SEPARATING HABIT AND RECOLLECTION IN YOUNG AND ELDERLY ADULTS

By

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Abstract

Memory slips are errors in performance that result when an automatic basis for responding (e.g., habit) opposes recollection for a prior event. Prior research has focused on factors that influence the probability of a memory slip while neglecting factors that facilitate performance. Using an extension of Jacoby's (1991) process-dissociation procedure, performance was examined in both a memory slip and a facilitation condition, revealing the separate contributions of habit and recollection. Results showed that manipulating the strength of habit affected estimates of habit but left recollection unchanged (Experiment 1). In contrast, manipulations of presentation rate and response time selectively influenced recollection (Experiments 2-3). Such results support a model of memory in which automatic and consciously controlled influences make independent contributions to performance.

The process-dissociation procedure was also used to examine the effects of aging on habit and recollection. It was shown that elderly adults produced more memory slips than young adults but also performed more poorly in a facilitation condition (Experiments 4 & 7). These results demonstrated age-related impairments in recollection in the presence of intact automatic responding. A similar pattern of results was observed using self-report measures of memory (Experiment 7). Older adults were also less able than the young to exploit distinctive contextual information to enhance their ability to recollect (Experiment 4). However, given more supportive study and retrieval conditions, elderly adults were able to benefit from distinctive contextual information at a level comparable to the young (Experiments 5 & 6). Quantitative and qualitative age-related deficits in recollective abilities are interpreted within a dual-process model of memory (e.g., Jacoby, 1991). The problem of distinguishing between a deficit in recollection and a deficit in inhibitory processes in older adults (e.g., Hasher & Zacks, 1988) is discussed, as is the importance of this distinction for purposes of repairing memory performance.

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Chapter 1

Introduction

By definition, amnesics are impaired in their ability to intentionally report on previously learned information. However, there has been a great deal of evidence demonstrating that amnesics show effects of prior learning in some situations (e.g., Cohen & Squire, 1980; Warrington & Weiskrantz, 1974). Citing a well-known example, the physician Claparede once pricked his amnesic patient with a pin when shaking her hand. Although the patient did not remember the incident minutes later, when Claparede held his hand out to her again, the patient refused to shake it, replying that "sometimes pins are hidden in people's hands" (Claparede, 1911/1951). The patient's behaviour provides a striking demonstration of remembering in the absence of awareness. Similarly, although amnesics cannot report an earlier presentation of a word when given a test of recognition memory or recall, they show evidence of memory by using the word more often as a completion for a word fragment than they would had the word not been presented earlier (for a review see Moscovitch, Vriezen, & Gottstein, 1993). Findings such as these support a distinction between intentional, consciously controlled influences of memory and automatic, unaware memory processes.

Theorists have been differentiating between consciously controlled and automatic influences in memory for some time. In 1890, William James distinguished between "the unconscious and conscious being of the mental state" (p.163), claiming that in addition to voluntary acts, people exhibit "tendencies for which we can give no explicit logical justification, but which are good inferences from certain premises. We know more than we can say. Our conclusions run ahead of our power to analyze their grounds" (p.166-167). James' ideas were important in suggesting that there are two different bases for making memory judgements. More recent dual process models of memory (e.g., Atkinson & Juola, 1974; Jacoby, 1991; Mandler, 1980) make a similar distinction between automatic and controlled processing. Automatic processing has been defined as a rapid basis for responding which is under the control of stimuli rather than intention, requiring minimal attentional capacity and awareness (e.g., Hasher & Zacks, 1979; Schneider & Shiffrin, 1977). In contrast, consciously controlled memory processing is aware, intentional and effortful (e.g., Jacoby, 1991; Logan, 1989).

Consciously controlled memory processes are typically measured by direct/explicit tests while automatic, unintentional memory processes are primarily reflected in performance on indirect/implicit tests. To illustrate the difference between these two types of tests, suppose that a pair of associatively related words was presented for study (e.g., knee - bend), and then memory was tested by presenting one word from the pair along with a fragment of the other word (knee - b_n_). For an indirect test of memory, people might be asked to complete the fragment with the first word that came to mind. The usual finding is that the target word (e.g., bend) is more likely to be produced as a completion than it would be had it not been earlier studied. Such results are interpreted as evidence for automatic, unconscious influences of memory because people are not asked to report on a prior event but rather, engage in a task that indirectly reflects their memory. For a direct test, people might be instructed to use the word and fragment as cues for recall of the earlier-studied word. Cued recall of a word is said to reflect consciously controlled, intentional use of memory.

In recent years there has been a great deal of interest and excitement investigating dissociations in memory performance across indirect and direct tests (e.g., Richardson-Klavehn & Bjork, 1988; Roediger & McDermott, 1993). Findings of such dissociations have been taken as evidence for different types of memory processes or systems. Similarly, researchers have distinguished between memory for "knowing how" and "knowing that" (e.g., Cohen & Squire, 1980), suggesting that the type of memory that reflects skills and habits is different from that which underlies conscious recollection of learned facts and information (e.g., Squire, 1987). For example, amnesia spares learning which supports the development of automatic responding, or habit, yet impairs recollection for specific information (for a review see Squire, Knowlton, & Musen, 1993). Dissociations between recollection and automatic influences of memory have also been demonstrated in adults with normal memory functioning (for a review, see Roediger & McDermott, 1993), and in the animal literature (e.g., Mishkin & Appenzeller, 1987; Squire, 1992).

Memory Slips

Comparing performance on direct and indirect tests of memory has been the most popular method for measuring automatic and consciously controlled processes (for a review, see Roediger & McDermott, 1993). However, the indirect/direct test distinction attempts to measure automatic and consciously controlled processes in isolation and therefore, does not provide the means to examine these processes as they occur together. The interplay between automatic and consciously controlled processes can be seen in daily life through the memory slips that people commit. These errors in performance occur when automatic responding and intention are opposed, leading to conflicting responses (e.g., Reason, 1979; Norman, 1981). Automaticity, in this case, is expressed in the form of a habit which emerges in situations where recollection fails.

As an example, suppose you are searching your home for the keys to your car. The "typical" place you keep your keys is on a table near the front door of your home. However, sometimes you leave your keys on the dresser in your bedroom, which is what happened on this occasion. What conditions make it likely that you will mistakenly begin the search for your keys at their typical location? One factor that is important is the past probability of leaving the keys in their typical place. The higher that probability, the stronger the habit of searching for them at that location will be and consequently, the more likely one will be to commit an error when the keys are elsewhere. A second class of factors is potentially independent of those that influence the strength of a habit, and has its effects by influencing the probability of recollecting where the keys were left. Inappropriately looking in the typical place for one's car keys might be more likely if one was rushed - a condition that makes recollection of earlier leaving the keys in an atypical place less likely.

The memory slip of searching for one's keys in the wrong location could be described as a failure in recollection in combination with proactive interference reflecting habit. Among the first to write about memory slips was William James (1890), who claimed that habit, a basis for automatic responding, can interfere with intended actions. Several years later, Freud analyzed behaviour slips, including "slips of the tongue" (1922). He argued that these errors reflect unconscious desires and thoughts because such utterances conflict with what people consciously intend to say. More recently, investigators have attempted to categorize these slips in performance into various types so as to develop theories of action and understand the cognitive mechanisms underlying them (e.g, Norman, 1981; Reason, 1979).

