31]. (The test of primacy was performed on these two sets of adjacent serial positions because of the apparent forgetting functions in both tests). The explicit test therefore showed a significant primacy effect but the implicit test did not. This result was in accordance with the hypothesis that stimulus pairs, the relationship between which was known prior to study and could not be learned during the study phase, would not show a primacy effect in a conceptual implicit test.

Further planned comparisons between serial positions 13-15 and 16-18 to investigate possible short-term recency effects were significantly different in the explicit test [t(71 = 2.52] but not in the implicit test [t(71) = 0.95]. (The test of short-term recency was performed on these two sets of adjacent serial positions because of the apparent forgetting functions in both tests). There was therefore a significant short-term recency effect in the explicit test. However, a steep forgetting function may have contributed to this effect. This steep forgetting function was confirmed by a 2 x 5 Polynomial Test of Order between Test and Non-Primacy Serial Positions (4-6, 7-9, 10-12, 13-15 and 16-19) which showed a significant linear forgetting trend [$F(1,142) = 37.44$, $MSe = 0.74$] with no interaction between Test and Non-Primacy Serial Positions [$F(1,142) = 0.63$, $MSe = 0.74$]. Both tests therefore showed rapid forgetting throughout the course of the test for non-primacy items. This forgetting was unlikely to be caused by decay to the associative connection between test cues and target items because priming was dependent on prior knowledge of the relationship between the forename/surname pairs which was unlikely to decay during the course of the experiment. (Activation of the prior knowledge of relationships between word stems and completions in Experiments 2 and 3, and between strongly related word pairs in Experiment 6, had not been found to decay to an appreciable extent.) Since decay was probably not implicated in forgetting the relationship between stimulus pairs, interference was more likely to be responsible for forgetting that occurred throughout the course of the test.

The next experiment was devised to try to replicate the results of this experiment with respect to primacy effects and to differentiate between short-term recency effects and forgetting trends found in the conceptual implicit and explicit tests throughout the thesis.

5.3 EXPERIMENT 8

Glanzer & Cunitz (1966) found that short-term recency effects disappeared when subjects performed an interpolated task between study and test. This manipulation should differentiate between short-term recency effects and other forms of forgetting which might occur during the course of the test. Short-term recency effects would be eliminated by a digit subtraction interpolated task but other forms of forgetting would not be affected to the same extent. Apart from this manipulation, Experiment 8 was identical to Experiment 7 with regard to stimuli and experimental procedures.

Method

Subjects. Seventy-two students and staff from Goldsmiths College, University of London, age range 18 - 36, participated in the experiment. They were randomly allocated to two groups of 36 subjects and tested individually or in pairs.

Design, Materials and Procedure. The design and materials were identical to Experiment 7. The only procedural difference was that all subjects were required to count backwards in threes, beginning from the number 59, for 30 seconds before starting the tests. This task was considered to be sufficiently demanding that subjects would not be able to rehearse the last few list items. All the subjects reported that they had conformed to the test instructions.

Results and Discussion

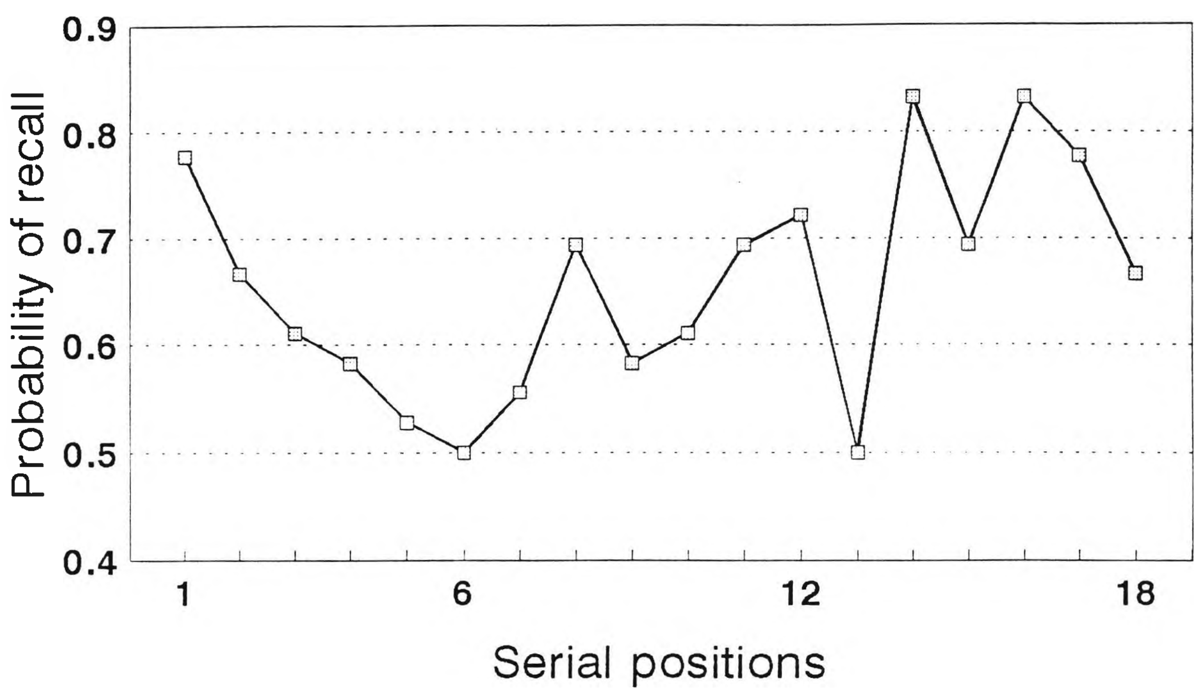
There was significant priming in the conceptual implicit test (target name generation prob. = 0.51, lure name generation prob. = 0.17) [t(35) = 11.84]. Incorrect recall in the explicit test was again very low (target name recall prob. = 0.66, incorrect recall prob. = 0.02) [t(35) = 20.81]. Graphs of the results of the implicit and explicit tests in Experiments 8 are shown in Figure 8. To reduce noise in the graphs, data were collapsed across three consecutive serial positions in each test. In addition, baseline generation (prob. = 0.17) was subtracted from each data point in the implicit test. A graph of these results is shown in Figure 8a. (Percentages of target names generated and recalled as a function of serial position and test are shown in Table 4, Appendix B.) It appears from Figures 8 and 8a that the interpolated task did not reduce the steep forgetting function in either test compared to Figures 7 and 7a in Experiment 7. There even appears to be a steeper rate of forgetting between serial positions 13-15 and 16-18 in the implicit test which would not have been predicted if a short-term serial position effect was responsible for this effect.

A 2 x 6 analysis of variance (ANOVA) was performed with one between-subjects factor, Test (implicit vs. explicit) and one within-subjects factor, Serial Position (probability of recall from serial positions 1-3 vs. 4-6 vs. 7-9 vs. 10-12, vs. 12-15 vs. 16-18) to calculate whether there was a significant difference between serial positions in the explicit test compared to the implicit test. The ANOVA was performed on the data for studied items, without

Experiment 8

Delayed Test

Explicit Test - Name Cued Recall



Implicit Test - Name Generation

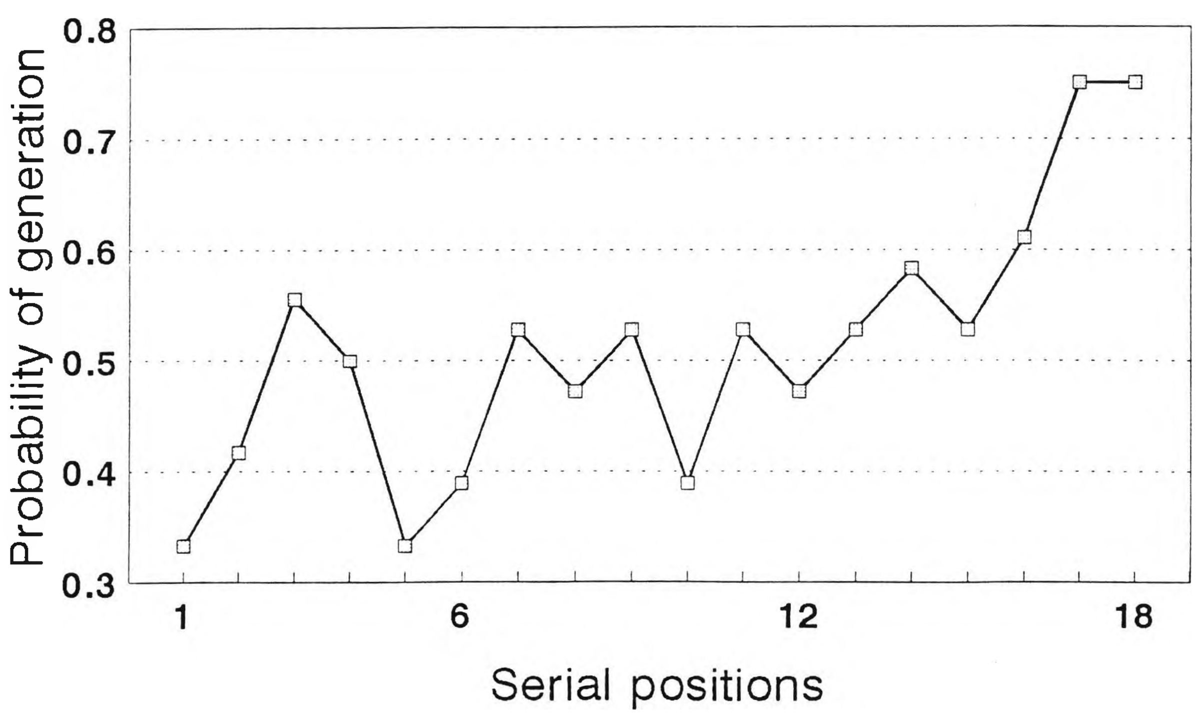


Figure 8

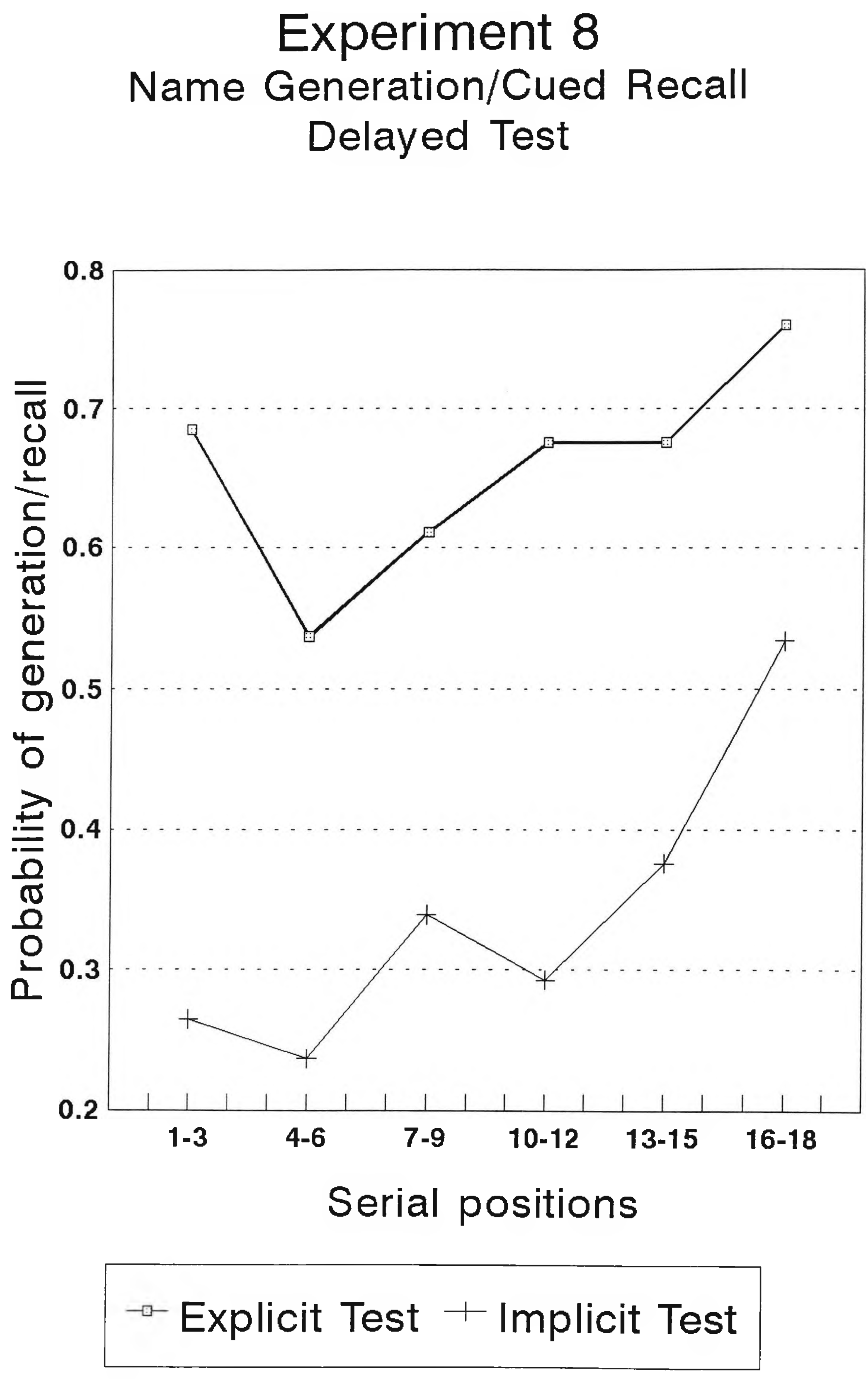

Experiment 8
Name Generation/Cued Recall
Delayed Test
Probability of generation/recall
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1-3
4-6
7-9
10-12
13-15
16-18
Serial positions
Explicit Test
Implicit Test

Figure 8a

subtracting baselines. The main effects of Test [F(1,70) = 14.18, MSe = 1.47] and Serial Position [F(5,350) = 7.97, MSe = 0.59] were significant but the interaction between Test and Serial Position [F(5,350) = 1.42, MSe = 0.59] was not significant. However, planned comparisons between serial positions 1-3 and adjacent serial positions 4-6 showed a significant primacy effect in the explicit test [t(35) = 2.36] but not in the implicit test [t(35) = .49]. These comparisons therefore replicated those in Experiments 7 by showing a primacy effect in the explicit test but no primacy effect in the implicit test.

Further planned comparisons between serial positions 13-15 and adjacent serial positions 16-18, to investigate whether the interpolated task affected possible short-term recency effects, showed a significant short-term recency effect in the implicit test [t(35) = 2.69] but not in the explicit test [t(35) = 1.46]. Compared to Experiment 7, it appears that the interpolated task detrimentally affected the explicit test but had a beneficial effect on the implicit test.

Confirmation that the interpolated task did not affect the overall forgetting function for non-primacy items in either test was obtained by a 2 x 5 Polynomial Test of Order between Test and Non-Primacy Serial Positions (4-6, 7-9, 10-12, 13-15 and 16-19) which showed a significant linear recency trend [F(142) = 37.44, MSe = 0.74] with no interaction between Test and Non-

Primacy Serial Positions [F(1,142) = 0.63, MSe = 0.74]. Both tests therefore showed rapid forgetting throughout the course of the test for non-primacy items.

General Discussion

There were no primacy effects in the implicit name generation tests compared to significant primacy effects in the explicit cued recall tests in both experiments. These results confirm the experimental hypothesis that no primacy effects would occur in conceptual implicit memory tests using stimulus word pairs in which no new or stronger associative connections are made at encoding. They agree with and extend the finding in Experiment 6 that no primacy effect occurred in free association when strongly related word pairs were the stimuli. They are also consistent with the results of Experiments 1-3 in which no primacy effects occurred in the perceptual implicit memory test of word stem completion.

The failure to find primacy effects in this conceptual priming test appears inconsistent with the finding that levels of processing manipulations have been found to affect conceptual implicit memory tests (Hamann, 1990; Srinivas & Roediger, 1990). If primacy is the result of more rehearsal or greater attention given to items at the beginning of a to-be-remembered-list (Atkinson & Shriffrin, 1968; Craik & Lockhart, 1972; Glenberg *et al.*, 1980; Rundus, 1971), then one might expect this deeper processing to result in a primacy effect in conceptual implicit memory tests.

An explanation is provided by Schacter and McGlynn (1989, Experiment 3) who found that a conceptual implicit free association test using unitised word pairs, consisting of strongly related words (*e.g. TABLE - CHAIR*) was not susceptible to a levels of processing study manipulation which significantly affected explicit cued recall. In Experiment 4 in the same study, they found that free association using non-unitised word pairs (*e.g. TABLE - KEY*) was susceptible to the levels of processing manipulation. The difference in susceptibility to levels of processing between the two implicit tests was therefore produced by the unitisation of one set of stimuli compared to the non-unitisation of the other set. Unitised word pairs do not require new or stronger associative connections to be made at encoding. The forename/surname stimuli used in the current experiments also did not require new or stronger associative connections to be made at encoding. Thus, the absence of primacy effects in the name generation tests is consistent with the finding of Schacter and McGlynn by not reflecting the deeper processing of primacy items.

The lack of primacy effects in these conceptual implicit tests provides further evidence that subjects, who were aware of a relationship between study and test, performed according to instructions. If they had been using intentional retrieval strategies, it is probable that primacy effects would have occurred in the implicit tests. Intentional retrieval in the form of explicit test instructions has therefore been shown to be a necessary prerequisite for primacy effects to occur with stimuli in which no new or strengthened associative connections were made at encoding in Experiments 7 and 8, and in Experiment 6 with strongly related word pairs. Conversely, the non-unitised, moderately or weakly related word pairs in Experiments 4, 5 and 6 produced primacy effects, irrespective of whether retrieval was intentional or not.

According to the multiple memory systems theory, conceptual priming occurs outside the PRS, possibly in the semantic system, and is susceptible to levels of processing effects (Schacter 1994). Consistent with this prediction, the multiple memory systems theory might have predicted primacy effects in the implicit tests in Experiments 7 and 8 which did not occur. The theory would not have differentiated between the conceptual implicit memory tests in Experiments 4 - 8 as to their susceptibility to primacy effects. However, an amendment to the multiple memory systems theory, that all priming is based on the PRS, but that an interaction between the PRS and episodic (or semantic) memory occurs when new or stronger associative connections are made at encoding (see General Discussion, Chapter 4), would explain why primacy effects occurred in free association of weakly and moderately related word pairs, but not in free association of strongly related word pairs nor in name generation in Experiments 4 - 8. Primacy effects would reflect the involvement of episodic (or semantic) memory during encoding; when this involvement occurred, primacy items would have been encoded better.

The results of this study are also not completely in line with the transfer appropriate processing theory, which predicts better retrieval according to the match of conceptually-driven or data-driven processes between encoding and test. Consistent with this theory, a primacy effect might be predicted in the name generation test, reflecting a greater overlap of conceptually-driven processes between encoding of the first few names and the conceptually-driven test. Encoding of non-primacy names would have less conceptually-driven processes in common with the test because they would not be subject to the increased elaborative or rote rehearsal or the greater attention afforded to the first few list items encoded.

Name generation priming in Experiments 7 and 8 showed significant forgetting throughout the duration of the tests. This finding contrasted with word stem completion priming in Experiments 2 and 3, and free association priming with strongly related word pairs in Experiment 6, in which no measurable forgetting occurred. As there was no measurable forgetting in word stem completion priming and free association of strongly related word pairs, it is unlikely that the forgetting that occurred in name generation priming was attributable to decay of the studied surname or to decay of the pre-existing relationship between the forename/surname pairs. (If decay of the stimulus word or decay to the pre-existing relationship was responsible for forgetting, then an implicit forgetting trend would have occurred in Experiments 2 and 3 and with strongly related word pairs in Experiment 6.)

The forgetting that occurred in name generation priming was consistent with similar forgetting that occurred in free association priming with moderately or weakly related word pairs in Experiments 4, 5 and 6. In free association priming, forgetting may have resulted from decay or interference to the encoded associative connections between pairs of stimulus words. However, as the associative connections between stimulus pairs were known prior to study in the name generation test, it is more likely that forgetting in this test, and possibly in the free association tests, was attributable to interference. The only conceptual implicit memory test in which forgetting did not occur was free association of strongly related word pairs in Experiment 6. It is feasible that interference did not occur in this test because the pre-existing connections between the stimulus words were too strong. Although the pre-existing connections between forename/surname pairs were also strong, they may have been more susceptible to interference than the strongly related word pairs. The weaker associative connections encoded between stimulus pairs in the other conceptual implicit memory tests would also have been susceptible to interference, contributing to forgetting in these tests.

Forgetting in the explicit tests showed a different pattern of results from forgetting in the implicit tests. In the explicit tests, a forgetting trend occurred, irrespective of the relationship between stimulus pairs. For example, in Experiment 6, explicit recall of both strongly and weakly related word pairs deteriorated throughout the course of the test for non-primacy items. In addition, in Experiments 2 and 3, explicit recall of non-primacy items deteriorated throughout the course of the test, even though the stimuli comprised individual words, not word pairs.

The forgetting trends for non-primacy items in both implicit name generation and explicit name cued recall were not affected by an interpolated task which would have eliminated short-term recency effects. It is therefore unlikely that short-term recency effects contributed to these forgetting trends. With regard to possible short-term recency effects, a comparison between the results of Experiments 7 and 8, showed that the interpolated task appeared to detrimentally affect explicit recall but beneficially affect implicit generation of the last few items. These results indicate that explicit name cued recall may have shown some short-term recency but implicit name generation did not. However, the comparison is between different experiments and may not therefore be reliable.

If short-term recency effects are attributable to subjects off-loading the contents of their short-term memory prior to recalling items from long-term memory, then any cognitive effort required to cue items at test would interfere with the off-loading process. If this is the case, explicit short-term recency effects may be inversely related to the amount of cognitive effort required to cue items at test. In this thesis, the cues in word stem cued recall, name cued recall and cued recall of strongly related word pairs subjectively appear to involve less cognitive effort than the cues in cued recall of moderately or weakly related word pairs. In accordance with this proposal, word stem cued recall and name cued recall appeared to show short-term recency effects whereas cued recall of moderately and weakly related word pairs did not. The only exception was cued recall of strongly related word pairs which would have been expected to produce a short-term recency effect according to the proposal, but did not. However, Figure 6(S)a shows a tendency towards a short-term recency effect. The results of this thesis therefore provide tentative support for this proposal.

The final experimental chapter investigated whether levels of processing effects in conceptual implicit memory tests showed the same susceptibility as primacy effects to the strength of the relationship between pairs of stimulus items.

CHAPTER 6

LEVELS OF PROCESSING EFFECTS IN CONCEPTUAL IMPLICIT MEMORY TESTS

6.1 Introduction

In this final experimental chapter, two further experiments are described which investigated levels of processing effects in conceptual implicit memory tests. If levels of processing effects are found to be dependent on whether new or stronger associative connections between encoded stimulus pairs are required to be made at encoding, this would also explain why levels of processing effects occur in conceptual implicit memory tests when new associations are required to be made during the encoding phase (see e.g. Schacter & Graf, 1985; 1989; Schacter & McGlynn, 1989, Experiments 2 & 4) but not when new associations are not required to be made (Schacter & McGlynn, 1989, Experiment 3).

The two experiments were conducted using the same tests as Experiments 4 - 8 and similar stimuli. Experiment 9 used the same free association test, and similar stimuli to Experiment 6. Consistent with the results of Experiment 6, which found primacy effects with weakly but not strongly related word pairs, it was predicted that levels of processing effects would occur with weakly but not strongly related word pairs. Experiment 10 used the name generation test and similar stimuli to Experiments 7 and 8. Consistent with the results of these two experiments, levels of processing effects were not predicted using this test.

6.2 EXPERIMENT 9

In Experiment 9 deep or shallow levels of processing was applied to strongly and weakly related word pairs at study. In the deep processing task, subjects were required to rate the word pairs as to how well related they were on a five point scale; in the shallow processing task, subjects were required to rate the word pairs for readability on a five point scale. Both these tasks therefore required subjects to respond to each word pair with a one digit response. In addition, the shallow processing task ensured that the word pairs were read, even if only at a shallow encoding level. It therefore avoided the possibility that subjects were performing a graphemic task without having processed the stimuli words, as has been found to occur in some between-subjects or blocked graphemic tasks (Challis & Brodbeck, 1992; Hayman & Jacoby, 1989; Thapar & Greene, 1994; see Sections 1.2.4 and 1.3.4). Subjects were then instructed to perform either a conceptual implicit test of free association or an explicit test of cued recall.

According to Schacter & McGlynn (1989, Experiment 3), highly related, unitised word pairs (e.g. *TABLE - CHAIR*) are not susceptible to levels of processing effects. Experiment 9 was based on Schacter & McGlynn's experiment but differed from it in three important ways. First, in Schacter & McGlynn's experiment, subjects were not informed of the relationship between the study phase and the implicit test. To help disguise this relationship, two intervening tasks were performed before the test. In Experiment 9, subjects were informed of the relationship between the study phase and the implicit test but were asked to try to ignore this relationship and write the first word that came to mind to each of the word cues. Informing subjects of the relationship between the study and test enabled the test to be performed immediately, without requiring intervening tasks. It also reduced the possibility that subjects, who became aware of the relationship between the study and test words during the test phase, might use intentional retrieval strategies (see e.g. Bowers & Schacter, 1990). Because of this possibility, Richardson-Klavehn, Lee, Joubran and Bjork (1994) recommended informing subjects of the connection between study and test but requesting them not to intentionally try to recollect previously studied items (see the previous discussion of this point in Section 2.6).

Second, in Schacter and McGlynn's experiment subjects were presented with the stimuli within different contexts in the deep and shallow processing tasks. In the deep processing task subjects saw the highly related word pairs within a sentence, whereas in the shallow processing task they saw the word pairs without the sentence frame. In this experiment, subjects saw the stimulus word pairs only in both the deep and shallow encoding conditions.

Third, in Schacter and McGlynn's experiment, subjects performed an implicit free association test immediately before an explicit cued recall test, using the same stimuli items in each. Performance in the explicit test may therefore have been confounded by performance in the implicit test. In addition, the implicit test included 55 non-presented items whereas the cued recall test did not include any non-presented items. To conform to the retrieval intentionality criterion (Schacter, *et al.*, 1989), the implicit and explicit tests in Experiment 9 were performed between-subjects. Everything about the implicit and explicit tests, including the time of testing and test sheet, was identical except for the instructions at test. These three methodological differences were made to increase the validity of the results of this experiment compared to Schacter and McGlynn's.

Experiment 9 was conducted using similar stimuli to that used in Experiment 6 and the same tests. Consistent with the results of Experiment 6 in which an explicit primacy effect occurred with both weakly and strongly related word pairs but an implicit primacy effect only occurred with weakly related word pairs, the explicit test was predicted to show a levels of processing effect with both strongly and weakly related word pairs but the implicit test was only predicted to show a levels of processing effect with weakly related word pairs.

The prediction of no levels of processing effect in free association priming of strongly related word pairs may be counter to the multiple memory systems theory as Schacter (1994) proposed that "One reasonable hypothesis is that both conceptual priming with familiar items and priming of new associations with novel pairs depend on a semantic memory system" p.254. If conceptual priming does depend on the semantic memory system, then it would presumably be susceptible to a levels of processing manipulation. The transfer appropriate processing theory would also predict a levels of processing effect in free association of strongly related word pairs because there would be more overlap of conceptual processes between the deep encoding condition and the conceptual test than between the shallow encoding condition and the test.

If no levels of processing effect was found with strongly related word pairs in the conceptual implicit test, this would be further support for the suggestion that levels of processing effects do not necessarily occur in conceptual implicit memory tests when no new or stronger associative connections are required to be made between stimuli pairs at encoding. It would also be consistent with the proposal that interactions between the PRS and episodic (or semantic) memory may be responsible for differences between perceptual and conceptual priming (see the General Discussion at the end of Chapter 4).

Method

Subjects. Eighty students from Glamorgan University, age range 18 - 38, participated in the experiment. They were randomly allocated to four groups of 20 subjects and tested in large groups.

Design and Materials. The design factors were Test (implicit vs. explicit), Levels of Processing (deep vs. shallow), and Word Relatedness (strongly vs. weakly related word pairs). Test and Levels of Processing were manipulated between-subjects and Word Relatedness was manipulated within-subjects.

