An Investigation of Automatic and Recollective Memory in Phonological Association

Jeff Cornell©

MA Thesis

Lakehead University

Thesis Supervisor: Dr. G. Hayman

Second Reader: Dr. D. Mazmanian

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Abstract

Two experiments manipulated the study variables associative pairing, attention, and modality, in an attempt to produce process dissociations (Jacoby, 1991) between estimates of recollective and automatic memory in a rhyme-based cued-recall task with university students. The experiments examined possible inferences drawn from earlier research with amnesiac subjects (Warrington & Weiskrantz, 1982) which implied that phonological association can occur in automatic or implicit memory as well as recollective or explicit memory. Experiment 1 found that manipulations of attention and study context affected estimates (cf. Jacoby, 1991) of recollective but not automatic phonological association. Experiment 2 replicated the effect of study context on estimates of recollective but not automatic memory and in addition found that manipulations of modality (and repetition) affected some estimates of automatic but had no effect on estimates of recollective phonological association. As found previously (see Jacoby & Dallas, 1981), Experiment 2 found that increasing the number of study presentations increased estimates of both recollective and automatic memory. Combined across the two experiments there appeared to be separate factors affecting recollective and automatic memory, but the evidence for automatic memory of phonological association was mixed.

Identifying Separable Components of Automatic and Recollective Memory Associations

Researchers have proposed that human memory can be usefully explained in terms of multiple, independent systems of memory (Jacoby & Dallas, 1981; Tulving, Schacter, & Stark, 1982; Warrington & Wieskrantz, 1982; Wieskrantz, 1987). The inference of multiple systems of memory has been based on the identification of task dissociations (Graf & Schacter, 1985; Schacter, 1987; Schacter & Tulving, 1994) and process dissociations (Jacoby, 1991; 1998). Converging evidence of the existence of independent systems of memory is provided by experiments showing a dissociation between what has been termed explicit and implicit memory in normal memory performance (Graf & Schacter, 1985; Parkin, Ried, & Russo, 1990; Schacter, 1987) and the observation of impaired explicit and intact implicit memory performance of patients with anterograde amnesia (Cermak, 1993; Warrington & Wieskrantz, 1982). Other researchers have proposed additional binary divisions of memory such as declarative and procedural memory (Cohen & Squire, 1980), and recollective and automatic memory (Jacoby, 1991) to explain the results. The distinctions made in these different theories of memory share fundamental similarities. Declarative, explicit, and recollective memory can be characterized as forms of memory related to volitional or conscious processing. Procedural, implicit, and automatic memory can be characterized as forms of memory related to preconscious or nonconscious processing not under volitional control. The latter are considered not to be mediated by intentional retrieval, nor accompanied by a subjective sense of remembering (Toth, Lindsay, & Jacoby, 1992).

Anterograde amnesia by definition reflects severe impairment in the acquisition of new memories, yet in many situations amnesiacs have been observed to have near normal levels of memory performance (Cutting, 1978; Warrington & Weiskrantz, 1982) where tests of implicit memory are used. In short, in situations where researchers have demonstrated that there is little or no reliable contribution of recollective memory but a measurable implicit memory component in normal performance, near normal memory performance has been observed in amnesiac populations (Graf & Schacter, 1985; Tulving, Schacter, & Stark, 1982; Warrington & Weiskrantz, 1982).

One situation where amnesiac memory performance has been shown to be relatively intact is rhyme-constrained (e.g., joker-poker; brain-train, etc.) paired-associate learning, as evidenced by preserved memory performance in cued-recall tasks using rhyming words as recall cues (Warrington & Wieskrantz, 1982). This type of memory for rhyme-constrained paired-associates has been examined in normal and amnesiac populations (Warrington & Weiskrantz, 1982; Winocur & Weiskrantz, 1976), but it has not been demonstrated that normal memory performance in these situations relies on two forms of memory, recollective and automatic. The present experiments fill this gap by using Jacoby's process dissociation framework to look for separate contributions of recollective and automatic memory in the acquisition of rhyme-constrained paired-associates.

The immediately following discussions present a brief overview of the experimental literature leading to the present research in four sections. The first section describes experimental evidence of dissociations between different tests of memory performance. The second section describes Jacoby's (1991) Process Dissociation Procedure, and the benefits this procedure offers to experimental measures of memory performance. The third section describes converging evidence of different systems of memory from research with amnesiacs. The fourth and final section describes experiments designed to use Jacoby's Process Dissociation Procedure to determine whether rhyme-constrained association is mediated by implicit as well as explicit forms of memory in normal memory performance.

Experimental Dissociations Between Tests of Memory Performance

It has been proposed that human memory must be explained in terms of independent systems of memory, rather than be considered a unitary phenomena (Tulving, Schacter & Stark, 1982; Warrington

& Wieskrantz, 1982; Wieskrantz, 1987). In practice, the multiple systems theories proposed have often been binary divisions of memory; for examples, declarative and procedural memory (Cohen & Squire, 1980), explicit and implicit memory (Graf & Schacter, 1985), and recollective and automatic memory (Jacoby 1991).

The terms declarative and procedural knowledge were first utilized in the study of artificial intelligence (Winograd, 1975; Winston, 1977) and cognitive psychology (Anderson, 1976), before being applied to memory (Cohen, 1981; Squire, 1982; Tulving, 1983). The procedural/declarative memory dichotomy is perhaps best known as applied to amnesia research, but is not restricted to this special case. The findings stemming from research with amnesiacs are discussed more fully in the third section of this paper. The procedural/declarative division of memory proposes one system of memory that permits learning and retention of how to perform a task as a motor sequence (procedural), for example, the movements required to ride a bicycle. This system is contrasted with another (declarative) which retains an abstract description (perhaps verbal) of the specific task being learned (Cermak, 1993). Cohen (1984) extended the domain of what is considered procedural memory by including performance on implicit verbal memory tasks which require that certain perceptual operations or procedures be repeated within the experimental paradigm.

More recently, the emphasis on the term procedural memory has diminished, as it has been shown that some subject-initiated processing beyond the pure perceptual characteristics of the stimulus can contribute to procedural memory task performance (Cermak, 1993; Musen, Shimamura, & Squire, 1990; Squire, 1994). Researchers in cognitive psychology and artificial intelligence have turned away from the procedural distinction for similar reasons (Squire, 1987). Knowledge which seemed declarative at one level of analysis often appeared procedural at other levels of analysis (Anderson, 1980; Rumelhart & Norman, 1985). In attempting to refine the term procedural memory, theorists have suggested substituting the term nondeclarative for procedural (Musen, Shimamura, & Squire, 1990). Further refining of the term and categorization of memory tasks has led to greater dissatisfaction with the term, as procedural memory has appeared to have three or four distinct meanings depending on the author using it (Roediger, 1990). Because all implicit memory tasks thought to map onto procedural memory are not performed alike and may depend on different processes, it has been suggested that the appropriate distinction is not between two different forms of memory, but between two different processes, either or both of which can be used for retrieval of the same representation (Jacoby & Dallas, 1981).

Recent research reflects a growing interest in the differences between explicit (recollective) and implicit (automatic) memory processes (Roediger, 1990; Schacter, 1987). An explicit memory process is the conscious recollection of a prior episode, whereas implicit memory processes are considered the effects of memory not mediated by intentional retrieval nor accompanied by the subjective sense of remembering (Toth, Lindsay, & Jacoby, 1992). Explicit and implicit memory processes are descriptive concepts primarily concerned with a person's psychological experience at the time of retrieval, and neither refer to, or imply the existence of two independent memory systems (Schacter, 1987). For example, the first investigator to use the terms explicit and implicit, referred to the expression of memory (Mcdougall, 1924), distinguishing between explicit and implicit recognition. For McDougall, explicit recognition was considered to involve conscious recognition of a past event, while implicit recognition was evidenced by changes in behaviour attributable to a recent event without any corresponding conscious recollection of, nor explicit reference to the event.

Researchers have found that performance of explicit and implicit forms of memory retrieval can be independent (see Schacter, 1987, for a review). Much of the data supporting this has been in the form of task dissociations. Typically, experiments utilizing the logic of task dissociation involve the manipulation of a single variable followed by the comparison of memory performance on two different tasks, one reflecting explicit memory performance, the other implicit. Dissociation has occurred if the results show that the manipulated variable affected subject performance in one task but not the other, or effects subject performance in opposite directions on the two tasks. Such dissociations show the absence of a positive correlation between explicit and implicit memory performance. The conclusion drawn from such dissociations is that the two tests measure separate variables. This conclusion is strengthened when other variables are shown to produce opposite effects on the two tests (Roediger & McDermott, 1993). Research has shown that a test is implicit by dissociating it from an explicit test within an experiment (Jacoby & Dallas, 1981; Jacoby, 1983) following the logic of task dissociation. For example, Jacoby (1983) demonstrated that generating a word from its antonym results in greater explicit memory performance than does reading a word, whereas reading a word results in greater implicit memory performance than does prior generation. Thus, performance in explicit and implicit memory tasks were shown to respond to different factors.

Several studies have reported stochastic independence between explicit and implicit measures of memory (Eich, 1984; Hayman & Tulving, 1989; Jacoby & Witherspoon, 1982; Schacter, Cooper, & Delaney, 1990; Tulving, Schacter, & Stark, 1982). Stochastic independence is the absence of statistical relation between two events which indicates that the events occur independently (Ostergaard & Jernigan, 1993).

Most of the research into implicit memory has been concerned with facilitation in the processing of a stimulus as a function of a recent encounter with the same stimulus (Kirsner, Speelman, & Schofield, 1993; Schacter, 1987). Two tests commonly used to measure such priming effects are word identification and stem/fragment completion tests.

Word identification tests involve subjects being briefly exposed to a stimulus, then being asked to identify the stimulus. Implicit memory performance is indicated by an increase in identifying recently exposed items relative to new items (i.e. items not recently exposed). For example, Winnick and Daniel (1970) provided results which revealed a dissociation between explicit and implicit memory utilizing the word identification task. This experiment contrasted word identification performance following three study conditions: reading a familiar word from a visual presentation, generation of the word from a picture, and generation of the word from its definition. Significant priming was observed in the visual/read condition, while no priming was observed in either of the generation conditions. In contrast, an explicit test of free recall revealed recall of words in both generation conditions to be considerably higher than in the visual/read condition.