Very little has been done to examine memory slips in experimental situations, and directly manipulate the likelihood of their occurrence. In particular, prior research has not attempted to tease apart the roles played by automatic and intentional responding in the production of memory slips. The indirect/direct test distinction provides no means of measuring automatic and consciously controlled processes as they occur together and therefore, offers little to the understanding of memory slips. Further, identifying processes with tasks, as is done by the direct/indirect test distinction, is problematic because conscious, intentional processes may contaminate performance on indirect tests (Reingold & Merikle, 1990; Toth, Reingold, & Jacoby, 1994) and, less obviously, automatic, unconscious processes may contaminate performance on direct tests (Jacoby, Toth & Yonelinas, 1993). To overcome the shortcomings of the direct/indirect test approach, I made use of Jacoby's (1991) process-dissociation procedure to separate the contribution of consciously controlled (recollection) and automatic responding (habit) within the same task. I will describe the process-dissociation procedure by outlining the basic structure of the experiments reported in this thesis.

Separating Habit and Recollection

The experiments reported here were designed to separate the contribution of habit from that of recollection failure as determinants of memory slips. To do this, I show that it is necessary to also examine performance in situations for which automatic influences of memory and intention work in concert. In such a situation, habit serves as a basis for correct responding rather than as a source of error. As an example, finding keys in their typical location may not always rely on one's ability to recollect having placed them there but instead, can reflect habit. By this approach, the automatic influences (habit) that serve as a source of educated guessing for an in concert test condition are the same as those that serve as a source of memory slips when automatic influences and recollection act in opposition. Results from in concert and opposition conditions are combined to separate the contributions of habit and recollection within the same task (e.g., Jacoby, 1991; Jacoby, Toth, & Yonelinas, 1993).

The experiments reported here were carried out to produce dissociations between recollection and a habit that was created during the experimental session. The first phase of each experiment was a training session designed to create habits of specific strengths. During this initial phase, participants were exposed to pairs of associatively related words with the probabilities of particular pairings being varied. A stimulus word was paired with two related words such that a "typical" response (e.g. knee - bend) occurred more often than an "atypical" response (e.g. knee - bone). In Experiment 1, for example, 15 times out of 20 when the stimulus word "knee" was shown, it was paired with the response "bend" whereas for the other 5 presentations of "knee", it was paired with the response "bone". The intention was to build a habit or automatic response in a manner similar to that produced by placing one's keys in the same location on 75% of occasions and in a different location on the remaining 25% of occasions.

Once a habit was established, the second phase of the experiment created a situation similar to that of remembering where one's keys were left on a particular occasion. In the second phase of the experiment, short lists of paired words were presented for participants to remember. Within each list, some pairs were presented with the response that was made most habitual or typical by training in Phase 1 (e.g., knee - bend) whereas for other pairs, the response that was atypical in Phase 1 was shown (e.g., knee - bone). After each study list, memory was tested by presenting participants with the stimulus word of each pair along with a fragment of the target word that could be completed with either the typical or atypical response (e.g., knee - b_n_). Participants were asked to complete the fragment by recalling the response that was paired with the stimulus word in the short list they had just studied. For this test of memory, recollection of the target word was congruent (acted in concert) with habit when the word studied in the short list was the response that was made typical in Phase 1, but was incongruent (acted in opposition) with recollection when the studied word was the atypical response from Phase 1. For incongruent items, erroneously completing a fragment with the response that occurred most frequently in Phase 1 corresponds to a memory slip. In contrast, for congruent items, responding on the same basis of habit established in Phase 1, or on the basis of recollection, would produce a correct response.

The Process-Dissociation Procedure

Process-dissociation estimates were derived based on performance in the study-test sessions. On congruent trials participants studied items that were made typical in the training session. Performance on congruent trials represent a facilitation condition in which participants could give the correct answer at test either by recollecting (R) the item in the short study list presented in Phase 2, or by relying on habit (H) to produce the response that was made typical in Phase 1 when recollection failed (1-R). Recollection of typical items was congruent with the habit participants had formed during training. The probability of correctly giving a typical response on congruent trials can be calculated as the probability of recollection or the probability of relying on habit when recollection fails:

Congruent: Prob(typical) = R + H (1 - R)

In contrast, on incongruent trials, participants studied items that were made atypical in the training session and therefore, habit was a source of error (opposition condition). Completing a fragment with a response that was made typical in Phase 1 but that did not appear in the study list that was presented in Phase 2 constituted a memory slip. To make this type of error, participants would have to fail to recollect the response they had just studied in the preceding list of word pairs (1-R) and rely on their habit (H) of giving the typical response. The probability of incorrectly giving a typical response on incongruent trials can be calculated as the probability of relying on habit when recollection fails:

Incongruent: Prob(typical) = H (1 - R)

By combining these two equations one can calculate estimates of recollection and habit. Subtracting the probability of a memory slip on incongruent trials from the probability of a correct response on congruent trials provides an estimate of recollection:

R = Congruent - Incongruent

Given an estimate of recollection, an estimate of habit can be obtained by simple algebra, dividing the probability of a memory slip in the incongruent condition by the estimated probability of a failure in recollection:

$$H = \text{Incongruent} / (1 - R)$$

The equations used to estimate the contributions of recollection and habit (automatic influences) are the same as those used in earlier experiments that have made use of Jacoby's (1991) process-dissociation procedure (e.g., Jacoby, et al., 1993). For those earlier experiments, inclusion test instructions were used to create a situation where automatic influences and recollection acted in concert, corresponding to the situation for congruent items. For an inclusion test, participants were instructed to use a word fragment as a cue for recall of an earlier-studied word, and if unable to do so, were to complete the fragment with the first word that came to mind. Exclusion test instructions were used to create a situation for which automatic influences of memory and recollection acted in opposition, corresponding to the situation for incongruent items. For an exclusion test, participants were instructed to complete fragments with words that were *not* earlier studied. The assumptions underlying the process-dissociation procedure are the same regardless of whether in concert and opposition conditions are created by a manipulation of test instructions or by manipulating the congruence of items with prior training, as in the present experiments.

The Independence Assumption

A critical assumption underlying the process-dissociation procedure is that automatic and intentional processes serve as independent bases for responding. That is, recollection can occur with or without automatic responding and vice versa. If recollection and habit operate independently of each other, then it should be possible to show that some variables affect one memory process while leaving the other unchanged, as is the case when learning abilities are preserved by amnesics. Returning to the "keys" example, it should be possible to show that factors influencing the habit that comes from typically leaving one's keys in a particular location are different from those that are important for recollecting where the keys were left on a particular occasion. Factors traditionally identified with diminished intentional control have been shown to produce dissociations of this sort (for a review, see Jacoby, Yonelinas, & Jennings, 1997). For example, dividing attention reduces recollection but leaves automatic influences unchanged, as do the effects of aging (e.g., Jacoby, Jennings, & Hay, 1996; Jennings & Jacoby, 1993, in press). The purpose of Experiments 1-3 was to separate the effects of habit and recollection in order to examine performance in a memory slip and a facilitation condition. It was expected that manipulating the strength of habit would affect estimates of habit but leave recollection unchanged. In contrast, manipulations of presentation rate and response time were expected to influence recollection but not habit. Such dissociations would support a dual-process model of memory in which automatic and intentional influences make *independent* contributions to performance.

Effects of Aging on Memory Slips

The research described thus far has focused on separating habit from recollection in young adults. However, a goal of Experiment 4 was to show that elderly adults are more prone to memory slips than are younger adults. How might one interpret the greater likelihood of these errors by older adults? One possibility is that memory slips result from failures to inhibit effects of habit. The elderly may be more prone to memory slips than younger adults because of a greater susceptibility to interference from prior learning (e.g., Winocur & Moscovitch, 1983) due to a deficit in inhibitory processes (e.g., Hasher & Zacks, 1988). Alternatively, a dual-process view of memory distinguishes between automatic and consciously controlled uses of memory. By such an account, memory slips result when a failure in recollection leaves habit unopposed. If elderly adults are more likely to experience failures in recollection than young adults, then they will be more likely to commit memory slips as a result.