Stimulus material was presented on two overheads. On each overhead was printed 20 word pairs, 10 of which were strongly related according to the Minnesota Word Association Norms (Jenkins, 1970), e.g. *MAN BOY, BATH WATER*, and 10 of which were weakly related, e.g. *SLEEP LATE, HEAD LICE.* Most of the word pairs had been used previously in Experiment 6. (Four new word pairs were required because Experiment 7 used 40 word pairs whereas Experiment 6 used two sets of 36 word pairs in which the first word was repeated across each set.) (See Appendix A for a full list of these word pairs.) Strongly and weakly related word pairs were listed randomly on the two overheads with the proviso that not more than three strongly or weakly related word pairs appeared in succession. During the course of the experiment the two sets of word pairs were counterbalanced such that when one set was presented as targets the other set formed the lures.

The first word of each word pair was listed in two columns on a test sheet. Six different random orders of these words resulted in six different test sheets. In addition, the first two words on each test sheet were filler items.

Alongside each word a row of dots indicated where written responses were required.

<u>Procedure</u>. Subjects were randomly assigned to one of the four experimental groups: deep processing, implicit test; deep processing, explicit test; shallow processing, implicit test; shallow processing, explicit test. The study was introduced as a pilot study to collect stimulus norms for a future experiment. Each subject received a test sheet, face down - six different test sheets were issued randomly.

The two deep processing groups were instructed to rate the word pairs they were about to see according to how well related they were on a five point scale. To remind them of the required scale, they were asked to write "*1 = not well related*" and "*5 = very well related*" at the top of their sheets. They were instructed to list their ratings in a column. The two shallow processing groups were instructed to rate the word pairs for readability on a five point scale. They were asked to write "*1 = difficult to read*" and "*5 = easy to read*" at the top of their sheets and list their ratings in a column. Subjects were then shown each word pair, through a mask for 3 seconds, and performed their rating tasks.

When all the word pairs had been rated, subjects were required to turn over their test sheets. The two implicit groups were asked to free associate to each of the words listed on the test sheet. They were instructed not to specifically try to remember words from the study phase but to write the first word that came into their heads. If no word came to mind, they should leave a blank and go on to the next word. The two explicit groups were asked to try to remember if each word on the test sheet was one of the words they had previously rated on the overhead. If they remembered the word, they should try to write down the word with which it was paired. They were instructed to write down words only if they remembered they were on the overhead and not to guess associations. Subjects were allowed five minutes for these tasks.

Results and Discussion

There was significant priming in all aspects of the conceptual implicit test following: deep processing of strongly related word pairs (target word association prob. = 0.46, lure word association prob. = 0.22) [$t(19) = 5.72$]; shallow processing of strongly related word pairs (target word association prob. = 0.33, lure word association prob. = 0.17) [$t(19) = 3.56$]; deep processing of weakly related word pairs (target word association prob. = 0.15, lure word association prob. = 0.01) [$t(19) = 3.24$]; and shallow processing of weakly related word pairs (target word association prob. = 0.14, lure word association prob. = 0.02) [$t(19) = 4.19$]. Incorrect recall in all aspects of the explicit test was very low following: deep processing of strongly related word pairs (target word recall prob. = 0.73, incorrect recall prob. = 0.03) [$t(19) = 17.67$]; shallow processing of strongly related word pairs (target word recall prob. = 0.34, incorrect recall prob. = 0.02) [$t(19) = 5.37$]; deep processing of weakly related word pairs (target word recall prob. = 0.59, incorrect recall prob. = 0.03) [t(19) = 11.90]; and shallow processing of weakly related word pairs (target word recall prob. = 0.31, incorrect recall prob. = 0.02) [t(19) = 5.93]).

Bar charts of the results of Experiment 9 are shown in Figure 9. In the lower bar chart, baseline association (deep processing of strongly related word pairs prob. = 0.22; shallow processing of strongly related word pairs prob. = 0.17; deep processing of weakly related word pairs prob. = 0.01; shallow processing of weakly related word pairs prob. = 0.02) has been subtracted from the implicit test results. (Percentages of target words associated and recalled as a function of word relatedness, levels of processing and test are shown in Table 5, Appendix B.) These figures indicate levels of processing effects in the explicit test for both strongly and weakly related word pairs but a levels of processing effect in the implicit test for strongly related word pairs only.

A 2 x 2 x 2 ANOVA was performed to investigate this interpretation of the data with two between-subjects factors, Test (implicit vs. explicit) and Levels of Processing (deep vs. shallow) and one within-subjects factor, Word Relatedness (strongly vs. weakly related word pairs). The main effects of Test [F(1,76) = 36.00, MSe = 5.44] and Levels of Processing [F(1,76) = 30.53, MSe = 5.44] were significant and there was a significant interaction between

Experiment 9

Word Association/Cued Recall

Levels of Processing - Strongly and Weakly Related Cues

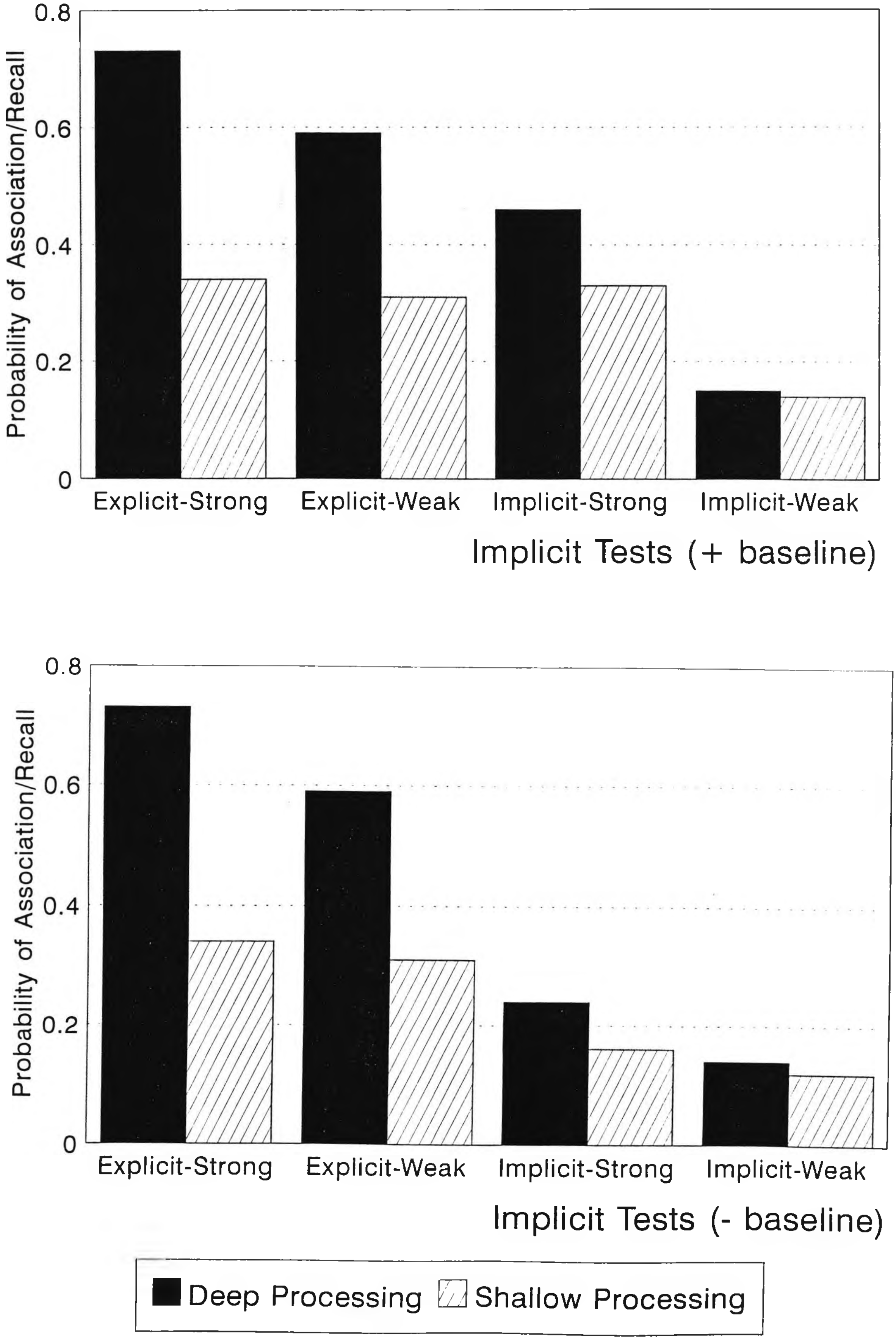


Figure 9

Test and Levels of Processing [$F(1,76) = 13.15$, $MSe = 5.44$]. The main effect of Word Relatedness was also significant [$F(1,76) = 59.88$, $MSe = 1.79$] with significant interactions between Word Relatedness and Test [$F(1,76) = 14.74$, $MSe = 1.79$] and between Word Relatedness and Levels of Processing [$F(1,76) = 7.07$, $MSe = 1.79$]. The three-way interaction between Word Relatedness, Test and Levels of Processing was not significant [$F(1,76) = 0.03$, $MSe = 1.79$]. The ANOVA was performed on the data for studied items without subtracting baseline performance in the implicit tests.

Separate one way ANOVAS were performed on the implicit and explicit tests to investigate the significant interactions between Test and Levels of Processing and between Test and Word Relatedness. In the explicit test there were significant main effects of Levels of Processing [$F(1,38) = 34.67$, $MSe = 6.57$] and Word Relatedness [$F(1,38) = 7.05$, $MSe = 1.93$] but the interaction between Levels of Processing and Word Relatedness was only approaching significance [$F(1,38) = 2.86$, $MSe = 1.93$]. Planned comparisons showed that Levels of Processing had a significant effect on recall of both strongly related word pairs [$t(38) = 5.86$] and weakly related word pairs [$t(38) = 4.47$]. In the implicit test the main effect of Levels of Processing was not significant [$F(1,38) = 2.27$, $MSe = 4.31$] but the main effect of Word Relatedness was [$F(1,38) = 72.70$, $MSe = 1.65$] and there was a significant interaction between Levels of Processing and Word Relatedness [$F(1,38) = 4.36$, $MSe = 1.65$]. The reason for this significant interaction was that Levels of Processing had a significant effect on strongly related word pairs [t(38) = 2.25] but not on weakly related word pairs [t(38) = 0.195].

Levels of processing therefore had more effect on the explicit test than on the implicit test, with strongly and weakly related word pairs both showing a levels of processing effect in the explicit test but only strongly related word pairs showing a levels of processing effect in the implicit test. Conversely, the strength of the relationship between word pairs had more effect on the implicit test than on the explicit test. However, this difference may have been attributable to higher baseline performance with strongly related than with weakly related word pairs in the implicit test. In Figure 9, with baseline association subtracted, there is less difference between priming of strongly and weakly related word pairs.

Baselines also differed between deep and shallow processing of strongly related word pairs in the implicit test, although not significantly so, [t(38) = 1.26]. However, a re-analysis of the implicit test results was performed in which the different baselines for deep and shallow processing of strongly and weakly related word pairs were subtracted. In this new analysis, the main effect of Levels of Processing was not significant [F(1,38) = 1.09, MSe = 4.59], the main effect of Word Relatedness was [F(1,38) = 4.92, MSe = 1.99] but there was no interaction between Levels of Processing and Word

Relatedness [$F(1,38) = 1.23$, $MSe = 1.99$]. Planned comparisons now showed that Levels of Processing had no effect on either strongly related word pairs [$t(38) = 1.38$], or weakly related word pairs [$t(38) = 0.28$].

It is difficult to know whether or not baselines should be subtracted in implicit tests before analysing the results. When strongly and weakly related cues are being compared in the same experiment, the baselines of each will obviously be different. Unfortunately, with or without subtraction of the baselines, a direct comparison between strongly and weakly related cues is not strictly possible. The reason for the difficulty is because comparison without subtracting baselines is weighted in favour of strongly related cues whereas comparison with baselines subtracted is weighted in favour of weakly related cues.

This difficulty does not apply to deep and shallow processing of strongly related word pairs, however. Strongly related cues showed a levels of processing effect when baselines were not subtracted but no levels of processing effect when baselines were subtracted in the implicit test, even though the two baselines did not differ significantly from each other. It therefore appears that the levels of processing effect for strongly related word pairs was a marginal effect - as would be predicted for word pairs which are strongly related but not unitised.

It had been predicted that weakly related word pairs, not strongly related word pairs, would show a levels of processing effect in the implicit test. In fact, weakly related word pairs did not show a levels of processing effect and strongly related word pairs showed a marginal effect which disappeared when baselines were subtracted prior to the analysis. The results of the implicit test were therefore different to the experimental hypothesis. There are two possible reasons for this discrepancy. First, the weakly related word pairs, although very weakly related according to the Minnesota Word Association Norms (Jenkins, 1970), were mainly common idioms, e.g. *FRUIT COCKTAIL, BLACK MAGIC*. Schacter & McGlynn (1989, Experiment 1) found that common idioms did not produce a levels of processing effect between two deep encoding conditions and one shallow encoding condition in an implicit free association test. (A third deep encoding condition, which had provided a definition of the common idioms, did produce a significant levels of processing effect when compared with the shallow encoding task.) Second, the strongly related word pairs, although very strongly related, were not necessarily unitised and were therefore still susceptible to a marginal levels of processing effect.

Unfortunately, the results of the implicit test in this experiment were not consistent with the results of the implicit test in Experiment 6 in which a one item primacy effect occurred with weakly related word pairs but no primacy effect occurred with strongly related word pairs. (Most of the word pairs in this experiment were the same as those used in Experiment 6.) The finding that levels of processing effects react differently to primacy effects with respect to the relationship between stimulus word pairs therefore indicates that primacy effects are not simply a manifestation of deeper processing of the first few list items compared to remaining list items.

Interestingly, priming of weakly related word pairs after deep processing in this experiment was very low (prob. = 0.15) compared to priming of weakly related word pairs in Experiment 6 (prob. = 0.42). Although there were differences between the two experiments which make direct comparisons difficult, priming of strongly related word pairs after deep processing in this experiment (prob. = 0.46), compared to priming of strongly related word pairs in Experiment 6 (prob. = 0.61), was not affected to the same extent. The lack of comparable priming for weakly and strongly related word pairs across this experiment and Experiment 6 may be attributable to the different test sheets used in the two experiments. In Experiment 6 the test was presented in the reverse to study order but in this experiment it was not. This experiment was not therefore able to capture immediate memory for studied items to the same extent as Experiment 6. Items which were forgotten quickly were therefore more likely to be lost in this experiment than in Experiment 6. The difference in priming of weakly related words between this experiment and Experiment 6 may therefore be attributable to the more rapid forgetting in priming of weakly related word pairs compared to strongly related word pairs which has been described previously. These results provide converging evidence that priming of strongly related word pairs is less prone to forgetting than priming of weakly related word pairs.

Comparison between the results of this experiment and Experiment 6 also indicates that conceptual implicit priming is more prone to forgetting than explicit recall. Explicit recall was similar after deep processing of strongly related word pairs in this experiment (prob. = 0.73) compared to recall of strongly related word pairs in Experiment 6 (prob. = 0.67); and after deep processing of weakly related word pairs in this experiment (prob. = 0.59) compared to recall of weakly related word pairs in Experiment 6 (prob. = 0.61).

The final experiment investigated whether a levels of processing effect would occur in the conceptual implicit name generation test used in Experiments 7 and 8. Unfortunately, because the presence or absence of primacy effects in Experiment 6 was not consistent with the presence or absence of levels of processing effects in Experiment 9, it is not possible to predict that no levels of processing effects will occur in name generation because no primacy effect occurred in this test in Experiments 7 and 8. However, it is feasible to predict that no levels of processing effect will occur in name generation because no connections between the forename/surname stimuli are made or strengthened during encoding.

6.3 EXPERIMENT 10

In this last experiment deep or shallow levels of processing were applied to the encoding phase of the conceptual implicit memory test of name generation test and the explicit test of name cued recall. In the deep processing task, subjects were required to rate famous surnames as to how familiar they were on a five point scale; in the shallow processing task, subjects were required to rate the surnames for readability on a five point scale. In the same way as Experiment 9, both these tasks therefore required subjects to respond to each word pair with a one digit response. The shallow processing task also ensured that the famous surnames were read, avoiding curtailment of semantic processing (e.g. Thapar & Greene, 1994; see Sections 1.2.4 and 1.3.4).

Levels of processing effects are not predicted in the implicit test because stronger associative connections are not able to be made at encoding. Even if it was possible for stronger associative connections to be made at encoding, such a manipulation should not produce a levels of processing effect in the name generation test as the forename/surname stimuli are unitised and therefore function as integrated units. According to Schacter & McGlynn (1989, Experiment 3), unitised word pairs (e.g. *TABLE - CHAIR*) are not susceptible to levels of processing effects.

This experiment was again based on Schacter and McGlynn's experiment but utilised the same three methodological improvements used in Experiment 9:

subjects were informed of the relationship between the study phase and the implicit test but were asked to try to ignore this relationship and write the first word that came to mind to each of the word cues; subjects saw the stimulus names in the same context in the deep and shallow encoding conditions; and the implicit and explicit tests conformed to the retrieval intentionality criterion of Schacter, *et al.* (1989). Consistent with Schacter and McGlynn's findings, a levels of processing effect was predicted in the explicit test but not in the conceptual implicit test.

Method

Subjects. Eighty students from City University and the University of East London, age range 18 - 35, participated in the experiment. They were randomly allocated to four groups of 20 subjects and tested in groups.

Design and Materials. The design factors were Test (implicit vs. explicit) and Levels of Processing (deep vs. shallow), both of which were manipulated between-subjects.

Stimulus material was presented on two overheads. On each overhead was printed 20 unique and easily identifiable surnames of famous people. All these famous people had different common forenames which were not present on the overheads, e.g. *SAVILLE (JIMMY), McQUEEN (STEVE)*. (See Appendix A for a full list of these names.) During the course of the experiment the two sets of names were counterbalanced such that when one set was presented as target names the other set formed the lure names. Forenames associated with each of the 40 surnames were randomly listed in two columns on a test sheet. Six different random orders of these forenames resulted in six different test sheets. In addition, the first two forenames on each test sheet were filler items. Alongside each forename a row of dots indicated where written responses were required.

Procedure. Subjects were randomly assigned to one of the four experimental groups: deep processing, implicit test; deep processing, explicit test; shallow processing, implicit test; shallow processing; explicit test. The study was introduced as a pilot study to collect stimulus norms for a future experiment. Each subject received a test sheet, face down - the six different test sheets were issued randomly.

The two deep processing groups were instructed to rate the surnames they were about to see for familiarity on a five point scale. To remind them of the required scale, they were asked to write "*1 = unfamiliar*" and "*5 = familiar*" at the top of their sheets. They were instructed to list their ratings in a column. The two shallow processing groups were instructed to rate the surnames for readability on a five point scale and were asked to write "*1 = difficult to read*" and "*5 = easy to read*" at the top of their sheets and to list their ratings in a column. Subjects were then shown each surname for 3 seconds (through a cardboard mask placed over the overhead) and performed their rating tasks.

When all the surnames had been rated, subjects were required to turn over their test sheets. The two implicit groups were asked to generate surnames to each of the forenames listed on the test sheet. They were instructed not to specifically try to remember surnames from the overhead but to write the first surname that came to mind. If no surname came to mind, they should leave a blank and go on to the next forename. The two explicit groups were asked to use the forenames as cues to try to remember surnames from the overhead. They were instructed only to write surnames if they could remember that the surname was on the overhead and not to guess surnames. Subjects were allowed five minutes for these tasks.

Results and Discussion

There was significant priming in the conceptual implicit test after both deep processing (target name generation prob. = 0.48, lure name generation prob. = 0.18) [$t(19) = 6.48$] and shallow processing (target name generation prob. = 0.43, lure name generation prob. = 0.12) [$t(19) = 6.02$]. Incorrect recall in the explicit test was very low for both deep processing (target name recall prob. = 0.60, incorrect recall prob. = .01) [$t(19) = 10.60$] and shallow processing (target name recall prob. = 0.46, incorrect recall prob. = 0.03) [$t(19) = 9.55$].

Bar charts of the results of Experiment 10 are shown in Figure 10. In the lower bar chart, baseline generation (deep processing prob. = 0.18; shallow processing prob. = 0.12) has been subtracted from the implicit test results. (Percentages of target names generated and recalled as a function of levels of processing and test are shown in Table 6, Appendix B.) In both bar charts, there appears to be a levels of processing effect in the explicit test but not in the implicit test.

A 2 x 2 ANOVA was performed to investigate this interpretation of the data with two between-subjects factors, Test (implicit vs. explicit) and Levels of Processing (deep vs. shallow). The main effect of Test was approaching significance [$F(1,76) = 2.93$, $MSe = 15.89$] and the main effect of Levels of Processing was significant [$F(1,76) = 4.43$, $MSe = 15.89$]. The interaction between Test and Levels of Processing was not significant [$F(1,76) = 1.20$, $MSe = 15.89$], but planned comparisons showed that the explicit test was susceptible to a levels of processing effect [$t(38) = 2.32$] but the implicit test was not [t(38 = 0.70]. The ANOVA was performed on the data for studied items without subtracting baseline performance in the implicit tests. These comparisons confirmed that there was a levels of processing effect in the explicit test but not in the implicit test. The lack of a levels of processing effect in the implicit test was possibly because associated forenames were automatically activated when surnames were seen, and the forename/surname connection was not therefore susceptible to different processing levels.

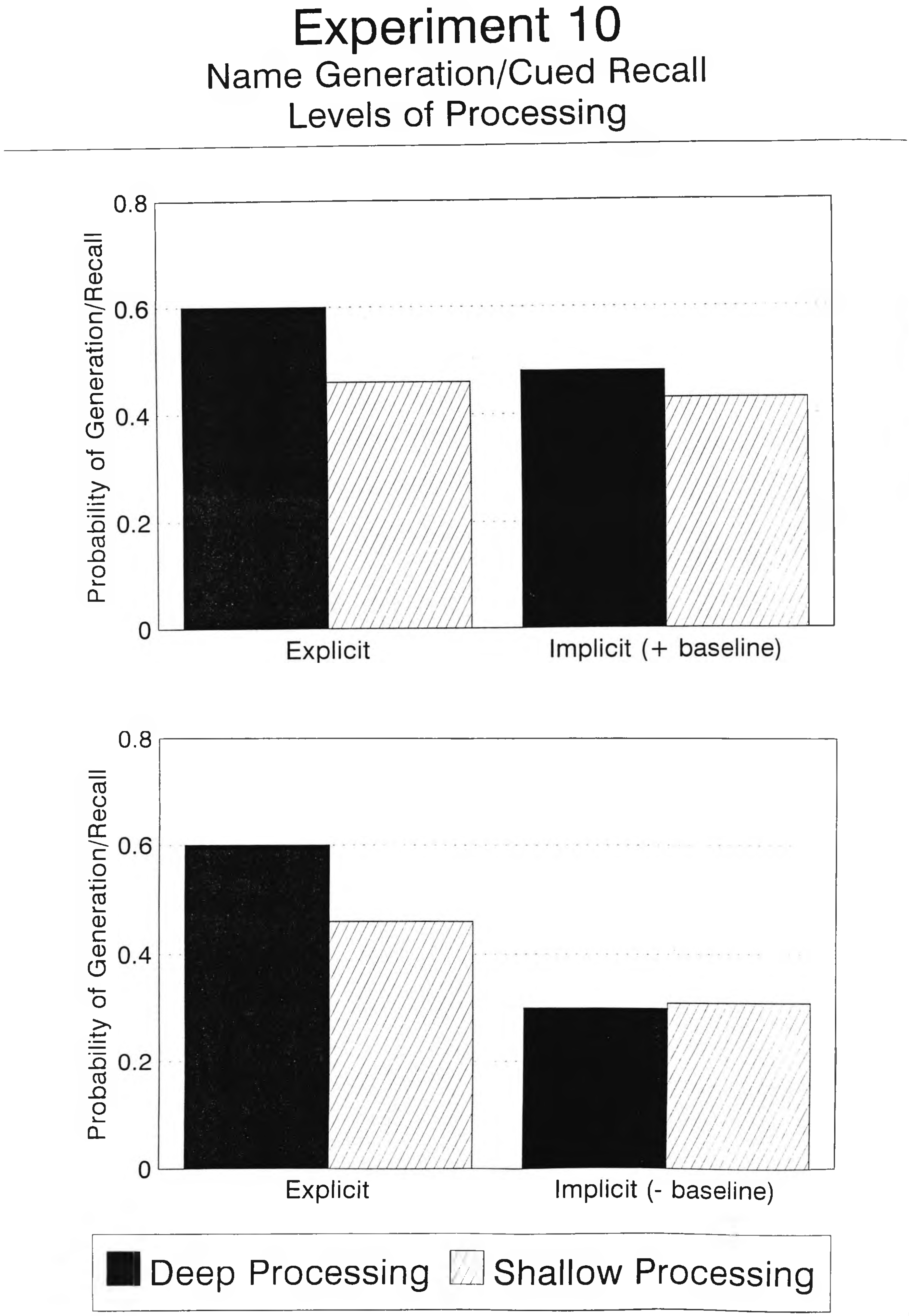

Experiment 10
Name Generation/Cued Recall
Levels of Processing
Probability of Generation/Recall
0.8
0.6
0.4
0.2
0
Explicit
Implicit (+ baseline)
Probability of Generation/Recall
0.8
0.6
0.4
0.2
0
Explicit
Implicit (- baseline)
Deep Processing
Shallow Processing

Figure 10

An interesting finding was that baseline performance after deep processing was significantly higher than baseline performance after shallow processing [t(38) = 2.23]. A re-examination of the test sheets did not produce any obvious reason for this difference - there were no extra blanks or non-famous surnames after shallow processing than after deep processing. One possible explanation for this difference is that, even though levels of processing had no effect on priming of the target surname, deep processing was beneficial in activating surnames associated with the target surname. Since target and lure surnames were drawn from the same pool of very well known personalities in the field of show business, sport, politics and history, lure surnames may have been activated in this manner. This is only a tenuous explanation, however, and the effect may have been spurious.

Since baselines were different between the deep and shallow processing conditions in the implicit test, a re-analysis of the experimental results was performed in which the different baselines were subtracted. In this new analysis, the main effect of Test was now significant [F(1,76) = 26.41, MSe = 16.91] but the main effect of Levels of Processing was not [F(1,76) = 2.93, MSe = 16.91]. The interaction between Test and Levels of Processing was now significant [F(1,76) = 3.94, MSe = 16.91]. Planned comparisons still showed that the explicit test was susceptible to a levels of processing effect [t(38) = 2.32] but the implicit test was not [t(38 = 0.18]. Subtracting the different baselines from the implicit test conditions therefore produced a significant interaction between the implicit and explicit tests which was not present before the baselines were subtracted. However, irrespective of whether baselines were included or not, the results of the planned comparisons were unchanged, with only the explicit test showing a significant levels of processing effect.

These results are consistent with the results of Schacter & McGlynn (1989, Experiment 3). The results of this experiment support their findings using an immediate conceptual implicit test, in which there is no perceptual overlap between study and test, and using better methodology which conforms to the retrieval intentionality criterion. Nonetheless, the results of this experiment do not support either the multiple memory systems theory or the transfer appropriate processing theory which would both have been more likely to have predicted a levels of processing effect in this conceptual implicit memory test. The results are in line with the suggested amendment to the multiple memory systems theory, however. According to this suggestion, no levels of processing effect should occur in a conceptual implicit memory test when no new or strengthened associative connections are required to be made at encoding, because no interaction between the PRS and episodic (or semantic) memory would be required to be made.

General Discussion

In the conceptual implicit tests in Experiments 9 and 10, levels of processing effects were not found with weakly related word pairs which were mainly common idioms; nor were they found with unitised forename/surname stimuli. Levels of processing effects were found with strongly related word pairs which were not fully unitised, but not when baseline completion was subtracted before the analysis. In contrast, levels of processing effects were found in all the comparable explicit tests in both experiments.

Unfortunately, Experiment 9 did not produce results in accordance with the experimental hypothesis which had predicted a levels of processing effect in free association priming with weakly related words but not with strongly related word pairs. Possible reasons for these unexpected results are that the strongly related word pairs, although strongly related according to the Minnesota Word Association Norms (Jenkins, 1970), were not unitised, and therefore produced a marginal levels of processing effect; conversely, the weakly related words, although very weakly related according to the Minnesota Word Association Norms, were mainly common idioms which have been found not to produce a levels of processing effect (Schacter & McGlynn, 1989). Notwithstanding, the results of Experiment 9 were not consistent with the results of Experiment 6, even though the stimulus word pairs were very similar. This discrepancy between the results of Experiment 10 and Experiment 6 demonstrates that primacy effects are not simply a reflection of deeper encoding of the first few list items. It is possible that rote rehearsal, which is thought to be involved in primacy effects, may be responsible for this difference.