Word stem/fragment completion tests involve presenting subjects with either a word stem (e.g., tab__ for table) or fragment (e.g., _ss_ss__ for assassin) which they are instructed to complete with the first word which comes to mind. Implicit memory performance is indicated by a greater proportion of stems or fragments completed where the word named is a studied word relative to non-studied words. For example, Tulving, Schacter, and Stark (1982) contrasted memory performance on recognition and word-fragment completion tasks on two occasions, one hour after study and seven days later. While recognition task performance showed a typical decrement after seven days, word-fragment completion task performance did not.

Additional factors that have been shown to affect explicit memory performance but not implicit memory performance include: changes in the size of a stimulus between study and test (Biederman & Cooper, 1992; Cooper, Schacter, Ballesteros, & Moore, 1992), age of subjects (Light & Singh, 1987; Light, Singh, & Capps, 1986), the extent to which to-be-remembered items form interitem associations (Schacter & Graf, 1986), and dividing attention at study (Gardiner, 1988; Gardiner & Java, 1990; Gardiner & Parkin, 1990; Graf & Mandler, 1984; Parkin, Ried, & Russo, 1990). Task dissociations between explicit and implicit memory performance have been found using a manipulation of stimulus size between study and test (Cooper, Schacter, Ballesteros, & Moore, 1992). Cooper et al. found that the manipulation of size greatly reduced explicit recognition, but had no effect on implicit task performance. Light and Singh (1987) contrasted young and older adults' explicit and implicit memory performance, as measured by cued recall and word-stem completion tests. It was found that there was no age difference in performance of the word-stem completion task (implicit), but performance of the cued-recall task (explicit) was significantly greater for young adults. Schacter and Graf (1986) examined whether the extent to which to-be-remembered items form inter-item associations would dissociate measures of explicit and implicit memory performance. Type of associative elaboration was manipulated by having subjects complete either a sentence generation or sentence rating study task. It was found that implicit memory performance was not significantly affected by the manipulation of elaboration at study, but explicit memory performance was nearly twice as high in the sentence generation condition as compared to the sentence rating condition. Parkin, Reid, and Russo (1990) examined the effect of dividing attention at study on subsequent explicit and implicit memory performance as measured by word recognition and word-fragment completion tasks. At study, subjects were presented target words as part of a sentence verification task (see Tulving, Schacter, & Stark, 1982). While performing this task, half the subjects also performed a secondary task of tone monitoring (see Anderson & Craik, 1974; Parkin, 1989; Parkin & Russo, 1990). Dividing attention at study was found to lower word recognition but not word-fragment completion performance. The data showed that a reduction in conscious processing resources during memory acquisition (dividing attention) reduced explicit, but not implicit, memory performance. Similar results have been shown by research investigating the false fame effect (Jacoby, Woloshyn, & Kelly, 1989). This experimental paradigm indexes implicit memory as familiarity, as shown by the false judgement of earlier presented non-famous names as famous. Typically, during a study session subjects are presented with famous and non-famous names, with it identified which names are non-famous. The familiarity of names is indicated by the earlier presented non-famous names being misinterpreted as famous. Using this paradigm, Jacoby, Woloshyn, and Kelly (1989) reported that divided attention greatly reduced recognition memory, but had no effect on familiarity as measured by fame judgements. When recognition memory and familiarity were placed in opposition, divided attention still had the effect of reducing recognition memory, yet having no effect on familiarity.

One factor that affects implicit memory but not explicit memory performance is the manipulation of the modality of presentation between study and test (Kirsner, Dunn, & Standen, 1989; Kirsner, Milech, & Standen, 1983; Kirsner & Smith, 1974; Scarborough, Gerard, & Cortese, 1979). It has been shown that both intermodality and intramodality shifts reduce implicit memory performance (Gardiner, Dawson, & Sutton, 1989; Jacoby & Hayman, 1987; Roediger & Blaxton, 1987). The manipulation of modality has been found to affect implicit test performance (Roediger & McDermott, 1993; Tulving & Schacter, 1990), but not explicit test performance (Roediger & Blaxton, 1987; Scarborough, Gerard, & Cortese, 1979). Jacoby and Dallas (1981) investigated the effect of changing modality of presentation between study (auditory) and test (visual) on subsequent performance on implicit (word identification) and explicit (yes/no recognition) tasks. It was found that changing modality severely reduced word identification performance, while having little or no effect on recognition performance. Similarly, Graf, Shimamura, and Squire (1985) reported priming in the stem completion task to be reduced by a study-test change in modality of presentation, while cued-recall performance was not affected.

In sum, variables such as stimulus size, age of subjects, inter-item associations, and divided attention, have been found to affect explicit memory performance, while implicit memory performance remains insensitive to these manipulations. In contrast, the manipulation of modality between study and test has been found to affect implicit memory performance, while explicit memory performance remains insensitive to the manipulation.

However, these investigations of explicit and implicit memory processes frequently confound memory processes with memory tasks. For example, Schacter (1987) used the terms explicit and implicit referring to both two forms of memory as well as two classes of memory tests, such as direct and indirect tests of memory. Examples of direct tests are tests such as recall or recognition, where subjects are instructed to consciously recollect a prior episode. Examples of indirect tests of memory are word identification, word fragment completion, and exemplar generation tests, where implicit memory performance is inferred from the effects of prior exposure on task performance. Addressing this concern, Roediger (1990) advocated the use of the terms explicit/implicit for distinguishing between forms of memory processing, and the terms direct/indirect to describe two different classes of tests.

A refinement of the experimental dissociation method is Jacoby's (1991) Process Dissociation Procedure where dissociations can be shown between processes contributing to a task, rather than dissociations between tasks. Jacoby's (1991)

Process Dissociation Procedure is the focus of the following section, where it will be discussed in detail.

A powerful refinement of the experimental dissociation method is the method of double dissociation, utilized by Jacoby & Kelly (1992), and earlier described by Shoben, Wescourt, and Smith, (1978). This method is an extension of the experimental dissociation method where an additional variable which is felt will yield an opposite or different pattern of dissociation is considered within the same experimental paradigm. Thus, the hypothesis of a distinction between two memory processes is supported by the finding that the manipulation of two variables yields different patterns of dissociation. For example, the manipulation of one variable affects explicit memory performance but not implicit, whereas manipulation of the other variable results in the opposite pattern, affecting implicit memory performance but not explicit.

Jacoby's Process Dissociation Procedure

Controlled processing is said to reflect a person's intentional use of memory, in contrast, automatic processing is said to occur as a passive consequence of stimulation not requiring intention nor accompanied by a sense of remembering (Jacoby, 1991). A strategy which may provide a demonstration of independence between intentional and automatic processing is to show interactions or task dissociations using two tasks, one identified with intentional processing and the other with automatic processing. Most task condition used to investigate implicit memory performance were designed to rule out intentional processing (Jacoby, 1991; Jacoby & Kelly, 1992). As such, task dissociations are often considered compelling evidence of automatic processing in memory task performance. However, when interpreting task dissociations, theorists face uncertainties when considering the degree of factor-or process-purity involved in the tasks employed. Jacoby (1991) argued that evidence using task dissociations can often be misleading when tasks are equated with processes and considered "pure" measures of the processes considered. As Jacoby points out, no test is "process pure", although some are more so than others. Indirect versus direct tests of memory may not equate purely with automatic versus intentional memory processes. Automatic processes may influence both indirect and direct tests of memory, the same being true of intentional processes. Thus, there is potential for cross-contamination of measures. Jacoby (1991) proposed an alternative solution to considering task dissociations as evidence of separate processes which may in fact both contribute to performance to varying degrees in many tasks. The process dissociation framework presented by Jacoby (1991) attempts to deal with this problem by estimating separate contributions for different processes that contribute to performance in a single task. That is, he does not equate processes with tasks.

Jacoby (1991) has developed an experimental paradigm, coupled with formulas to allow for the separate estimation of intentional and automatic processes within a single task rather than using different tasks to assess intentional and automatic processes. The formulas provided by Jacoby rely on facilitation and interference paradigms in order to draw inferences about the role of intentional and automatic processes in recall during a memory experiment. The process dissociation procedure requires two instructional conditions (inclusion and exclusion instructions). Responses from these two conditions are transformed to produce estimates of two hypothetical independent processes. The response instructions combine a facilitation paradigm (inclusion condition) with an interference paradigm (exclusion condition) to estimate the separate contributions of automatic and recollective memory processes on a memory task. The logic underlying the procedure is that recollection represents the difference between responding to specified items when people are attempting to select for such items as when they are attempting to select against the items. More precisely, control in task performance is felt to be measured as the difference between performance on a task when a person is trying to as compared with trying not to use information from a particular source (conscious recollection).

The inclusion (Inc) condition outlined by Jacoby (1991) is said to reflect the combined probability of recollecting a target word and of automatically producing a target word without any accompanying conscious recollection. Performance in the inclusion condition is considered the result of one or both of two independent processes (Recollection, R, and Familiarity, F). For example, Inclusion instructions in the word-stem completion task would require subjects to use the word stems presented as cues to help them remember previously presented words. If they could not think of an earlier presented word, they were to complete the word-stem with the first word which came to mind. The formula for producing the studied word in the Inclusion condition is:

$$Inc = R + F\ (1-R) \qquad (1)$$

where R = recollection, and F = familiarity (see Jacoby, 1991, p.527).

In contrast to the Inclusion condition, Exclusion testing is said to reflect the probability of automatically producing a target word which is not recollected. Performance in the Exclusion condition is considered the result of failure of recollection as a cue during the exclusion of familiar items. Thus, target items that are to be excluded which subjects incorrectly produce during testing, must be familiar (F) but not recollected (1-R). For example, Exclusion instructions in the word-stem completion task would require subjects to use the word stems presented as cues to help them remember previously presented words, but to complete the word stems with words which were not presented earlier - the idea being to exclude, or avoid producing previously seen target words. The formula for the probability of producing the studied words in the exclusion condition is:

$$Exc = F\,(1-R) \qquad (2)$$

The probabilities of producing studied words in the inclusion and exclusion conditions allow an estimate of recollective memory performance to be calculated. The formula used to assess the recollective component of memory performance is:

$$RC = Inc - Exc \qquad (3)$$

The probability of producing studied words in the exclusion condition also allows an estimate of the automatic component of memory performance to be calculated using the formula:

$$AU = Exc / (1-R) \qquad (4)$$

According to Jacoby (1991) these formulas can be used to separate conscious and unconscious influences of memory by positioning them in opposition to each other rather than by identifying tests that provide unique measures of conscious and unconscious memory.