Older adults, in comparison to younger adults, are typically disadvantaged in their performance on direct tests of memory, such as tests of recognition and recall, but are less so in their performance on indirect tests of memory (for reviews, see Craik & Jennings, 1992; Hultsch & Dixon, 1990). Results of early experiments showed that elderly participants revealed an amount of priming on indirect tests that was comparable to that demonstrated by younger participants. Although these findings were taken as evidence that implicit memory does not change with age, there is now evidence of small age-related differences in performance on indirect tests of memory (for a review, see Light, 1991). Based on prior research that has demonstrated aging selectively affects recollection but leaves automatic processing intact (for reviews, see Jacoby, et al., 1996, 1997), it was expected that elderly adults would be less able to recollect an earlier event but not differ in their reliance on habit when recollection failed compared to younger adults.

Age-related differences in memory were expected to be restricted to a difference in recollection. It was predicted that older adults would produce more memory slips than young adults in the opposition condition but further, that they would be disadvantaged in a condition where habit and recollection acted in concert, showing that the problem is one of recollection rather than a deficit in inhibitory processes. By a dual-process account, recollection serves as an alternative to habit as a basis for responding, rather than simply inhibiting the effects of habit when the two act in opposition. The difference between recollection and inhibition accounts has implications for the approaches taken to repair memory performance of elderly adults. An inhibition account would train older adults to suppress interfering information whereas a dual-process account such as the one proposed here, would focus on means of enhancing recollection by helping the elderly to expand and elaborate upon information that is available.

Qualitative Processing Deficits in Older Adults

In addition to quantitative deficits in recollective processing, it has been suggested that there are age differences in the type of processing performed by young and elderly adults. Several researchers have reported that aging produces deficits in elaborative processing of item-specific information (see Craik & Jennings, 1992; Light, 1991 for reviews). In particular, it has been claimed that elderly adults do not utilize unique contextual associations when encoding and retrieving material in memory but, instead, process information in a more general, shallow manner. This lack of associative integration and elaborative processing carried out by the aged may produce less distinctive memory representations and therefore, may explain why older adults often do more poorly than young adults on memory tests providing specific retrieval cues (e.g., Burke & Light, 1981; Craik & Byrd, 1982; Craik & Simon, 1980; Rabinowitz & Ackerman, 1982; Rabinowitz, Craik, & Ackerman, 1982).

The distinction between general and specific encoding of information can be illustrated with a study reported by Craik and Simon (1980). In their experiments, participants were instructed to recall target words from earlier presented sentences (e.g., The highlight of the circus was the clumsy BEAR) when given either context-specific cues (e.g., "clumsy") or general descriptions of the words without reference to the context of the sentence (e.g., "wild animal"). The effectiveness of cue type varied with age. Young adults recalled a higher proportion of words given specific cues as compared to general cues, but this pattern of results was reversed for elderly participants. Older adults performed better when given general cues, suggesting that they encode material more generally, in terms of global semantic characteristics, and are less likely to integrate unique aspects of contextual detail in their representations.

Further support for the hypothesis that older adults have difficulties performing elaborative processing has come from studies employing levels of processing manipulations (e.g., Eysenck, 1974; Simon, 1979), where processing depth indicates more extensive semantic analysis. Eysenck showed that elderly adults have increasing deficits in memory performance with "deeper" orienting tasks, compared to younger adults. Convergent findings were reported by Simon who demonstrated that semantic cues were less effective than phonemic cues with increasing age. Elderly adults also have difficulties monitoring contextual information such as source (e.g., Dywan & Jacoby, 1990; Ferguson, Hashtroudi & Johnson, 1992; McIntyre & Craik, 1987). Johnson and her colleagues (1992; Johnson, Hashtroudi & Lindsay, 1993) have discussed the importance of "binding" aspects of specific contexts to form memories, especially involved in source decisions, and suggest that older adults may be particularly poor at carrying out such activities.

Cognitive Resources and Self-Initiated Processing

The semantic distinctiveness of items from other current information, as well as from previously accumulated knowledge, is an important determinant of memorability (e.g., Craik & Jacoby, 1979; Moscovitch & Craik, 1976). A failure to integrate items with contextually-specific information should lead to a more general encoding of semantic information, lacking in distinctiveness, which should be poorly retrieved because it does not uniquely specify its target. Craik and his colleagues (e.g., 1985, 1987; Craik & Byrd, 1982; Craik & Simon, 1980) have suggested a substantial amount of cognitive resources are required to differentiate an item from other similar items in memory. If insufficient cognitive resources are available, then there is a reduction in the richness and depth of processing involved and thus a less distinctive encoding of information may occur. It has been proposed that elderly adults lack the cognitive resources needed to carry out elaborative processing of contextual information. Indeed, many studies have supported this explanation of age-related deficits in memory functioning (e.g., Cohen, 1979; Craik, 1986; Simon, 1979). Further support has come from studies in which young adults show impairments in their ability to utilize specific but not general retrieval cues when performing under conditions of divided attention (e.g., Rabinowitz, et al., 1982) or speeded presentation (Simon, 1979).

Although young adults can spontaneously elaborate information presented to them, older adults may be less likely to perform elaborative processing unless guided by external sources (e.g., Hulicka & Grossman, 1967; Treat & Reese, 1976). In studies that have reported no age differences in the processing of contextual information, older adults have typically been provided with mediational strategies, have been allowed sufficient time to process information, or have performed highly structured tasks (see Craik, 1986; Craik & Rabinowitz, 1985; Multhaup, 1995). Based on such findings it has been suggested that a fundamental difficulty for older adults is the processing and remembering of information in unstructured situations. Craik (1983, 1986) proposed a 'production deficiency' explanation of age differences in memory in which he argued that elderly adults have deficits in spontaneously initiating memorial processing, especially involving elaborative and integrative strategies.

The proposal that elderly adults are impaired in their ability to perform elaborative and integrative processing is a useful framework in which to interpret memory impairments in older adults but the evidence supporting this view has been inconsistent across studies. That is, while some researchers have demonstrated deficits in elaborative processing in elderly adults, others have been unable to replicate this finding (see Salthouse, 1991 for a review). Moreover, if the nature and extent of memorial processing is controlled across participants by providing additional guidance for the older adults, age differences sometimes remain. Such results suggest that a production deficiency explanation of age differences in memory performance by itself is not sufficient to explain memory impairments associated with aging.

In this thesis, I suggest that an age-related deficit in consciously controlled processes might prevent elderly participants from exploiting the meaning of items in a manner necessary to produce elaborated, context-specific encoding of information. In addition to comparing the effects of aging on habit and recollection, the purpose of Experiments 4-6 was to investigate age differences in elaborative processing to assess the extent to which young and elderly adults are able to exploit distinctive contextual information afforded in the experimental materials. Age-related deficits in elaborative processing were expected to reduce the extent to which older adults take advantage of distinctive contextual information to enhance recollection. Habit estimates were not expected to differ across distinctiveness manipulations.

Self-Reported Awareness of Memory

By comparing performance in a memory slip and facilitation condition, the process-dissociation procedure serves as an objective means of evaluating conscious recollection. However, to what extent are young and elderly adults aware that they are recollecting when they are doing so? That is, what is the relation between subjective awareness and memory performance? These questions were addressed in Experiment 7 by comparing estimates of memory performance using the process-dissociation procedure to subjective memory judgements that were derived from an adaptation of the remember/know procedure introduced by Tulving (1985) and used extensively by Gardiner and his colleagues (Gardiner, 1988; Gardiner & Java, 1991; Gardiner & Parkin, 1990; Parkin & Walter, 1992).