The absence of a levels of processing effect in name generation priming in Experiment 10 was in accordance with the experimental hypothesis that no levels of processing effect would occur in conceptual priming of stimulus pairs which did not require any new associative connections or any strengthening of existing associative connections at encoding.

These results do no support either the multiple memory systems theory, or the transfer appropriate processing theory, both of which would be more likely to predict a levels of processing effect in the these conceptual implicit tests (see General Discussion at the end of Chapter 3 and the introduction to Experiment 9). They are, however, consistent with the proposal that new or strengthened associative connections, attributable to an interaction between the PRS and episodic (or semantic) memory during the encoding phase, produce levels of processing dissociations between perceptual and conceptual priming. In Experiment 9, the stimuli were either strongly related word pairs or mainly common idioms, neither of which have been found to benefit from encoding new or associative connections enough to produce a levels of processing effect (Schacter & McGlynn, 1989). In Experiment 10, it was not possible for new associative connections to be made to the pre-existing unitised relationship between the forename/surname stimuli.

In the explicit tests, a comparison of Figures 9 and 10 shows that a larger levels of processing effect occurred in the cued recall test for both strongly and weakly related word pairs in Experiment 9 than in the name cued recall test in Experiment 10. Two possible reasons for this difference in the levels of processing effect across the two tests may be because any level of encoding of the famous surnames automatically activated their associated forenames or because shallow encoding of unique famous surnames is more memorable than shallow encoding of word pairs.

In summary, the only indication of a levels of processing effect in conceptual priming in these two experiments was in a free association test with strongly related, but not unitised, word pairs and even this effect did not occur when baseline completion levels were subtracted before the analysis. Levels of processing effects were not found in a name generation test, in which associative connections between the stimulus pairs were known prior to the test, nor in a free association test with weakly related word pairs which were mainly common idioms. In comparison, levels of processing effects occurred in all the comparable explicit test results. Overall, these results show that levels of processing effects do not necessarily occur in conceptual implicit memory tests.

CHAPTER 7

CONCLUDING DISCUSSION

7.1 Introduction

The following concluding discussion is divided into five sections. In Section 7.2 the aims of the thesis are briefly re-stated, and in Section 7.3 the experimental findings are summarised. Section 7.4 examines the experimental results in the light of the two main theoretical explanations for dissociations between implicit and explicit memory tests, the multiple memory systems theory (see Section 1.5.1) and the transfer appropriate processing theory (see Section 1.5.2). Section 7.5 identifies any areas of study that have not been fully explored in this thesis and that might benefit from future research. Finally Section 7.6 concludes the thesis.

7.2 Aims of the Thesis

The main aim of the thesis was to examine serial position effects in perceptual and conceptual implicit memory tests and to compare the results with performance in explicit memory tests which were identical in all respects to the implicit tests except for different test instructions. This stipulation would enable implicit and explicit test performance to be directly compared without any factors, other than differing test instructions, having to be taken into account, in accordance with the retrieval intentionality criterion (Schacter, *et al.*, 1989).

A summary of the current literature into the properties of perceptual and conceptual priming highlighted some currently unresolved questions. For example, why did perceptually and conceptually based priming differ in their susceptibility to encoding manipulations such as levels of processing and the generation effect? In addition, there is a shortage of properly controlled experimental data, particularly in relation to some variables, such as retention interval and interference effects, in the current literature. The detailed breakdown of test performance provided by an examination of serial position effects in perceptually and conceptually based priming would provide empirical data from a fresh perspective which should prove useful in helping to answer unresolved questions and bolstering current knowledge about the effects of some under-researched variables.

Particular importance was attached to ensuring that all the studies were methodologically sound, so that the results that emerged were valid. In order that test performance was uncontaminated by such factors as word frequency or ease of completion, rigorous counterbalancing procedures would be adopted. In addition, since the tests would be conducted immediately and all the stimuli items would be tested, it was proposed that subjects in the implicit tests were informed of the relationship between study and test items but were instructed to disregard this relationship during test performance. This instruction, and subsequent checks that subjects performed according to the test instructions, were adopted to ensure that subjects did not use explicit strategies when performing the implicit tests (Richardson-Klavehn, et al., 1994).

The findings of these studies were related to the two current theoretical explanations for dissociations between implicit and explicit memory tests, the multiple memory systems theory and the transfer appropriate processing theory. Speculations were made as to whether each theory would make predictions in accordance with the experimental results. These speculations helped to determine which theoretical explanation was better able to account for the experimental findings.

7.3 Summary of Experimental Results

In Chapter 3, three experiments examined serial position effects in the perceptual implicit memory test of word stem completion compared with the explicit memory test of word stem cued recall. Experiment 1 was designed to measure primacy effects whereas Experiments 2 and 3 were designed to measure primacy and short-term recency effects. Word stem completion was not found to be susceptible to any serial position effects whereas word stem cued recall showed both primacy and short-term recency effects. However, forgetting that occurred for non-primacy items during the course of the explicit tests may have contributed to the explicit short-term recency effects in Experiments 2 and 3.

In Chapter 4, Experiments 4 - 6 examined serial position effects in the conceptual implicit test of free association compared with the explicit test of cued recall. In Experiment 4, moderately related word pairs were used as stimuli; in Experiment 5, weakly related word pairs were used; and in

Experiment 6, strongly and weakly related word pairs were used. Primacy effects were found in the explicit test with both strongly and weakly related word pairs, but primacy effects in the implicit test were found to be dependent on the degree of relatedness of word pairs as follows: weakly related word pairs produced one or two items primacy effects; moderately related word pairs showed a tendency towards a primacy effect; but strongly related word pairs showed no such tendency.

None of the implicit or explicit tests in Experiments 4 - 6 appeared to show short-term recency effects. However, it was difficult to differentiate between possible short-term recency effects and the forgetting trends which occurred during most of the tests. (The only test in which such a trend did not occur was the implicit free association test with strongly related word pairs in Experiment 6.) These forgetting trends had not previously occurred in word stem completion in Experiments 2 and 3, only in word stem cued recall.

In Chapter 5, two further experiments extended the findings of Experiments 4 - 6 by examining serial position effects in a new conceptual implicit memory test of name generation compared to an explicit memory test of name cued recall. The unitised stimuli in these experiments did not require any new or strengthened associative connections to be made at encoding. Primacy effects occurred in both the explicit tests but not in either of the implicit tests. Conversely, forgetting occurred in all the tests. In Experiment 8, a short interpolated task, inserted between study and test to negate short-term recency effects, appeared to have a detrimental effect on the last items recalled in the explicit test, compared to Experiment 7, providing tentative evidence for a short-term recency effect. The interpolated task did not have a detrimental effect on priming of the last few items in the implicit test, providing evidence that short-term recency effects did not occur in the implicit test.

In Chapter 6, two final experiments investigated levels of processing effects in the two conceptual implicit tests used in the thesis. In Experiment 9, both strongly and weakly related word pairs showed levels of processing effects in cued recall, but only strongly related word pairs showed marginal levels of processing effects in free association which did not occur if baseline completion was subtracted prior to the analysis. In Experiment 10, name cued recall showed levels of processing effects but name generation did not.

Overall, the implicit tests therefore yielded four main results. First, implicit memory only produced primacy effects when stronger associative connections were made between stimulus word pairs during encoding. Second, there was forgetting during the course of the test for non-primacy items in all but one of the conceptual implicit tests (free association with strongly related word pairs) which did not occur in the perceptual implicit tests. Since neither the strongly related word pairs in the free association test, nor the single word stimuli in the perceptual word stem completion tests required stronger associative connections to be made between stimulus pairs at encoding, strengthening associative connections appears to be implicated in the forgetting trend. The forgetting trend was not decreased when associative connections between stimulus pairs were known prior to encoding, indicating that interference to the associative connections, not decay, was mainly responsible. It was also not affected by an interpolated task which would have negated any short-term recency effects. Third, name generation was the only test which showed continuity between primacy and levels of processing, as it did not show either effect. In the free association test, weakly related word pairs showed a primacy effect but no levels of processing effect whereas strongly related word pairs showed a marginal levels of processing effect (which did not occur if baseline performance was subtracted prior to the analysis) but no primacy effect. Primacy effects are not therefore synonymous with a deeper processing level. Fourth, it is unlikely that any short-term recency effects occurred in any of the implicit tests.

In comparison, the explicit tests yielded different results. First, primacy effects occurred in all the explicit tests, irrespective of whether or not new connecting links were established at encoding. As explicit primacy effects occurred when implicit primacy effects did not, it is unlikely that the two effects were attributable to the same single underlying cause. Second, recency trends occurred in all the explicit tests, even with single word stimuli. Again, as explicit recency trends occurred when implicit recency trends did not, it is unlikely that these effects were attributable to the same single cause. Third, levels of processing effects occurred in all the explicit tests, irrespective of whether or not the relationship between stimuli pairs was known prior to encoding. It is therefore unlikely that levels of processing effects in explicit and implicit memory were attributable to the same single cause. Fourth, it is difficult to be sure whether or not explicit cued recall tests produced short-term recency effects because of the recency trends which were present in all the explicit tests. However, there appeared to be a short-term recency effect in some of the explicit tests, and an interpolated task, included to eliminate short-term recency effects, appeared to detrimentally affect explicit recall of the last few items in the name cued recall test.

7.4 An examination of the experimental results in the light of the two main theoretical explanations for dissociations between implicit and explicit memory tests

7.4.1 Multiple memory systems theory

In the multiple memory systems theory, Schacter and Tulving (1994) initially proposed five different memory systems: procedural, PRS, primary, semantic and episodic (see Section 1.5.1). According to this theory, explicit memory is based on the episodic memory system; perceptually based priming is based on the PRS; whereas conceptually based priming, including priming of new associations, occurs outside the PRS and possibly depends on the semantic system (Schacter, 1994).

In the experimental results, all the explicit tests behaved in a similar manner as they all showed evidence of conceptual processing in the form of primacy effects, recency trends or levels of processing effects. The only difference between them was that some of them appeared to show short-term recency effects and some did not. A possible reason for this difference is that retrieval cues which involved more cognitive effort may have interfered with off-loading the contents of short-term memory more than retrieval cues which involved less cognitive effort (see the General Discussion at the end of Chapter 5). As all the explicit tests otherwise behaved in a similar manner, it is plausible that they mainly depended on the episodic memory system, without very much input from other systems.

If all perceptual implicit memory tests depend on the PRS, they might all be expected to show corresponding evidence of data driven processing. Similarly, if all conceptual implicit memory tests depend on the semantic system, they might all be expected to show corresponding evidence of conceptually driven processing. As the experimental work in this thesis only involved one type of perceptual implicit memory test, it is only possible to compare the behaviour of the different conceptual implicit memory tests that were used. In such a comparison, name generation did not show a primacy effect, nor a levels of processing effect, but it did show a recency trend. Free association of strongly related word pairs was susceptible to a marginal levels of processing effect (when baseline completion was subtracted prior to the analysis the effect did not occur) but free association of weakly related word pairs was not. Even in the same experiment, free association of strongly and weakly related word pairs produced different results, with weakly related word pairs showing a primacy effect and a recency trend but strongly related word pairs not showing either effect. Since the conceptual implicit memory tests in this thesis behaved so differently, compared to the explicit tests which all behaved in a similar manner, it is unlikely that they only depended on the semantic system without some other factor being involved.

In an extension to the multiple memory systems theory, Schacter (1994) noted that "some perceptual-specificity effects in priming may involve an interaction or collaboration between the PRS and episodic (or semantic) memory system." (p.252) (see Section 1.5.1). Schacter's suggestion might be adapted to account for the above experimental results. The episodic (or semantic) memory system may be involved during study episodes which involve making new associative connections, or strengthening existing associative connections between stimulus pairs. This suggestion would explain why primacy effects were not found in free association with strongly related word pairs but were found with weakly related word pairs - only weakly related word pairs would require episodic (or semantic) memory involvement to strengthen the associative connections. It would explain why no primacy effects nor levels of processing effects occurred in name generation - no episodic (or semantic) memory involvement was required to join the forename and surname pairs because the relationship between them was already known.

Episodic (or semantic) involvement during encoding when new or stronger associative connections are made might also explain amnesic patients' preserved conceptual priming when no new connections are required to be made at encoding (e.g. Gardner, Boller, Moreines & Butters, 1973) but their impaired priming when new connections are required (e.g. Graf & Schacter, 1985) (See Section 1.3.2 for a more detailed discussion). It would also explain the absence of levels of processing effects in most perceptual implicit memory tests (e.g. Graf & Mandler, 1984), and in conceptual implicit memory tests with unitised stimuli (Schacter & McGlynn, 1989), but the presence of levels of processing effects when new connections are required to be made at encoding (e.g. Graf & Schacter, 1985; see Section 1.3.4).

It is unlikely that episodic (or semantic) involvement would be with the PRS since conceptual priming has been found to be modality independent (Blaxton, 1989; Challis & Sidhu, 1993; Srinivas & Roediger, 1990) whereas the sub-systems of the PRS are presumed to be modality specific (Schacter & Tulving, 1994). As stated above, Schacter proposed that perceptual priming is based on the PRS but conceptual priming occurs outside the PRS, possibly in the semantic system. There are other possible theoretical explanations of priming which might explain the experimental findings.

Squire and his colleagues (see e.g. Squire, 1992a) proposed that all priming is based on a sub-division of the procedural memory system; it is concerned with task performance (knowing how), and functions at a non-conscious level. In comparison, declarative memory is concerned with memory for facts and events (knowing that), and is available to consciousness (see Section 1.5.1). However, some additional distinction between perceptual and conceptual priming would be required to account for the finding that perceptual priming is mainly modality specific (e.g. Graf, Shimamura & Squire, 1985; Scarborough, Cortese & Scarborough, 1977), but conceptual priming is not (e.g. Blaxton, 1989; Challis &

Sidhu, 1993). Neither does this theory adequately explain the serial position differences found between different implicit memory tests in this thesis. An explanation of these differences would still require the involvement of another system or process, such as the episodic (or semantic) system, when stronger or new associative connections are required to be made at encoding.

The theoretical explanation proposed by Graf and Mandler (1984) of two different memory organising processes, integration and elaboration (see Section 1.5.2), might better explain the experimental findings. It is possible that perceptual priming may depend on activation of pre-existing memory representations whereas conceptual priming may depend on elaboration of new memory representations. However, this explanation would not explain why primacy effects occurred in some conceptual implicit memory tests, but not in others. A possible revision to this theory might be that all implicit memory tests depend on both activation and elaboration and that different implicit memory tests rely more on one process than the other.

Perhaps the best theoretical explanation of the basis for perceptual and conceptual priming was proposed by Kirsner, Dunn and Standen (1989). Although their research specifically applied to repetition priming, it might also extend to other forms of priming. Their original proposal was that priming involves two systems or processes. One system is modality specific and sensitive to perceptual similarities between study and test but not to word frequency effects. The other system is modality independent and is only sensitive to word frequency effects, not to perceptual similarities between study and test items. In their chapter, Kirsner et al. amended this original theory by proposing that the second system is concerned with output or production and is also modality specific. However, their original theory is able to account for the finding that perceptual priming is sensitive to modality changes (e.g. Graf, Shimamura & Square, 1985) but conceptual priming is not (e.g. Challis & Sidhu, 1993) better than their amended theory.

The modality specific system may be based in the PRS whereas the modality independent system might be based in semantic memory. Perceptual and conceptual priming may depend on these two systems in varying proportions depending on the implicit test. For example, lexical decision might rely on the modality specific system to a greater extent than free association which might rely more on the modality independent system. When there is no perceptual overlap between study and test, as in name generation, priming might entirely rely on the modality independent system. If it was the case that representations in the modality independent system were more susceptible to decay or interference than those in the modality specific system, forgetting would be more likely to occur in those representations that mainly relied on the latter system. In accordance with this prediction, no measurable forgetting was found in word stem completion which is classified as a perceptual implicit memory test and would therefore be more likely to depend on the modality specific system. Conversely, rapid forgetting was found in name generation which would entirely depend on the modality independent system.

However, even this proposal does not explain the experimental finding that primacy effects in conceptual implicit priming were inversely related to the strength of existing associative connections between stimulus pairs. To explain this finding, it would still be necessary to postulate that the episodic (or semantic) memory system is used to strengthen existing associations or make new associations between stimulus pairs during encoding. Such interactions would presumably be with the modality independent system.

7.4.2 Transfer appropriate processing

According to this theory, a study episode involves a combination of data driven and conceptually driven processing. Dissociations between implicit and explicit tests occur because implicit tests are more likely to access data driven processes whereas explicit tests are more likely to access conceptually driven processes (Roediger, 1990; see Section 1.5.2).

In many respects, the results of the experiments in this thesis are in accordance with this theory. For example, all the conceptual implicit memory tests showed some evidence of conceptual processing in the form of primacy effects, levels of processing effects or forgetting trends, whereas the perceptual implicit memory tests showed none of these effects. Indeed, conceptually driven processing, involving episodic (or semantic) connections between stimulus pairs, has been proposed to explain the differences which occurred between the two conceptual implicit tests, and conceptually driven processing has been cited as the reason why perceptually based priming shows modality specificity but conceptually based priming does not (See Section 7.4.1 above).

However, it is difficult to account for some of the differences found between the conceptual implicit and explicit memory tests in this thesis within the transfer appropriate processing theory alone. For example, according to the transfer appropriate processing theory, name cued recall showed a levels of processing effect because it accessed more conceptually driven processes which overlapped better with conceptually driven deep encoding than with data driven shallow encoding. Presumably, name generation did not show a levels of processing effect, even though it is a conceptual implicit memory test, because there was less overlap between conceptually driven processes at encoding and test. Following this line of reasoning, a data driven implicit test, such as perceptual identification, would involve more data driven processes which should overlap better with data driven shallow encoding to produce a reversed levels of processing effect. This has not been found to be the case (Jacoby & Dallas, 1981, Experiment 1; Graf & Ryan, 1990; Hashtroudi, Ferguson, Rappold & Chrosniak, 1988; see Section 1.2.4).

The primacy effects which occurred in word stem cued recall but not in word stem completion, are also problematic for the transfer appropriate processing theory. It is unlikely that subjects were deliberately using the beginning of the test as a benchmark to explicitly remember primacy items, as the list items were all cued in a random order (Experiment 1), or in the reverse order (Experiments 2 and 3), precluding this type of retrieval strategy. According to the transfer appropriate processing theory, the primacy effects in word stem cued recall were attributable to a greater overlap of conceptually driven processes between the word stem cued recall test and encoding of primacy items than between the test and encoding of non-primacy items. Presumably then, the lack of primacy effects in word stem completion resulted from less overlap of conceptually driven processes between the test and encoding of primacy items. If this is the case, there would be more overlap of data-driven processes between the word stem completion test and the encoding of non-primacy items, resulting in a reversed primacy effect. This did not occur in any of the word stem completion tests.

It is also difficult to explain some of the divergent results between the conceptual implicit free association tests used in this thesis within the transfer appropriate processing theory alone. For example, free association of weakly related word pairs showed evidence of conceptually driven processing in the form of primacy effects and recency trends which free association of strongly related word pairs did not, whereas free association of strongly related word pairs showed evidence of conceptually driven processing in the form of levels of processing effects which free association of weakly related word pairs did not.

Another finding which is difficult to explain within the transfer appropriate processing theory is the high incidence of non-recognition of implicitly generated target words. In word stem completion, the figure was as high as 22 per cent, even though subjects falsely recognised 12 per cent of their generated words. A similar level of non-recognition of target words would be unlikely to occur in a data-driven explicit memory test. Since the transfer appropriate processing theory proposes that the overlap of data-driven or conceptually-driven processes between study and test is responsible for retrieval, a difference in recognition of target words between implicit and explicit data-driven processes would not be predicted. Instead of being associated with implicit generation, recognition of implicitly generated target words appeared to depend on the distinctiveness of the target words, a usual characteristic of explicit recognition tests (Gregg, 1976). This lack of concordance between implicit and explicit retrieval is easier to account for within the multiple memory systems theory than within the transfer appropriate processing theory.

There are therefore anomalies between the results of the implicit and explicit tests which are not adequately explained by the transfer appropriate processing theory alone. This is not to say that transfer appropriate processing does not have an important role to play in any explanation of the underlying processes associated with memory.

7.5 Proposed future research

The results of this thesis have brought to light a number of interesting findings which have not been fully explored. The following section therefore identifies any areas of study that might benefit from future research.

An interesting finding which requires future research, is the lack of a levels of processing effect in free association with weakly related word pairs, which were mainly common idioms, compared to a marginal levels of processing effect with strongly related word pairs (when baselines were not subtracted before the analysis). Presumably, moderately related word pairs which were not common idioms should produce a higher levels of processing effect than strongly related word pairs. However, such research might be difficult as priming effects disappear if word pairs are too weakly related without being common idioms.

The reason for the forgetting trend for non-primacy items in conceptual implicit memory tests should also be investigated further. Interference to the associative connection between stimulus items at encoding was possibly responsible for this forgetting trend in name generation but this finding should be extended to other conceptual implicit memory tests. In addition, experimental work might be directed towards establishing whether interference occurs during the encoding phase, during the test phase or during both encoding and test.

Another interesting finding which requires further research is that an interpolated number subtraction task between study and test in Experiment 8 appeared to beneficially affect implicit generation but detrimentally affect explicit recall of the last few names, compared to Experiment 7 in which there was no interpolated task. If it is the case that immediate priming was actually enhanced by an interpolated number subtraction task, it follows that encoding of the stimuli was still proceeding during the task and is therefore relatively slow and was not affected by dividing attention. However, it is possible that the finding was spurious and future research is required to determine whether or not it was a true effect. If it was found to be a true effect, more research should ascertain whether perceptual implicit memory tests and other conceptual implicit memory tests also show the effect.

The counter-intuitive finding that baseline completion in the name generation test was enhanced by deep processing, even though there was no levels of processing effect for target name generation, may also have been spurious and therefore requires replication. However, it is possible that the effect was real and that deep processing of a target name activated associated names but shallow processing did not. The levels of processing effect for associated names, but not for target names, may have occurred because target names were activated by both deep and shallow processing. A replication of this finding might explain why some conceptual implicit memory tests are susceptible to levels of processing effects, even when no associative connections are required to be learned or strengthened at encoding, and no interaction with episodic memory is necessary.

With reference to explicit short-term recency effects, it would be interesting to systematically vary retrieval cues to investigate whether this would influence the effect. If short-term recency effects are attributable to subjects off-loading items from short-term memory, presumably rhyming cues would interfere less with this off-loading process than conceptually related cues. If this was found to be the case, this would strengthen the view that short-term recency effects in free recall are attributable to subjects off-loading the contents of short-term memory before retrieving items from long-term memory.

7.6 Conclusions

This thesis demonstrated many new dissociations between implicit and explicit memory tests. These dissociations included primacy effects in all the explicit memory tests which did not occur in word stem completion, name generation nor in free association of strongly related word pairs; forgetting trends in all the explicit tests which were not present in word stem completion nor in free association of strongly related word pairs; levels of processing effects in explicit cued recall of names and words which did not occur in implicit name generation and free association; and possible short-term recency effects in some of the explicit memory tests which did not occur in the implicit tests.

The only primacy effects which occurred in implicit memory tests were found to be attributable to whether or not stronger associative connections between stimulus pairs were made at encoding. When stronger associative connections were not required to be made, as was the case in word-stem completion, free association of strongly related word pairs, and name generation, no primacy effects occurred. Explicit memory tests were not found to be sensitive to whether or not stronger associative connections were made at encoding to the same extent as conceptual implicit memory tests, as primacy effects occurred in every explicit test, including word stem cued recall, cued recall of strongly related word pairs, and name cued recall.

None of the implicit memory tests appeared to show short-term recency effects. Conversely, in the explicit tests, there appeared to be some short-term recency effects, which may have been related to how easily words were recalled from the cues provided. It was suggested that cues which required more cognitive effort might interfere more with items being off-loaded from short-term memory. However, measurement of short-term recency effects was confounded by forgetting which occurred during all the relevant explicit tests and most of the conceptual implicit tests. In the conceptual implicit tests, these extended recency effects were possibly found to be attributable to interference to the associative connections between stimulus pairs. In the explicit tests, the extended recency effects were not found to depend on associative connections between stimulus pairs to the same extent as in the conceptual implicit tests as extended recency effects occurred in all the explicit tests, including word stem cued recall in which no associative connections were made at encoding.

It was found that the incidence of non-recognition of implicitly generated target words was relatively high. In addition, recognition of target words appeared to depend on the distinctiveness of these words, rather than on implicit generation of the words.

Conceptual priming in name generation and in free association of weakly related word pairs, which were mainly common idioms, did not show a levels of processing effect and free association of strongly related word pairs only showed a marginal levels of processing effect which did not occur when baseline completion was subtracted prior to the analysis. In comparison, levels of processing effects occurred in all the explicit tests. These results show that levels of processing effects do not necessarily occur in conceptual implicit memory tests.

The above results have been shown to be inconsistent with both the multiple memory systems theory and the transfer appropriate processing theory. However, an amendment to the multiple memory systems theory would account for all the above findings. This amendment is based on Kirsner et al.'s proposal that priming involves two systems or processes. One of these systems is modality specific and sensitive to perceptual similarities between study and test, but not to word frequency effects, whereas the other system is modality independent and only sensitive to word frequency effects. It is also necessary to propose that the episodic (or semantic) memory is used when new or stronger associative connections are required to be made between pairs of stimulus items at encoding. These interactions would probably be with the modality independent system.

It is therefore suggested that the multiple memory systems theory be extended by specifying that implicit memory involves two systems, in varying proportions depending on the priming test. One of these systems would be based on the PRS, the other might be based on the semantic memory system. In addition, the episodic (or semantic system) would be required to strengthen associative connections or establish new associative connections when encoding pairs of stimulus items. This speculative proposal resolves many of the currently unexplained features of conceptual implicit memory tests. Hopefully, it will stimulate further research which will eventually lead to a better understanding of the systems and processes underlying human memory.