Process dissociations have been used to help identify separate contributions of two or more memory processes to performance of the same task. Whereas task dissociations can reveal the existence of different forms of processing, process dissociations allow for the examination of the separate contributions of two processes in one task. This is accomplished by comparing performance on a task when two types of processes act in concert to when the two types of processes act in opposition. These facilitation and interference paradigms are used to segregate automaticity from intentionality. This allows for the examination of factors which affect one type of processing while leaving the other invariant or unaffected. Dividing attention at study is one such factor. Divided attention at study requires subjects to attend to two tasks, a primary and a secondary task. Using divided attention, process dissociations have been shown where recollective processes are negatively affected while automatic processes remain insensitive to the manipulation (Jacoby, 1991; Parkin & Russo, 1990).

Because the terms explicit and implicit memory processes have been associated with the use of different tasks, the terms recollective and automatic memory will be used in the following to refer to separate contributions of intentional and automatic memory processes within one task.

Converging Evidence of Multiple Systems of Memory from Research with Amnesiacs

The hypothesis that different types of memory are required to account for human memory is supported by the pattern of impaired and preserved memory performance observed in anterograde amnesia. Evidence from memory impaired populations and memory dissociations in normal populations provide converging support of dissociations between implicit and explicit memory processes (Toth, Lindsay, & Jacoby, 1992; Roediger, 1990; Roediger & McDermott, 1993). It is widely assumed that with amnesiacs evidence of new learning reflects implicit memory, as by definition amnesiacs cannot use explicit memory. The amnesiac syndrome is characterized by normal perceptual, linguistic, and intellectual functioning, while there is a marked inability to explicitly recall or remember recent events and new information (Schacter, 1987). Amnesiac patients are severely impaired on standard tests of recall and recognition, and have difficulties performing in real-life situations which require explicit remembering (Schacter, 1983).

Although anterograde amnesia by definition reflects severe impairment in the acquisition of new memories, in some situations amnesiacs have been observed to have near normal levels of memory performance (Cutting, 1978; Warrington & Weiskrantz, 1982). Amnesiacs can acquire modifications in their semantic and procedural knowledge, but lack the ability to know when and how the changes were acquired (episodic memory)(Cermak, 1993; Squire, 1987; Warrington & Weiskrantz, 1982). Semantic knowledge is considered general knowledge of the world embedded in meaningful context, including the knowledge needed for language use (Roediger & Srinivas, 1993). Similar to situations where amnesiacs acquire semantic and procedural knowledge yet lack any memory of acquisition, is a related phenomena termed "source amnesia" (Schacter, Harbluk, & McLachlan, 1984; Shimamura & Squire, 1987). Amnesiacs who have previously performed new memory tasks will subsequently deny being aware of performing these tasks (Talland, 1965). Thus, while showing modifications of what is taken to be procedural memory, these subjects lack a declarative memory of the acquisition of task performance. It has been proposed that amnesiacs learn and retain procedures required to perform a task, but cannot acquire declarative knowledge of this act (Cohen & Squire, 1980). Weiskrantz (1987) reported that both procedural and semantic knowledge structures can be modified although the subject cannot recall when or where they learned the information. The learning of new semantic content has shown robustness, forgetting rates being similar to controls (Glisky & Schacter, 1988; Huppert & Piercy, 1979; Matis & Kovner, 1984; McAndrews, Glisky, & Schacter, 1987; Tulving, Hayman & Macdonald, 1991; Tulving, Schacter, & Stark, 1982). Researchers have shown acquisition by amnesiacs of novel facts (Schacter, Harbluk, & McLachlan, 1984) and preferences (Johnson, Kim, & Risse, 1985). As well, research on amnesiacs has shown preserved perceptual, motor, and cognitive skills such as: mirror reading (Cohen & Squire, 1980; Moscovitch, 1982), rotary pursuit (Milner, Corkin, & Teuber, 1968), and puzzle solving (Brooks & Baddeley, 1976). Similar findings of implicit memory performance in amnesiacs have been reported for tasks involving word identification (Cermack, Talbot, Schandler, & Wolbarst, 1985), lexical decisions (Moscovitch, 1982), free association (Schacter, 1985; Shimamura & Squire, 1984), and naming fragmented pictures/words (Warrington & Weiskrantz, 1968; 1970). The knowledge acquired during these studies and the complexity of the laboratory tasks involved has been relatively simple. So it is of interest that amnesiacs can acquire domain specific implicit memory performance in a more complex everyday task of some utility. Glisky, Schacter, and Tulving (1986) examined whether amnesiacs can acquire the knowledge needed to operate and interact with a computer, contrasting amnesiac performance to that of a control group. The data indicated that amnesiacs can acquire and retain the knowledge necessary to use computer programs and perform a variety of computer functions. Even densely amnesiac patients acquired and retained the ability to write and execute simple computer programs, and perform disk storage and retrieval operations, all without explicit recall of any prior exposure with a computer. All of these studies suggest that amnesiac patients can display implicit memory performance within specific domains as evidenced by memory performance on specific tasks.

In many of the situations where near normal memory performance has been observed in amnesiac populations, researchers have demonstrated that there is little or no reliable contribution of recollective memory in normal performance (Graf & Schacter, 1985; Tulving, Schacter, & Stark, 1982; Warrington & Weiskrantz, 1982). That is, amnesiac patients appear to exhibit near normal levels of memory performance in tasks which primarily engage automatic uses of memory. For this reason it has been suggested that anterograde amnesia reflects impairment only of recollective memory, with automatic memory processes essentially unimpaired (Cermak, 1993; Warrington and Weiskrantz, 1982).

Amnesiac memory performance may be due to purely automatic processing which is sufficient to support an automatic component, while strategic or conceptual processing may not be available to amnesiacs, impairing recollective performance. This pattern of loss in recollective memory, and preservation in automatic memory, is consistent with and can be explained by systems of memory approaches.

Research with subjects who have anterograde amnesia has documented abilities to learn and retain new information under specific learning situations, such as rule-based paired-associate learning (Cutting, 1978; Warrington & Weiskrantz, 1982). Warrington & Weiskrantz (1982) reported rhyme-constrained (e.g., joker-poker; brain-train, etc.) paired-associate learning using a rhyme-based cued-recall task with amnesiac subjects. This type of memory test involves the acquisition and retention of word pairs which are associated by a consistent rule, that is, "name a word which rhymes with the following word." In these experiments, amnesiac and control subjects studied pairs of rhyming words (e.g., brain - TRAIN) and were presented during testing with the first word of each rhyming pair and asked to name a second word which rhymed (e.g., brain - ?). For both groups, guessing was strongly encouraged. Amnesiac and control subjects performed this task at similar above chance levels of performance.

The finding of equivalent performance on the rhyme-constrained paired-associate task was found to contrast with poor memory performance by the amnesiac group on linguistic and semantic paired-associate learning tasks. These tasks are believed to benefit from cognitive mediation and recollective memory processes that are considered impaired in amnesiacs. Thus, the experiment demonstrated a qualitative difference in automatic memory performance between amnesiac and control subjects in learning different types of paired associates. More importantly, it showed that amnesiacs can acquire phonemically related (rhyme-constrained) paired-associates in a learning task at levels equivalent to control subjects.

The automatic memory performance with amnesiacs and normal populations requires an associative rule at retrieval, such as rhyming, and without an associative rule amnesiacs show chance responding (Graf & Schacter, 1985). Rules based on rhyme or meaning relations have been found to be effective, providing a rule which constrains responding at retrieval. The nature of the task utilized by Warrington and Weiskrantz (1981) provided a general retrieval rule which was identical for all cue presentations (to produce a word which rhymes with the cue) and subjects responses were to be constrained by the operations of general phonological knowledge, rather than a reliance on episodic cues. Thus, the task allowed a demonstration of retained phonemic paired-associate learning, in which awareness of the prior study episode was not necessary to show automatic memory performance for either group.

In a multiple memory systems view, normal everyday memory performance reflects separate contributions from the independent systems. Thus, one of the predictions of a multiple memory systems approach is that in situations where amnesiacs show reliable memory performance one would expect to find an automatic memory component in a non-impaired population, in addition to a recollective component. That is, in a task which amnesiac performance is above chance, then memory performance must be mediated by automatic memory, and one should be able to identify a similar automatic component in normal memory performance. This is suggested because the inverse is true: in situations where normal subjects have shown automatic memory performance, amnesiac subjects have shown preserved memory performance (Cermak, 1993; Roediger, 1990).

However, it is always possible in any given comparison using a clinical population such as amnesiacs that the amnesiac patients may have some residual episodic or recollective memory that will support their responding. If so, the observations of modifications of semantic memory in amnesia are not as interesting because they could be explained in terms of normal (explicit, declarative) but slow, learning and memory. To show that the memory performance observed in amnesiac patients is a form of automatic memory, evidence must be found in a non-impaired population of automatic memory retrieval that is independent of retrieval from intact recollective memory processes. The question becomes whether the preserved automatic memory performance of amnesiacs is due to the residual capacities of one system, or is situationally dependant upon two systems. If two different memory systems support rule-based memory in normal populations, then it should be possible to identify factors which dissociate memory performance in the two systems.

Because the memory performance of amnesiacs could be an artifact of a patient having residual unimpaired recollective memory, then to fully account for the data, identification of automatic memory in the same tasks with normal subjects is necessary before one can confidently conclude that a particular task can be supported by automatic memory performance. But, because in normal subjects memory performance in any particular task may be a result of automatic memory, recollective memory, or both, then to identify an automatic component we must separate recollective from automatic memory components. Such a function is provided by Jacoby's (1991) process dissociation procedure. Consequently it was proposed that the process dissociation procedure could be used to measure recollective and automatic memory processes in a memory task (rhyme-based association) in which amnesiac patients perform well. Although this task has been previously investigated in the normal population and in amnesia (Warrington & Weiskrantz, 1982; Winocur & Weiskrantz, 1976), it has not yet been investigated in the normal population in terms of separate estimates of recollective and automatic memory. The present experiments are designed to investigate the hypothesis that the rhyme-based association, similar to that reported by Warrington and Weiskrantz (1982) with amnesiacs, has an automatic memory component in normal populations.