In the original remember/know procedure, participants are asked to report on the subjective experience of memory after studying a list of words by classifying whether they "remember" or "know" words from the study list. A "remember" response is to be made if participants are able to recollect specific details of the study presentation of a word, such as its appearance or associations that came to mind during its presentation. Participants are told to respond "know" if the word is so familiar that they are certain the word was studied but they are unable to recollect any details of its prior presentation. By definition, "remember" responses map onto recollection, while automatic, unintentional responding may underlie "know" responses (but see Donaldson, 1996 and Donaldson, MacKenzie, & Underhill, 1996, for a single process interpretation).

The process-dissociation and remember/know procedures have many similarities, however, there is an essential difference between the two paradigms. The remember/know procedure makes the assumption, at least implicitly, that intentional and automatic memory processes are mutually exclusive, as participants can respond either "remember" or "know" but never both responses. However, if recollection and automatic influences of memory are independent of each other, then each process should be able to occur with or without the other (see Jacoby, et al., 1997). Consequently, the subjective report procedure used in Experiment 7 was modified from the original remember/know procedure to incorporate independence between automatic and intentional memory processes. The probability of correctly completing a fragment and saying "recall" when it was specifically remembered served as a subjective measure of recollection that was essentially identical to "remember" responses in the original procedure (subjective recollection (R') = "recall"). In contrast, automatic influences of memory were adjusted for independence and therefore, were calculated as the proportion of correct responses not "recalled" (equivalent to "know" responses)/(1-R').

Using the independence version of the remember/know procedure, experiments with young adults have shown parallel effects on subjective and objective measures of memory across a variety of manipulations (e.g., Jacoby, et al., 1997; Yonelinas & Jacoby, 1995). In contrast, most studies that have examined awareness of memory functioning in older adults have tended to use procedures that ask elderly adults to assess or predict the contents of memory without separating the contribution of intentional and automatic bases of responding (for a review, see Lovelace, 1990). As an exception, Parkin and Walter (1992) used Tulving's (1985) remember/know paradigm to examine the effects of aging on subjective report and found that "remember" responses declined with age but "know" responses increased. A difficulty with these findings is that estimates of "know" responses were based on the assumption that conscious remembering and automatic influences of memory operate exclusively of each other. In contrast, Jennings and Jacoby (reported in Jacoby et al., 1997) found different results when they used an independence assumption with the remember/know procedure. They found that subjective recollection declines with age but subjective reports of familiarity, or automatic influences, were unaffected by the aging process. Although this pattern of results suggested a degree of correspondence between objective and subjective measures of memory, such a comparison has not been made within the same experiment. Therefore, in Experiment 7, estimates of objective and subjective memory measures were compared for young and elderly participants performing a common memory test using the habit paradigm described earlier. The purpose of Experiment 7 was to assess the extent to which self-reported memory awareness corresponded with objective memory performance.

Summary

To summarize, in Experiment 1, the strength of habit acquired during the training session was manipulated. Experiments 2 and 3 were designed to investigate the effects of speeded presentation at study, and speeded responding at test, respectively. Experiments 4-6 examined the effects of aging on habit and recollection, as well as qualitative differences in the extent to which participants are able to exploit distinctive contextual information to enhance recollection. Experiment 7 compared objective memory performance to subjective awareness of memory functioning in young and elderly adults.

Chapter 2

Separating Habit and Recollection in Young Adults: Memory Slips and Process Dissociations

In Experiment 1, the magnitude of the habit strength acquired during training was varied. Manipulations of habit strength were expected to influence estimates of automatic influences (habit) but leave recollection unchanged. In contrast, Experiments 2 and 3 examined the effects of speeded presentation of study lists in Phase 2, and speeded responding at test, respectively. It was expected that these manipulations would affect recollection but leave automatic influences unchanged, demonstrating a dissociation opposite to that produced by the manipulation of habit. Such findings would provide support for a dual-process model of memory (e.g., Jacoby, 1991) in which habit and recollection make independent contributions to performance.

Experiment 1

The first experiment manipulated the "strength" of habit acquired during the training session. In situations where habit is strong, it should be difficult to oppose its influence and therefore, memory slips should often occur. This view is similar to early learning work by Hull (1943), in which he proposed that as the number of repeated pairings between a stimulus and a response increases, so does the strength of that association or habit. To manipulate the strength of habit in Experiment 1, the probability of a particular response appearing with a stimulus word was varied in the initial training session (Phase 1). Two different probability conditions were used such that participants saw some "typical" items with a 75% probability and other "typical" items with 50% probability (for the 50% condition, one set of items was arbitrarily designated as typical). For example, in the 75% condition, the typical response "bend" appeared with the stimulus word "knee" on 75% of the trials (15 of 20 presentations) while the atypical response "bone" only appeared on 25% of the trials (5 of 20 presentations). The strength of the habit created during the training session was expected to be stronger for typical items in the 75% condition than in the 50% condition, because in the 50% condition "typical" items only appeared on 10 of the 20 training trials. The different strength associated with typical items in the 75% and 50% conditions was expected to influence habit performance in Phase 2. In contrast, recollection of an item in the study lists in Phase 2 was not expected to differ for items in the 75% and 50% conditions.

The extent to which the objective probability of presenting items during training was reflected by estimates of habit was also examined in Experiment 1. A great deal of experimental evidence has suggested that both animals and humans are very sensitive to the rate at which environmental events occur. Given a two-choice learning situation, participants tend to choose each of the alternatives with a probability that reflects the likelihood of their prior occurrence (e.g., Voss, Thompson, & Keegan, 1959) and thereby show probability matching (e.g., Estes, 1976). Similar demonstrations of probabilistic classification learning have been reported with amnesic patients (Knowlton, Squire & Gluck, 1994). Habit estimates were expected to reflect probability matching such that estimated habit in the 75% condition would be near .75. However, probability matching is not expected to be exact because any random responding produces regression toward a mean of .50 when there are only two alternatives.

As a source of converging evidence for the estimates of habit, items were included which were designed to measure guessing. These "guessing" items appeared within the test but were not presented in the study list for which memory was tested. Participants were to respond to these items with the first word that came to mind and therefore, this measure served as an indirect test of memory. All guessing items were familiar to the participants as they had been seen during the training session (Phase 1) in either the 50% or the 75% conditions, however, because these items were not presented in the Phase 2 study list, they could not be "recollected". Participants' responses to "guessing" items were expected to provide a relatively pure measure of habit against which we could compare estimates of habit derived from congruent and incongruent test conditions. If estimated habit and measured guessing converged, it would provide support for the validity of estimates gained from the process-dissociation procedure.

Method

Participants and materials. Twenty introductory psychology students from McMaster University participated in the experiment for course credit.

A set of 18 stimulus words paired with two associatively related responses (e.g., knee - bend, knee - bone) was selected from the norms reported by Jacoby (1996). Words from these norms were chosen from a range of association frequencies with the majority occurring in the medium range. Both associatively related responses contained the same number of letters and could be used to complete the same word fragment (e.g., knee - b_n_). The two related responses were arbitrarily chosen to be presented as a typical or atypical response in a particular list. The list of 18 pairs was divided into two sets of 9 pairs each to construct training pairs for the 75% and 50% conditions. The pre-experimental probability of completing fragments with the various responses was equated across sets of pairs used to construct conditions. Further, assignment of responses to conditions was counterbalanced across formats so that all words occurred equally often as the typical and atypical responses in both the 75% and the 50% conditions.

Design and procedure. All participants were tested individually on a PC-compatible computer using Schneider's (1990) Micro-Experimental Laboratory (MEL) software. Words were presented in the middle of the screen in lowercase letters. The character size of the stimuli was approximately 3 x 4 mm and participants were seated approximately 70-75 cm from the screen.