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APPENDIX A

STIMULI

Experiments 1 and 2

List A	List B
Wealth	Trance
Pantry	Cousin
Fleece	Supper
Volume	Bunion
Thirst	Banner
Church	Famine
Guitar	Puppet
Motion	Scream
Signal	Carpet
Hatred	Branch
Target	Pencil
Violin	Instep
Maiden	Damson
Accent	Office
Grocer	Misery
Friday	Advice
Nation	Stance
Spider	Prefix

Experiment 3

List A	List B
Lather	Rosary
Anchor	Lentil
Outing	Circle
Prince	Trough
Salmon	Radish
Armour	Corner
Empire	Wallet
Excise	Locket
Infant	Forest
Tongue	Pollen
Vanity	Melody
Heaven	Defeat
Sleeve	Jacket
Driver	Notice
Modern	Immune
Jungle	Rustle
Horror	Cheese
Hyphen	Quiver

Experiment 4 - Moderately Related Word Pairs

List A	List B
White Wash	Easy Chair
Sheep Wool	Loud Noise
Carpet Rug	Spider Fly
Yellow Sun	Square Peg
Lion Roar	Ocean Wave
Fruit Orange	Wish Bone
Birthday Card	Whistle Blow
Silver Locket	Bow Ribbon
Soldier War	Hand Glove
Table Cloth	Needle Pin
Bed Rest	River Board
Religion Faith	Lamp Shade
House Garden	Cold Water
Sleep Dream	Private School
Boil Egg	Car Driver
Guide Scout	Butterfly Net
Pine Forest	Stomach Pain
Wooden Spoon	Rhythm Guitar

Experiment 5 - Weakly Related Word Pairs

List A	List B
Hard Luck	Blossom Cherry
Heavy Burden	Green Valley
Hungry Man	Table Tennis
Short Hand	Sour Puss
Mountain Range	High Noon
Loud Bang	Ocean Floor
Rough Ground	Square Mile
Bath Oil	White Wash
House Guest	Cold Weather
Blue Heaven	Window Box
Light Switch	Slow Train
Carpet Slipper	Long Time
Yellow Fever	Dream World
Street Pavement	Bitter Lemon
Soft Drink	Red Hair
Trouble Strife	Deep Pit
Bed Bug	Dark Alley
Cheese Spread	Earth Quake

Experiment 6 - Strongly and Weakly Related Word Pairs

Strongly Related	**Weakly Related**
List A	**List A**
Sleep Dream	Sleep Late
Anger Fear	Anger Divorce
Command Order	Command Post
Loud Noise	Loud Voice
Earth Round	Earth Mother
Window Glass	Window Shopping
Fruit Vegetable	Fruit Cocktail
Hand Finger	Hand Lotion
White Snow	White Cliff
Blue Red	Blue Blood
Music Song	Music Therapy
Stem Flower	Stem Flow
City Town	City Life
Joy Happy	Joy Ride
Man Boy	Man Child
Bath Water	Bath Sponge
Chair Sit	Chair Stool
Ocean Sea	Ocean Voyage
List B	**List B**
Baby Cry	Baby Doll
Cold Warm	Cold Wind
Bread Knife	Bread Stale
Deep Shallow	Deep South
Wish Want	Wish Fulfilment
Foot Shoe	Foot Big
Green Grass	Green Giant
Bed Rest	Bed Clothes
Hard Soft	Hard Cash
Shift Fast	Shift Kick
Bitter Sour	Bitter Pill
Head Hair	Head Lice
Dark Night	Dark Corner
House Home	House Fly
Square Circle	Square Hole
Hungry Food	Hungry Wolf
Smooth Rough	Smooth Sailing
Health Sickness	Health Club

Experiments 7 and 8

List A	List B
Kate Adie	Tony Blackburn
Shirley Bassey	Billy Connolly
Anne Boleyn	Tom Cruise
Michael Caine	Charles Darwin
Noel Coward	David Frost
Oliver Cromwell	Paul Gascoigne
Robert de Niro	Gary Glitter
Ken Dodd	Jack Nicholson
Chris Eubank	Bill Oddie
Bob Geldof	Diana Rigg
Roy Hattersley	Jimmy Saville
Edward Heath	Jane Seymour
John McEnroe	Frank Sinatra
Freddie Mercury	Rod Steiger
Richard Nixon	Patrick Swayze
Linda Lusardi	Terry Venables
Peter O'Toole	Kim Wilde
Norman Wisdom	William Wordsworth

Filler Names

Churchill	Streisand
Coe	Monroe
Keegan	Agassi
Minogue	Garland
Peck	Hoffman
Piggott	Reagan

Experiment 9 - Strongly and Weakly Related Word Pairs

Strongly Related

List A

Bitter Sour
Smooth Rough
Wish Want
Bed Rest
Swift Fast
Square Circle
Cold Warm
Foot Shoe
Green Grass
Hard Soft

List B

Man Boy
Bath Water
Loud Noise
Window Glass
Ocean Sea
Music Song
City Town
Chair Sit
Earth Round
Short Long

Weakly Related

List A

Dark Corner
Hungry Wolf
Baby Doll
Bread Stale
Deep South
Head Lice
House Fly
Health Club
Blue Blood
Stem Flow

List B

Joy Ride
Sleep Late
Command Post
Trouble Strife
Black Magic
Anger Divorce
Fruit Cocktail
Hand Lotion
White Cliff
High Note

Experiment 10 - Famous Names

List A	**List B**
Kate Adie	Tony Blackburn
John Major	William Wordsworth
Michael Caine	Charles Dickens
Anne Boleyn	Jimmy Saville
Bob Geldof	Bill Oddie
Bette Midler	Garry Glitter
Freddie Mercury	Jack Nicholson
Burt Lancaster	Frank Sinatra
Harry Secombe	Chris Eubank
Ian Paisley	Linda Lusardi
Norman Wisdom	Steve McQueen
Shirley Bassey	Billy Connolly
Robert de Niro	David Frost
Noel Coward	Jane Seymour
Walter Raleigh	Terry Venables
Barry Manilow	Patrick Swayze
Ken Dodd	Paul Gascoigne
Oliver Cromwell	Tom Cruise
Catherine Zeta Jones	George Formby
Christopher Columbus	Fred Astaire

APPENDIX B

Table 1

Percentage of target words completed/recalled as a function of Serial Position and Test in Experiments 1, 2 and 3

Serial Position	Experiment 1		Experiment 2		Experiment 3	
	Implicit	Explicit	Implicit	Explicit	Implicit	Explicit
1	67	94	67	86	61	78
2	44	78	58	72	56	69
3	61	61	58	61	53	69
4	56	50	64	58	58	61
5	67	61	53	67	53	64
6	50	61	75	50	50	61
7	44	44	69	58	64	58
8	56	50	64	50	75	61
9	56	56	64	56	58	67
10	44	56	75	67	69	50
11	56	61	67	61	75	61
12	67	50	69	64	69	64
13	44	56	61	56	58	58
14	61	56	67	61	58	81
15	50	56	67	72	50	61
16	50	56	67	72	58	67
17	61	50	64	69	56	72
18	61	61	69	81	72	72

Table 2

Percentage of target words associated/recalled as a function of Serial Position and Test in Experiments 4 and 5

Serial Position	Experiment 4		Experiment 5	
	Implicit	Explicit	Implicit	Explicit
1	65	85	57	65
2	57	64	49	57
3	46	68	35	49
4	57	65	43	49
5	47	56	36	53
6	46	65	36	46
7	46	63	54	54
8	49	67	47	51
9	51	60	36	61
10	47	68	46	63
11	58	68	50	51
12	61	68	60	61
13	56	72	42	60
14	61	68	61	57
15	60	63	50	61
16	75	74	61	60
17	60	72	50	64
18	51	61	60	54

Table 3

Percentage of target words associated/recalled as a function of Serial Position, Word Relatedness and Test in Experiment 6

Experiment 6				
Serial Position	Strongly Related		Weakly Related	
	Implicit	Explicit	Implicit	Explicit
1	53	81	50	67
2	56	69	31	67
3	56	72	22	67
4	61	75	31	44
5	56	67	33	56
6	64	64	31	58
7	53	53	33	53
8	50	58	44	64
9	72	69	42	61
10	69	56	47	58
11	64	67	42	61
12	69	72	50	61
13	64	64	50	64
14	47	67	47	67
15	64	61	44	61
16	53	78	53	56
17	69	64	58	64
18	58	72	39	69

Table 4

Percentage of target names generated/recalled as a function of Serial Position and Test in Experiments 7 and 8

Serial Position	Experiment 7		Experiment 8	
	Implicit	Explicit	Implicit	Explicit
1	49	69	33	78
2	49	68	42	67
3	50	67	56	61
4	49	47	50	58
5	47	51	33	53
6	47	60	39	50
7	49	53	53	56
8	42	65	47	69
9	69	56	53	58
10	58	58	39	61
11	50	63	53	69
12	49	69	47	72
13	63	53	53	50
14	67	65	58	83
15	63	65	53	69
16	61	72	61	83
17	67	69	75	78
18	78	72	75	67

Table 5

Percentage of target words associated/recalled as a function of Word Relatedness, Levels of Processing and Test in Experiment 9

Experiment 9							
Strongly Related				Weakly Related			
Implicit		Explicit		Implicit		Explicit	
Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow
50	60	70	20	50	30	60	10
40	20	70	70	10	30	70	70
40	50	90	10	0	10	70	30
60	50	60	50	20	10	60	60
50	70	90	20	0	20	80	30
40	30	60	10	20	0	60	10
30	50	50	10	0	10	40	10
20	10	80	70	10	0	30	50
60	30	60	40	0	0	70	30
50	30	60	40	0	10	50	30
60	10	90	0	30	10	60	10
60	50	80	40	10	50	80	20
30	30	60	30	20	30	30	10
30	40	90	10	10	30	50	30
50	0	80	40	10	10	80	30
20	30	90	80	0	0	60	10
10	30	90	10	0	10	70	20
70	30	60	80	70	10	90	80
80	10	80	30	30	10	60	40
60	20	40	10	10	0	10	30

Table 6

Percentage of target names generated/recalled as a function of Levels of Processing and Test in Experiment 10

Experiment 10			
Implicit		Explicit	
Deep	Shallow	Deep	Shallow
65	85	80	45
15	70	80	35
60	40	35	30
60	60	80	40
15	25	65	30
65	60	85	60
60	75	75	65
30	50	100	65
70	55	85	55
15	65	70	45
60	15	40	35
40	25	30	50
35	20	55	50
60	20	40	20
30	30	60	60
55	40	40	30
30	50	65	15
60	40	70	45
65	60	75	60
65	30	80	45

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Dissociating Face Processing Skills: Decisions about Lip-read Speech, Expression, and Identity

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The separability of different subcomponents of face processing has been regularly affirmed, but not always so clearly demonstrated. In particular, the ability to extract speech from faces (lip-reading) has been shown to dissociate doubly from face identification in neurological but not in other populations. In this series of experiments with undergraduates, the classification of speech sounds (lip-reading) from personally familiar and unfamiliar face photographs was explored using speeded manual responses. The independence of lip-reading from identity-based processing was confirmed. Furthermore, the established pattern of independence of expression-matching from, and dependence of identity-matching on, face familiarity was extended to personally familiar faces and "difficult"-emotion decisions. The implications of these findings are discussed.

Most hearing people claim to be unable to lip-read, but they nevertheless make use of seen face movements in a range of settings. They lip-read to disambiguate speech in noisy environments or where there is some hearing loss. Lip movements are not noticed when they are well synchronized with a sound track, but they are easily detected when not. The audio-visual fusion illusion (McGurk & Macdonald, 1976) is a compelling case where a seen lip pattern can moderate the perceived auditory speech sound. Moreover, some silent lip-speech patterns can be easily discriminated when context is given or inferred (e.g. Campbell & Dodd, 1982). This can apply even when still photographs are used. For

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instance, point vowels, such as a seen-to-be-spoken "ee" and "oo", can be readily distinguished (Campbell, 1986; Summerfield & McGrath, 1984).

Cognitive accounts of face processing have indicated separability of a number of different functions, including identifying people, analyzing emotional expression, and classifying faces by age, gender, or ethnicity (Figure 1). There is neuropsychological evidence for the independence of lip-reading from other face-processing skills. Campbell (1992) has shown dissociations between the ability to read speech from faces and other face-based abilities. The most telling of these are double dissociations. Thus patients have been described who can lip-read speech but cannot match faces for expression, and vice-versa (Campbell, Landis, & Regard, 1986).

This evidence, although it is suggestive, is not conclusive. Confirming evidence should be sought from studies using other methodologies. The studies reported here have, as their primary aim, the elucidation of the separability of lip-speech classification from face-identification skill, using a matching paradigm with normal subjects. In the course of this, we also sought to test further the extent to which expression judgements may be independent of identity processing.

Face Familiarity and Expression Judgement

Young, McWeeny, Hay, and Ellis (1986) used a speeded matching paradigm with normal adult subjects to test the separability of expression and identification components in a face-processing model that indicated separable components of face processing (Bruce & Young, 1986).

Their results showed that face familiarity (derived from pictures of famous faces) speeded identity-matching for pairs of faces ("is this one face or two different faces?"). All the matches were made across pictures of different view of the face, so that subjects could not and would not use simple pictorial identity (i.e. pictorial image similarity) as the basis for the decision. One way for an advantage for familiar faces to come about would be if identity matching across different face pictures could utilize top-down activation from Face Recognition Units (FRUs)—"evidence-collecting devices" that signal that a known person's face had been encountered. FRUs are not instantiated for unknown faces. FRU activation would be fast and automatic (analogous to logogen activation for skilled word recognition—see Bruce & Young, 1986; Morton, 1979) and triggered by any perception of the known face; for unfamiliar faces, matching would be solely an aspect of the stage described by Bruce and Young as directed visual processing (structural analysis of face characteristics constrained by the task demands). Gender decisions, expression, and age judgements are examples of such directed visual processing. One simple possibility is that *all* such tasks should be affected by face familiarity. This would occur if exposure to the face simply provided more fluent processing. Yet expression decisions on face pairs were found to be *independent* of face familiarity by Young, McWeeny, et al. (1986). Bruce and Young (1986), therefore, reasoned that, prior to further analysis by the identity (FRU) system, faces are "normalized" for expression. Expressions change face shape according to regular, generalizable principles (Ekman, 1982).

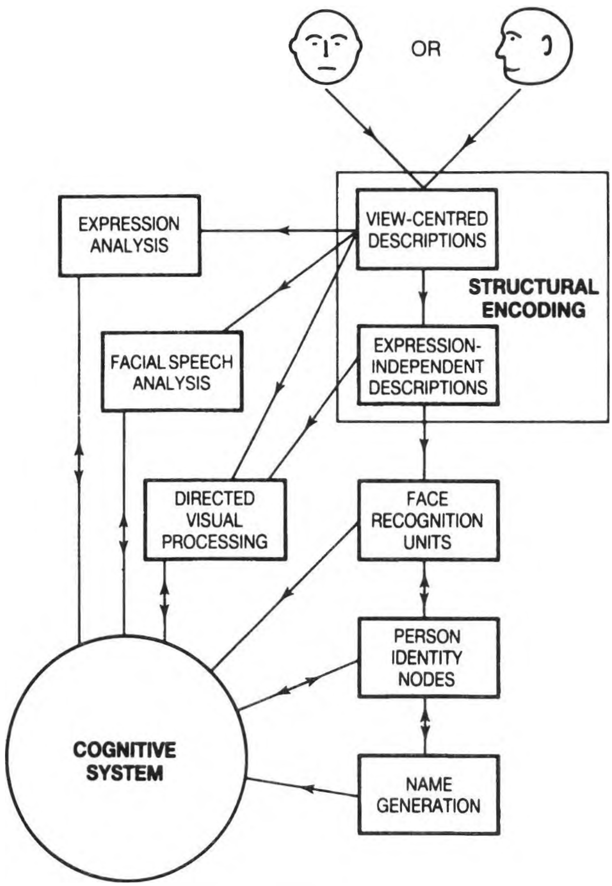

FIG. 1. A framework for understanding face recognition (from Bruce & Young, 1986).

Testing Independence of Face-processing Skills: Shifting Theoretical Bases

At the time this theory of face recognition was proposed, models of higher visual processing tended to conceptualize stages as strictly serial, separate, and independent. However, more recent theoretical approaches indicate that not only may visual identification/recognition procedures work in cascade (complete categorization/identification is not required for processing to proceed to a later stage), but also that more interactive systems can allow a range of cross-talk between higher and lower levels. Furthermore, it is by no means clear that the identification of an object across different views and other manipulations *necessitates* the "normalization" of the visual form to a stored prototype (an idea that underlies the notion of "expression-independent" face representations). An identity may be construed through a set of exemplars with rather different features identifying and discriminating between them (for a number of examples, see tutorial essays in Farah & Ratcliff, 1994). It is perfectly feasible, for example, that, at the level of FRU instantiation, idiosyncratic identification features—including idiosyncratic expressions—may be stored as part of the discriminating identity of the face of that individual. From this perspective, the insensitivity of expression matching to identity in experimental tasks may reflect insufficiently rigorous testing rather than any necessary independence of processing. One aim of the studies reported here is to extend the reported studies on independence of separate face-processing skills in order to test the strength of the separate streams hypothesis more fully.

Personal Familiarity and Face Processing

In most work reported to date, famous faces rather than those that are personally familiar have been used. Bruce (1986) and Roberts and Bruce (1988) pioneered the use of personally familiar face pictures in this type of paradigm, but their explorations were limited to contrasting personally familiar and unfamiliar faces from a single site, which allows the possibility of a confound between personal familiarity and some specific structural differences between the familiar and unfamiliar faces used.

Some distinctions might be expected between the effects of familiarity based on fame and familiarity based on personal knowledge. Famous faces may be learned on the basis of a very few, often repeated examples showing stereotyped or unique expressions (Che Guevara, Napoleon, Lenin, Abraham Lincoln are examples of such "iconic" faces). Tasks that tap identity may also differ depending on the nature of the familiarity. Famous faces are readily classified by occupation (e.g. Young, Ellis, Flude, McWeeny, & Hay, 1986)—but occupation (and other semantic attributes) may be less readily accessed for a personally familiar face, particularly when it is seen out of context (Young, Hay, & Ellis, 1985). As far as structural matching is concerned, Bruce (1986) and Roberts and Bruce (1988) have shown that where matches are required across different views, identity matching is faster for pictures of familiar than of unfamiliar faces, confirming the findings for famous faces on this task. Bruce (1986) also found that gender decisions were sometimes speeded by (personal) face familiarity, suggesting that gender decisions for familiar faces can be efficiently mediated by knowledge of the person's identity (also Ellis, Ellis, & Hosie, 1993, for a similar finding in children). In Bruce's (1986) study, expression decisions were not affected by personal familiarity. However, only smiles were tested. Idiosyncratic effects may be instantiated at the FRU level for more complex expressions or more difficult discriminations of emotion (see Experiment 3 of the present series).

The separable sub-components model suggests that, like expression processing, lip-reading and face-familiarity detection are dissociable processes and therefore that output from structural encoding to the FRU level is "speech-independent". It has already been pointed out that this conclusion, based entirely on neuropsychological dissociations in limited numbers of subjects (Campbell, 1992; Campbell et al., 1986, 1990), may be too strong. In recognizing lip-speech patterns in pictures of faces, we may take into account individual peculiarities of facial gesture—variation in lip rounding for some consonants, for example. Matching judgements of lip-speech could, in principle, use information derived from knowledge of the particular, known face.

Lip-reading is a consequence of speaking, and the facial actions used in the production of language vary from one language community to another and from one dialect to another. Different individuals have idiosyncratic speech movements: lisps—for example, where "s" is pronounced "th"—are as visible as they are audible, as it is the position of the tongue between the teeth that generates the lisp, whereas dialectal variations in vowel pronunciation can be directly observable as differences in mouth shape. It is therefore possible that, far from accessing the visual correlates of the person's identity (FRU), analysis of lip-speech could sometimes map onto known voice representations and hence access amodal or multimodal person information by an indirect route, possibly with the PIN (the person-identity node) as the point of convergence.

The series of studies reported here has the main aim of exploring the extent to which lip-speech classification tasks may be independent of identity processing. Expression judgements are included in a number of the studies to provide a comparison and control for lip-reading classification. A secondary aim was to explore the extent to which personal familiarity might moderate reported findings on the independence of these processes.

EXPERIMENT 1

In this first study we explored the extent to which lip-speech and identity processing may be differentially sensitive to face familiarity. We used a paradigm closely modelled on that of Young, McWeeny, et al. (1986), where pairs of faces (both personally familiar or personally unfamiliar) were presented for "same–different" decisions. The identity decision was "Are the faces of one person or two different people?" and the lip-speech and expression tasks required the subject to decide whether the pair of speech utterances or facial expressions was the same on the two faces. Conditions were blocked by task, with familiar and unfamiliar faces randomly intermixed. Following earlier findings using famous faces, we predicted that face familiarity would affect the identity task (familiar faces should be matched more quickly), but neither the lip-reading nor the expression task should be affected by familiarity. In these studies, posed expressions and lip shapes were derived from personally familiar faces (subjects' teachers and colleagues), taken from video-clips that allowed a greater degree of control of the material than is usually possible from photographs of famous faces (e.g. lighting conditions, expression, and angle of view).

The design of this study allowed a further aspect of the separate streams hypothesis to be explored. The within-subjects experimental design means that stimuli presented on one occasion for an identity or lip-reading/expression judgement recur in the second phase of the experiment—but for a different decision. Could we predict systematic effects of such prior presentation?

Ellis, Young, and Flude (1990) have studied the effect of prior exposure to a face picture (in a prime task) on decision speed to a second presentation of the face (in a target task). Expression, gender, and identity-based judgements were contrasted in this series of experiments using famous faces. The pattern of results suggested different processing characteristics for identity than for expression and gender categorization. Expression and gender judgements did not show repetition priming. Identity-based judgements (judgements of occupation or of fame) were primed by earlier identity judgements, but also by making sex and gender judgements on previously seen faces. Thus, exposure to a known face can have different effects depending on the task performed in the priming and target conditions. Only when the target task requires identity judgement does prior exposure of a known face (under different task demand conditions) speed the decision.

In terms of the present study, although the principal aim was to determine the effect of familiarity on the three different tasks of identity, expression, and lip-reading judgement, a secondary aim was to explore the extent to which the pattern described by Ellis et al. (1990) might recur in this paradigm. On the basis of earlier findings we predicted that, although exposure to lip-speech or expression may speed subsequent identity judgements, the converse pattern should not occur (identity matching should not speed lip-speech or expression). Generalized practice effects might be predicted to occur independently of task type. It should be borne in mind that this is a weak test. The experiment did not test for repetition priming directly as *all* the stimuli presented in the first phase were seen in Phase 2.

Method

Subjects. Sixty-four psychology students, 32 from Goldsmiths College, University of London, and 32 from Southampton University, of age range 18–42, participated in the experiment. Subjects from Goldsmiths College were familiar with the Goldsmiths staff but unfamiliar with the Southampton staff, whose faces were used as stimuli in the study, whereas subjects from Southampton University were familiar with the Southampton staff but unfamiliar with the Goldsmiths staff. Subjects were randomly allocated to four groups (see below) and tested individually.

Design and Materials. The design factors were task (lip-reading vs. identity judgements, *or* expression vs. identity judgements), order (lip-reading first, identity judgement second vs. identity judgement first, lip-reading second *or* expression judgement first, identity judgement second vs. identity judgement first, expression judgement second), site (Goldsmiths vs. Southampton), and familiarity (familiar vs. unfamiliar). Order and site were between-subjects factors and test and familiarity were within-subjects factors.

Stimulus material was compiled from black-and-white images of the faces of eight psychology lecturers and office staff: two men and two women from Goldsmiths College and two men and two women from Southampton University, approximately matched for age and appearance (see Figure 2). Each individual posed for full- and three-quarter-face views of two expressions ("happy" and "sad"), and two lip shapes ("FOOD" and "FEED"), which were captured on video. Expressions were achieved by instruction with an element of induction (i.e. "smile: think of something happy"; "think of something really sad, and try to look sad"). The best eight images for each individual—2 happy (1 full face, 1 three-quarter); 2 sad; 2 "oo" and 2 "ee"—were "grabbed" onto an Apple Macintosh computer using Quickimage software, cropped around the hairline, and adjusted for size (approximately 4 × 5 cm) and brightness using Adobe Photoshop software. The lip-shape faces comprised one set of stimuli and the expression faces a second set.

During the study, two faces appeared together on the screen, one full-face on the left and one three-quarter face on the right. Faces within each set were paired in four different ways.

1. the same identity with the same expression/lip shape
2. the same identity with different expressions/lip shapes
3. different identities with the same expression/lip shape
4. different identities with different expressions/lip shapes

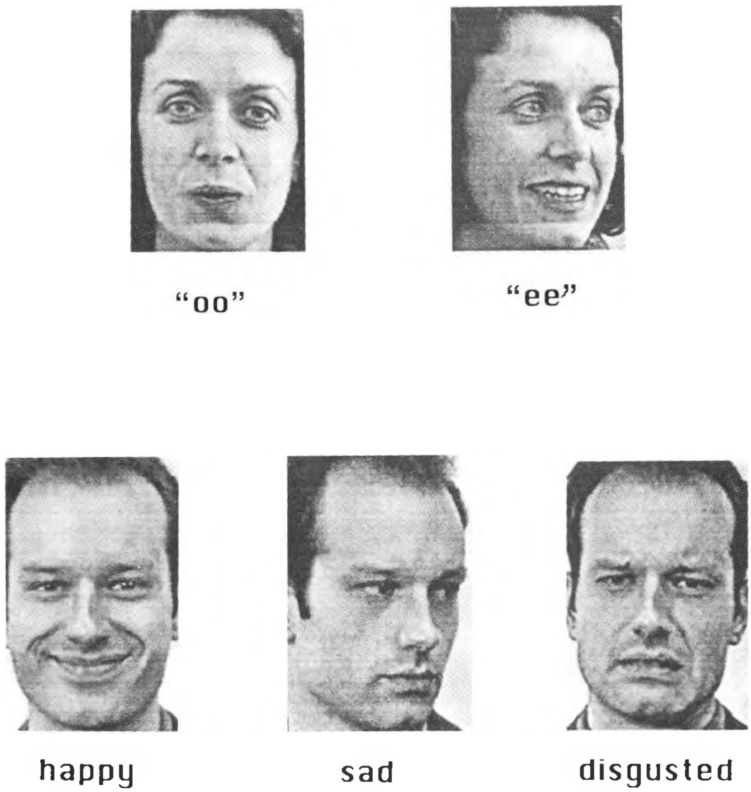

FIG. 2. Examples of faces, views, expressions, and lip shapes used in the studies.

When different identities were paired, they were always of the same sex and from the same university. All possible combinations of these four conditions resulted in 64 pairs of faces in each stimulus set.

Task procedures and control were designed using SuperLab software. Four tests were designed: an expression judgement test and an identity judgement test using the expression set; and a lip-reading judgement test and an identity judgement test using the lip-shape set. In each of the tests, all 64 pairs of faces from the relevant set appeared on the screen, one pair at a time in a random order, with 16 pairs of faces in each of the above conditions. Of these 16 pairs of faces, 8 were from Goldsmiths and 8 were from Southampton, so that each subject performed 8 trials on familiar faces and 8 trials on unfamiliar faces in each of the above conditions.

For practice purposes, an additional 32 pairs of faces of two extra women from Goldsmiths College were prepared in the same way as the test stimuli. Of these, 16 pairs of expression faces formed practice trials in the expression/identity tests and 16 pairs of lip-shape faces formed practice trials in the lip-reading/identity tests. Instructions relating to practice task performance were included, and feedback of "CORRECT" or "WRONG" was given for these practice tasks only.

A criterion of not more than 10 errors per subject was set, and two subjects were replaced because they exceeded this criterion. Median correct reaction times and error rates were calculated for 8 experimental conditions for each subject.

Procedure. Subjects were randomly allocated to one of four groups and tested individually. One group performed an expression judgement test followed by an identity judgement test using the expression test stimuli. A second group performed the same tests but in the reverse order. A third group performed a lip-reading judgement test followed by an identity judgement test using the lip-shape stimuli, and a fourth group performed these tests in the reverse order.

Each subject sat facing a 16" high-density colour monitor, at a distance of 60 cm, and read the instructions on the screen. In the expression judgement test the instructions read as follows:

> In each of the following trials, two faces will appear together on the screen. Each face will have either a happy or a sad expression. For each pair of faces please strike the "s" key if you think that the two faces have the *s*ame expression or the "d" key if they have *d*ifferent expressions. Please respond as quickly as you can as your reaction times will be measured. Strike any key to continue.

In the lip-reading test, subjects were informed that the two faces on the screen would be mouthing either "FOOD" or "FEED". They were instructed to respond by pressing the "s" button for same-sound and the "d" button for different-sound judgements. In the identity judgement test subjects were informed that the two faces would be of the same person or of two different people and their task was to judge whether the two faces had the same or different identities, using the "s" and "d" keys as described above.

Before each test, subjects completed 16 practice trials for which they received feedback to acquaint them with the test procedure. Between the two tests subjects performed an unrelated task for approximately 10 min. After both tasks had been completed, subjects were thanked for their participation, and the purpose of the study was explained to them. The overall duration of the study was approximately 20 min.

Results

The first analysis contrasted median correct reaction times for identity matching with the other task, whether lip-reading or expression. This was a within-subjects ANOVA in which the two factors examined were task (identity or lip-read/expression) and face familiarity. In this analysis, for clarity, neither order nor site of testing, which were fully counterbalanced, were examined.

The main effect of task was significant, $F(1, 63) = 105.47$, $p < 0.001$, with identity matching being faster than expression or lip-speech matching. The main effect of familiarity was also significant, $F(1, 63) = 34.59$; $p < 0.001$. Familiar faces were matched faster, overall. However the interaction between familiarity and task was also significant, $F(1, 63) = 6.89$; $p = 0.01$.

This overall analysis was followed up with separate detailed analyses. Relevant means are shown in Table 1. The first question was whether identity decisions were affected by familiarity in this experiment. In this mixed-design ANOVA, the between-subject factors were type of face (varying in either expression or in lip-speech pattern), order of condition tested (identity or other task first), site of testing (Southampton or London). The within-subject factor was familiarity (Southampton or London faces seen by London or Southampton subjects). The main effect of familiarity was highly significant, $F(1, 56) = 32.7$, $p < 0.001$, and did not interact with any other factor. Familiar faces were judged

TABLE 1
Experiment 1. Effects of Task and Order: Mean of Median Correct RT, Mean Standard Deviation of Correct RT, and Error Rate

	Familiar			*Unfamiliar*		
	RT (msec)	*SD (msec)*	*Errors (%)*	*RT (msec)*	*SD (msec)*	*Errors (%)*
Identity						
first	1042	300	2.57	1136	273	2.58
second	938	115	2.87	1022	197	2.58
Expression						
first	1183	271	2.31	1201	236	2.94
second	1201	171	2.90	1251	182	2.65
Lip-reading						
first	1652	256	2.84	1628	343	2.18
second	1407	327	2.84	1475	431	2.90

more quickly than were unfamiliar faces. There was also a significant effect of order of task, $F(1, 56) = 5.52$, $p < 0.05$, in favour of identity as the second task (i.e. a practice effect). This failed to interact with any other factor. No other main effects or interactions approached significance.