Rhyme-based Paired-associate Learning in Normal Subjects using Jacoby's Process Dissociation Procedure

To clarify the findings of studies with amnesiacs, Experiment 1 examined factors in rhyme-based paired-associate memory by attempting to identify dissociations between recollective and automatic memory in healthy subjects following manipulations of attention and study context. It was predicted that estimates of recollective memory would be reduced by dividing attention, but that estimates of automatic memory would be insensitive to the manipulation of attention (Jacoby, Woloshyn, & Kelly, 1989; Parkin, Ried, & Russo, 1990). In particular, it was predicted that the manipulation of rhyme context at study would result in more recollective and automatic responses in an intact rhyme paired condition than in a broken, repaired or new word conditions of cued-recall performance.

Experiment 2 examined the effect of manipulating modality and number of study presentations on rhyme-based paired-associate memory. It was predicted that estimates of recollective memory would be insensitive to the manipulation of modality, but that estimates of automatic memory would be reduced by changing modality between study and test (Kirsner, Dunn, & Standen, 1989; Kirsner, Milech, & Standen, 1983; Kirsner & Smith, 1974; Jacoby & Dallas, 1981; Scarborough, Gerard, & Cortese, 1979). It was also predicted that both recollective and automatic components would be influenced by the number of study presentations (Hayman, MacDonald, & Tulving, 1993; Jacoby & Dallas, 1981).

Experiment 1

Experiment 1 was a modification of an earlier study (Scott, 1994), in which the number of study presentations for study pairs was increased from one presentation used in Scott's study, to three presentations. Scott's (1994) experiment examined the relative contributions of automatic and recollective memory in rhyme-based paired-associate memory using estimates of automatic and recollective memory obtained from the process dissociation procedure (Jacoby, 1991) using inclusion and exclusion instruction conditions at test.

Memory performance was measured in three study/test conditions (intact, broken, repaired) and compared with a non-studied condition (new). In the intact rhyme context, the study trials included an explicit presentation of rhyme-paired associates. For example, at study two words (a cue and response word) were presented as a study pair (e.g. brain-TRAIN), and at test the cue (brain) was presented as a cue for the rhyme response (TRAIN). In the broken rhyme condition, the study trials presented the to-be-tested cue and its rhyme response in separate (non-rhyming) pairs. For example, at study the cue and response words were presented in two different study pairs (e.g. brain-FABLE and table-TRAIN) and at test the cue (brain) was presented as a cue for a rhyme response (TRAIN). In the repaired rhyme condition, the study trials presented the rhyme response paired with a different rhyme cue than that to be used at test. For example, at study the rhyme response was presented as part of an alternate rhyme pair (e.g. rain-TRAIN), and at test the cue (brain) was presented as a cue for the rhyme response (TRAIN). The broken and repaired rhyme conditions were included to examine alternate explanations of any priming observed in the intact condition. The broken condition tested an explanation of item-specific response-priming, while the repaired condition tested an explanation of facilitation from non-specific rhyme processing. The new condition (new) examined chance responding in non-studied rhyme pairs providing a base rate of association between a test cue (brain) and a rhyme response (TRAIN). Performance in a rhyme-based memory task may not be due exclusively to phonological association in that effects of prior presentation can occur at both the pair (word or phonological association) and item (word response) level. Inclusion of control conditions (repaired and broken) allowed for an assessment of phonological association by contrasting intact with control conditions. Also, this allowed testing of alternate explanations for the memory performance observed by contrasting performance in the control conditions with the unstudied (new) condition. An assessment of pair (phonological association) and item (word response) effects for both experiments is provided in the general discussion, but as pair effects are the focus of the experiments, only pair effects will be discussed in the individual experiments.

Subjects encoded the various pairs under full or divided attention conditions. Subjects in the full (and divided) attention condition read study pairs aloud. Subjects in the divided attention condition also attended to a secondary task which required that they monitor auditorially presented random numbers for odd-digit sequences (Jennings & Jacoby, 1993).

Scott found that the manipulation of attention (focused and divided) affected recollective but not automatic memory processes. Although there was a significant difference in automatic memory between new and intact conditions, there were no significant differences in automatic memory between broken, repaired and new conditions. However, this failure to find a difference from broken and repaired study presentations may have been due to floor effects in automatic memory.

Jacoby and Dallas (1981) reported finding increases due to study repetition in both tests of recollective and automatic memory. In the present experiments, the to-be-associated word pairs were presented three times in order to avoid potential floor effects. Implicit memory performance in amnesiacs can benefit from repeated presentations (Hayman, MacDonald, & Tulving, 1993), supporting the notion that repeated presentations creates a more robust automization of the study information. In summary, the possibility of floor effects influencing the results of the pilot study (Scott, 1994) was examined by presenting the study pairs three times in Experiment 1 with the expectation that this repetition would increase both recollective and automatic performance.

Based on Scott's (1994) experiment, it was hypothesized that the manipulation of dividing attention at study with a secondary task would affect recollective but not automatic memory estimates, and that the manipulation of rhyme context at study would result in more recollective responses in the intact rhyme paired conditions than in the broken, repaired or new word conditions. In terms of automatic memory, intact being greater than broken and repaired conditions is what can be expected if automatic rhyme-based paired association memory occurs, and intact being equal to broken and repaired which are in turn greater than new can be expected if no automatic rhyme-based paired association occurs.

Experiment 1

Method

Subjects

Thirty-two introductory psychology students at Lakehead University received a bonus mark for an hour's participation.

Materials

Ninety-six sets of 3 rhyming words (rhyme triplets) were taken from Scott (1994). The rhyme triplets were taken from "The Rhyming Dictionary" (Wood, 1992) with the constraint that at least 3 words shared the same rhyming sound, and no more than 10 words shared the same rhyming sound. Each triplet word was assigned arbitrarily to one of three rhyme categories: 1) cue,

2) response, and 3) alternate cue. The assignments were constrained such that rare and common target-response words (based on frequency counts listed in Thorndike and Lorge, 1944) were evenly distributed over three rhyme context conditions (intact, broken, and repaired). This equated the number of rhyme alternatives over the rhyme context conditions in order to reduce variability between conditions in the number of response alternatives. More precisely, word assignments counterbalanced rhyme context conditions such that target rhyme and alternatives are equally probable in terms of: 1) sound alternatives, and 2) frequency in the English language. At study, two words were presented as pair associates with the first and second word serving as "cue" and "response" respectively. The cue words served as a rhyme "cue" in all test conditions, and were presented as study cues in the intact and broken study conditions. The response words were designated as the rhyme "targets" in all four test conditions, and were presented in study rhyme pairs in the intact and repaired study conditions.

At test there were four rhyme context conditions: 1) intact-rhyme, 2) broken-rhyme, 3) repaired-rhyme, 4) new-rhyme. In the intact-rhyme condition, the to-be-tested cue and its designated rhyme response were presented as a pair. For example, at study the to-be-tested cue and its designated rhyme response were presented as a study pair (e.g., brain-TRAIN), and at test the cue (brain) was presented as a cue for the target-response rhyme (TRAIN). In the broken-rhyme condition, study trials broke the pairing of the to-be-tested cue and its designated rhyme response by presenting these words in separate non-rhyming word pairs. For example, at study the cue and response words were presented in two different study pairs (e.g., brain-FABLE and table-TRAIN) and at test the cue (brain) was presented as a cue for the target-response rhyme (TRAIN). In the repaired rhyme condition, study trials reinforced an alternate rhyme association by presenting the not-to-be-tested alternate cue paired with the designated rhyme response word. The test cue was not presented during study trials. For example, at study the response rhyme was presented as part of an alternate study pair (e.g., rain-TRAIN), and at test the cue (brain) was presented as a cue for the target-response rhyme (TRAIN). A non-studied condition (new) examined base rate production of target-response words to test cues (e.g., brain) in the absence of prior study presentation of the test cue or designated response word.

Counterbalancing the 96 word triplets over the four study/test conditions and two test instruction conditions (inclusion, exclusion) resulted in the creation of eight sub-lists. Counterbalancing the eight sub-lists over two orders of test instruction and two study groups (focal/divided attention) required 32 subjects for complete counterbalancing. Twenty additional rhyme triplets were taken from Scott (1994) to create primacy and recency buffers for study list presentation. There were 8 primacy and 12 recency buffer pairs at study, which were the same for all subjects.

Apparatus

Study and testing materials were presented and responses collected under the control of an Apple IIe computer.

Design

The design was a 2 X 3 between-within manipulation of study conditions (2 levels of attention applied to 3 levels of study context) with the addition of a single non-studied condition introduced at test. As such, at test there were four levels of the within-subjects factor test condition (intact, broken, repaired, and new), and two levels of the between subjects factor attention (focal and divided). The test conditions measured transfer to cued rhyme production as a function of study context.

The between subjects factor (attention) was manipulated by assigning subjects to one of two study groups, focused or divided attention. Thus focused and divided attention groups read aloud the same word pairs at study, but the divided attention group had also to attend to a secondary task.

In order to create estimates of recollective and automatic memory using Jacoby's Process Dissociation Procedure, the use of inclusion and exclusion testing conditions similar to those used by Jacoby, Toth, Lindsay, & Debner (1992) during testing were required. Responses in these two conditions were then used to create estimates of recollective and automatic memory.

Procedure

Each subject was tested individually in a small office/laboratory. As they arrived, subjects were alternately assigned to one of two groups, focal or divided attention. At the beginning of the session, subjects were given an explanation and examples of the study procedure. In the study session, subjects read aloud pairs of words presented in the center of a green monochrome monitor. Cue words were presented in lower case letters. Response words were presented directly below the cue words in upper case letters. Each word pair was presented for two seconds, with a .5 second inter-stimulus interval. The complete set of rhyming pairs (84 pairs) was presented before a second presentation of the set of 84 rhyming pairs began, and the second presentation was completed before the third and final presentation of 84 pairs began. The study session proceeded with no delays or breaks to signal the initiation of the second and third presentation of the complete set of rhyming pairs. The order of presentation of rhyming pairs in the second and third presentations was randomized. The order of presentation of rhyming pairs in the second and third presentations was also randomized to ensure that subjects were not given the same sequence of pairs in the three blocks of rhyming pairs. Subjects read rhyme pairs aloud until the computer signalled that the study session had been completed (approximately 12 minutes for both groups).