In the training phase, word pairs were presented, with the first word being intact and the second word missing some of its letters (e.g., knee - b_n_). Participants were instructed to guess the word that would complete the fragment. They were told that the correct completion word would be semantically related to the intact word. The word and fragment remained on the screen for 2 s, during which time participants were to respond aloud by saying their predicted completion word. Next, the "correct" completion word was presented for 1 s. There were always two possible completions for each fragment (e.g., bend and bone for knee - b_n_), only one of which was presented as correct on any given trial. Participants were told that more than one response would appear with each stimulus word, and were instructed to try to predict the response that would appear for each particular trial. They were informed that some completion words would appear more often than others. Two pairs of words that did not appear elsewhere in the experiment were used to illustrate the procedure and then participants engaged in five successive blocks of training. The experimenter recorded all of the participants' responses.

The proportion of trials on which "typical" responses were presented in training (75% and 50%) was manipulated within-participants. The training session consisted of five blocks of 72 presentations. Each block contained 36 presentations of pairs representing the 75% condition and 36 presentations of pairs representing the 50% condition. Each of the 9 pairs in each condition was presented four times per block.

For the 75% condition, the typical response was presented three times and the atypical response was presented once in each block; for the 50% condition, typical and atypical responses were each presented twice in each block. The order of the items within each block was random with the restriction that the same stimulus word could not be presented more than three times in a row.

Following training, participants received 18 successive study-test lists, divided into two blocks of nine lists. Each study list contained 8 of the word pairs that had been presented during training (e.g., knee - bend). Participants were instructed to silently read the word pairs and to remember them for the memory test that would follow presentation of the study list. After each study list, participants received a cued-recall test of memory for the word pairs just seen. For that cued-recall test, stimulus words were presented with a fragmented version of the response with which they were paired in the study list (e.g., knee - b_n_) which were the same cues presented during the training session in Phase 1. Participants were instructed to complete fragments by recalling aloud the response word from each pair in the list just studied. They were told that if they could not remember the studied item, they were to guess with the first response that came to mind. Further, participants were warned that some pairs would be tested although they did not appear in the study list just presented. For those test items, participants were told to complete the fragment with the first word that came to mind. Word pairs were presented for test at a 3-s rate, during which time participants were to respond. Again, the experimenter recorded all responses.

Each study list contained 8 word pairs and was presented at a rate of 1s per pair, with a 500 ms inter-pair interval. The study lists maintained the earlier proportion of typical and atypical items from training. For each study list of eight items, four items were presented from the 75% condition (three stimuli paired with their typical responses, one paired with its atypical response) and four items were presented from the 50% condition (two stimuli paired with their typical responses, two paired with atypical responses). Within each set of nine study lists, each typical item in the 75% condition was presented three times across different lists, while each atypical item was presented only once. For the 50% condition, each typical and atypical item was presented twice. Test cues were presented for all eight study items and for two additional items that were not presented in the preceding study list. For these two additional "guessing" items, one stimulus was always selected from each of the two probability conditions (75% and 50%). Within each set of nine tests, all stimulus words and their respective fragments appeared as guessing items once. The presentation order for all items in the study and test lists was randomly determined and remained fixed across participants, with the constraint that no item was repeated within a list.

Participants performed a short distractor task between study and test. A random number between 30-100 was presented on the computer screen immediately after each study list. Each number appeared for 1 s followed by a blank screen for 6.5

s. During that time, participants were required to count backwards by threes aloud, as quickly as possible, starting with the number that appeared on the screen. It was emphasized that the backwards counting should continue until a message appeared that instructed them to begin the test. The purpose of the distractor task was to prevent participants from rehearsing items in short-term memory. Following each test, the entire study-test procedure started again with a new study list until all 18 lists had been studied and tested. Different numbers were presented for the distractor task between each study-test trial. After completing nine study-test blocks, participants rested for a few minutes while the second set of nine study-test blocks was loaded into the computer.

The significance level for all statistical tests was set at $p < .05$. Tests revealing significant main effects will not be reported when variables producing those main effects entered into significant interactions.

Results and Discussion

The purpose of the initial training phase was to create habits of different strengths. As expected, by the final block of training, the probability of a typical item being given as a response in the 75% condition was greater than that in the 50% condition (.64 versus .50).

The data of interest came from Phase 2 of the experiment, in which participants attempted to remember specific study lists. Study lists included congruent trials, for which habit from training and recollection from the study list worked together to facilitate responding for the typical items. For incongruent trials, the habit of giving the typical completion opposed recollection of the atypical item from the study list. The probability of correctly giving a typical item as a response on congruent and incorrectly giving a typical item as a response on incongruent trials is shown in Table 1, for both the 75% and 50% conditions.

The probability of a typical response on congruent trials (correct responses) was significantly greater than the probability of a typical response on incongruent trials (incorrect responses), F (1, 19) = 128.18, MSe = .030. The proportion of training trials for typical responses also had a significant effect on responding, as participants showed a higher probability of giving a typical response in the 75% condition than in the 50% condition, F (1, 19) = 17.85, MSe = .012. The interaction of the two factors did not approach significance, F (1, 19) < 1.

A separate analysis of performance on incongruent trials showed that participants in the 75% condition gave typical responses significantly more often than did participants in the 50% condition, F (1, 19) = 7.15, MSe = .011, demonstrating that memory slips were more likely to occur when habit was stronger. A corresponding analysis of performance on congruent trials showed that the probability of giving a typical response was significantly higher for the 75% condition than it was for the 50% condition, F (1, 19)= 21.41, MSe = .006. Thus, the stronger habit increased the probability of producing a typical response, increasing the probability of correct responding on congruent trials and the probability of a memory slip on incongruent trials.

Insert Table 1 about here

Estimates of recollection and habit. Using the equations presented earlier, the probability of recollection was estimated as the difference between the probability of giving a typical response on the congruent and incongruent trials. As shown in Table 1, the probability of presenting typical items during training did not affect the probability of recollection, F (1, 19) < 1. This result supports the prediction that recollection would not differ for the 75% typical items and the 50% typical items.

Although recollection was left invariant, manipulating the probability of seeing typical items during the training session was expected to affect estimates of habit. A process dissociation of this type would support the assumption that automatic and intentional influences of memory make independent contributions to performance by showing that the two types of influences can be manipulated independently. The equations described earlier were used to derive estimates of habit (see Table 1). Analysis of those estimates revealed that habit in the 75% condition was significantly greater than in the 50% condition, F (1, 19) = 28.44, MSe = .014, demonstrating that automatic influences of memory were indeed affected by the prior history of the items. As expected, the estimates of habit obtained for the 75% and the 50% conditions approximated the actual probability of the typical items being presented during training.

As a source of converging evidence for estimates of habit, performance on "guessing" items was examined. It was expected that participants' guessing responses would reflect automatic influences of memory such that the probability of seeing a typical response in training would have a significant effect on guessing scores. Guessing scores were calculated as the total proportion of typical responses given at test for items that were not presented in the study list preceding their test (see Table 1). Guessing scores in the 75% condition were greater than those in the 50% condition $F(1, 19) = 16.85$, $MSe = .018$ and again, probability matching was evident.

To compare the two measures of automatic influences, a two-way analysis of variance was performed on the proportion of typical responses seen in training (75% and 50%) and type of automatic measure (habit and guessing). As expected, a significant difference between the 75% and 50% conditions emerged, with estimates in the 75% condition being greater than estimates in the 50% condition $F(1,19) = 27.44$, $MSe = .025$. The type of automatic measure approached significance, with estimates of habit falling below guessing $F(1, 19) = 5.51$, $MSe = .007$; however this difference between estimates of habit and guessing did not replicate across Experiments 2 and 3. The interaction between the probability of typical items seen in Phase 1 and the type of automatic measure did not approach significance, $F(1, 19) < 1$.