A second ANOVA compared lip-reading and expression judgements, in a single analysis, for sensitivity to familiarity in a manner similar to that outlined above. In this mixed-design ANOVA, the between-subject factors were responses to type of face (expression or lip-speech judgements), order of condition tested (was the lip-reading/ expression task performed first or second?) and site of testing (Southampton or London). The within-subject factor was familiarity (Southampton or London personnel seen by London or Southampton subjects).

Expression judgements were significantly faster than lip-reading judgements, $F(1, 56) = 20.45$, $p < 0.0001$. No other effects were significant. In particular, there was no effect of familiarity on expression or lip-reading judgements, $F(1, 56) = 2.71$, $p = 0.11$, and no interaction of familiarity with any other variable at any level.

It is worth remarking that, although the means of Table 1 suggest an effect of order of presentation for lip-speech judgements, this failed to reach significance as a main effect, $F(1, 56) = 3.36$, $p = 0.073$, or as an interaction with task type, $F(1, 56) = 1.18$, $p = 0.28$.

Errors for each subject for each condition were noted (see Table 1). Effects on error rates were neither large not statistically reliable, and they do not suggest any modulation of the RT effects by a speed–accuracy tradeoff.

Discussion

The results of these analyses give a clear answer to the main questions posed in the introduction. Using a small set of personally familiar faces, crossed by site of familiarity, identity decisions for face-pairs (one person or two different people?) were significantly affected by familiarity. Responses were faster for known than for unknown faces.

This was a robust effect, which was not moderated by the type of face seen (expressing an emotion or producing a speech sound), nor by any of the other experimental variables. In addition, these decisions were found to be performed faster after prior exposure to the faces for either a lip-reading or an expression task. This might suggest priming, along the lines of the findings of Ellis et al. (1990). More parsimoniously, however, it could simply reflect practice at work. *All* the faces seen in the task performed second were also seen in the task performed first. In contrast to identity decisions, neither lip-speech classification nor expression classification was reliably facilitated by known familiarity of the face. Although expression judgements were faster than lip-speech judgements in this study, this was not moderated by any other factor.

This study, therefore, provides the first evidence from neurologically unimpaired subjects that lip-speech processing, like expression processing, can be considered to be achieved independently of knowledge of individual faces. It also extends earlier findings on the separability of expression and identity judgements to personally familiar faces across different sites.

EXPERIMENT 2

Experiment 1 established that identity tasks were performed faster after previous exposure to a lip-speech or an expression judgement task. This could be due simply to practice with the faces or, more interestingly, to some priming of identity decisions. This possibility may be entertained because symmetrical effects of prior exposure (on expression/lip-reading decisions) did *not* occur. There is, moreover, the hint (see Table 1) that lip-speech decision rather than expression matching benefits most from prior exposure to the face. Overall, Experiment 1 hints that there may be repetition priming between identity and lip-speech decisions, and Experiment 2 was designed to investigate this further, while also attempting to replicate the independence of lip-speech processing from the effects of face familiarity found in Experiment 1. In Experiment 1, the failure to find an effect of familiarity was embedded in a general failure to find an effect of familiarity on both expression and lip judgements.

In this experiment, subjects were presented first with an identity-matching task on pairs of "speaking" face pictures, followed by a lip-reading classification task, as in Experiment 1. However, in this study half the face-pairs seen were "old" (from the identification task), and half were "new" (individuals not seen in the identification task). If priming of the structural representation occurs in lip-speech classification, it should be confined to "old" faces.

Both familiar and unfamiliar faces were again presented in order to establish more firmly the extent to which lip-speech decisions may be sensitive to knowledge of individual identity.

Method

Subjects. Subjects in this experiment had not performed Experiment 1. They were 20 psychology students from Goldsmiths College, University of London. All were familiar with Goldsmiths staff and unfamiliar with the Southampton staff pictured in the study. Subjects were randomly allocated to two groups of 10 subjects and were tested individually.

Design, Materials, and Procedure. The design factors were task (identity vs. lip-reading judgements), prior exposure (lip-reading judgements of faces seen in the identity-judgement task vs. faces not seen before) and familiarity (familiar—i.e. Goldsmiths—faces, and unfamiliar—i.e. Southampton—faces). Lip-shape images from Experiment 1 comprised the stimulus material. One group of 10 subjects performed identity judgements on the 32 pairs of male faces, whereas the other group of 10 subjects performed identity judgements on the 32 pairs of female faces. Both groups performed lip-reading judgements on all 64 pairs of faces.

Practice tasks, instructions, and display conditions were as in Experiment 1. Subjects performed the identity task first and then the lip-reading task. The procedure differed from Experiment 1 in that this was the only order of task and that 32 decisions (not 64) were made in the identity task.

Results

Three subjects had scores greater than 2 *SD* different from the mean for one or more conditions and were dropped from the analysis (one from the "female faces first" condition, two from the "male face first" condition).

Table 2 shows the means and standard deviations of the median reaction times for the relevant conditions for the remaining 17 subjects. Subjects in Experiment 2 were somewhat faster than those in Experiment 1 performing under similar task conditions. A repeated-measures ANOVA in which the factors were familiarity and task showed no main effect of familiarity, $F(32, 2) = 0.06$, and a significant main effect of task, $F(32, 2) = 22.52$, $p < 0.001$. Identity decisions were easier than the lip-speech classification tasks. There were no significant differences between the two lip-speech matching conditions (Scheffé comparisons).

The experimental hypothesis generated from Experiment 1 was that familiarity should affect identity but not lip-speech classification. Separate univariate planned comparisons on the interaction term, $F(2) = 4.44$, $p < 0.03$, upheld this prediction. Familiarity significantly reduced identity match RT, $p < 0.05$, but did not reduce RT in either of the two lip-speech matching conditions; if anything, decisions were slower for familiar items, but not reliably so, $p = 0.1$.

TABLE 2
Experiment 2. Effects of Task and Priming: Mean of Median Correct RT, Mean Standard Deviation of Correct RT, and Error Rate

	Familiar			*Unfamiliar*		
	RT (*msec*)	*SD* (*msec*)	*Errors* (*%*)	*RT* (*msec*)	*SD* (*msec*)	*Errors* (*%*)
Identity						
always presented first	943	136	2.13	992	159	2.14
Lip-reading						
first exposure—"unprimed"	1256	283	2.00	1209	259	1.83
second exposure—"primed"	1254	260	2.40	1233	274	2.14

Discussion

This study confirmed that lip-speech decisions on pairs of photographs of faces were not facilitated by personal familiarity with the face, whereas identity matching was sensitive to this variable. In this respect they replicated the findings of Experiment 1.

This study was designed to explore the possibility that some of the order effects in Experiment 1 might be related to priming rather than to practice. However, the results were negative: faces for a lip-speech match decision that had not been seen previously in an identification task were responded to at least as quickly as faces that had been seen before. There is no priming from identity to speech-decision in this paradigm.

Thus Experiment 2 confirms the main finding of Experiment 1 and extends it. Lip-speech appears to be processed via a stream separate from that for identity. It shows no sensitivity to personal familiarity (unlike identity matching) and, under these conditions, is not primed from prior exposure to the faces for an identity task.

EXPERIMENT 3

Experiments 1 and 2 found no evidence for facilitation of lip-speech decisions by identity knowledge. In Experiment 3 we explored the extent to which expression judgements may also be independent of identity.

Although the data reported so far confirm the impression that expression can be processed independently of facial identity, the conclusion that they *must* be independently processed rests mainly on suggestive but nevertheless limited neuropsychological evidence (Bowers, Bauer, Coslett, & Heilman, 1985; Kurucz & Feldmar, 1979; Kurucz, Feldmar, & Werner, 1979; Parry, Young, Saul, & Moss, 1991). To date, unlike the clear neuropsychological dissociation between face recognition and lip-reading (Campbell et al., 1986), double dissociations between expression and identity judgement between single contrasted cases have not been demonstrated. However, one recent group study of acquired visual disorder provides more convincing evidence for dissociation, in different patterns of vulnerability for identification and for expression perception in different patients (Young, Newcombe, De Haan, Small, & Hay, 1993).

That said, the evidence for separate streams in experimental studies with normal populations is strong, both from matching studies and from priming studies. As we have already suggested, there are, nevertheless, some good reasons for further investigating the claim that expression dissociates from identity processing. (1) Expression judgements in the priming studies reported by Ellis et al. (1990) tended to be faster than identity judgements: they may therefore be made on the basis of incomplete (curtailed) facial information, which would simply not allow familiarity to exert an effect as the whole face may not be processed. More difficult expressions may be required to test the independence theory stringently. (2) Personal familiarity may not affect decisions in the same way as for expressions derived from famous faces. In support of these two claims, Peng (1989) reports that personal familiarity affected speed of expression identification for video clips of induced expression in students. This was particularly marked for expressions of fear and disgust. Disgust, in particular, may be expressed idiosyncratically. If knowledge of the individual affects one's interpretation of any facial expression, this is where we might expect to find it.

In this study, therefore, the matching of expression and identity for pairs of face images derived from personally familiar people was tested, using a more difficult expression task than that of Experiment 1. Pilot testing established that, for these particular sitters, the expressions of "disgust" and of "happiness" were reliably and accurately discriminated.

Method

Subjects. Thirty-two psychology students, 16 from Goldsmiths College, University of London, and 16 from Southampton University, participated in the experiment. As in the previous experiments, subjects from Goldsmiths College were familiar with the Goldsmiths staff but unfamiliar with the Southampton staff whose faces were used as stimuli in the study, whereas subjects from Southampton University were familiar with the Southampton staff but not with the Goldsmiths staff.

Design and Materials. The design factors were task (identity vs. expression judgements), familiarity (familiar vs. unfamiliar faces) and site (Goldsmiths vs. Southampton). The first two factors were varied within subjects with order of task performance counterbalanced across subjects at each site.

Stimulus faces differed from the faces used in the expression test in Experiment 1 in only one respect: The expression on each "sad" face was changed to an expression of "disgust". The "disgust" expressions were induced in the 8 sitters by instruction and by induction (they read a short text of a disgusting event in order to help produce the appropriate face) and video clips of these expressions were recorded. Using the same software as for Experiment 1, the best still image of each expression (one three-quarter and one full face) was selected (see Figure 2). As in Experiment 1, once the faces had been selected for goodness of expression and similar pictorial quality, they were cropped, and the angle of the head in the frame was adjusted to make the photographs as pictorially similar as possible.

A series of 16 practice trials was designed, similar to those of Experiment 1, using pictures of faces of two further members of staff not used in the experiment proper, who posed with "happy" and "disgusted" faces.

Procedure. The procedure was similar to that described for the identity and expression judgement tasks in Experiment 1, but with minor differences. The response keys were changed from "s" and "d" to "z" for same and "/" for different (identity or expression). These are widely separated on the keyboard and were chosen to minimize response selection difficulty. The instructions were altered to incorporate this change as well as the change in expression from "sad" to "disgusted".

Results

The means of the relevant median reaction times are shown in Table 3. ANOVA was performed on these data as in the previous experiments. The between-subjects variables were order of task (expression first or identity first) and site (Goldsmiths or Southampton). Within-subjects variables were familiarity (personally familiar or unfamiliar) and task (expression or identity).

Neither of the between-subjects variables had a significant main effect, for order, $F(1, 28) = 2.56$, for site, $F(1, 28) = 0.076$. No interactions of these variables with any others were significant. There was a main effect of task, $F(1, 28) = 153.14$; $p < 0.001$.

TABLE 3
Experiment 3. Effect of Task: Mean of Median Correct RT, Mean Standard Deviation of Correct RT, and Error Rate

	Familiar			*Unfamiliar*		
	RT (msec)	*SD (msec)*	*Errors (%)*	*RT (msec)*	*SD (msec)*	*Errors (%)*
Expression	1376	184	3.10	1380	178	2.46
Identity	972	122	2.34	1088	133	2.70

Expression judgements were slower than identity judgements. There was also a significant effect of familiarity, $F(1, 28) = 26.79$, $p < 0.001$—familiar faces were processed more quickly than unfamiliar ones—and a significant Familiarity × Task interaction, $F(1, 28) = 23.81$, $p < 0.001$. Although familiarity failed to affect expression decisions, it had a significant effect, $p < 0.001$, on identity matching.

There were no reliable differences between conditions in error rate, and no suggestion of a trade-off between accuracy and speed in this study.

Discussion

This study confirmed the findings of Experiment 1 using a more difficult expression-matching task, which in turn generated longer reaction times for expression decisions than those reported in Experiment 1. Expression judgement times in this study appear comparable to those for lip-speech judgements in Experiment 1 (Table 1)—that is, although expression judgements ("happy" and "disgust") were slower than in Experiment 1 ("happy", "sad"), there is still no evidence that such judgements were sensitive to personal familiarity with the face. In contrast, despite their overall slowing in comparison to Experiment 1, identity judgements on these faces continued to show marked sensitivity to face familiarity. This finding further extends and confirms the findings and conclusions of Young, McWeeny, et al. (1986) to include more difficult decisions on personally familiar faces.

EXPERIMENT 4

Experiments 1 to 3 have confirmed that expression and lip-reading judgements are not sensitive to face familiarity in the same way as identity judgements. Moreover, the relative difficulty of the task does not seem to exert a direct influence on this independence. There may, nevertheless, be important reasons to ask the question again, using a different methodology. In the first place, the argument for independence of sub-processes rests on a failure to find an effect of familiarity—that is, demonstrating a null effect. More crucially, however, the two-face matching paradigm may not be the most appropriate way to test for the ways in which knowledge of the person might affect lip-speech or expression processing. Although each pair of pictures differed in viewpoint, the claim could be made that only parts of the face, rather than the whole face, are required to make the appropriate match for expression or lip-reading.

A quite different criticism could also be made of the previous experiments. The lip-speech matching task itself (Experiments 1, 2) required analysis of pairs of simultaneously presented faces and was relatively difficult, with long median reaction times. Perhaps the very difficulty of the task (length of reaction time) masked any effects of familiarity? Other, easier tasks might better test the hypothesis that face familiarity affects lip-speech classification.

In this experiment, *single* face images derived from the same source as those in Experiment 1 were presented for the decision, "Is this someone saying 'FEED' or saying 'FOOD'?" The image could be that of a personally familiar or non-familiar person. This requires that the subject generate a representation from memory ("what does 'food' look like?") to match to the perceived display; it could therefore be interpreted to be a stronger test of the independence hypothesis than the two-face matching task, which simply required that the faces be matched for overall lower-face shape. If people use their representations of known faces speaking to guide their performance, we would predict that known faces should give faster responses than unknown ones. Similarly, an expression judgement task ("is this person happy or disgusted?") was used to test the independence hypothesis for expression. The "happy/disgust" comparison was chosen both because it appears to generate matching times comparable with those for lip-reading (Experiment 3) and also because the facial expression of "disgust" may be more variable/idiosyncratic than that of sadness. If familiarity with the face affects expression decisions at all, we would expect to see it in this task.

Method

Subjects. Sixty-four psychology students, 32 from Goldsmiths College, University of London, and 32 from Southampton University, participated in the experiment. As in the previous experiments, subjects from Goldsmiths College were familiar with the Goldsmiths staff but unfamiliar with the Southampton staff whose faces were used as stimuli in the study, whereas subjects from Southampton University were familiar with the Southampton staff but unfamiliar with the Goldsmiths staff.

Design and Materials. The design factors were task (lip-reading vs. expression judgements), order (lip-reading first, expression judgement second vs. expression judgement first, lip-reading second), site (Goldsmiths vs. Southampton), and familiarity (familiar vs. unfamiliar) with familiarity and task as within-subjects factors. The order of task performance was counterbalanced across subjects at each site. Stimulus faces for the lip-reading task were the 32 "OO" and "EE" lip-shape faces from Experiment 1. Faces appeared twice, once in each of two consecutive blocks. Within a block, faces were presented singly in a pre-determined random order. A face remained on the screen until subjects responded by pressing any key, after which another face appeared. Stimulus faces for the expression task were the 32 "happy" and "disgusted" expression faces from Experiment 3. These faces were presented in the same manner and order as for the lip-reading task. Practice lip-reading trials involved 8 additional lip-shape faces, each face appearing twice, once in two consecutive blocks. Faces were presented singly in a random order, with "CORRECT" or "WRONG" feedback provided after each response. Practice expression trials were prepared from 8 additional "happy"- and "disgust"-expression faces in the same manner.

A criterion of not more than 10 errors per subject was set, and four subjects were replaced because they exceeded this criterion.

Procedure. Subjects were randomly allocated to one of two groups and tested individually. One group performed the expression judgement task followed by the lip-reading judgement task, whereas the other group performed the same tasks in the reverse order.

In the expression judgement task, subjects read the following instructions:

> In each of the following trials a face will appear on the screen. Each face will have either a happy or a disgusted expression. For each face please strike the "z" key if the face has a happy expression or the "/" key if the face has a disgusted expression. Please respond as quickly as possible as your reaction times will be measured. Strike any key when ready.

In the lip-reading judgement task, subjects read similar instructions, which specified that each face would be mouthing "FOOD" or "FEED", and the "z" key should be struck if the face was mouthing "FOOD" or the "/" key if the face was mouthing "FEED".

Before each test, subjects completed 16 practice trials, for which they received feedback to acquaint them with the test procedure. Between the two tests subjects performed an unrelated task for approximately 10 min.

Results

Table 4 shows the means of the median correct reaction times for all subjects in the main conditions of the experiment. The data were analysed by mixed ANOVA in which the between-subjects factors were site (Goldsmiths or Southampton), order (lip-reading or expression test first); the within-subjects factors were familiarity (familiar or unfamiliar) and task (lip-reading or expression). Neither of the between-subjects factors had a significant main effect. Moreover, site failed to interact with any other variables. Of the within-subjects variables, task had a significant effect, $F(1, 60) = 20.97$, $p < 0.001$. Despite the increase in difficulty of the expression judgement task, it was still faster than the lip-reading task. Familiarity failed to exert a significant effect overall, $F = 0.72$, and failed to interact with task, $F(1, 60) = 3.332$, $p = 0.73$.

A number of interactions with order were significant. Familiarity interacted with order, $F(1, 60) = 16.67$, $p < 0.001$. Unfamiliar faces were relatively faster on the second presentation than were familiar faces. Order also interacted with task, $F(1, 60) = 8.95$, $p < 0.01$. Order had little effect on expression judgements, but the lip-reading task was performed more quickly when it was the second task, $p = 0.05$.

The most convincing interpretation of these interactions is that lip-reading classification, in particular, benefits from prior exposure to the experimental faces—that is, from practice with those faces (note that practice was not with identical pictures of the faces). In this experiment the benefit was more marked for unfamiliar faces. There were no further significant effects.

TABLE 4
Experiment 4. Effects of Task and Order: Mean of Median Correct RT, Mean Standard Deviation of Correct RT, and Error Rate

	Familiar			*Unfamiliar*		
	RT (msec)	*SD (msec)*	*Errors (%)*	*RT (msec)*	*SD (msec)*	*Errors (%)*
Expression						
first	715	97	2.31	692	89	2.38
second	692	114	2.06	689	105	1.38
Lip-reading						
first	766	121	1.94	795	151	1.19
second	731	93	2.00	714	84	1.25

There were no reliable differences among error rates, and no suggestions of speed–error trade-offs in these data.

Discussion

Using an experimental paradigm different from that of Experiments 1 and 2, the relationship between face familiarity, expression, and lip-reading judgements was clarified. Lip-speech judgements resembled expression judgements in that both were generally insensitive to face familiarity. The reaction-times for the conditions were roughly comparable, although lip-speech decisions were still slower than (difficult) expression decisions. Despite this main effect of task, there was no sign of an interaction between task and familiarity, although order effects may moderate the general conclusion that familiarity does not affect lip-speech classification (see further on). Once again, site of testing failed to affect the speed of response—that is, familiarity in this experiment was not confounded with other factors (such as structural distinctiveness or typicality) associated with specific faces.

GENERAL DISCUSSION

These four experiments were designed to explore the classification of face images for lip-speech in the context of a separate sub-components model of face processing. Our experimental hypothesis, based on comparable studies of expression judgement and on extant neurological dissociations, was that lip-speech judgements would be insensitive to personal familiarity of the face. The hypothesis was confirmed. Experiments 1, 2 and 4 all failed to show familiarity of the face facilitating the categorization of lip-speech pictures. But identity judgements in all tested conditions were systematically affected by familiarity, a finding in line with earlier reports, and which can now be extended to personally familiar faces and across different types of face picture (full and three-quarter faces saying "food" and "feed", as well as over "happy" and "sad" faces). We also confirmed that expression judgements were independent of face familiarity for difficult as well as for easy decisions on these personally familiar faces. Thus, despite the development of sophisticated, more "permeable" stage models of face processing than those suggested by Bruce and Young (1986), we have confirmed the basic premise of the model, that separate processing streams are set up for the identification of faces and for other face-reading tasks. The complete functional separation of identity from other face-processing tasks demonstrated in the experiments reported here as well as in a number of other reaction-time studies may also complement some neurophysiological aspects of face processing. Primate studies suggest that ensembles of cells in various parts of the dorsal (occipito-temporal) processing system subserve different functions with respect to faces. Anterior parts of the temporal cortex are required for face identification (face memories), but earlier parts of the stream appear to be separately and distinctively concerned with (for example) detecting eye-gaze direction, matching on the basis of identity, and analysing emotion (Tovee & Cohen-Tovee, 1993). What is still puzzling is the physiological and functional basis whereby face familiarity affects simple identity (same-face or different-face?) matching. Does this involve some input from anterior temporal systems, or is it a function of greater exposure to familiar than to unfamiliar faces? Further experiments in neuropsychology, experimental psychology, and neurophysiology should help to resolve this question.

How ecologically valid are these findings? Pictures of speaking faces are, in some sense, rather unnatural as photographic images. Moreover, while the specific speech sound can often be read from the mouth pattern, the communicative aspect of the facial action is dynamic; it is temporally ordered, as is speech. The ecological validity of this particular lip-speech task, compared with both expression and identity judgement, is questionable. More naturalistic displays, especially those that are dynamically ordered, might give further insights into the processes underlying the identification of facial speech, and particularly its sensitivity to familiarity.

Walker, Bruce, and O'Malley (in press) report that susceptibility to the McGurk and MacDonald (1976) auditory–visual fusion illusion (where, for example, a seen "ga" is synchronized with a heard "ba" to give the impression that "da" was spoken) *is* sensitive to knowledge of facial identity. Where face–voice combinations were from different individuals, susceptibility to fusions was more marked for unfamiliar face–voice combinations than for familiar faces paired with unfamiliar voices. This is an interesting contrast to earlier findings, which suggested that McGurk effects are not very sensitive to idiosyncratic distinctions between faces but reflect powerful amodal phonological processes. For example, gender differences between the seen and heard voice (where both are unfamiliar) do not reduce susceptibility to the effect (Green, Kuhl, Meltzoff, & Stevens, 1991).

Thus it would seem that lip-reading can interact with face knowledge in some quite complex ways. Although lip-reading needs to be relatively independent of the ability to identify an individual (or how else could we use lip-speech to understand noisy speech uttered by an unfamiliar face), nevertheless knowledge of a person's identity may sometimes modify speech percepts. We have been unable to find such evidence in this study of still face pictures.

It is further possible that lip-reading may not be the only task that interacts with face familiarity in such ways. Peng (1989) reported that the identification of facial expression shown in video clips of induced (i.e. "real" rather than "posed") facial expressions was sensitive to personal familiarity. Further explorations of dynamic facial actions might provide a different perspective on the possible independence of face-processing skills from face familiarity than that provided from the speeded classification of photographs.

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A ROSE is A. Rose is a rose? Exploring the Implicit and Explicit Memorial Structure of Word/Name Homographs

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Three experiments explored word/name homographs (GARLAND—musical star/wreath of flowers) to determine the extent to which presenting them for study as surnames or as content words affected memory on immediate retest. Implicit and explicit measures were taken.

Implicit memory occurred reliably on all variants of this task. Names were better remembered than words when the forename was presented as a cue and subjects were asked to generate a surname. This finding conforms with the suggestion (Bredart, Valentine, Calder, & Gassi, 1995) that there is a dedicated name-output stage in the memory system, and suggests that this can be activated under some implicit memory conditions. Further experiments showed that this name advantage was not upheld under other (word but not name) cued-recall conditions. Under these conditions, implicit memory is sensitive to the perceptual rather than the contextual conditions of presentation.

INTRODUCTION

How are common British surnames that are also content words (Butcher, Bell, Fry, Rose) represented and accessed in mental space? This might be viewed solely as an exploration in the natural history of psychology, useful as a curiosity of English. However the implications are deeper. Proper names identify unique events (individuals) through a label that usually has only limited associative meaning (country of origin, gender). By contrast content words rarely refer to unique episodes, events, locales, or individuals, but are capable of activating a wide range of semantic associations and combine to form further associative

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representations. Names distinguish and specify individual, idiosyncratic exemplars (people, places) while words characterise and agglomerate unique events in more general descriptive terms. Although words can be synonyms of each other (e.g. MARRIAGE = WEDDING), the definition of a name is not equivalent to the name itself and cannot be substituted for it in discourse without awkwardness. Names and words, even when they refer to the same exemplar, have different pragmatic, semantic, and syntactic consequences.

Surnames such as Fortune, Garland, Major, which could also be content-words, are homographic. They refer, separately, both to individuals (with the concomitants of uniqueness, episodic quality, specific associations to the person) and to more generic concepts (object terms with little episodic "flavour", more general semantic associations). The studies reported here ask to what extent dissociated memory processes can be demonstrated for such labels, which have the same surface form, when they are taken to refer to an individual (e.g. Mr. DAY) or to a generic concept (DAY—24 hours).

There are some indications that these different characteristics of names and words affect experimental tasks. Durso and O'Sullivan (1983) suggested that the semantic representations related to proper names have more in common with pictures than with common words, and demonstrated conditions under which names for people and places (US states) were primed by previous exposure to the cross-modal (pictorial) exemplar. By contrast, common word naming was not primed by exposure to the corresponding picture. They argued that pictures and proper names share the property of semantic specificity in contrast to the more generic quality of common words.

Valentine, Bredart, Lawson, and Ward (1991) proposed that, although on input (written) names would at first be processed just as any other written word, they would then activate a specific stage—that of name representations—which mediates between, on the one hand, information about a familiar person and, on the other, the processing of words in the language system (for example in reading aloud or lexical decision).

How names then relate to other knowledge one may have about the person is currently contentious: Burton and Bruce (1992, 1993) have proposed that names may be represented simply as (unique) semantic features of individual person knowledge, with no special representational status; Bredart et al. (1995), by contrast, reassert that names do have separate representational status as lexical (output) units. Both approaches are supported by computational models. One advantage of Bredart et al.'s model is that it allows a natural account of patients such as NP (Hanley, 1995) who can retrieve and produce any number of distinguishing semantic attributes of an individual on confrontation (NP has no apparent phonological or semantic problem) but cannot retrieve the name without cueing.

Do these models offer useful predictions when words that might be names are input for remembering later, as in the present study? Burton and Bruce (1993) explicitly consider this, in the light of the findings of Valentine et al. (1993). Valentine et al. (1993) explored repetition priming in lexical decision where items were presented as names (e.g. Kenneth Baker) or as words (e.g. BAKER). Mode of presentation failed to affect the degree of repetition priming, which was marked in all cases. Burton and Bruce suggest that their model might predict this non-specific effect because the algorithm that captures priming (reactivation causes a change in weights in the system according to a Hebbian update rule) affects the system as a whole. Words that also happen to be names access the system through the same, common, lexical recognition stage and then have similar effects throughout the system. To the extent that the Bredart et al. (1995) model assumes a common lexical processing stage at input, the same logic applies and we would predict similar implicit memory functions (e.g. word-stem completions) for words that had previously been presented as names or as words. Such a result, however, (like those of Valentine et al., 1993) can only confirm a null hypothesis. Bredart's model suggests that names may also enjoy special status in comparison with other words at the level of semantic representation, and one aim of the studies reported here is to attempt to find evidence from an implicit memory task for such a stage: that is, to examine whether there are conditions under which name-specific priming may occur.