The stimulus timing, task response, and characteristics of the visual presentation of the rhyming pairs were identical for both focused and divided attention subjects. The only difference between the two groups was that subjects in the divided attention condition were informed that random digits (zero to nine) would be presented auditorially in a random order using the digit sequence used by Jennings & Jacoby (1993). The auditory presentation of each digit was from a voice synthesizer driven by the computer, and new digits were presented every 3.5 seconds. Subjects in the divided attention condition were instructed to monitor for the occurrence of three odd numbers in a continuous sequence and to indicate detection of the sequence by raising a hand. Accuracy of detection of odd-digit sequences was monitored by the experimenter. Subjects were told of the occurrence of the third odd-number sequence they had failed to detect, redirecting their attention to the secondary task in order to ensure that both tasks were attended to. This prompting of failure to detect three consecutive odd-digit sequences was required very infrequently, the majority of subjects performing the task above the 85% accuracy level.

There was a 5 minute study-to-test interval. During this interval, subjects participated in casual conversation with the experimenter, to prevent rehearsal of study materials.

In the test session, cue words were presented in the center of a monochrome screen and subjects were asked to respond by naming aloud a rhyme associate in one of two instruction conditions (inclusion, exclusion). In the inclusion condition, subjects were instructed "to respond with a word which would create a rhyming pair, if possible the one with which the presented cue word was paired during study, or any other rhyming word if they could not remember a study rhyme". In the exclusion condition, subjects were instructed "to respond with a word which rhymed with the cue word, but not a word that had been paired with the cue word during study". Each of the instruction conditions consisted of the presentation of 48 cue words, 12 from each of the four test conditions (intact, broken, repaired, and non-studied) presented in a random order. Cue words remained on the screen until subjects produced a rhyme response.

To counterbalance the ordering of tests, half the subjects received inclusion instructions first and exclusion instructions second, and the remaining subjects received exclusion instructions first and inclusion instructions second. Subjects responded by naming a word that rhymed with the presented cue, and the experimenter typed this word into the computer. The experimenter typed the responses rather than the subject to minimize spelling and typing errors. An electronic tone was produced if 30 seconds elapsed without a response, whereupon the experimenter reiterated the retrieval instructions and asked for a response. This occurred infrequently, as most subjects responded promptly to the test cues. Incorrect entries or spelling mistakes made by the experimenter could be corrected at the completion of testing.

Results

Table 1 displays the mean responses in the two test instruction conditions (exclusion and inclusion) as a function of attention (focused and divided attention) and study (intact, broken, repaired, and new) conditions. The exclusion and inclusion responses for each attention and study condition were used to produce estimates of automatic and recollective memory performance for each subject using the formulas (1 - 4) mentioned previously (see also Jacoby, 1991). Table 2 displays the eight estimates of mean automatic and recollective memory. Separate analyses of variance (ANOVA) were performed on each of these dependent variables. In each dependent variable the first analysis considered old versus new performance, while a second analysis considered only differences between the old conditions and corrected for between group differences in the level of new responses or in guessing by subtracting the non-studied from the studied conditions.

Recollective Memory: Old versus New

A 2 X 4 between-within subjects ANOVA comparing 2 levels of attention (focal versus divide) and 4 levels of test condition (intact, broken, repaired, and new) revealed no significant between-subjects effect of attention ($F < 1$), a significant within-subjects main effect of study context [$F(3,90) = 20.47$, $MSe = .02$], and a significant interaction between attention and study context [$F(3,90) = 2.73$, $MSe = .02$].

To compare the studied conditions (intact, broken, and repaired) with the new condition a critical difference was calculated using Fisher's LSD and the MSe of the interaction, [$t(df = 90) = 2.00$, $p < .05$], (All t-values reported in the following analyses are two-tailed unless stated otherwise). The resulting critical difference of .10 indicated that in the focused attention group, the intact (mean = .40) and repaired (mean = .20) conditions were significantly greater than the new condition (mean = .03), while in the divided attention group only the intact (mean = .28) study context was significantly greater than the new (mean = .07) study context.

Corrected (Old - New) Recollective Memory

While the new response did not differ significantly between the two attention groups [t(df = 30) = -.81, p = .424], there was a higher proportion of new responses in the divided attention (mean = .07) than in the focal (mean = .03) attention condition, perhaps indicating a greater tendency for guessing in the divided attention condition. To reduce the possibility of guessing in the divided attention group inflating responses in the study conditions, estimates of automatic and recollective memory performance were adjusted by subtracting performance in the new condition from the three studied conditions, creating three studied conditions corrected for guessing (intact, broken, and repaired) for each subject. Table 3 displays the corrected mean proportions of recollective and automatic memory performance.

A 2 X 3 between-within subjects ANOVA comparing 2 levels of attention (focal versus divided) and 3 levels of study context (intact, broken, and repaired) revealed no significant between-subjects effect of attention condition [$F(1,30)$ = 2.13, MSe = .10], a significant main effect of study context [$F(2,60)$ = 19.35, MSe = .02], and a significant interaction between attention and study context [$F(2,60)$ = 3.06, MSe = .02].

To examine the interaction between attention and study context, a critical difference was calculated using Fisher's LSD and the MSe of the interaction, [t(df = 60) = 2.00, p = .05]. The resulting critical difference of .06 indicated that memory performance was significantly greater in the focused than divided attention group for intact (means = .36 and .21, for focused and divided) and repaired (means = .16 and .03, for focused and divided), but not broken (means = .07 and .08, for focused and divided) study context. For both attention groups, recollective memory performance in the intact study context was significantly greater than in the broken or repaired study context.

Automatic Memory: Old versus New

A 2 X 4 between-within subjects ANOVA comparing 2 levels of attention (focal versus divided) and 4 levels of test condition (intact, broken, repaired, and new) revealed no between-subjects effect of attention (F < 1), a significant within-subjects main effect of study context [F(3,90) = 9.16, MSe = .01], and no interaction between attention and study context (F < 1).

To compare the studied conditions (intact, broken, and repaired) with the new condition a critical difference was calculated using Fisher's LSD and the MSe of the main effect, [t(df = 90) = 2.00, p < .05]. The resulting critical difference of .05 indicated that all studied conditions (means = .35, .31, and .32 for intact, broken, and repaired respectively) were significantly greater than the new condition (mean = .23).

Corrected (Old - New) Automatic Memory

A 2 X 3 between-within subjects ANOVA comparing 2 levels of attention (focal versus divided) and 3 levels of study context (intact, broken, and repaired) revealed no significant between-subjects effect of attention ($F < 1$), within-subjects main effect of study context [$F(2,60) = 1.57$, $MSe = .01$], or interaction between attention and study context ($F < 1$).

Discussion

Experiment 1 was conducted to examine the inference from studies with amnesiacs (Warrington & Wieskrantz, 1982) that phonological associations could occur by way of automatic memory. To identify separate recollective and automatic factors in phonological association, Jacoby's (1991) Process Dissociation Procedure was used. To check the independence of these estimates the experiment attempted to identify dissociations between recollective and automatic memory as a result of manipulations of attention and study context. While recollective memory performance revealed an effect of phonological association, no effect of phonological association was found in automatic memory.

The manipulation of rhyme context at study resulted in more recollective responses in the intact rhyme paired condition than in the repaired condition while the focused but not divided repaired condition was found to be greater than the non-studied condition, thus, providing evidence of phonological association in recollective memory performance. Automatic memory performance in all studied conditions (intact, broken, repaired) was found to be reliably greater than non-studied, which implies an effect of memory from the prior presentation, but the rhyme context manipulations did not result in differences between the intact, broken, and repaired rhyme conditions. Not finding a benefit of an intact context implies that there is no effect of phonological association in automatic memory performance.

There were other dissociations between recollective and automatic memory in addition to phonological association. Manipulations of attention affected recollective but not automatic memory performance. Recollective memory performance was significantly reduced by dividing attention at study although the size of the reduction depended upon the rhyme context manipulation. Intact and repaired, but not broken, rhyme context conditions showed significant reductions in recollective memory performance from dividing attention . Automatic memory performance was found to be unaffected by the manipulation of attention as well as of study context. This process dissociation between recollective and automatic memory is consistent with the assumption of independence between recollective and automatic memory performance using Jacoby's (1994) Process Dissociation Procedure. However, a single dissociation does not exclude the interpretation that recollective and automatic memory differ in their sensitivity to a single underlying memory trace with recollective producing a more sensitive measure than automatic memory. To avoid this interpretation it would be useful to examine a manipulation which could produce the second leg of a double dissociation. That is, a manipulation that affected automatic but not recollective memory. In which case a differential sensitivity interpretation cannot explain the data. Experiment 2, was designed to provide an opportunity to observe the second leg of such a double dissociation.

An unexpected result of Experiment 1 was that there was no significant differences between attention conditions for the broken context condition. It is suggested that this failure to show a benefit of focused attention in the broken condition might reflect a response conflict unique to this condition where subjects attempted to simultaneously recall the study associate (a non-rhyming word) using a rhyme cue, which resulted in conflicting response information. Because of this potential response conflict in retrieval of rhyme associates in the broken study context, the broken context was not used in Experiment 2.

Experiment 1 also attempted to clarify Scott's (1994) results in automatic memory performance. Scott (1994) found a significant increase in automatic memory between intact and non-studied condition, but no significant differences between the broken, repaired, and non-studied condition or between intact broken and repaired contexts. These failures to find significant differences was thought possibly to be due to the presence of floor effects. Experiment 1 used three presentations at study rather than one presentation as used by Scott (1994) in an attempt to avoid floor effects. In Experiment 1, estimates of automatic memory in all study conditions were significantly greater than performance in the non-studied condition. That is, the results are consistent with the interpretation of floor effects in Scott's (1994) study. However, to confirm this interpretation, the effects of study repetition (1 or 3 presentations) were explicitly manipulated in Experiment 2.