Using the process-dissociation procedure devised by Jacoby (1991), I was able to separate the contributions of automatic and intentional memory processes within a single task. Based on estimates gained from this procedure, it was found that manipulating the typicality of responses by means of training influenced habit but had no effect on recollection. Strength of word pair associations was manipulated by presenting typical items with a probability of either 75% or 50%. When habit was strong (75% condition), the likelihood of a memory slip being committed was higher than when habit was weak (50% condition). Although a strong habit was a source of error in the memory slip case, it helped performance in the facilitation case; there was a greater probability of correctly remembering the typical items in the 75% than in the 50% condition. It is important to note that the estimates of habit computed with the process-dissociation equations and those gained from guessing items closely approximated the actual proportions used for presenting items during the training session (75% and 50%). The importance of this probability matching will be further considered in the General Discussion in Chapter 5.

The finding that manipulating the strength of habit influenced the estimated contribution of habit but left recollection invariant provides support for the independence assumption underlying the process-dissociation procedure. Manipulations used in the following experiments were expected to produce process dissociations of a form that would be opposite to that produced by the manipulation of habit, providing further evidence of the functional independence of habit and recollection. Manipulations in later experiments were expected to influence recollection but leave the estimated contribution of habit unchanged.

Experiment 2

The purpose of Experiment 2 was to examine differential effects of presentation rate of the study lists shown in Phase 2. This manipulation varied the amount of study time allowed for items whose presentation was to be recollected. Returning to the "keys" example in the Introduction, the manipulation is akin to varying the amount of time one spent rehearsing the location where one's keys were left on a particular occasion. It was expected that a fast presentation rate at study would have a detrimental effect on recollection but would not influence the contribution of habit. The lack of effect on habit was expected because habit should reflect prior learning from Phase 1 and consequently, should be relatively unaffected by presentation rate in a particular short list. Additionally, Experiment 2 further investigated the influence of prior presentations on later memory performance using a level of habit strength different from those used in Experiment 1. A habit strength of 67% was created during the training session by presenting typical responses on 67% of the occasions and atypical items on the remaining 33% of occasions in Phase 1.

Method

Participants and materials. The participants were 16 undergraduates in a first year psychology course at McMaster University who participated for course credit. The materials and details of list construction were the same as Experiment 1.

Design and procedure. The procedure was the same as in Experiment 1 with the following exceptions: during the initial training phase, participants were presented with typical items on 67% of the occasions. Training consisted of three blocks of 108 presentations each. Within each block, each stimulus was presented six times: four times with its typical response and two times with its atypical response. In Phase 2, presentation rate of the study lists was manipulated such that all participants received nine study lists at a slow rate (1000 ms/item) and nine study lists at a fast rate (300 ms/item). A random ordering of fast and slow lists was constructed and then divided into two blocks of nine lists such that five at a given rate and four at the other rate appeared in each set of 9 study/test blocks. The position of the fast and slow lists within the ordering was counter-balanced across participants.

The study lists maintained the earlier proportion of typical and atypical responses from training. Each list contained nine word pairs, six of which had responses made typical by training and three that had responses made atypical by training. Each of the 18 typical items was presented three times across the nine study lists for each rate. Each of the 18 atypical items was presented once, with an additional nine of the possible 18 atypical items chosen randomly for a second presentation. The selection of these nine items was counterbalanced across participants so that all atypical items were tested equally often in the fast and slow conditions. The order of the items was randomly determined, and remained fixed throughout the experiment. All other details of the procedure were the same as Experiment 1, as were analyses of results.

Results and Discussion

During the training session, the intention was to create a habit strength of 67% by presenting typical items as responses on 67% of the trials. In line with expectations, the probability of responding with a typical item in the final block of training was .63.

The mean probability of responding with a typical item on congruent and incongruent trials was investigated for fast and slow presentation rates and a significant interaction emerged, $F\ (1,\ 15) = 32.75$, $MSe = .005$ (see Table 2). Analysis of only congruent trials revealed that when items were presented at a fast, rather than a slow rate, participants were less likely to correctly give a typical response $F\ (1,\ 15) = 13.78$, $MSe = .001$. For the incongruent trials, participants were more likely to mistakenly give a typical item as a response when items were presented at a fast rate $F\ (1,\ 15) = 16.41$, $MSe = .012$. That is, participants had fewer correct responses in the facilitation condition and committed more memory slips in the opposition condition when only a short amount of time was allowed for study.

Insert Table 2 about here

Estimates of recollection and automatic influences. An analysis of estimates of recollection (Table 2) showed that recollection was much higher when items were presented at a slow rate as compared to a faster rate $F\ (1,\ 15) = 32.75$, $MSe = .010$.

An analysis of estimates of habit (Table 2) showed that manipulating presentation rate had no effect on automatic influences of memory $F(1, 15) = 1.3$, $MSe = .005$. Again, the estimates closely matched the actual probability of having seen a typical item during the training session (67%). These results show that recollection was affected by an experimental manipulation that left habit invariant, further supporting a dual-process model of memory in which components make independent contributions to performance. The dissociation shown by these results is opposite to the one found in Experiment 1, thus demonstrating that both automatic and intentional influences of memory can be selectively manipulated.

Guessing scores were again used to provide converging evidence for the estimates of habit (Table 2). As expected, the analysis of habit estimates and guessing scores did not reveal significant effects. The difference between guessing and estimates of habit was not significant $F(1, 15) = 3.03$, $MSe = .009$, $p<.10$. The effect of presentation rate and the interaction of type of measure with presentation rate also were not significant, $Fs < 1$. For both measures of automatic influences, probability matching was again evident.

The results of Experiment 2 showed that manipulations of presentation rate at study affected recollection, but left habit unchanged. These results provide further evidence for the assumption of independence between intentional and automatic memory, as put forth by Jacoby's dual-process model of memory (Jacoby, 1991). In addition, there were no differences between estimates of habit and guessing, suggesting that automatic influences from the training session were reflected similarly in both types of measures and both measures again approximated the proportion of typical items seen during training (67%).

Experiment 3

A third experiment was carried out to extend the findings of Experiment 2. In our daily lives, we are often faced with situations where we have to make decisions quickly and it is in these rushed situations that we seem most susceptible to memory slips. Returning to the "keys" example, it is likely that one would mistakenly begin the search for the keys at their typical location when hurried to find the keys. In a similar manner, the effects of speeded responding were investigated in Experiment 3 by imposing a deadline for responding at the time of test. It was expected that the contribution of conscious recollection would be reduced when only a short amount of time was allowed for responding, but deadlining was not expected to influence the contribution of habit. Typical responses were again presented on 67% of the trials in the training session so as to create a habit strength of that magnitude. Once again, it was expected that the probability of seeing a typical item in the training session would be reflected in estimates of habit.

Method

Participants and materials. Twenty-four undergraduates enrolled in an introductory psychology course at McMaster University participated for course credit. The same materials, word lists, randomized orders, and counter-balancing conditions from Experiment 2 were used in Experiment 3.

Design and procedure. The training and study-test blocks were identical to Experiment 2 with the following exceptions: all study lists were presented at a rate of 1000 ms per word pair, with a 500 ms inter-pair interval. The amount of time allowed to respond to test items was manipulated between lists and varied within participants. For half of the tests, a long deadline was imposed on participants' responding (3000 ms) and on the other half, a short deadline was imposed (1000 ms). The computer triggered a "beep" when time for responding elapsed and then the next test item appeared on the screen.