Implicit and Explicit Memory: Some General Considerations

The studies reported here are concerned with the effects of presenting items for recall which could be either words or names, and testing them, implicitly and explicitly, under contrasting conditions. Most implicit memory effects are data-driven; that is, the conditions of presentation do not have a specific effect. However, cross-domain priming and implicit memory have been reported (e.g. Hirshman, Snodgrass, Mindes, & Feenan, 1990; McLelland & Pring, 1991; Roediger & McDermott, 1993; Schacter & Graf, 1989), suggesting that implicit memory need not be confined to data-driven processing. Transfer-appropriate processing theory (Morris, Bransford & Franks, 1977; Roediger, 1990) suggests that the extent of implicit memory varies directly as a function of the degree to which study and test tap similar cognitive processes. This approach suggests that the fit between encoding and test is crucial. This may mean that items presented as *words* and tested by word-stem completion should show greater implicit memory than items presented as *names* and then tested with word-stems. Blaxton (1989) showed that implicit conceptual tests (category exemplar naming) were sensitive to levels of semantic processing at encoding. This was only seen when a conceptual memory test was employed. Word-stem completion, which was the test used here, is generally considered to be a perceptual test (Roediger, Weldon, & Challice, 1989), and may therefore be thought unlikely to be sensitive to encoding variations. However, as cross-domain priming occurs under word-stem completion, it is by no means clear that it *is* solely a perceptual task. So, when encoding conditions are varied, as by presenting items as names or as words, stem-completion may possibly show sensitivity to encoding conditions.

In the experiments presented here, different associative and conceptual classification tasks were used at encoding, in systematic explorations of the effects of depth of encoding (i.e. contrasting semantic and orthographic encoding conditions). If implicit memory is sensitive to these "deeper" non-perceptual factors, it should be apparent under these conditions.

As far as explicit memory for names is concerned, it should be pointed out that models such as those of Burton and Bruce (1993) or of Valentine et al. (1991) and Bredart et al. (1995) make no specific predictions (see Bruce, Burton, & Walker, 1994). One general point should be made, however. Encoding specificity affects recognition in a marked manner (Thomson & Tulving, 1970). For example, when the associative semantic context of a target word is reinstated at test (e.g. traffic-JAM, log-JAM), recognition is better than when it is not (traffic-JAM, strawberry-JAM; Light & Carter-Sobell, 1970). This may hold for cued recall as well (Roediger & Adelson, 1980, cited in Roediger, 1990). On this basis, we would predict that the encoding context "names" should improve explicit memory for names and the encoding context "words" should improve explicit memory for words. That is, explicit recall may be better when encoding and test homograph meanings are the same than when they are different.

EXPERIMENT 1
GENERATING ASSOCIATIONS TO WORDS AND TO SURNAMES: USING A FORENAME RECALL CUE

Our aim in this first experiment was to establish the extent to which implicit memory for word/name homographs can be established where the task requires relatively deep encoding (generating semantic associates) and a specific cue is presented at the recall stage. Most generally, these conditions are those under which conceptual, as opposed to perceptual, implicit memory has been demonstrated (Blaxton, 1989; Roediger & McDermott, 1993). More specifically, if, once the written letter string (name/word) has been processed, there is a specific lexical representation site for real names (Bredart et al., 1995), which is separable from other semantic information about people, the presentation of a forename cue should preferentially activate the associated surname.

We were also interested to establish the pattern of *explicit* memory for words and names under these conditions. To what extent is the aware recollection of a previous encoding task (generating associations to a word or a name) useful in remembering that item when a forename cue is given? Does the pattern of recall differ between explicit and implicit recall under these conditions?

Method

Subjects. Fifty-six students from Goldsmith's College, age range 18–38 years, participated in the experiment. They were randomly allocated to four groups of 14 subjects and tested individually or in pairs.

Design and Materials. The design factors were Name/Word Encoding and Test (implicit vs. explicit), both conducted between-subjects.

Stimulus material comprised 16 unique and easily identified famous surnames which were also words, each of which had a unique "common" forename, e.g. MAJOR (John), COWARD (Noel). These 16 name/words were printed in upper case on cards. These cards were divided into two sets of eight name/words in which overall frequency[1] was matched across the sets. In addition, a further eight famous name/words were used as fillers in both sets (see Appendix 1 for a list of target and filler names).

There was one test sheet on which 40 common forenames appeared, printed in upper case in two columns. These included 24 lure forenames, which were not related to the inspection series. Interspersed among these were 16 forenames related to eight target surnames from each stimulus set. For each subject, the eight unstudied target surnames provided a level of baseline performance. Study names were fully counterbalanced across all experimental conditions.

Procedure. Subjects were randomly assigned to one of the four experimental groups (Name/Implicit, Name/Explicit, Word/Implicit, Word/Explicit). The Name groups received the following instruction:

> I would like you to write down a one word association to each of the following surnames of famous personalities. Any association connected to the personality is acceptable except the forename. For example, to the surname HOLLY, you might write "singer", "spectacles", or "Crickets" but not "Buddy". You must write an association to the surname not to a word. If you don't recognise the surname, leave a blank.

The Word groups received the following instruction:

> I would like you to write down a one-word association to each of the following words. Any association connected to the word is acceptable. For example, to the word HOLLY, you might write "ivy", "bush", or "Christmas". You must write an association to the word, not to a name. If you can't think of an association, leave a blank.

No instructions were given to try to remember these surnames/words, which were presented on cards at the rate of one card every four seconds.

Subjects were tested immediately. In the *implicit* tests, they were asked to complete each presented forename with the first surname they thought of, either the name of a famous person or someone they knew personally. If they could not think of a surname they were to leave a blank. This was presented as

[1] Frequency throughout refers to word rather than name frequency. We know of no reliable surname frequency norms, although surname frequency for English names may be derived from telephone directories etc.

a fluency task and they were instructed to try not to think back to the study cards. In the *explicit* tests, subjects were asked to try to match the surnames/ words they had seen previously to the forenames to make the name of a famous personality. So if NICK was presented and they remembered they had seen the surname/word BERRY previously, they would write it next to that particular forename cue.

Results

Preliminary statistical analysis showed significant differences between unstudied and experimental items (priming) in the implicit test [$t(27)=7.37$, $P<0.001$] and in the explicit one [$t(27)=9.706$, $P<0.001$]. That is, there was priming in both conditions.

In this and in subsequent experiments, the unstudied list correct probability was subtracted from the target correct completion probability for each subject to derive the corrected probability score (see Fig. 1).

A 2 × 2 Analysis of Variance (ANOVA) was performed on corrected probability scores with two between-subjects factors, Name/Word Encoding and Test (implicit/explicit). There was a significant effect of Test [$F(1,52)=4.95$, $MSe=3.93$, $P=0.03$; implicit recall better] and of Name/Word encoding

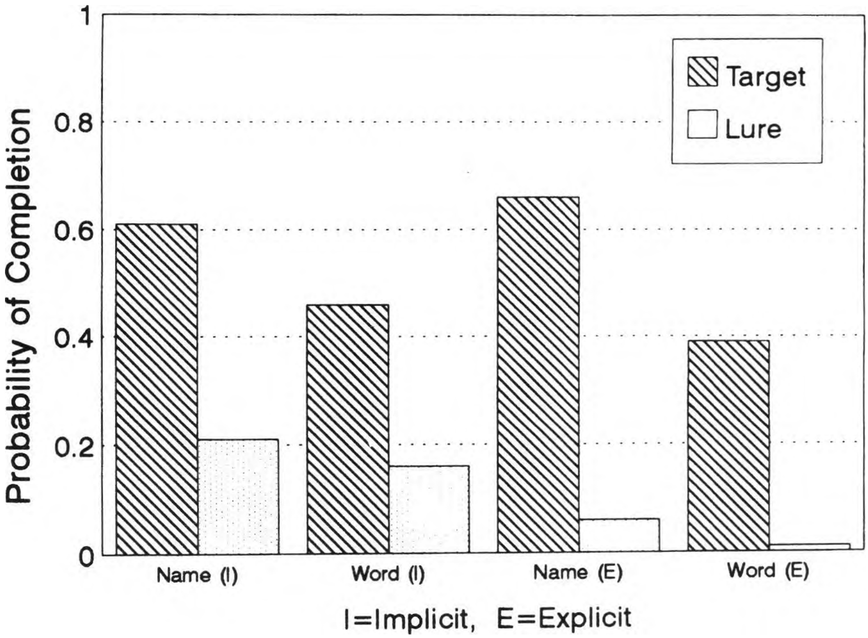

FIG. 1. Name/Word Experiment 1: mean implicit and explicit target and lure response probabilities.

[$F(1,52) = 5.57$, $MSe = 3.93$, $P < 0.02$; names better than words]. The interaction between Test and Name/Word Encoding did not reach significance [$F(1,52) = 0.77$, $MSe = 3.93$, $P = 0.39$].

Discussion

When subjects generated specific associations to homographs presented either as words or as famous surnames there was a marked advantage to the name-study condition when the famous forename was presented as an explicit recall cue. This effect was apparent as a main effect and did not interact with implicit/explicit recall conditions. Subjects were instructed not to generate a forename as an association, and we cannot know to what extent forenames were activated on inspection, but then suppressed (not produced). Be that as it may, forenames serve as highly specific cues for name recall under explicit and implicit encoding conditions.

This result would not be specifically predicted in a model where names had no special memorial status other than their uniqueness, as suggested by Burton and Bruce (1992). On that model it is more likely that across-the-board implicit memory effects should be seen, following enhanced general activation of word/name items on their second exposure. The finding of a (sur)name-specific effect, following instructions to subjects to make name associations, accords more closely with Bredart et al.'s (1995) model. It suggests that names have quite specific status in relation to knowledge about people, and that activation of the forename given the surname does not have the same consequences for later name retrieval as activating other information about the individual on presentation of the surname.

EXPERIMENT 2A: ASSOCIATIONS TO WORDS AND TO NAMES; EFFECTS ON EXPLICIT AND IMPLICIT STEM COMPLETION

Experiment 1 confirmed that forenames are "special cues" for remembering surnames—even when these are homographs of real words. That experiment used word-associates (i.e. forenames for surnames) as inspection cues. But what of a more usual cue for implicit memory? Word stems (e.g. BE... for BERRY) reinstate some aspects of the inspected stimulus at recall and have generated reliable and sensitive implicit memory effects, both perceptual and conceptual. Moreover, word-stem completion for implicit memory, and word-stems provided as cues for explicit recall, provide identical cues for memory. They allow us to control recall mode tightly across the different tests.

Varying the depth of encoding at inspection can generate systematic differences in explicit memory, whereas implicit memory is usually, but not always, unaffected by this variable (Roediger & Challis, 1992). In this study, depth of encoding at presentation was manipulated for both types of material by contrasting a "deeper" semantic task, one of association to the presented item, with a "shallower" structural task based on graphemic analysis. The deep encoding task was that for each item presented, subjects were asked to generate a good associate. For the name condition, this was required to be a forename.

Following Experiment 1, it was predicted that (sur)names might be better recognised than words (explicit task). For the implicit task, a data-limited explanation of implicit priming would predict no effect. Valentine et al.'s (1993) findings of identical repetition priming effects for word/name homographs suggest, also, that there will be no specific effects of words and names under these conditions. Furthermore, as this task, unlike that of Experiment 1, does not require access to name representations (forename plus surname), Bredart et al.'s (1995) model does not predict differential effects either.

Limited depth-of-processing effects in the implicit task but more pronounced ones in the explicit task were also predicted, in line with the majority of earlier findings.

Method

Subjects. Thirty-two students from Goldsmiths' College, University of London, aged 19–40 years, participated in the experiment. They were randomly allocated to two groups of 16 subjects and were tested either individually or in pairs.

Design and Materials. The design factors were Name/Word Encoding, Depth of Processing (semantics vs. graphemic) and Test-Type (implicit vs. explicit). Name/Word Encoding was a between-subjects factors, whereas Test-Type and Depth of Processing were within-subjects factors. Depth of Processing was counterbalanced for order (semantic or graphemic first) across subjects within each group, but the implicit test preceded the explicit test for each subject for two reasons. First, this order was necessary to introduce the implicit test as a filler task before the memory task; second, it ensured a measure of implicit memory unaffected by prior recognition would be obtained.

The stimuli were 80 cards on each of which a word was printed in upper-case letters. These were words that were also common British surnames. Two judges were asked "what famous person has this surname?". Only items for which readily generated celebrity (i.e. reasonably specific) forenames were given, were retained in the final set. In addition, each name/word fulfilled the criterion that its first three letters formed the initial stem for at least six English words; e.g. HEATH; HEAt, HEArd, HEArt, HEArth, HEAther: SQUIRE; SQUid, SQUirt, SQUint, SQUeal, SQUirrel. Overall frequency and length of the name/words were matched across the sets. The items used are shown in Appendix 2. The 80 cards were allocated to four equal sets. Care was taken to ensure that name/words were evenly distributed by frequency and word length between these sets. During the experiments these four stimuli sets were used in each of the experimental conditions.

For each memory test, subjects received a test sheet of 40 three-letter word stems, printed in capital letters in two columns. On one test sheet were word stems of half of the name/words from each of the four sets of stimulus cards, listed in a random order. On the other test sheet were word stems of the remaining name/words. Thus all subjects received word stems from half the items presented at study split across the implicit and explicit conditions. Target and lure stems were fully counterbalanced.

Procedure. Subjects were randomly assigned to the Name or to the Word group. They were told that they would be presented with lists of surnames or words to remember.

The semantic study task was to generate an *associate* to the presented item. Thus, for name presentations, subjects were asked to think of a specific forename for that particular surname, and to write it down. For word presentations, subjects were asked to generate a word that could be specifically associated with the item. For the graphemic task, subjects were required to write down two letters that did not appear in each item presented. They were also asked to vary the letters they selected to write down. Cards were presented in a random order at the rate of one card every five seconds.

After the study tasks had been completed (semantic and graphemic), subjects were given a disguised implicit memory test which they were informed was a filler task to distract them from the forthcoming memory test. They were instructed to complete a sheet of 40 three-letter word stems with the first word that came to mind, as quickly as possible, using any number of letters to complete a word. They were also instructed that if a word did not immediately come to mind they were to move on to the next stem. Of the 40 word stems in the test sheet, 10 were stems of items seen under semantic encoding, 10 were stems of items seen under graphemic encoding, and 20 were stems of lures. (Lures comprised 10 stems from each of the two sets not presented.) Target and lure word stems were fully counterbalanced.

When this implicit memory test had been completed, subjects were asked to perform the explicit memory test which was also a test of stem completion. That is, subjects in the ''names'' condition completed the written stems with items that they were sure had been presented in the study phase. They were told not to guess any completions. Similar instructions were given to subjects in the ''words' condition.

Finally subjects were thanked for their participation in the experiment, the purpose of which was explained to them. The entire procedure took 20 minutes for each subject.

Results

As in Experiment 1, corrected probability scores for explicit word-stem cued recall and implicit word-stem completion were derived by subtracting probability of lure from target correct probability. The results for each group are summarised in Fig. 2.

Preliminary analysis showed no effect of order of task presentation, and data were collapsed across this variable. There was significant priming in the implicit test, with all corrected probability (target–lure) scores significantly greater than zero.

A 2 × 2 × 2 ANOVA was performed in which the between-subjects variable was Name/Word Encoding, and the within-subjects variables were Depth of Processing (graphemic/semantic) and Test-Type (implicit/explicit).

The effect of Depth of Processing was significant [$F(1,30) = 51.45$, $Mse = 0.02$, $P < 0.001$; semantically encoded material was better remembered] and so was that of Test-Type [$F(1,30) = 8.26$, $Mse = 0.04$, $P < 0.01$; implicit performance was better]. The interaction between Depth of Processing and Test-Type was also significant [$F(1,30) = 36.20$, $MSe = 0.03$, $P < 0.001$]. Examination of this interaction showed that the effect of Depth of Processing was significant for the explicit condition only, and favoured semantic encoding

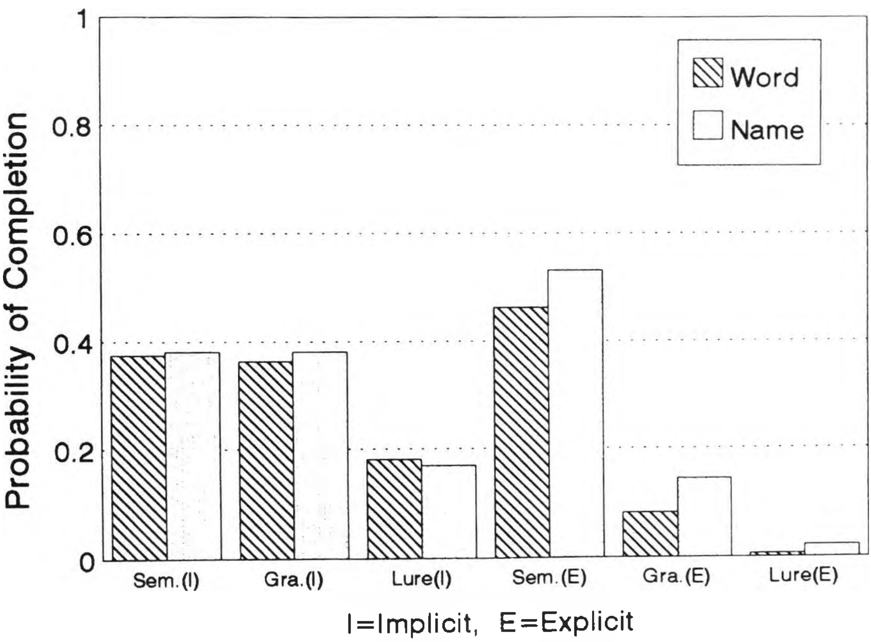

FIG. 2. Name/Word Experiment 2a: mean implicit and explicit lure response probabilities as a function of depth of encoding (associative judgements).

[$F(1,20)=47.86$, $Mse=0.05$, $P<0.001$]. There was no main effect of Name/Word Encoding ($F=1.5$) and no further interactions of this factor with any other experimental variable.

Thus, in this study which showed no effect of word/name encoding on any variable, implicit memory was unaffected by depth of encoding, while explicit memory was sensitive to this variable, in the predicted direction.

Discussion

First, implicit priming was achieved on this task. Second, for *all* aspects of the study, words and names showed similar characteristics. That is, name/word instructions failed to affect explicit or implicit performance in a reliable manner. Both words and names were affected similarly by depth of encoding (semantic better than graphemic) in the explicit task, whereas in the implicit task, depth of encoding failed to affect the pattern of completions. This is entirely in line with most reported studies of implicit processing.

Word stems failed to distinguish name and word presentation conditions either in implicit or explicit performance. The tests used were clearly sensitive, as reliable implicit memory and depth-of-processing effects on explicit performance were achieved. Could methodological difficulties obscure any "real" name/word differences here?

One possibility could be that performance on the implicit task (which always preceded the explicit task) affected explicit performance. If implicit performance failed to respect the word/name encoding difference, then any "carryover" from this earlier task could mask explicit differences. The next experiment controlled for this possibility by eliminating the implicit memory conditions. If name instruction and word instruction (as between-subject factors) differentially affect recollection, this ought to be apparent in this study, where prior implicit measures, which might obscure a differential pattern, cannot affect the data.

EXPERIMENT 2B: SURNAMES OF WELL-KNOWN PERSONALITIES WHICH ARE ALSO COMMON NOUNS: EFFECTS OF ENCODING INSTRUCTION ON EXPLICIT WORD-STEM COMPLETION

In this study, following the rationale outlined earlier, explicit word-stem cued recall for semantically and graphemically encoded homograph lists presented as words and as names was examined. There were also some further, minor, methodological changes as indicated.

Method

Subjects. Thirty-two students from Goldsmiths' College and from schools and colleges throughout the UK, age range 17–31 years, participated in the experiment. They were randomly allocated to two groups of 16 subjects and tested individually or in pairs. None had performed any other experiments in this series.

Design and Materials. The design factors were Name/Word Encoding and Depth of Processing (semantic vs. graphemic) with Name/Word Encoding conducted between-subjects and Depth of Processing within-subjects. The semantic and graphemic tasks were counterbalanced for order across subjects within each group.

Stimulus material comprised 40 of the 80 name/words of well-known personalities used in Experiment 2a. These name/words were divided into four sets of 10 name/words with overall frequency and length of the name/words approximately matched across the sets. There was one test sheet on which appeared 44 three-letter word stems, printed in upper case in two columns. The first four word stems were lures which did not occur in any of the four stimuli sets. The remaining 40 word stems matched name words from the stimuli sets, listed in a pseudo-random order with the proviso that no more than three word stems from one stimulus set appeared concurrently. For each subject two of these sets of name words had been previously encoded, one in a semantic task and one in a graphemic task and the two remaining sets formed the lures. Target and lure stems were fully counterbalanced.

Procedure. The procedure was similar to Experiment 2a but with three differences. First, subjects were not given explicit instructions to remember name/words; that is, *incidental* memory was tested. The main reason for this change was that subjects were to be tested immediately after study and it was thought that incidental instructions would help to generate non-ceiling levels of performance. Second, instructions in the semantic study task were made more similar for the Name and Word groups, through the use of examples. In the Name group subjects were instructed to generate a name associated with each surname, e.g. "Noel" for COWARD, or "Neil" for DIAMOND; in the Word group subjects were instructed to generate a word associated with each word, e.g. "bully" for COWARD or "gem" for DIAMOND. Third, *only* explicit memory was tested in an immediate word-stem completion test.

Two subjects in the Name group were replaced because the associates they generated included fewer than 50% of first names, and one subject in the word group was replaced because he included some famous first names in his word associations.

Results

Figure 3 summarises the results of this study. They appear to be very similar to the explicit test results of Experiment 2a, but with higher performance in all conditions. This higher overall performance is probably because subjects were tested immediately, whereas in the previous experiments subjects had performed an implicit memory test first.

Preliminary analysis showed no effect of order of presentation (semantic or graphemic task first) and data were collapsed across this variable. A 2 × 2 ANOVA was performed in which the between-subjects variable was Name/Word Encoding, and the within-subjects variable was Depth of Processing. Only the main effect of Depth of Processing was significant [$F(1,30) = 86.93$, $Mse = 3.52$, $P < 0.001$; semantic processing better]. There was no main effect of Name/Word Encoding ($F = 0.49$) and no interaction between Name/Word Encoding and Depth of Processing.

Discussion of Experiments 2a & b

Although this study again underlines the major effect of depth of processing, no further significant effects were obtained. In particular there was no name-superiority in recall.

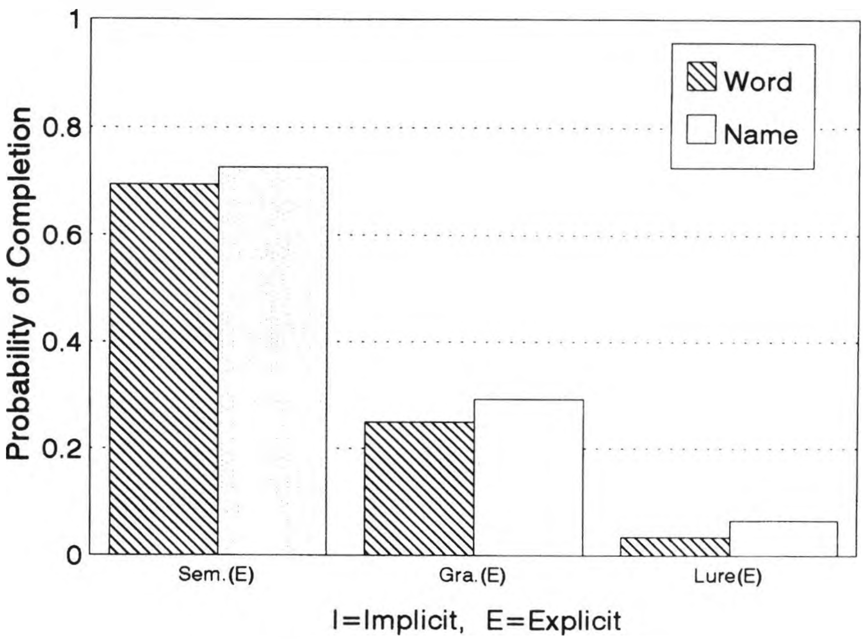

FIG. 3. Name/Word Experiment 2b: mean explicit response probabilities as a function of depth of encoding.

These experiments with different groups of subjects failed to find any significant difference between homographs presented as lists of words and as lists of names in terms of memory performance, whereas other factors manipulated in the tests affected memory reliably. Implicit memory, when tested, was insensitive both to the word/name factor and to depth-of-processing instructions, confirming that perceptual rather than conceptual approaches best fit these data.

These results are in clear contrast to those of Experiment 1 using forenames as cues. The specificity of the cue, and the use of a forename cue at recall or word-completion is critical in generating word/name differences for homographic material.

EXPERIMENT 3: EXPLICIT AND IMPLICIT STEM COMPLETION FOR WORD/NAME HOMOGRAPHS: EFFECTS OF FAMILIARITY (FREQUENCY) DECISION

Experiment 2 failed to show a name/word difference in word-stem cued recall or word-stem completion for either implicit or explicit cued recall. Null effects can arise when an experiment is insufficiently sensitive and/or as a result of noise in the data. The null hypothesis cannot be confirmed logically or statistically. Nevertheless, converging evidence can be brought to bear to examine the strength of the hypothesis. In this study we examine the effects of a different encoding task than that of producing associates.

Our main consideration in selecting the semantic encoding task was to ensure that identical instructions could be given for word and name conditions, and that these would permit specific associations to be made to the items that would call on similar resources for words and names. The task of familiarity decision (how common is this word/name?) also appeared to fit these criteria.

In this study we used a between-subjects design. In Experiment 2a implicit and explicit memory were tested within subjects (although across different materials). It is possible that this was responsible for the pattern of results; in particular, as name/word encoding failed to affect implicit memory, and the implicit task was always performed first, the explicit task that followed may have been affected by performance on the implicit task, although the control experiment (2b) makes this look unlikely.

Method

Subjects. Sixty-four students from Goldsmiths' College, aged 19–35 years, participated in the study. They were allocated randomly to one of four groups of 16 subjects and tested individually.

Design and Materials. The design factors were Name/Word Encoding, Test-Type (implicit vs. explicit) and Depth of Processing (semantic vs. graphemic). Name/Word Encoding and Test-Type were between-subjects factors whereas Depth of Processing was a within-subjects factor with semantic and graphemic tasks counterbalanced for order across subjects within each group. The stimulus material and test sheet were identical to Experiment 2a.

Stimulus material comprised 40 of the 80 name/words used in Experiment 2a. These were divided into four equal-sized sets in which overall frequency and length was balanced across the sets. On the test sheet 44 three-letter word stems appeared, printed in upper case in two columns. The first four word stems were fillers which did not occur in any of the other four stimulus sets. The remaining 40 word stems matched name/words from the stimulus sets, listed in a pseudo-random order. For each subject, two of these sets had been previously encoded; one in a semantic task and one in a graphemic task. The two remaining sets formed lures. Target and lure stems were thus fully counterbalanced.

Procedure. Subjects were randomly assigned to one of the four experimental groups (Name/Implicit, Name/Explicit, Word/Implicit, Word/Explicit). The Name groups were informed that they would perform two tasks on surnames of famous personalities, whereas the Word groups were informed that they would perform two tasks on words. No instructions were given to try to remember these surnames/words. All four groups received similar instructions in the semantic and graphemic tasks. In the semantic task they were required to rate each surname/word for frequency in the population/vocabulary on a scale of 1–3, with 1 being rare and 3 being frequent, and to write their rating down. In the graphemic task they were again required to write down two letters that did not appear in each surname/word presented. The surnames/words were presented on cards at the rate of one card every three seconds.

Subjects were tested immediately. The implicit and explicit tests were similar to those in Experiment 2a but subjects only performed one test. On completion, subjects were asked whether they had noticed anything odd about the names/words they had encoded. In the ''Names'' condition nine subjects noticed that the names were also words, and in the ''Words'' condition four subjects noticed that the words were also names. Subjects who had performed the implicit test were also asked whether they had completed word stems with the first word to come to mind. all the subjects agreed that they had, although most subjects realised that there was a connection between study and test.