In summary, manipulations of attention and study context in Experiment 1 affected recollective but not automatic memory performance. The results provide evidence of automatic memory retrieval that is independent of retrieval from recollective memory processes (using an intact population). This is consistent with earlier findings (Graf & Schacter, 1985; Jacoby, 1991; Jacoby & Kelly, 1992; Jacoby et al., 1989; Jennings & Jacoby, 1993; Scott, 1994). However, no differences were found between intact and control context conditions (broken, repaired), suggesting a lack of phonological association in automatic memory performance. Experiment 2 offered an opportunity to replicate this failure to find an effect of phonological association in automatic memory performance, and to identify a study manipulation that affected automatic but not recollective memory in order to provide the second leg of a double dissociation.

Experiment 2

Experiment 1 demonstrated a single process dissociation between automatic and recollective memory performance by manipulating two factors (attention, study context), which affected recollective memory but not automatic memory performance.

Experiment 2 offered an opportunity to look for a dissociation in the reverse direction to those seen in Experiment 1 by evaluating recollective and automatic memory performance in a phonological association task using a factor (modality) previously found to effect automatic but not recollective memory performance (Kirsner, Dunn, & Standen, 1989; Kirsner, Milech, & Standen, 1983; Kirsner & Smith, 1974; Jacoby & Dallas, 1981; Scarborough, Gerard, & Cortese, 1979).

The design of Experiment 2 was identical to Experiment 1 with the following four major exceptions: 1) modality of presentation at study (auditory or visual) was manipulated as a within-subjects factor, 2) there was no manipulation of divided attention, 3) the number of study pair presentations (1 or 3) was manipulated as a between-subjects factor, and 4) the broken study context was removed. Other minor modifications required by the manipulation of modality in terms of materials, apparatus, and procedure are discussed in the method section.

Based on earlier findings (Kirsner, Dunn, & Standen, 1989; Kirsner, Milech, & Standen, 1983; Kirsner & Smith, 1974; Jacoby & Dallas, 1981) it was predicted that automatic memory in experiment 2 would be affected by the manipulation of modality while recollective memory would be unaffected by this manipulation. As in Experiment 1 it was predicted that, the manipulation of rhyme context at study would result in more recollective responses in the intact rhyme paired condition than in the repaired or new word conditions, but there would be no differences between intact and repaired automatic responses which in turn would be greater than the new condition.

Experiment 2 also examined the effects of repetition (1 or 3 study presentations) in the same experiment in order to consider the explanation of the differences in automatic memory found between the pilot study and Experiment 1. It was hypothesized that both types of memory (recollective and automatic) would be influenced by repetition (e.g., Jacoby & Dallas, 1981; Scarborough, Gerard, & Cortese, 1979).

Method

Subjects

Forty introductory psychology students at Lakehead University received a bonus mark for an hour's participation.

Materials & Apparatus

Experiment 2 used the same materials as those used in Experiment 1, with the following exceptions and modifications: 1) counterbalancing required that the set of rhyming words be expanded from 96 triplets to 120 triplets, 2) there were 5 counterbalanced test conditions, requiring five sub-lists, 3) due to auditory presentation of cues, 8 homonyms were removed by exchanging target with non-homonyms from the buffer rhyme triplets, 4) counterbalancing the 5 sub-lists required a minimum of 20 subjects, 5) study and testing materials were presented and controlled by a Macintosh computer on a colour monitor with stereo speakers for auditory output.

As in Experiment 1, rare and common target and response words were distributed as evenly as possible over the 5 sub-lists using frequency counts listed in Thorndike and Lorge (1959), and sub-lists were equated in terms of the number of rhyme alternatives to cue words sharing the same rhyming sound based on frequencies listed in "The Rhyming Dictionary" (Wood, 1992). Equating rare and common rhyme alternatives across sub-lists was done to reduce variability between the sub-lists in the number of response alternatives.

Design

The design was a 2 X 2 X 2 mixed factorial. The main experimental study conditions were formed by the combination of the two within-subjects factors: study modality (visual versus auditory presentation of response items) and study context (intact versus repaired pairs) with the addition of a single non-studied condition (new) introduced at test. The design also included the manipulation of study presentation repetition (1 or 3 presentations) as a between-subjects factor. As such, at test there were 5 levels of within-subjects test condition (visual/intact, visual/repaired, auditory/intact, auditory/repaired, and new) applied to 2 levels of the between-subjects factor study repetition (1 or 3 presentations). This allowed examination of the effects of a prior presentation in the intact and repaired rhyme study context in one of two input modalities (visual or auditory response words), by comparing performance in studied conditions with the non-study condition.

In all study conditions cue words were presented in both visual and auditory modalities to ensure the robustness of cue presentation was equal for both modality conditions. In the visual-intact rhyme condition, the study trials presented cue words in both modalities and response words visually in rhyming pairs where there was an explicit association between cue and response words. For example, at study subjects saw and heard "brain", then saw "TRAIN" immediately after presentation of "brain". At test the cue (brain) was presented visually as a cue for the response rhyme (TRAIN). The auditory-intact condition was identical to the visual-intact condition with the exception that the response rhyme was presented auditorially rather than visually. For example, at study subjects saw and heard "brain" then heard "TRAIN" immediately after presentation of "brain". At test the cue (brain) was presented visually as a cue for the response rhyme (TRAIN). In the visual-repaired condition, the study trials presented visually the response rhyme paired with the alternate cue. For example, at study the response rhyme (TRAIN) was presented visually as part of a study-rhyme pair (e.g., rain-TRAIN), and at test the cue (brain) was presented visually as a cue for the response rhyme (TRAIN). The auditory-repaired condition was identical to the visual-repaired condition with the exception that the response rhyme was presented auditorially rather than visually. For example, at study subjects saw and heard "rain" then heard "TRAIN" immediately after presentation of "rain". At test the cue (brain) was presented visually as a cue for the response rhyme (TRAIN). Thus, cue word presentation was identical for visual and auditory conditions, only the study modality of rhyme response was varied.

There were two levels of the between-subjects factor, study repetition (one and three presentations), which allowed direct examination of possible increases in recollective and automatic memory performance due to repetition of rhyme pairs.

As in Experiment 1, to assess automatic and recollective contributions to memory, responses in inclusion and exclusion instructional conditions were used in the formulas provided by Jacoby et al. (1991) to create estimates of recollective and automatic memory.

Procedure

Experiment 2 utilized the same procedure as Experiment 1 with the following modifications; 1) during the study session, subjects were visually presented with rhyming words in the center of a colour monitor, 2) auditory presentation of rhyming words was produced by the computer speakers, 3) during the study session, the first word in the rhyming pair was presented visually on the monitor and auditorially over the speakers, while the second word in the rhyming pair was presented *either* visually on the monitor, or auditorially over the speakers, 4) there was no divided attention condition, 5) there was a 2.5 second inter-stimulus interval, while the duration of presentation varies to correspond with the duration of auditory presentation (mean approximately 1 second), and 6) there are two study presentations, one and three repetitions.

The two study presentations, one or three repetitions of the study list, took 8 and 20 minutes respectively to complete. The one repetition study presentation involved presentation of 8 primacy buffers followed by 96 rhyme pairs, followed by 12 recency buffers. For subjects in the three repetition condition, the study presentation was the same as in Experiment 1 with exceptions in terms of materials (120 rhyming pairs), and modality of presentation (visual or auditory response words) as noted earlier. As in Experiment 1, the study session continued until the computer signalled that the study session had been completed. The computer recorded typed responses and latency in the test phases.

Results

Table 4 displays the mean responses in the two test instruction conditions (exclusion and inclusion instruction) as a function of number of study presentations (1 and 3 presentations) and study (visual and auditory crossed with intact and repaired, plus unstudied) conditions. As in Experiment 1, the inclusion and exclusion responses for each presentation and study condition were used to produce estimates (recollective and automatic memory) for each subject. Table 5 displays the twenty estimates of mean automatic and recollective memory. As in Experiment 1 separate analyses of variance (ANOVA) were performed for the two dependent variables: automatic and recollective estimates of memory, and for each dependant variable a first analysis considered old versus new performance, while a second analysis considered only differences between the old conditions corrected for guessing.

Recollective Memory: Old versus New

A 2 X 5 between-within subjects ANOVA comparing 2 levels of study repetition (1,3) and 5 levels of test condition (visual-intact, visual-repaired, auditory-intact, auditory-repaired, and new) revealed a significant between-subjects effect of repetition [$F(1,38) = 5.17$, $MSe = .20$], a significant within-subjects main effect of study context [$F(4,152) = 20.55$, $MSe = .04$], and a significant interaction between repetition and study context [$F(4,152) = 3.78$, $MSe = .04$].

To compare the studied conditions (visual-intact, visual-repaired, auditory-intact, auditory-repaired) with the new condition, a critical difference was calculated using Fisher's

LSD and the MSe of the interaction [t(df = 152) = 1.96, $p < .05$]. The resulting critical difference of .12 indicated that with a single study presentation, only the intact study contexts (means = .20 and .16 for visual-and auditory-intact) were significantly greater than the new condition (mean = -.02), while with three presentations, the visual-and auditory-intact (means = .49 and .42 for visual-and auditory-intact), and visual repaired (mean = .15) study contexts were significantly greater than the new condition (mean = .02). In short, all studied conditions were found to be significantly greater than the new condition except the auditory-repaired study context for both levels of study repetition and the visual-repaired condition for single repetition. A one factor between, one factor within ANOVA was performed using the repaired and new study contexts only to consider this interaction. The analysis revealed that there were no significant differences between repaired conditions, while all repaired conditions were significantly greater than the new condition [F(2,76) = 6.04, MSe = .03].

Corrected (Old - New) Recollective Memory

Table 6 displays the corrected mean proportions of recollective and automatic memory performance. An ANOVA comparing modality (visual, auditory) and study context (intact, repaired) within-subjects, and study repetition (1,3) between-subjects revealed significant main effects of repetition [$F(1,38) = 4.23$, $MSe = .14$], and study context [$F(1,38) = 29.97$, $MSe = .06$], and a significant interaction [$F(1,38) = 8.36$, $MSe = .06$]. There was a non-significant main effect of modality [$F(1,38) = 1.42$, $MSe = .03$], and its two-way interaction with presentation, and it's three-way interaction with repetition and study context ($F < 1$) in all comparisons.