After the presentation of each study list, participants were informed whether the upcoming tests would have a long or a short deadline, and were instructed to respond before the computer beeped. They were told that any response given after the beep would not be counted. In reality, responses were scored without reference to their meeting deadline for purposes of analyses. Using word pairs that did not appear elsewhere in the experiment, eight practice trials (4 short and 4 long deadlines) were provided to allow participants to become familiar with the response deadlines.

Results and Discussion

The purpose of the training session was to create a habit strength of 67%. In line with expectations, the mean probability of giving a typical item as a response in the final block of training was .57.

The mean probability of responding with a typical item on congruent and incongruent trials was examined for short and long deadline conditions, and a significant interaction was found, $F(1, 23) = 17.03$, $MSe = .008$ (see Table 3). Further analyses showed that the probability of correctly giving a typical item as a response on congruent trials was greater in the long deadline condition $F(1, 23) = 10.07$, $MSe = .005$. In contrast, the probability of incorrectly giving a typical response on incongruent trials, the likelihood of committing a memory slip, was greater in the short deadline condition $F(1, 23) = 10.661$, $MSe = .008$. These results supported the prediction that memory slips would be more prevalent when participants were pressed for time.

Insert Table 3 about here

Estimates of recollection and automatic influences. An analysis of recollection estimates (Table 3) revealed that recollection was higher when participants were allowed more time to respond at test (long deadline) than when they were forced to respond quickly $F(1, 23) = 17.03$, $MSe = .016$. The effect of response deadline on recollection estimates was similar to the effect of varying presentation rate observed in Experiment 2.

An analysis of estimates of habit (Table 3) confirmed that there was no difference between the short and long deadline conditions $F(1, 23) < 1$. Once again, probability matching was apparent, as the estimates of habit approximated the earlier proportion of typical items presented during the training session (.62 versus .67 respectively).

As a source of converging evidence for estimates of habit, guessing scores were computed (Table 3). Guessing scores were not significantly affected by deadlines at test $F(1, 23) = 2.53$, $MSe = .009$. An analysis of habit estimates and guessing scores did not reveal a significant difference between the two measures, $F(1, 23) = 2.07$, $MSe = .009$. Furthermore, that analysis showed that neither response deadline, $F(1, 23) = 2.81$, $MSe = .004$, $p = .103$, nor the interaction of response deadline with type of measure, $F(1, 23) < 1$, produced a significant effect.

The results of Experiment 3 showed that memory slips were more likely when participants were forced to respond quickly than when they were allowed to respond at a more leisurely pace. In addition to the increase in errors on incongruent trials, requiring fast responding resulted in fewer correct responses on congruent trials. That is, the deadline manipulation had a significant effect on recollection such that a short deadline significantly lowered conscious recollection as compared to a longer deadline. However, the deadline manipulation did not affect estimates of automatic influences. Estimates for habit and guessing again approximated the proportion of typical responses presented during the training session, showing probability matching.

In summary, results from Experiments 1-3 showed that some factors influence estimates of habit but do not affect recollection and vice-versa. Varying an item's prior history (i.e., habit strength) influenced the automatic component but left the contribution of recollection unchanged (Experiment 1). In contrast, estimates of habit were not affected by manipulating the amount of time to study an item (Experiment 2) or by manipulating the amount of time given to respond at test (Experiment 3). However, recollection was significantly influenced by both of these factors. Such functional dissociations support a dual-process model of memory in which consciously controlled and automatic processes make independent contributions to memory performance (Jacoby, 1991).

Chapter 3

The Effects of Aging on Habit and Recollection

Consider the story of an aging math professor in Winnipeg who went to a conference in Chicago and was unable to find his airline ticket when he was ready to return home. After an extensive search for his ticket failed, he bought another and upon arriving in Winnipeg called his wife to pick him up at the airport. She responded that she would be unable to do so because they only had one car and he had driven it to Chicago!

In Experiments 4-6, I sought to gain a better understanding of the bases for such errors in older adults and to demonstrate that elderly adults are more prone to memory slips than are younger adults. Had the elderly math professor in the earlier example recollected driving to the conference, he would have avoided the error of flying back to Winnipeg, leaving his car in Chicago. His error reflected a habit that likely resulted from frequently flying to conferences, in combination with a failure in recollection. As discussed earlier, a situation in which the effects of habit are counter to one's purposes, as in the memory-slip example above, is one of the two conditions required for the process-dissociation procedure. The other is an "in concert" condition, in which the effects of habit produce a response that is the same as that produced by recollection and therefore, habit facilitates performance. For example, had the math professor flown to the conference as he typically did, his habit formed by flying to prior conferences would have helped him on his way home.

In Experiment 3, it was demonstrated that memory slips were more likely when people were required to respond rapidly at the time of test, supporting the commonplace observation that errors reflecting habit are most likely when one is rushed. These findings might be interpreted as a failure to inhibit, or "keep out" the effects of habit (e.g., Hasher & Zacks, 1988). However, a weakness of such an inhibition account is that it only focuses on the opposition condition. In contrast, memory slips may result from a failure to "bring in", or recollect, a particular event when speeded responding is required. Fast responding reduced accuracy in situations where habit and recollection operated in opposition *and* in situations where the two processes acted in concert (facilitation condition). If participants are impaired in their ability to inhibit typical responses from training, then they should not be disadvantaged in a facilitation condition because habit is a source of correct responding rather than a source of error. The process-dissociation procedure was used to combine results from the in concert and opposition conditions and showed that fast responding reduced the probability of recollection but left habit unchanged. Similarly, it was expected that age-related differences in memory would be restricted to a difference in recollection. Older adults were expected to produce more memory slips than young adults in the opposition condition but were also expected to show deficits in situations where habit and recollection acted in concert.

In addition, an age-related deficit in consciously controlled processing might prevent elderly participants from exploiting the meaning of items in a manner necessary to produce elaborated, context-specific encoding of information. If elderly adults have difficulty adding richness and depth to memorial processing, they should produce less distinctive representations, reducing the likelihood that such information will be retrieved later (e.g., Craik & Jacoby, 1979; Moscovitch & Craik, 1976; Till & Walsh, 1980). Such an account suggests that there are qualitative differences in processing performed by young and elderly adults which may underlie age-related deficits on tests using specific retrieval cues (e.g., Burke & Light, 1981; Craik & Byrd, 1982; Craik & Simon, 1980; Rabinowitz & Ackerman, 1982; Rabinowitz, et al., 1982), as well as deficits in monitoring contextual information to make source judgements (e.g., Ferguson, et al., 1992; McIntyre & Craik, 1987).

Therefore, another purpose of Experiment 4 was to investigate age differences in elaborative processing to assess the extent to which young and elderly adults are able to exploit distinctive contextual information afforded in the experimental materials. Age-related deficits in elaborative processing were expected to reduce the extent to which older adults take advantage of distinctive contextual information to enhance recollection.

The stimuli were homographs paired with typical and atypical responses such that the distinctiveness of the atypical response words was manipulated between participants. One half of the participants were randomly assigned to a *non-distinctive* condition in which the typical and atypical responses reflected the same meaning of the homograph (e.g., organ - music, organ - piano). The other half of the participants were assigned to a *distinctive* condition in which the typical and atypical responses reflected different meanings of the stimulus word (organ - music, organ - body). Manipulating the semantic relatedness of the typical and atypical responses was expected to affect recollection. Young adults should process associative information in an elaborative, integrative manner, showing a benefit in performance in the distinctive condition over the non-distinctive condition. In contrast, it was expected that older adults would not show a difference in recollection across distinctiveness conditions because they would be less able to elaborate the semantic relation between the stimulus and response words to take advantage of the unique meanings in the distinctive condition. Estimates of habit were not expected to differ across distinctiveness condition or by age. Rather, it was expected that estimates of habit would reflect training from the first phase of the experiment by approximating the probability with which typical items were presented (75%).