Results

The results for each group are summarised in Fig. 4. Corrected probability scores for all the tests were derived by subtracting the probability of lure from

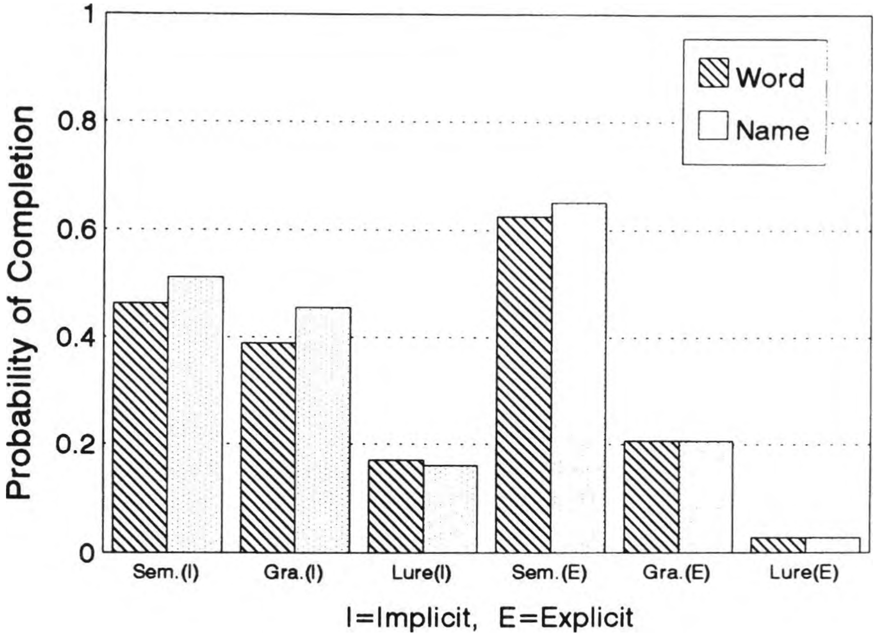

FIG. 4. Name/Word Experiment 3: mean implicit and explicit target and lure response probabilities as a function of depth of encoding (frequency judgement).

target correct probability for each subject. These scores were, once again, significantly different than zero in all conditions. There was priming in all conditions in this task.

A 2 × 2 × 2 ANOVA was performed on corrected probability scores with two between-subjects factors (Name/Word Encoding and Test-Type) and one within-subjects factor (Depth of Processing). There was a significant effect of Depth of Processing [$F(1,60) = 78.14$, $MSe = 2.53$, $P < 0.001$; semantic task better] and a significant interaction between Depth of Processing and Test-Type [$F(1,60) = 42.31$, $MSe = 2.53$, $P < 0.001$] reflecting a significant effect of Depth of Processing for explicit memory only. There was no effect of Name/Word Encoding ($F = 1.029$) and no interaction of Name/Word Encoding with any other factor.

Discussion

In this experiment, which used a between-subjects design, explicit and implicit stem completion, and a frequency-judgement task for deep encoding, the results echo those reported for the previous experiment, with effects of test-type (explicit better) and of depth of processing (semantic better). Again there was a marked interaction between the two, so that although implicit memory was not sensitive to the semantic encoding task, explicit memory was. However this pattern did not include any further effects due to name/word instructions. When encoding instructions led the subject to encode the names as names and the words as words, there was no apparent difference in explicit or implicit memory, tested by cued recall, as a function of this orientation.

GENERAL DISCUSSION

> In the proposition 'Green is green'—where the first word is the proper name of a person and the last an adjective—these words do not merely have different meanings: they are different symbols
>
> Wittgenstein, *Tractatus* 3.323

The three experiments reported here were designed to explore the extent to which words and names might make use of separate routes through memory systems. By using word/famous-name homographs, superficial aspects of presentation (orthographic features, frequency) were controlled. By equating encoding conditions for memorising names and words, and by testing memory using identical (cue-based) procedures for these homographs, the procedures by which material was encoded and remembered were controlled closely, too.

Implicit Memory

In line with findings reported by Valentine et al. (1993) for repetition priming, implicit memory for word/name homographs was not sensitive to conditions of presentation: word stems were reliably completed more often for items that had been seen earlier than those that had not. But it made no difference whether these had been seen as names or words, under deep or shallow encoding conditions. This finding comports with a number of models of the processing of words and names, which have as a common first stage the lexical processing of the letter string. Activation throughout the system then follows in a non-discriminating way, giving rise to such "across the board" effects (see e.g. Burton & Bruce, 1993).

The results of Experiments 2a, 2b and 3 also converge on findings reported by Masson and McLeod (1992), using a different paradigm. In a series of studies of tachistoscopic perceptual identification for written words they found similar levels of priming for homographic words previously generated to a sentence cue. The meaning of the homograph was immaterial: priming was as marked for items generated for the less likely meaning (e.g. *bank*, as in riverbank) as for items generated to fit the primary meaning (e.g. *bank* for money). To the extent that proper names and common words are homographs, these findings are echoed in the present study.

The one exception to this pattern of similar priming for words and names was in Experiment 1, where subjects were required to generate name or word associations on first presentation and were cued to generate a surname on the (explicit or implicit) memory task. Under these conditions *name-specific* memory was seen. One way in which this could come about would be by activation of a further, separate name-specific locus, as has been proposed by Bredart et al. (1995). In order for this proposal to be tested more securely, further experiments are required which would explore the priming of surname word stems, and these are conceptually and practically difficult to perform (under what conditions may a surname be "the first thing that comes into your head"—the *sine qua non* of implicit word-stem completion?) Other paradigms (e.g. identification speed) may be required.

Overall, these findings support a perceptual processing account of implicit memory (Graf & Schacter, 1985) rather than a transfer-appropriate processing account (Blaxton, 1989), with the possible exception of Experiment 1. We cannot, however, go further than this in comparing implicit and explicit memory, and would hesitate to claim that implicit memory necessarily dissociates (empirically and theoretically) from explicit memory on the basis of the data given here.

Explicit Memory

The focus of this set of experiments was on implicit rather than explicit memory; nevertheless, some points are worth making concerning explicit cued recall. Although one recent study (Stanhope & Cohen, 1993) suggests that words might be more readily learned and remembered than names because they are more meaningful, the studies reported here suggest that in the established memory system, and when surface characteristics of stimulus and response are appropriately controlled, there is little sign of such an advantage in explicit recall when subjects were required to generate specific associates or to judge frequency of the to-be-remembered item. Memorability for names and words was sensitive to other factors, such depth of encoding, but not differentially so. The manipulations in the present study may, of course, not have been suitable for such differences to emerge.

Bruce et al. (1994) suggest that it may be misguided to use current models of name and word processing to predict relative differences in overt memorability of names and words, and, on the whole, we concur. However, the enhanced memorability of names under the name-specific encoding conditions of Experiment 1 suggests that the associations between forenames and surnames are special. In that study, unlike the following ones, there was no interaction between implicit recall and the name/word factor; both explicit and implicit cues gave rise to a name advantage. Names are not only unique to the individual but may be instantiated in a separate part of the system which can be activated by *specific* name-information. Further studies will test the adequacy of this conclusion.

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APPENDIX 1

Names/Words Experiment 1

Targets:	*Fillers:*
Noel COWARD	Roy CASTLE
Bob HOPE	James HUNT
Edward HEATH	Gregory PECK
Robin HOOD	Anne DIAMOND
Norman WISDOM	George BUSH
Judy GARLAND	Jimmy YOUNG
Oliver TWIST	Buddy HOLLY
John MAJOR	Mr BEAN
Tom CRUISE	
Michael WINNER	
David FROST	
Charles DANCE	
Bryan FERRY	
Gary GLITTER	
Freddy MERCURY	
Christopher WREN	

APPENDIX 2

Names/Words Experiments 2 & 3

Set A	*Set B*	*Set C*	*Set D*
ARCHER	BACON	BARBER	BISHOP
BLACK	BLOOM	BROWN	BOND
BUSH	CARPENTER	CASTLE	CHASE
CHERRY	CLOSE	COOK	COTTON
COWARD	CRANE	CRISP	CRUISE
DANCE	DIAMOND	DOMINO	DRAKE
FAITH	FAME	FARROW	FERRY
FOOT	FROST	FORD	GARLAND
HAMMER	GREEN	GLITTER	GRANT
HUNT	HEATH	HOLLY	HOOD
LANE	HURT	KING	LAMB
MILLER	LAUREL	MARSH	MERCURY
PHOENIX	MOLE	NIGHTINGALE	PEEL
READ	POPE	PORTER	PRICE
SERGEANT	REED	RICE	ROSE
SNOW	SHEPHERD	SILVER	SMART
STEEL	SOUL	SUMMER	STARK
TWIST	STONE	THAW	SWIFT
WISDOM	VALENTINE	WHITE	WINNER
WORTH	WONDER	WOOD	YOUNG

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Age differences in memory for prospective compared with retrospective subject-performed tasks

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In two experiments, younger and older adults studied three lists of verbal phrases, each of the latter describing a simple action. One list was studied and recalled verbally; one was recalled verbally, but the actions were performed at study [retrospective SPTs (subject-performed tasks)]; and one was studied verbally and the actions were performed at test (prospective SPTs). With long lists, but not with short ones, retrospective-SPT recall exceeded verbal recall and older adults recalled fewer SPTs than did younger adults. Prospective-SPT recall did not exceed verbal recall at either list length, and in each of these prospective-SPT tests, older adults recalled fewer action phrases than did younger adults. Thus, it appears that when retrospective and prospective tasks are equated there are marked age differences that are generally consistent with the view that memory impairment in the elderly is more likely to occur in tasks that make higher attentional processing demands.

Recent years have seen the development of at least two distinct lines of research on memory for actions. One line of research concerns memory for actions that a person performed in the past. Another concerns memory for actions that a person intends to perform in the future, termed "prospective memory." As the White Queen remarks in *Alice Through the Looking Glass*, "It's a poor sort of memory that only works backwards."

Memory for actions that a person performed in the past has commonly been studied by presenting subjects with brief verbal phrases, each of which describes a simple action—such as "peel a banana" or "raise your hat." Subjects either perform the actions at study—a condition referred to as "subject-performed tasks" (SPTs)—or learn the phrases verbally. They then take a verbal recall test.

Recall of SPTs is often (though not always) superior to verbal recall and seems to differ from verbal recall in a number of other ways (see, e.g., Cohen, 1981, 1983). For example, recall of SPTs shows no primacy effects. It has been suggested that SPTs are encoded more automatically or in a more elaborative form, with multimodal components that include visual and motor components (for a brief review, see Nilsson & Craik, 1990).

We are grateful to Lars-Goran Nilsson for providing us with translations of the action phrases used in his studies. In addition, we thank members of the University of the Third Age for their cooperation. Barbara Brooks is now at the Department of Psychology, Goldsmiths' College, University of London, New Cross, London SE14 6NW. Correspondence on this article should be addressed to John Gardiner, Department of Psychology, City University, Northampton Square, London EC1V 0HB, U.K.

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Memory for actions that a person intends to perform at some future time has been studied using a variety of tasks both in the laboratory and in the natural environment (for a review, see Morris, 1992). In the laboratory these tasks have included pressing a particular key (Schonfield & Shooter, reported by Welford, 1958) and changing pens at some later point in the procedure (Dobbs & Rule, 1987). In the natural environment these tasks have included keeping a diary, making a telephone call, and mailing a card with a particular message (Moscovitch, 1982; Poon & Schaffer, 1982; West, 1984). All these tasks, too, might equally well be termed SPTs, although in these studies, unlike traditional SPT research, subjects have typically been required to remember to perform only one task, or at most a few, and to remember to do so at a particular time without being further prompted by the experimenter. Unlike previous research, our concern is mainly with memory for what the actions are rather than for the time at which they have to be performed.

There has been relatively little research on memory for tasks to be performed in the future and, until the present study, there had been none in which a direct comparison has been made between what we shall call memory for prospective SPTs and memory for retrospective SPTs. One major aim of the present article is to report the results of such a comparison. A key feature of this comparison, of course, is that the same tasks are used in prospective and retrospective performance conditions. In previous studies, prospective and retrospective memory tasks have been different (e.g., Einstein & McDaniel, 1990; Kvavilashvili, 1987; Maylor, 1990; Wilkins & Baddeley, 1978).

In making this comparison we took a lead from a procedure developed by Koriat, Ben-Zur, and Nussbaum

(1990) for studying what we refer to as prospective SPTs. Koriat et al. had subjects study action phrases for either a verbal recall test or a test in which the actions had to be performed. Across a variety of conditions in each of three experiments, Koriat et al. found that subjects actually recalled more of the actions when they had to perform them in the test. Koriat et al.'s third experiment deliberately paralleled the procedure used in retrospective SPT research in that it had a larger, more varied set of tasks and a longer retention interval. In discussion, Koriat et al. suggested that there may be similarities between the effect they obtained and retrospective-SPT recall: Both phenomena might reflect similar representational properties—elaborative properties that involve visual and motor components. On the other hand, Koriat et al. found that there were primacy effects in their performance condition, effects that are not found in retrospective-SPT recall. This suggests that memory for prospective tasks is less automatic and more effortful than memory for retrospective tasks.

A second major aim of the present article was to report further evidence on these issues provided by a comparison of how well younger and older adults did in both retrospective- and prospective-SPT recall.

With respect to both retrospective and prospective tasks, evidence from previous studies of age differences is equivocal. Earlier studies of retrospective SPTs showed that age differences were greatly attenuated (Backman & Nilsson, 1984, 1985), but more recent studies have found age differences in retrospective-SPT recall similar to those obtained following verbal-study conditions (Cohen, Sandler, & Schroeder, 1987; Nilsson & Craik, 1990).

Craik and Jennings (1992) point out that further work is obviously needed to resolve this discrepancy. They also suggest that neither presentation rate nor list length is likely to be the differentiating variable, because the different outcomes have been obtained with the same presentation rate, and the same outcomes have been obtained with short and long lists. The evidence concerning possible list-length effects, however, is not strong. In one study, the comparison between long and short lists was made between experiments—experiments that differed with respect to various other conditions, too (Nilsson & Craik, 1990). In the other case, where the list-length comparison was made within one experiment, there was at least a tendency for age differences in SPT recall to be attenuated with short lists (see Cohen et al., 1987, Figure 3).

Nor is the evidence from previous studies of actions to be performed in the future any less equivocal. Some studies have found no age-related memory decrement in such tasks (Cockburn & Smith, 1988; Einstein & McDaniel, 1990; West, 1988). In other studies, or other conditions of the same studies, it has been found that older adults do less well than younger adults (Cockburn & Smith, 1988; Dobbs & Rule, 1987; West, 1988). What any differentiating variable might be in such studies is even less clear, not least because of the greater variety of tasks used and because, in studies carried out in the natural environment, many variables remain uncontrolled.

Craik's (1983, 1986) theory of age-related decrements in memory is that they are most likely to occur under more demanding task conditions, conditions that provide little or no "environmental support" at either encoding or retrieval. That is, age differences are most likely to occur when encoding or retrieval tasks "require self-initiated constructive operations"—operations that require more attention and effort (Craik, 1983, p. 350). Essentially, older people carry out such self-initiated processing less efficiently. As Einstein and McDaniel (1990) argued, according to this theory one would expect marked age differences in prospective SPTs. In contrast, retrospective SPTs provide very strong environmental support at encoding, including activation of the motor system (Engelkamp & Zimmer, 1985). Older adults may sometimes benefit disproportionately from this support because younger adults are more adept at spontaneously initiating the richer, more elaborative encoding that these SPTs provide automatically (see Craik & Jennings, 1992). Thus, Craik's theory predicts that, other things being equal, age differences are more likely with prospective SPTs than with retrospective SPTs. Moreover, this theory further predicts that age differences within retrospective-SPT recall should also increase if the task is made more demanding in other ways.

Alternatively, taking the view that both prospective and retrospective SPTs share similar underlying representational properties (Koriat et al., 1990), one could predict that there might be parallel effects of age in the two kinds of task.

EXPERIMENT 1

In this experiment, younger and older adults studied three lists of 15 action phrases. One list was studied verbally for a verbal recall test; one was studied verbally for subjects to perform the actions at test (prospective SPTs); and one was recalled verbally after subjects had performed the actions at study (retrospective SPTs).

The action phrases were based on those used in previous similar studies (Backman & Nilsson, 1984; Koriat et al. 1990; Nilsson & Craik, 1990), except that all of them involved an imaginary object. In previous studies the actions have usually been more varied, sometimes also involving real objects or no object. We used only actions involving imaginary objects because Koriat et al. reported that these were the actions that produced the largest advantage in prospective SPTs.

Method

Subjects. Two groups of 18 volunteer subjects each participated in the experiment. One group consisted of 8 female and 10 male undergraduate students from City University, London, with an age range of 18-32 years and a mean age of 20 years. The other group was composed of 11 female and 7 male older adults, most of whom were members of the University of the Third Age, with an age range of 60–83 years and a mean age of 69 years. All subjects were community dwelling and non-institutionalized. They were tested individually and were paid for their participation in the experiment, which lasted approximately 30 minutes. Older subjects performed significantly better than younger subjects on a shortened version of the Mill Hill Vocabulary Test [mean scores 17.17 vs. 13.89, $t(34) = 4.56$, $p < .001$]. Younger subjects had more years of full-time education than older subjects, but the difference was not significant [mean years 13.89 vs. 12.86, $t(34) = 1.42$, $p > .10$].

Design and Materials. The factors were age (younger vs. older adults) and task (retrospective-SPT vs. prospective-SPT vs. verbal-control tasks). Task was a within-subject factor, with the three tasks counterbalanced for order across subjects within each age group.

Stimulus material comprised 60 cards, each typed with an action phrase involving an imaginary object—for example, "fly a kite," "beat an egg," "pump up a bicycle tyre." (A full list of these action phrases is available on request.) Fifteen cards were set aside to be used as practice cards; the remaining 45 were randomly allocated to three equal sets. During the experiment, six different random allocations of these 45 cards were used and each allocation was counterbalanced across the three tasks.

Procedure. Subjects were tested individually. They initially read an explanatory note describing the procedure. Before each critical study phase, the subjects were presented and tested with five action phrases for practice with each particular study and test procedure to ensure that they knew in advance exactly what the study and test conditions were. During each critical study phase, the subjects heard the experimenter read aloud 15 action phrases at six-second intervals. There followed a short oral instruction appropriate for the test. In the retrospective-SPT condition, the subjects performed the tasks after each phrase was presented. They then recalled orally any tasks they remembered. In the prospective-SPT condition, the subjects listened to the phrases anticipating that they would be required to perform the tasks. They then performed any tasks they remembered. In the verbal-control condition, subjects listened to the phrases and recalled orally any they remembered. For each test, subjects were allowed about two minutes for recall. When all three tests had been completed, subjects spent 10 minutes performing a shortened version of the Mill Hill Vocabulary Test.

A lenient scoring procedure was used for prospective SPTs. If a task could be clearly recognized it was allowed. On two occasions, a subject's performance proved impenetrable and he or she was asked to name the task.

Results and Discussion

The principal results of the experiment are summarized in Figure 1. The main features of these results are readily apparent. Younger adults' memory performance was similar for all three lists, although there was a tendency for recall of retrospective-SPT lists to exceed recall of the other two. In contrast, older adults were markedly impaired in their recall of both prospective-SPT lists and verbal-control lists, but recalled considerably more from retrospective-SPT lists, so that for the latter, age differences were essentially absent.

Statistical analyses of variance (ANOVAs) support the foregoing description of the data. In these analyses, the alpha level was set at .05 throughout. Since preliminary analyses showed no significant effect of order and no significant interaction between order and task or age, data were collapsed across this variable.[1] A 2×3 ANOVA was then performed with the factors age and task. There was a significant main effect of age [$F(1,34) = 13.39$, $MS_e = 4.21$] and of task [$F(2,68) = 12.69$, $MS_e = 2.62$], and

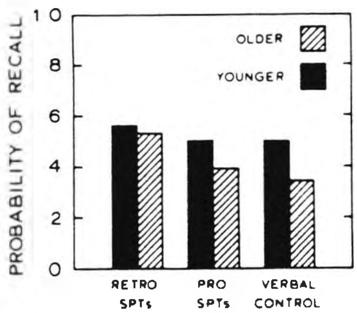

Figure 1. Probability of task recall as a function of age.

the interaction between task and age was also significant [$F(2,68) = 3.70$, $MS_e = 2.62$].

Tukey *HSD* comparisons, performed to trace the source of the above interaction, showed that age was not significant in retrospective-SPT recall ($p = .993$), that it approached significance in prospective-SPT recall ($p = .079$), and that it was significant in verbal-control recall ($p = .002$).

Separate ANOVAs were performed to investigate differences between the three tasks within each age group. No significant difference between the three tasks was found for younger subjects [$F(2,34) = 1.18$, $MS_e = 3.32$], but there was a significant difference for older subjects [$F(2,34) = 20.32$, $MS_e = 1.92$].

Tukey *HSD* comparisons performed on older subjects' scores showed significant differences between retrospective-SPT and verbal-control recall ($p < .001$), and between retrospective- and prospective-SPT recall ($p = .003$), but not between prospective-SPT and verbal-control recall ($p = .77$).

The serial position data for the three tests were recorded. To reduce noise, these data were combined over each three consecutive serial positions. These data are summarized in Table 1. The important issue concerning these data is whether there are primacy effects in prospective SPTs (Koriat et al., 1990) and not in retrospective SPTs (Cohen, 1981, 1983). The presence of primacy effects was assessed by comparing probabilities of recall for serial positions 1–3 with probabilities of recall for serial positions 7–9. Separate 2×2 ANOVAs were performed for each of the three tests, with serial position as the first factor and age as the second factor. There was no significant effect of serial position in retrospective-SPT recall [$F(1,34) = 1.44$, $MS_e = 0.62$]. There were significant effects of serial position both in prospective-SPT recall [$F(1,34) = 13.63$, $MS_e = 0.74$] and in the verbal-control condition [$F(1,34) = 11.52$, $MS_e = 0.69$]. The only other significant effects in these analyses were main effects of age both in prospective-SPT recall [$F(1,34) = 6.78$, $MS_e = 0.74$] and in the verbal-control condition [$F(1,34) = 11.52$, $MS_e = 0.69$].

Thus, the results of this experiment show some similarities and some differences compared with those obtained

Table 1
Probability of Recall as a Function of Serial Position, Age, and Task in Experiment 1

Age/Task	Serial Positions 1-3	4-6	7-9	10-12	13-15
Younger Adults					
Retrospective SPT	.51	.60	.62	.67	.93
Prospective SPT	.80	.69	.47	.47	.56
Verbal	.82	.51	.44	.44	.80
Older Adults					
Retrospective SPT	.62	.44	.69	.62	.80
Prospective SPT	.56	.47	.29	.42	.62
Verbal	.49	.36	.33	.35	.53

in previous studies. Most surprising, perhaps, is the failure to replicate Koriat et al.'s (1990) effect of superior recall of prospective SPTs compared with the verbal-control condition. No obvious reason for this difference is apparent, particularly given that our experiment was closely modeled on Koriat et al.'s third experiment and used the kind of actions that, in their experiment, produced the largest effect. On the other hand, our experiment did replicate their finding of primacy effects in this prospective task.

Other studies than ours have found little difference in younger adults' recall of retrospective-SPT lists and verbal-control lists (Backman & Nilsson, 1984, 1985). In these studies list lengths have been short. With short lists, it is quite likely that sometimes younger adults spontaneously initiate rich, elaborative encoding strategies that offset any possible benefits from encoding these SPTs. Older adults are less likely to be able to do this and so benefit more from the environmentally driven encoding that these retrospective SPTs automatically provide (Craik, 1983, 1986).

More broadly, insofar as list length affects general task difficulty, it is possible that this factor is sometimes implicated in determining both the circumstances in which younger adults show superior recall of retrospective SPTs and the circumstances in which older adults benefit disproportionately from such tasks. As we mentioned in the introduction, evidence concerning this possibility is sparse, but data reported by Cohen et al. (1987, Figure 3) are at least suggestive of it. Experiment 2 was designed to provide further evidence.

EXPERIMENT 2

Essentially, Experiment 2 was a replication of Experiment 1 with the added factor of list length. Younger and older adults received the same three study-test conditions as before, but for lists both of 12 action phrases (slightly shorter but fairly similar to list length in Experiment 1) and of 24 action phrases.

Method

Subjects. Two groups of 18 volunteer subjects each participated in the experiment. One group consisted of 11 female and 7 male students from City University, London, with an age range of 18-34 years and a mean age of 25 years. The other group comprised 11 female and 7 male older adults, most of whom were members of the University of the Third Age, with an age range of 60-78 years and a mean age of 68 years. All subjects were community dwelling and non-institutionalized. They were tested individually and were paid for their participation in the experiment, which lasted approximately 30 minutes. Older subjects performed significantly better than younger subjects on a shortened version of the Mill Hill Vocabulary Test [mean scores 10.72 vs. 14.83, $t(34) = 2.63, p < .025$]. Younger subjects had spent longer than older subjects in full-time education [mean years 16.33 vs. 11.89, $t(34) = 4.49, p < .001$].

Design and Materials. The factors were age (younger vs. older adults), task (retrospective-SPT vs. prospective-SPT vs. verbal-control tasks), and list length (short vs. long lists). Task and list length were within-subject factors, with the six conditions counterbalanced for order across subjects within each age group.

Stimulus material comprised 117 cards, each typed with a different action phrase. Nine cards were used as practice cards. The remaining 108 cards were randomly allocated to three sets of 12 cards and three sets of 24 cards. As in Experiment 1, six different random allocations of these cards were used, with each allocation counterbalanced across the three tasks.

Procedure. The procedure was similar to that of Experiment 1, except that each subject had six lists—two for each task, one a short list and the other a long list.

Results and Discussion

The principal results of this experiment are summarized in Figure 2, from which it is apparent that, for the short lists, these results are similar to those of Experiment 1. The younger adults' memory performance was similar for all three lists, although there was a slight tendency toward lower recall of prospective-SPT lists. The older adults were again markedly impaired in their recall both of prospective-SPT lists and of verbal-control lists, but recalled disproportionately more from retrospective-SPT lists. With the long lists, a different pattern of data emerged. Both younger and older adults benefited to a similar extent from retrospective SPTs, compared with the verbal controls; and similar age differences are apparent for all three tasks. Finally, it is obvious once again that the experiment did not replicate the superior recall of prospective SPTs reported by Koriat et al. (1990).

Statistical analyses support the foregoing description of the data. Since preliminary analyses showed no significant effect of task order and no significant interaction involving task order, data were collapsed across this vari-

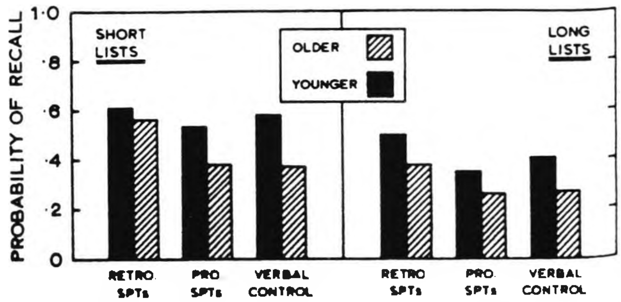

Figure 2. Probability of task recall as a function of age and list length.

able.[2] A 2×2×3 ANOVA was then performed with the factors age, list length, and task. There were significant main effects of age [$F(1,34) = 24.82$, $MS_e = 0.04$], list length [$F(1,34) = 95.08$, $MS_e = 0.01$], and task [$F(2,68) = 31.37$, $MS_e = 0.01$]. There was a significant interaction between task and age [$F(2,68) = 3.21$, $MS_e = 0.01$], but not between list length and age [$F(1,34) < 1$] or between list length and task [$F(2,68) < 1$]. The overall interaction between age, list length, and task was significant [$F(2,68) = 4.17$, $MS_e = 0.01$].

Tukey *HSD* comparisons were performed between the three short lists and between the three long lists to trace the source of the interaction between test and age. Between the three short lists, the effect of age was not significant for retrospective-SPT recall ($p = .854$), but it was significant for prospective-SPT recall ($p = .013$) and for verbal-control recall ($p < .001$). Between the three long lists, the effect of age was significant for retrospective-SPT recall ($p = .006$), approached significance for prospective SPT recall ($p = .076$), and was significant for verbal-control recall ($p = .002$).

Separate ANOVAs were performed to investigate differences between the six lists within each age group. For younger subjects, there were significant effects of list length [$F(1,17) = 87.29$, $MS_e = 0.01$] and task [$F(2,34) = 10.7$, $MS_e = 0.01$], and the interaction between list length and task just reached significance [$F(2,34) = 3.26$, $MS_e = 0.01$]. For older subjects, there were also significant effects of list length [$F(1,17) = 29.8$, $MS_e = 0.02$] and task [$F(2,34) = 23.53$, $MS_e = 0.01$], but the interaction between list length and task was not significant [$F(2,34) = 1.82$, $MS_e = 0.11$].