To examine the interaction between repetitions and intact/repaired study context, a critical difference was calculated using Fisher's LSD and the MSe of the interaction [$t(df = 38) = 2.04$, $p = .05$]. The calculated critical difference of .16 indicated that memory performance with intact context was significantly greater than with repaired context for three presentations (means = .43 and .12 for intact and repaired) but not single presentation (means = .20 and .11 for intact and repaired). A single factor within-subjects ANOVA was performed using the single presentation group only to verify this interpretation of the interaction. The analysis confirmed that there were no significant differences between intact and repaired context conditions for the single presentation group [$F(3,57) = 1.84$, $MSe = .04$].

Automatic Memory: Old versus New

A 2 X 5 between-within subjects ANOVA comparing 2 levels of study repetition (1,3) and 5 levels of test condition (visual-intact, visual-repaired, auditory-intact, auditory-repaired, and new) revealed a non-significant between-subjects effect of repetition [$F(1,38) = 3.07$, MSe = .04], and a significant within-subjects main effect of study context [$F(4,152) = 19.80$, MSe = .02]. The interaction between repetition and study context was not significant ($F < 1$).

To compare the studied conditions (visual-intact, visual-repaired, auditory-intact, auditory-repaired) with the new condition, a critical difference was calculated using Fisher's LSD and the MSe of the main effect [$t(df = 152) = 1.96$, $p < .05$]. The critical difference of .06 indicated that all studied conditions were significantly greater than the new condition.

Corrected (Old - New) Automatic Memory

Table 6 displays the corrected mean proportions of recollective and automatic memory performance. An ANOVA comparing modality (visual, auditory) and study context (intact, repaired) within-subjects, and study repetition (1,3) between-subjects revealed a significant between-subjects effect of repetition [$F(1,38) = 5.90$, MSe = .05], a main effect of study context [$F(1,38) = 9.15$, MSe = .03], and no interaction between repetition and study context ($F < 1$). There was no main effect of modality [$F(1,38) = 2.62$, $MSe = .02$], but the interaction between modality and study context was significant [$F(1,38) = 12.25$, $MSe = .02$]. There was no two-way interaction between modality and repetition ($F < 1$), or three-way interaction between modality, repetition, and study context ($F < 1$).

To examine the interaction between modality and study context, a critical difference was calculated using Fisher's LSD and the MSe of the interaction [$t(df = 38) = 2.04$, $p = .05$]. The resulting critical difference of .07 indicated that memory performance was greater following a visual than an auditory presentation in the intact (means = .27 and .16 for visual and auditory) but not repaired (means = .12 and .15 for visual and auditory) study contexts.

Discussion

There were two important results observed in Experiment 2: the effect of modality on phonological association and the effect of repetition.

Modality and Phonological Association

There was no main effect of or interaction involving modality in recollective memory performance, but there was a main effect and no interaction involving phonological association (more responses in the intact than the repaired condition).

However, while there was no main effect of modality in automatic memory performance, there was an interaction between modality and phonological association as well as a main effect of phonological association. Modality interacted with phonological association such that a modality effect occurred only in the intact condition or intact being greater than repaired was observed only in the same modality conditions. In summary, maintaining the same modality between the study response word and test cue interacted with intact versus repaired in automatic but not recollective memory. Thus the results provided some suggestion of a second leg of a double-dissociation between recollective and automatic memory in a phonological association task. However there is a difficulty here in that in Experiment 2 there was a phonological association effect in automatic memory, while in Experiment 1 there was not.

Phonological association in automatic memory in Experiment 2 occurred in essentially the same conditions used in Experiment 1 (same modality for study and test cue) which failed to find evidence of phonological association in automatic memory. This failure to replicate the effect of phonological association in automatic memory may be due simply to chance or more interestingly it may be a result of differences in study encoding between the two experiments. It is suggested that chance is not a likely explanation of the differences in phonological association in automatic memory observed between Experiments 1 and 2 because both Experiments 1 and 2 employed two groups of subjects and both groups within each of the experiments showed similar patterns of automatic memory. It is proposed that the differences observed between the two experiments in automatic memory more likely reflect differences between the two experiments in study encoding.

Phonological association in automatic memory may have been influenced by differences in processing at study introduced by task differences between the two experiments. The instructions to subjects (speak the two words aloud) did not differ between the two experiments, but the nature of the study presentation did differ. In Experiment 2, cue words at study were heard as well as seen, while in Experiment 1 study, cue words were only seen. Hearing as well as seeing cue words may have enhanced rhyme-based processing at study, thus leading to better automatic memory for rhyme information in Experiment 2. Alternatively the difference in phonological association in automatic memory between the two experiments may be due to the rapid visual presentation employed in Experiment 2 relative to Experiment 1. To control visual and auditory study presentation duration in Experiment 2, rhyme response words were presented visually in Experiment 2 only for the amount of time it took to play its matching sound file and would then disappear from the screen. As the typical duration was less than 1 second, this resulted in subjects having to recall the visual response word rather than read it as they spoke the two words aloud. Thus subjects were required to actively encode the word pairs in working memory in order to repeat them back in Experiment 2. In contrast, Experiment 1 presented both words of the pair simultaneously on the screen for sufficient time for subjects to begin speaking the pair and thus did not require the same degree of encoding in working memory.

Repetition

Experiment 2 also examined the effects of manipulating study presentation (1 versus 3). As expected, both recollective and automatic memory performance were influenced by repetition and showed significant increases in estimates of memory due to increased repetition of study materials (Jacoby & Dallas, 1981). However, unlike the pilot experiment (Scott, 1994) one presentation at study resulted in all automatic study conditions being significantly greater than the non-studied condition. Scott found that only the intact condition was significantly greater than the non-studied condition. Thus a single study presentation does not necessarily lead to floor effects. Nonetheless, the observation of increases in memory performance from three relative to one repetition is consistent with floor effects as a possible explanation of Scott's results.

In conclusion, the manipulation of study modality revealed a complex dissociation between factors affecting recollective and automatic memory. The results of Experiment 2 provided some suggestion of a second leg of a double-dissociation between recollective and automatic memory in a phonological association task but failed to replicate the automatic memory results of Experiment 1. The expected effect of greater memory performance due to increased repetition of study presentation was confirmed, however floor effects were not observed in automatic memory performance with only one study presentation.

General Discussion

The two experiments reported here sought to identify two types of memory (recollective and automatic) in phonological association using healthy or non-memory-impaired subjects. This was done to validate the inference drawn from the amnesia literature that phonological association has two components, one which is impaired in amnesiac subjects (a recollective component) and one which is intact (an automatic component).

The experiments used Jacoby's Process Dissociation Procedure to identify seperate recollective and automatic memory components, with introductory psychology students serving as the non-memory impaired population. It was predicted that if phonological association occurred independently in recollective and automatic memory then it should be possible to obtain independent measures of phonological association in the two memory processes. The experiments also manipulated encoding and retrieval conditions to provide converging evidence, using process dissociations, of the independence of the measures of recollective and automatic memory estimated by Jacoby's method.

Given that the estimates of recollective and automatic memory are independent (but see Curran & Hintzman, 1995), some general statements can be made about dissociations found in the current experiments. The manipulation of attention affected only recollective memory, while the manipulation of modality affected only automatic memory, only in some conditions. Thus, while the data are consistent with separate recollective and automatic estimates of memory, the evidence of independence was incomplete in that a clear double-dissociation was not found.

Effects from a prior presentation can occur at both the pair (word or phonological association) and item (word response) level. Although item effects are not of primary interest in this study, a brief summary is nonetheless provided following the discussion of pair effects. I will end with a discussion about how the present results generalize to phonological association in amnesiac patients.

Pair Effects

Pair effects (required to identify phonological association in memory performance) were estimated in both experiments by comparing intact with repaired performance. In recollective memory there was clear evidence of phonological association with intact being greater than repaired in all conditions. There was an interaction in Experiment 1 in which phonological association in recollective memory was greater with focal than divided attention.

In contrast, there were only a few conditions where phonological association might have occurred in automatic memory if at all. In Experiment 1 there was no evidence of phonological association in automatic memory performance. That is, there was no benefit of intact versus repaired context in estimates of automatic memory, in either the focal or divided attention group. However phonological association was observed in automatic memory in Experiment 2 for same but not different modality conditions, for both one and three study repetition groups. That is, maintaining the same modality between study response word and test cue interacted with intact versus repaired context in automatic memory.

It is proposed that there may be some limited conditions, as previously discussed in Experiment 2, which produce phonological association in automatic memory. Alternatively, it may be that the automatic memory results of Experiment 2 are not replicable.

Further research is needed to verify either or both patterns of results found in Experiments 1 and 2. If both experiments are replicable, then situational factors included in experiment 2's procedure must result in encoding strategies which produce phonological association in automatic memory. To test what these factors may be, future research should manipulate separately the factors that differed between experiments 1 and 2. That is, study duration and joint auditory/visual presentation of the study cue.

The short study duration of cue words in Experiment 2 required subjects to manipulate the study information in working memory before speaking the word pair aloud, while in Experiment 1 the cue word was present until after the subjects had spoken the word pair aloud. That is, it may be that active manipulation of the cue and response word in a phonological based working memory buffer is necessary to produce phonological association in automatic memory. It may be that this concurrent processing in working memory present in Experiment 2 but not Experiment 1 produces phonological association in automatic memory.

The joint presentation of the study cue word in auditory and visual modality may have emphasized the phonological information encoded about the cue word in Experiment 2, whereas in Experiment 1 the silent presentation may have not emphasized that information. That is, in order to produce phonological association in automatic memory an explicit processing of the rhyme may be required, simply reading the word pair may not provide sufficient phonological information.

Given that the pattern of results in Experiments 1 and 2 are replicable, the modality specificity of the results would also have to be tested using auditory study and test cues, rather than visual. That is, does any same/different modality manipulation produce the interaction between modality and phonological association observed in experiment 2, or is the result due to the visual cue modality as used in Experiment 2? To test this, a future experiment could replicate the modality conditions of Experiment 2 (visual cue-visual response and visual cue-auditory response) adding two conditions (auditory cue-auditory response and auditory cue-visual response), while manipulating study context (intact and repaired). If it is a general modality specific effect of phonological association in automatic memory, then the same pattern of interaction should be observed with auditory as well as visual test cues. That is, intact being greater than repaired in the same but not different modality.

In summary, the present experiments did not find robust support for phonological association occurring in automatic memory. Overall the results are more consistent with only a single source of phonological association (recollective memory).