Tukey *HSD* comparisons performed on younger subjects' scores showed no significant differences in recall between the three short lists. For the three long lists, there were significant differences between retrospective- and prospective-SPT recall ($p = .001$) and between retrospective-SPT and verbal-control recall ($p = .038$), but not between prospective-SPT and verbal-control recall ($p = .354$).

Tukey *HSD* comparisons performed on older subjects' scores showed significant differences for the short lists between retrospective- and prospective-SPT recall ($p = .002$) and between retrospective-SPT and verbal-control recall ($p = .001$), but not between prospective-SPT and verbal-control recall ($p = .926$). For the three long lists, there were significant differences between retrospective- and prospective-SPT recall ($p = .001$) and between retrospective-SPT and verbal-control recall ($p = .004$), but not between prospective-SPT and verbal-control recall ($p = .950$).

Serial-position data were also recorded in this experiment, but it is not worth reporting these in any detail because they add little of any importance to the serial-position data summarized in Table 1. In Experiment 2, as well, whereas there were primacy effects in prospective SPTs, there were no such effects in retrospective SPTs.

GENERAL DISCUSSION

The two experiments reported here provide a direct comparison between memory for retrospective and prospective SPTs in younger and older adults. In addition, general task difficulty was manipulated by comparing short with long lists. There were two main findings. First, it was found that both age differences in retrospective-SPT recall and the superior recall of these SPTs depended on list length. With short lists, older adults recalled about as many retrospective SPTs as did younger adults and, unlike the older adults, younger adults recalled about as many of these SPTs as they did the equivalent verbal phrases. With long lists, both younger and older adults showed superior recall of retrospective SPTs compared with their recall of the equivalent verbal phrases, and these SPT effects were similar for each age group. In addition, older adults showed a similar decrement across all three tasks. Second, it was found that there was little difference between the recall of prospective SPTs and that of the equivalent verbal phrases in either younger or older adults. We discuss each of these findings in turn.

The first of these findings is consistent with the idea that with short lists younger adults have little difficulty in spontaneously engaging in rich, elaborative encoding strategies that largely offset the encoding benefits that retrospective SPTs provide automatically. For younger adults, these benefits emerge with longer lists, which demand much more effortful processing.

Older adults, however, have fewer attentional resources than younger adults (Craik & Byrd, 1982) and are less capable, even with short lists, of spontaneously being able to encode in a rich, elaborative fashion. In these circumstances, older adults show superior recall of retrospective SPTs, and their recall of these lists is similar to that of younger adults. With long lists, where task demands are high, both younger and older adults show similar retrospective-SPT effects.

These findings are clearly consistent with Craik's (1983, 1986) theory of age-related impairments in memory, and they go some way toward resolving the apparent discrepancy between earlier and more recent studies of age differences in retrospective-SPT recall (Craik & Jennings, 1992). Moreover, the only previous study in which list length was manipulated within one experiment found similar results. Cohen et al. (1987) found significant age differences in SPT recall with long lists but not with short lists. In that study, however, unlike ours, younger as well as older adults benefited from retrospective-SPT recall even with short lists, which suggests that other factors may contribute to and interact with these list-length effects.

Our second main finding was that there was no evidence of the superior memory that Koriat et al. (1990) had found for prospective SPTs compared with the equivalent verbal phrases. The failure to replicate this effect is particularly puzzling because the SPT conditions in our experiments were closely modeled on the conditions used in their third experiment and we deliberately chose the kinds of actions that Koriat et al. found gave rise to the largest effect—namely, those involving imaginary objects.

Clearly, replicability per se is not in question. Koriat et al. (1990) replicated their effect across a variety of conditions in each of three experiments. Similarly, across all conditions of our two experiments there are no less than six replications of the critical contrast. The evidence therefore points to some as-yet-unknown boundary conditions which limit the generality of the effect. It will obviously require additional research to resolve this issue.

While it seems unlikely, for the reasons we have already discussed, that differences in the nature of the actions used can be the crucial factor, it is possible that differences in the subject populations might be. Koriat et al. (1990) suggested that their effect might reflect greater visual and motoric encoding when subjects anticipate having to perform the actions rather than merely recall verbal phrases. Maybe students in Haifa show more initiative in this respect than students in London; it would not be the first time, even with respect to our own laboratory, that differences between results found by different researchers have turned out to be due to differences in the nature of the subjects (see Gardiner, Gregg, & Hampton, 1988; Nairne, Pusen, & Widner, 1985; Nairne & Widner, 1988).

Be that as it may, our experiments provide evidence of several dissociations between memory for prospective and retrospective SPTs. These dissociations involve age-related effects, list-length effects, and primacy effects. In general, memory for prospective SPTs was shown to be similar to verbal recall of the action phrases. It was retrospective-SPT recall that proved the odd one out. Thus, our evidence weakens the case for supposing that memory for actions is fundamentally similar in retrospective and prospective tasks.

The terms "retrospective" and "prospective" have been used here strictly to refer to tasks (or task performance). Specifically, they refer to whether, at the end of the study period, the subject has already performed the actions or intends to perform the actions in the forthcoming test. For several reasons, we have avoided the terms "retrospective memory" and "prospective memory."

One reason is that the latter terms have been used in the literature to refer to different forms of memory as well as to different memory tasks. Morris (1992), for example, discussed prospective memory both as a memory system and as a type of task. Gardiner and Java (1993) have argued that memory theory needs to reform its use of terminology so as to avoid such confounding of terms (see also Roediger & McDermott, in press).

The terms retrospective memory and prospective memory are confusing for another reason, reminiscent of the White Queen's discourse on memory in *Alice Through the Looking Glass*. Memory is inherently both retrospective and prospective; it always works both backwards and forwards in time. Consider the three main conditions in the present experiments. In all three conditions, recall performance is retrospective in relation to the verbal phrases presented at study and prospective in relation to the test and the subject's intentions to perform that test. Thus even to label these *conditions* as either retrospective or prospective memory would be misleading; it is the *actions* that are retrospective or prospective, depending on whether they were performed at study or were intended to be performed at test.

The intention to perform the actions at test must depend on memory for the verbal phrases, and our data, unlike the data obtained by Koriat et al. (1990), revealed no functional differences between this prospective-SPT condition and the verbal-recall control condition. As we pointed out in the introduction, this prospective-SPT condition differs in several ways from the conditions that have usually been investigated under the rubric of "prospective memory." Theoretical claims that memory for actions that a person intends to perform in the future is a different form of memory to that observed in standard laboratory tests, such as free recall, have typically confounded the prospective versus retrospective comparison with gross differences in the nature of the tasks. The prospective-SPT condition as used in the present studies, when combined with the retrospective-SPT and verbal-control conditions, does at least allow such comparisons to be made in a relatively unconfounded way. And under these unconfounded conditions, there is little evidence that memory for future actions—at least in terms of what the actions are, if not in terms of the time at which they have to be performed—differs much from what used to be called verbal memory.

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NOTES

1. The details concerning order effects were as follows: for the main effect of order [$F(2,30) = 1.55$, $MS_e = 4.30$]; for the interaction between order and task [$F(4,60) = 1.19$, $MS_e = 2.71$]; for the interaction between order and age [$F(2,30) < 1$, $MS_e = 4.30$]; for the interaction between order, task, and age [$F(4,60) < 1$, $MS_e = 2.71$].

2. The details concerning order effects were as follows: for the main effect of order [$F(2,30) = 1.14$, $MS_e = 0.04$]; for the interaction between order and task [$F(4,60) < 1$, $MS_e = 0.01$]; for the interaction between order and age [$F(2,30) < 1$, $MS_e = 0.04$]; for the interaction between order and list length [$F(2,30) < 1$, $MS_e = 0.01$]; for the interaction between order, task, and age [$F(4,60) < 1$, $MS_e = 0.01$]; for the interaction between order, task, and list length [$F(4,60) < 1$, $MS_e = 0.01$]; for the interaction between order, age, and list length [$F(2,30) = 2.21$, $MS_e = 0.01$]; for the interaction between order, task, age, and list length [$F(4,60) = 1.60$, $MS_e = 0.01$].

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A comparison of serial position effects in implicit and explicit word-stem completion

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In this study I examined a further possible dissociation between implicit and explicit memory—whether implicit memory produces serial position effects that are similar to those found in explicit memory. When implicit word-stem completion and explicit word-stem cued recall were compared, only the explicit test showed significant primacy and recency effects. The explicit test was sensitive to the order in which stimuli words were encoded, but the implicit test was not. This dissociation between implicit and explicit memory provides further evidence that conscious retrieval processes were not involved in the implicit test.

In their review of implicit memory, Roediger and McDermott (1993) stated that "Although examination of serial position effects has guided research about other issues in the study of memory, work on implicit memory is a clear exception at this point in time" (Roediger & McDermott, 1993, p. 115). Referring specifically to primacy effects, they noted that "the voluminous implicit memory literature is almost mute on the issue as to whether a primacy effect exists on any implicit memory test" (Roediger & McDermott, 1993, p. 115).

The general consensus of opinion is that primacy effects arise from either more rehearsal (elaborative or rote) or greater attention devoted to the first few items in a to-be-remembered list than to the remaining items (Atkinson & Shiffrin, 1968; Craik & Lockhart, 1972; Glenberg et al., 1980; Rundus, 1971).

There is less consensus about the explanation for recency effects. The standard theory is that recency effects in free recall occur because subjects off-load the contents of their short-term memory prior to retrieving items from long-term memory (Craik, 1970; Glanzer & Cunitz, 1966). Indeed, the recency effect disappears when a subject is asked to count backward for 30 sec before recalling a list of words (Glanzer & Cunitz, 1966). Doubts about this explanation arose when Bjork and Whitten (1974) reported a long-term recency effect, which occurred when 12 sec of distractor task preceded the presentation of each study item. This long-term recency effect survived a 20-sec retention interval in which the same distractor task was performed. Presumably, any items in short-term memory would have been displaced during this period. A number of explanations for the long-term recency effect have been proposed. They include the strategic use of short-term memory (Poltrock & MacLeod, 1977), the distinctiveness of the most recent items in a well-ordered series (Bjork & Whitten, 1974; Glenberg et al., 1980), and retrieval using ordinal information (Baddeley & Hitch, 1977; for a brief review see Greene, 1986).

Although they differ in their explanations, one assumption that all these theories make is that serial position effects reflect conscious retrieval of studied items. If this assumption is correct, serial position effects should not occur in implicit memory tests that assess indirect memory for a study episode. Implicit memory tests do not require subjects to consciously refer back to that episode and should not reflect any evidence of effortful retrieval. For example, a variable such as levels of processing, which manipulates the extent of conscious recollection in normal subjects, produces a significant effect in explicit but not in implicit memory tests (see Roediger & McDermott, 1993, for a review).

There have been only four studies investigating whether primacy or recency effects occur in implicit memory tasks. The first, by Sloman, Hayman, Ohta, Law, and Tulving (1988, Experiment 1), indicated the existence of a recency effect and a single-item primacy effect in primed word-fragment completion. However, a closer examination of the experimental procedure in that study reveals that word-fragment completion involved both effortful and automatic memory processes. The instructions to the subjects stated that they were to "try to complete each fragment with a study-list word" (Sloman et al., 1988, p. 227). It is possible that the effortful component of the task was responsible for the serial position effects obtained.

In the second study, McKenzie and Humphreys (1991) found a significant recency effect in implicit word-stem completion. Their subjects completed significantly more word stems in an immediate test than they did in a delayed test. However, this recency effect is different from the short-lived recency component of the serial position curve, which disappears if a subject is asked to count backward

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for 30 sec before recalling a list of words (Glanzer & Cunitz, 1966).

In a more relevant previous study, Rybash and Osborne (1991) investigated serial position effects in free recall, implicit word-stem completion, and explicit word-stem cued recall. Their results indicated that all three tests produced a significant recency effect, but only free recall produced a significant primacy effect. Since no details about presentation orders were included in the methodology, it may be inferred that all of their subjects were presented with the study words in the same order. The first few words may have been less memorable or less easily completed than the remaining words, negating any possible primacy effects in all but the free-recall test. Similarly, the last few words may have been more memorable or more easily completed, producing a spurious recency effect in the cued-recall and word-stem completion tests. The significant recency effect in the word-stem completion and cued-recall tests was surprising because the test sheet contained 48 word stems, and any recency effects would presumably have disappeared before the relevant word stems were completed.

The latest study to investigate serial position effects in implicit word-stem completion was performed by Gershberg and Shimamura (in press). In two of three experiments they found transient primacy effects in implicit word-stem completion, which only occurred when the first half of the word stems tested were analyzed separately. They also found transient recency effects in one of three experiments. It should be noted, however, that they did not find consistent primacy effects in an explicit test of word-stem cued recall, nor did they find consistent recency effects in an immediate word-stem cued-recall test or even in an immediate free-recall test. There is therefore clearly a need for evidence of serial position effects in explicit tasks in conjunction with effects—or a lack of them—in implicit tasks.

The purpose of the present study was to provide reliable evidence as to whether serial position effects exist in implicit word-stem completion. An explicit test of word-stem cued recall was included, in which the test stimuli and study instructions were identical to the implicit test and only the test instructions differed. The results of these two tests therefore fulfilled the retrieval intentionality criterion of Schacter, Bowers, and Booker (1989) and could be directly compared. Any differences in the results would be attributable to the different test instructions.

EXPERIMENT 1

Experiment 1 was devised to investigate whether a primacy effect exists in an implicit word-stem completion test. Word stems were completed under explicit or implicit test instructions, but all other aspects of the study were the same. The order of presentation of words was rotated so that any significant results would be reliable and not contaminated by differences in word memorability or ease of completion. The serial positions of target word stems completed in the two tests were compared to see whether there were any differences in the effects obtained.

Method

Subjects. Thirty-six students from City University, London, and Goldsmiths College, University of London, age range 18–36 years, participated in the experiment. They were randomly allocated to two groups of 18 subjects each, and were tested either individually or in pairs.

Design and Materials. The design factors were test (implicit vs. explicit) and serial position; test was conducted between subjects, and serial position was conducted within subjects.

The stimulus material comprised 36 cards. Printed on each card in capital letters was a six-letter noun; these words were selected from materials prepared by Java (1991; Java & Gardiner, 1991). The first three letters of each word formed the initial word stem of at least six words found in the *Concise Oxford Dictionary*.

The 36 cards were randomly allocated to two sets of 18 words. During the course of the experiment, the two card sets were counterbalanced so that when one set was presented as target words, the other set formed the lure words. The cards within each set were sequentially numbered from 1–18. The sequential order of each set of cards was kept constant during the course of the experiment, but the positional order varied. Each set of cards was advanced by two numbers after it had been presented once in the implicit and once in the explicit memory task. This procedure resulted in each word's appearing once in every other serial position.

The test order was held constant in the form of one test sheet of 40 three-letter word stems, printed in capital letters in two columns. The first 4 word stems were filler items, followed by word stems from both sets of words, listed in a pseudorandom order with no more than 3 consecutive word stems from one set.

Procedure. The subjects were randomly assigned to either the implicit or explicit test group and were tested either individually or in pairs. Both groups received the same preliminary instructions—to try to memorize the words they were about to see. One set of 18 words was then shown to them on cards, one card at a time for 2 sec. After 1 subject from each group had been presented with the cards in an identical order, the positional order of the cards was advanced by 2 words (while keeping the sequential order the same) before the cards were presented again. In addition, alternate subjects in each group received a different set of cards.

The subjects were tested immediately. In the explicit test, they were instructed to write completions to the word stems of any words they could remember from the study cards. They were informed of the presence of some lure word stems and were instructed to leave these blank. They were also asked not to guess completions. In the implicit test, the subjects were asked to complete every word stem with the first word that came to mind. If a word did not immediately come to mind, they were to leave it blank. They were advised that word stems from some study words would be included in the list, but that they should only complete word stems with these words if they were the first words that came to mind. Three minutes were allowed for this task.

On completion, the subjects in the implicit test were asked whether they had actually completed word stems with the first word that came to mind, or whether they had deliberately tried to remember words from the study episode. All the subjects reported that they had completed the word stems with the first word that had come to mind.

Results and Discussion

There was a significant priming effect in the implicit memory test (target word-stem completion, $p = .552$; lure word-stem completion, $p = .197$) [$t(17) = 9.94$]. Since the level of completion of lure word stems was relatively low, baseline completion should not have affected any possible serial position effects. Similarly, incorrect completions in the explicit test were very low (target word-stem completion, $p = .586$; wrong completion, $p = .03$) [$t(17) = 13.42$], indicating that guessing should not have affected serial position effects in the explicit test.

The results of Experiment 1 are shown in Table 1. A graph of these results, collapsed across three consecutive serial positions to reduce noise and with baseline completion subtracted in the implicit test, is shown in Figure 1. It appears from the graph that explicit word-stem cued recall produced a primacy effect, but implicit word-stem completion did not.

To investigate this interpretation of the data, a 2×2 analysis of variance (ANOVA) was performed with one between-subjects factor (test; implicit vs. explicit) and one within-subjects factor (serial position; probability of recall from primacy Serial Positions 1-3 vs. probability of recall from asymptote Serial Positions 7-12). (The choice of these serial positions as indicators of primacy effects and asymptote levels was arbitrary and did not influence the results.) The ANOVA was performed on the data for studied items, without subtracting baselines (i.e., not the data shown in Figure 1).

The alpha level was set at .05 in all the statistical analyses. The main effect of test was not significant [$F(1,34) = 1.78$, $MS_e = 0.86$], but that of serial position was [$F(1,34) = 8.59$, $MS_e = 0.39$], and there was a significant interaction between test and serial position [$F(1,34) = 4.73$, $MS_e = 0.39$]. Separate ANOVAs were performed between the primacy and asymptote serial positions from each test to find the reason for this interaction. In the implicit test, the difference between these serial positions was not significant [$F(17) = 0.29$, $MS_e = 0.39$], but it was significant in the explicit test [$F(17) = 13.11$, $MS_e = 0.39$].

Table 1
Percentage of Target Words Completed as a Function of Serial Position and Test in Experiments 1 and 2

Serial	Experiment 1		Experiment 2	
Position	Implicit	Explicit	Implicit	Explicit
1	67	94	67	86
2	44	78	58	72
3	61	61	58	61
4	56	50	64	58
5	67	61	53	67
6	50	61	75	50
7	44	44	69	58
8	56	50	64	50
9	56	56	64	56
10	44	56	75	67
11	56	61	67	61
12	67	50	69	64
13	44	56	61	56
14	61	56	67	61
15	50	56	67	72
16	50	56	67	72
17	61	50	64	69
18	61	61	69	81

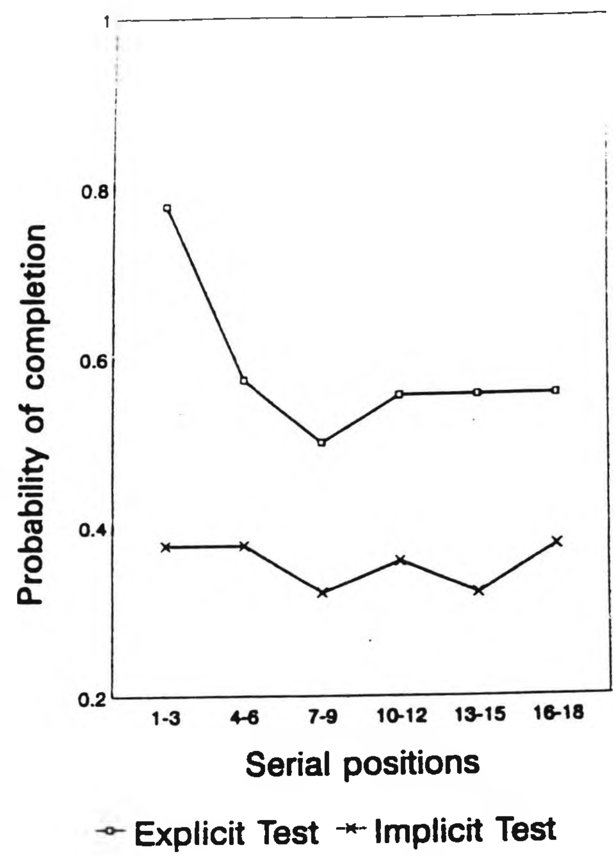

Figure 1. Experiment 1: Probability of completion of target words as a function of serial position and test.

These results show a primacy effect in explicit cued recall, but not in implicit word-stem completion. This difference could not be attributed to greater variability in the implicit test, since both tests had identical mean square error terms.

The design of the test sheet in Experiment 1 made it unlikely that a recency effect would occur in either test—any possible recency effects would have disappeared during the time it took the subjects to work through the four filler word stems and intervening word stems. It was therefore necessary to alter the test sheet so that the most recently seen words were presented first in order to capture any possible recency effects.

EXPERIMENT 2

Because serial position recency effects are short lived when words are encoded without an interpolating task (Craik, 1970; Glanzer & Cunitz, 1966), it was necessary to design a new test sheet that would provide an optimal test for recency. On this new test sheet, word stems of the words on the study cards appeared in the reverse order, beginning with the word stem of the last word presented at study.

Method

Subjects. Seventy-two students and staff members from City University, London, and Goldsmiths College, University of London, age range 18–42 years, participated in the experiment. They were randomly allocated to two groups of 36 subjects each, and were tested individually.

Design and Materials. The experimental design was similar to that of Experiment 1, except the cards were only advanced by one word after they had been presented to 1 subject from each experimental group. This procedure allowed full counterbalancing of serial positions, since every word appeared once in every serial position for each test.

The stimuli were also identical to those of Experiment 1, but the test sheet was designed to capture any possible recency effects. It contained 36 three-letter word stems, printed in capital letters and equally spaced around the circumference of a circle; word stems from each set appeared alternately. The test sheet was covered by a cardboard circular mask, fixed at the center, with a three-sided cutout on the circumference that allowed one word stem to be viewed at a time. When the mask was rotated in a clockwise direction, the subjects saw word stems from the study cards, in reverse order, interspersed by lure word stems.

Procedure. The procedure was also similar to that of Experiment 1, with the following differences. In Experiment 2, the subjects were all tested individually. The positional order of the cards was advanced by one word instead of two after presentation in the implicit and explicit tests. This resulted in each word's appearing once in every serial position. Immediately after seeing the study words, the subjects were given a test sheet with the mask open at the lure word preceding the last study word they had seen. Additional instructions to move the mask clockwise for each word stem were given. The subjects were only allowed to view each word stem once.

Results and Discussion

In the implicit test, baseline word-stem completion was again relatively low (p = .205) compared with target word-stem completion (p = .654) [$t(35)$ = 14.16]. Similarly, wrong completions in the explicit test were low (p = .073) compared with target completions (p = .645) [$t(35)$ = 18.44].

The results of Experiment 2 are shown in Table 1. A graph of these results, collapsed across three consecutive serial positions to reduce noise and with baseline completion subtracted in the implicit test, is shown in Figure 2. It appears from the graph that explicit word-stem cued recall produced a primacy and recency effect, but implicit word-stem completion did not.

A 2×3 ANOVA was performed on studied items with one between-subjects factor (test; implicit vs. explicit) and one within-subjects factor (serial position; probability of recall from primacy Serial Positions 1-3 vs. asymptote Serial Positions 7-12 vs. recency Serial Positions 16-18) to calculate whether there were significant serial position effects in the explicit test compared with the implicit test. (The choice of these serial positions as indicators of primacy, asymptote, and recency was arbitrary and did not influence the results.) Neither the main effect of test [$F(1,70)$ = 0.63, MS_e = 0.97] nor the main effect of serial position [$F(2,140)$ = 1.44, MS_e = 0.51] was significant, but there was a significant interaction between test and serial position [$F(2,140)$ = 3.81, MS_e = 0.51].

One-way ANOVAs were performed on each test to investigate the reason for this interaction. In the implicit test, the main effect of serial position was not significant [$F(2,70)$ = 0.97, MS_e = 0.45], but it was significant in the explicit test [$F(2,70)$ = 3.95, MS_e = 0.57]. In the explicit test, a paired t test between the primacy and asymptote probabilities was significant [$t(35)$ = 2.51], as was a paired t test between the asymptote and recency probabilities [$t(17)$ = 2.60].

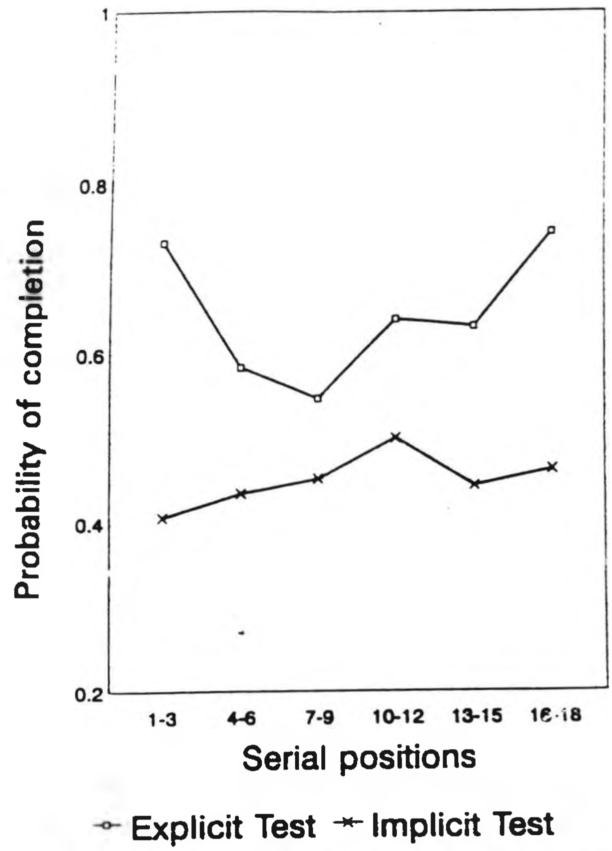

Figure 2. Experiment 2: Probability of completion of target words as a function of serial position and test.

These results show that primacy and recency effects were found in explicit word-stem cued recall but not in implicit word-stem completion. This difference could not be attributed to greater variability in the implicit test, since this test had a lower mean square error term than the explicit test.

When the results of the two experiments are compared, it is apparent that target word-stem completion rates in the implicit tests differed (Experiment 1, p = .552; Experiment 2, p = .654). Since the stimuli and study conditions were identical, it is probable that this difference was due to the different test sheets. The absence of four filler word stems in Experiment 2 may be one contributory factor, but a further factor might be that in Experiment 2 word stems were presented one at a time, which was more similar to the manner in which they were encoded. The increased similarity between encoding and test conditions may have provided more optimal conditions for retrieval from implicit memory.

A comparison of the graphs of the two explicit tests shows that the primacy effect was higher in Experiment 1 than in Experiment 2. This difference may be because word stems of studied words appeared in the reverse order on the test sheet in Experiment 2. The first words encoded (from which the primacy effect is measured) were therefore the last word stems completed, resulting in a lower primacy effect.

GENERAL DISCUSSION

There was little indication of serial position effects in the implicit test in either experiment, whereas the explicit test, which was identical to the implicit test in all but the test instructions, showed a primacy effect in Experiments 1 and 2 and a recency effect in Experiment 2.

The lack of serial position effects in the implicit tests differed from the findings of Sloman et al. (1988, Experiment 1), discussed in the introduction. The most probable reason for this difference was the intentional use of conscious retrieval in Sloman et al.'s study.

The results of the present study also differed from those of Rybash and Osborne (1991) and Gershberg and Shimamura (in press), also discussed previously. The main difference between the three studies was the different methodological procedures used. For example, the order in which the target words were presented to the subjects differed between the studies. In Rybash and Osborne's study, all the subjects studied the same list of target words in the same order. In Gershberg and Shimamura's study, each subject studied one of two target-word lists in one of two different orders. In this study, the subjects also studied one of two target-word lists, but each list was presented in 9 different orders in Experiment 1 and in 18 different orders in Experiment 2. Only by such an extensive rotation of words at encoding can differences in word frequency and ease of completion of word stems be adequately controlled.

As well as providing evidence for the lack of serial position effects in implicit memory, these results provide tangible evidence that the test-aware subjects performed according to instructions in the implicit test. If they had been using explicit strategies, it is probable that serial position effects in the implicit test would have been similar to those in the explicit test.

In conclusion, the finding that implicit word-stem completion does not show serial position effects but that explicit word-stem cued recall does, reveals another dissociation between tests of implicit and explicit memory and provides further evidence that conscious retrieval processes are not involved in this implicit memory test.

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