But it may be that phonological association in automatic memory can occur in some limited and yet to be specified contexts.

Item Effects

Item effects were evaluated by comparing non-studied with repaired performance in Experiments 1 and 2. Item effects were observed in all automatic memory conditions in both experiments, and most but not all conditions in recollective memory. Across experiments only one condition failed to be significantly greater than the non-studied (Experiment 1, divided attention repaired). Only a single dissociation was found in item effects. The manipulation of attention was found to affect recollective but not automatic item memory in Experiment 1. The manipulation of modality did not affect either recollective or automatic item memory in Experiment 2. Thus, weaker evidence of dissociation was found with item than pair effects. The implications of the present results for interpretations of phonological association in amnesiac populations are considered in the following section.

Generalizability to Phonological Association in Amnesiac Patients

Near normal memory effects in amnesiacs on some tests of memory in the face of severe or general memory impairments have often been taken as evidence of implicit memory (Cermak, 1993; Cohen, 1984; Graf & Schacter, 1985; Graf, Squire & Mandler, 1984; McAndrews, Glisky & Schacter, 1987; Hayman, Macdonald, &

Tulving, 1993; Hirst, Johnson, Kim, Phelps, Risse, & Volpe, 1986; Schacter, 1987; Squire, Shimamura, & Graf, 1985; Tulving, Schacter, & Stark, 1982; Warrington & Weiskrantz, 1982). Warrington & Wieskrantz (1982) did not use the term implicit memory but found amnesiacs' memory performance in the phonological association task to be equivalent to that of control subjects, in contrast to significantly reduced memory performance in recall and recognition tasks. It might be inferred that amnesiac performance in the phonological association task reflects phonologically-based associations supported by implicit (automatic) memory. The present results question this inference although they cannot rule out that automatic memory may support phonological association under some yet unspecified conditions.

It is possible that phonological association (in automatic memory) occurs only in some situations. In Experiment 1 there was no evidence of phonological association in either of two groups. However, in automatic memory performance in Experiment 2, phonological association occured in the same modality condition for both repetition (one and three) groups. Finding phonological association in one experiment but not the other may be a chance event but is not likely to be so, as the presence and absence of phonological association in automatic memory was replicated by two groups in each case. It may be that the presence and absence of phonological association is due to situational factors which affect phonological processing at study. If phonological association in automatic (or implicit) memory is a rare (or non-existent) event, then what can be said about the evidence from the amnesiac subjects?

It may be possible that there are situations where phonological association does occur in automatic memory because of processing factors which promote rehearsal of phonological association in working memory. Thus, it is possible that the procedures used with amnesiac patients (Warrington & Weiskrantz, 1982) created the appropriate conditions (as discussed previously) that can support phonological association in automatic memory. If the automatic memory results of Experiment 2 are replicable, assessment of what processing factors may be involved is required to help confirm this suggestion.

Alternatively, the memory effects observed with amnesiac performance may be largely due to item and not pair effects. If so, then there is no reason to assume phonological association is present in amnesiac performance. The reason for this comment is that unfortunately Warrington and Weiskrantz (1982) did not provide controls for identifying item effects (which the present results indicate were probably occuring), resulting in the inability to separate out item from pair effects in amnesiac subjects' performance. Evidence of phonological association in amnesiac populations has been reported by several researchers

(Cutting, 1978; Maki, Bylsma, & Brandt, 2000; McLean & Hitch, 1999; Nickels, Howard, & Best, 1997; Warrington & Weiskrantz, 1982; Winocur & Weiskrantz, 1976). Again, unfortunately these studies did not provide procedures that allow the isolation of item and pair effects within the phonological association task. The distinction between item and pair effects in amnesiac performance of rhyme-based memory tasks was not relevant to their investigations. However, considering present results, it would be useful to evaluate performance in amnesiac subjects using controls for item effects before concluding that phonological association is present in implicit or automatic memory.

Another factor limiting generalization to the patient literature is the possibility that recollective and automatic memory as measured by Jacoby's method do not perfectly map onto the pattern of retention and loss of memory performance in amnesia. This possibility would be difficult to assess as amnesiacs would find responding to some of Jacoby's test instructions (i.e., exclusion testing) problematic. Subject performance during exclusion testing relies on recall and recognition, in which by definition amnesiacs are deficient (Hayman et al., 1993; Schacter, 1987; Schacter & Tulving, 1994).

Finally, the fact that amnesiac subjects show some capability of phonological association may not be entirely due to implicit memory effects. Researchers have noted that density of amnesia is a continuum rather than a dichotomy, and that even selecting for criterion indicating severe amnesia does not neccessarily exclude recollective processes (Hirst et al., 1986). Thus, there is the possibility that amnesiac subjects of mixed etiologies (Alcoholic Korsafoff's Syndrome, Encephalitis, and Head Injury) may have some residual recollective capabilities.

Summary

The purpose of the present research was to seek evidence of two types of memory (recollective and automatic) in phonological association when using normal (non-memory impaired) subjects. Finding two independent sources of phonological association would support an inference drawn from the amnesia literature that amnesiac memory performance in the phonological association task provides evidence of an implicit (or automatic) form of associative memory. It was predicted that non-memory impaired subjects would display separate automatic memory (similar to amnesiac subjects) as well as recollective memory components of phonological association. However, the results provide poor support for phonological association in automatic memory although they do not totally exclude it. It is suggested evidence of phonological association in amnesiac populations may be contaminated by the presence of item effects and by the presence of some residual recollective memory ability. In conclusion, poor evidence of phonological association occuring in automatic memory was found in non-impaired populations. However there were a few conditions which require further experimentation before it can be concluded that phonological association does not occur in automatic (or implicit) memory.

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Table 1

Mean Proportions of Memory Performance under Exclusion and Inclusion Instructions for Both Focused and Divided Attention Across Four Rhyme Manipulations in Experiment 1.

	Rhyme Relation from Study to Test							
Testing Instructions	Intact		Broken		Repaired		New	
Exclusion								
Focused Attention	.22	(.04)	.30	(.04)	.28	(.02)	.23	(.02)
Divided Attention	.26	(.03)	.25	(.03)	.27	(.03)	.20	(.03)
Inclusion								
Focused Attention	.62	(.03)	.41	(.03)	.47	(.03)	.27	(.03)
Divided Attention	.54	(.04)	.41	(.03)	.37	(.03)	.28	(.02)

Note: Numbers in parenthesis are standard errors of the mean.

Table 2

Mean Proportions of Recollective and Automatic Memory Performance for Both Focused and Divided Attention Across Four Rhyme Manipulations in Experiment 1.

	Rhyme Relation from Study to Test							
Element of Memory	Intact		Broken		Repaired		New	
Recollective								
Focused Attention	.40	(.05)	.10	(.05)	.20	(.04)	.03	(.03)
Divided Attention	.28	(.05)	.16	(.04)	.10	(.04)	.07	(.04)
Automatic								
Focused Attention	.35	(.04)	.32	(.04)	.34	(.02)	.24	(.02)
Divided Attention	.35	(.03)	.29	(.02)	.29	(.02)	.21	(.02)

Note: Numbers in parenthesis are standard errors of the mean.

Table 3

Mean Proportions of Recollective and Automatic Memory (Corrected for Guessing) for Both Focused and Divided Attention Across Three Rhyme Manipulations in Experiment 1.

Element of Memory	Rhyme Relation from Study to Test: Intact		Broken		Repaired	
Recollective						
Focused Attention	.36	(.05)	.07	(.05)	.16	(.06)
Divided Attention	.21	(.06)	.08	(.05)	.03	(.04)
Automatic						
Focused Attention	.10	(.04)	.08	(.04)	.10	(.02)
Divided Attention	.14	(.04)	.08	(.03)	.08	(.03)

Note: Numbers in parenthesis are standard errors of the mean.

Table 4

Mean Proportions of Memory Performance under Exclusion and Inclusion Instructions for Both 1 and 3 Study Presentations Across Five Rhyme Presentation Manipulations in Experiment 2.

Testing Instructions	Rhyme Relation from Study to Test				
	Visual		Auditory		
	Intact	Repaired	Intact	Repaired	New
Exclusion					
1 Presentation	.31 (.03)	.25 (.04)	.26 (.04)	.28 (.04)	.18 (.02)
3 Presentations	.25 (.04)	.30 (.05)	.24 (.04)	.30 (.03)	.15 (.02)
Inclusion					
1 Presentation	.50 (.04)	.33 (.03)	.42 (.04)	.36 (.04)	.15 (.03)
3 Presentations	.73 (.04)	.45 (.03)	.65 (.04)	.43 (.04)	.18 (.02)

Note: Numbers in parenthesis are standard errors of the mean.

Table 5

Mean Proportions of Recollective and Automatic Memory Performance for Both 1 and 3 Study Presentations Across Five Rhyme Presentation Manipulations in Experiment 2.

Element of Memory	Rhyme Relation from Study to Test				
	Visual		Auditory		
	Intact	Repaired	Intact	Repaired	New
Recollective					
1 Presentation	.20 (.05)	.08 (.04)	.16 (.07)	.08 (.06)	-.02 (.05)
3 Presentations	.49 (.07)	.15 (.07)	.42 (.08)	.13 (.06)	.02 (.04)
Automatic					
1 Presentation	.38 (.03)	.25 (.03)	.29 (.03)	.28 (.04)	.17 (.01)
3 Presentations	.47 (.05)	.30 (.04)	.35 (.05)	.34 (.02)	.15 (.01)

Note: Numbers in parenthesis are standard errors of the mean.

Table 6

Mean Proportions of Recollective and Automatic Memory (Corrected for Guessing) for 1 and 3 Study Presentations Across Four Rhyme Presentation Manipulations in Experiment 2.

Element of Memory	Rhyme Relation from Study to Test							
	Visual				Auditory			
	Intact		Repaired		Intact		Repaired	
Recollective								
1 Presentation	.22	(.05)	.11	(.05)	.18	(.06)	.10	(.04)
3 Presentations	.47	(.06)	.13	(.07)	.40	(.08)	.11	(.05)
Automatic								
1 Presentation	.22	(.03)	.08	(.03)	.12	(.03)	.12	(.03)
3 Presentations	.32	(.05)	.15	(.04)	.20	(.05)	.19	(.02)

Note: Numbers in parenthesis are standard errors of the mean.