A dual-process view focusses on enhancing recollection as a means of removing age differences in memory. Although age-related impairments in recollection were expected in Experiment 4, later experiments were designed to show that under some conditions elderly participants are able to exploit distinctiveness of materials to enhance recollection. Performance was expected to differ for congruent as well as for incongruent test conditions, in contrast to an inhibition account of aging that would focus on the incongruent test condition alone.

Experiment 4

Method

Participants and materials. The young adults were 32 introductory psychology students at McMaster University who participated in the experiment for course credit. The elderly adults were 32 volunteers over the age of 60, who were alumni of either McMaster University or the University of Toronto. All participants reported to be in good health and were randomly assigned to a distinctiveness condition with the constraint that participants in each condition be approximately equal in age. For the young adults, the mean age was 19.3 years in the non-distinctive condition and 19.9 years in the distinctive condition. The mean age of the elderly adults was 71.1 years and 71.2 years in the non-distinctive and distinctive conditions respectively. The data from one elderly adult were discarded because he was not able to complete the task.

A pool of 16 homographs (words with one spelling but multiple meanings), were selected from the norms collected by Perfetti, Lindsey, and Garson (1971). Two pairs of highly related associates were chosen for each homograph, each reflecting a different interpretation (e.g., organ -music/piano and organ - body/heart). For each typical response (e.g., organ - music), there was an atypical response assigned to the non-distinctive condition (e.g., organ - piano) and an atypical response assigned to the distinctive condition (e.g., organ - heart), which reflected the same and different meaning as compared to the typical response, respectively. Lists were counter-balanced for pre-experimental familiarity and all items occurred equally often as typical and atypical responses and equally often across distinctiveness conditions.

Design and procedure. The training phase was identical to earlier experiments except that participants were presented with a stimulus word and were instructed to guess an associated word without the assistance of a word fragment (e.g., organ -). All other aspects of the training procedure were maintained from Experiments 1-3. The structure of the training session was consistent across distinctiveness conditions with the only difference being whether the atypical responses reflected the same or different meaning as the typical responses.

The training session consisted of three blocks of 128 presentations, each block containing eight presentations of each stimulus item with six typical and two atypical responses. The typical responses appeared with a probability of 75% in each block of training. Across the 3 blocks, 24 presentations of each of the 16 homograph stimulus words were shown to participants (18 typical responses, 6 atypical responses). The order of the items in each block was random, with the restriction that the same item could not be presented more than three times in a row. The distinctiveness of typical and atypical items was manipulated between participants.

Following training, participants received 16 successive study-test lists, divided into two blocks of eight lists. Each study list contained eight of the word pairs seen earlier in training (e.g., organ - music). As before, participants were instructed to read the word pairs silently and to remember them for a memory test that would follow. After each study list, participants received a cued-recall test for the word pairs they had just seen. The test items included a stimulus word from the training session (e.g. organ -) to which participants were instructed to verbally report the responses they remembered from the preceding study list. Guessing items were again included as a converging measure of automatic influences that could be compared to habit estimates derived with the process dissociation procedure.

Each study list contained eight word pairs and was presented at a 1-s rate, with a 500 ms interpair interval. The study lists maintained the earlier proportion of typical and atypical items presented in the training session. That is, for each study list of eight items, six typical items and two atypical items were presented, maintaining the 75-25 probabilities from Phase 1. Test cues were presented at a 3-s rate for all eight study words and for the two additional "guessing" items. Within each set of eight tests, all stimulus words appeared as "guessing" items once and it was ensured that they never overlapped with items presented in the study list. For each set of 8 study-test sessions, typical items appeared three times and atypical items were presented once across lists. All other aspects of design and procedure were maintained from earlier experiments.

The significance level for all statistical tests was set at $p < .05$. Tests revealing significant main effects are not reported when variables producing those main effects entered into significant interactions, unless the comparison was of particular interest.

Results and Discussion

During the training session, the intention was to create a habit strength of 75% by presenting typical items as responses on 75% of the trials. Somewhat in line with expectations, the mean probability of responding with a typical item in the final block of training was .68 for the young adults (means of .70 and .65 for the non-distinctive and distinctive conditions respectively) and .60 for the elderly adults (means of .63 and .57 for the non-distinctive and distinctive conditions). The probability of responding with a typical item in the training session, analyzed across age, training block, and distinctiveness condition, revealed significant effects of age F (1, 60) = 17.82 , MSe = .02 and blocks F (2, 120) = 117.11, MSe = .01. These results revealed that young adults produced more typical responses in training than did the older adults (means of .61 and .52 respectively) and not surprisingly, overall performance improved across successive blocks for both age groups (means of .44, .61 and .64 across blocks 1- 3 respectively). No other effects approached significance and thus no further analyses were performed on these data.

The data of interest came from Phase 2 of the experiment in which participants attempted to remember specific study lists. Study lists consisted of both congruent trials, in which habit and recollection worked together to facilitate responding with typical responses, and incongruent trials, in which habit opposed responding with atypical responses. The probabilities of correctly giving a typical item as a response on congruent trials and incorrectly producing a typical item as a response on incongruent trials are shown in Table 4, for both distinctiveness conditions and age groups.

The probability of producing a typical response on congruent trials (correct responses) was significantly greater for young adults than for the elderly, F (1, 60) = 11.48, *MSe* = .005 but there was no effect of distinctiveness condition F (1, 60) = 1.41, *MSe* = .005, and the interaction did not approach significance F (1, 60) $<$ 1.

The probability of incorrectly responding with a typical item on incongruent trials was a measure of memory slips. Analysis of performance on incongruent trials confirmed that older adults are more susceptible to memory slips overall F (1, 60) = 27.02, *MSe* = .015, but more specifically, a significant interaction emerged between age and distinctiveness condition F (1, 60) = 3.89, *MSe* = .015. Further investigation of the interaction showed that errors on incongruent trials were significantly greater in the non-distinctive than in the distinctive condition for the young adults (means of .41 and .29 respectively), F (1, 30) = 6.66, *MSe* = .018, however, for the older adults, there was no difference in performance between distinctiveness conditions (means of .51 and .50 respectively), F (1, 30) $<$ 1.

Insert Table 4 about here

Estimates of recollection and automatic influences. Using the equations from the process-dissociation procedure presented earlier, recollection was estimated as the difference between the probability of giving a typical response on the congruent and incongruent trials (Table 4). Analysis of the recollection estimates revealed a main effect of age $F(1, 60) = 36.80$, $MSe = .021$ and also revealed a significant interaction between age and distinctiveness condition $F(1, 60) = 4.40$, $MSe = .021$. For the young adults, further analyses confirmed that recollection estimates were greater in the distinctive versus non-distinctive condition, $F(1, 30) = 8.23$, $MSe = .025$. In contrast, recollection estimates did not differ between the distinctiveness conditions for the elderly, $F(1, 30) < 1$. These findings support the prediction that recollection would be enhanced in the distinctive condition for the young adults only.

The process-dissociation equations were also used to derive estimates of habit (Table 4). As a source of converging evidence for estimates of habit, performance on guessing items was examined. The guessing scores were calculated as the total proportion of typical responses given at test, for items that were not presented in the preceding study list (see Table 4). An age x distinctiveness x measure of automatic influences analysis of variance performed on these data did not reveal a significant effect of age $F(1, 60) < 1$ or distinctiveness condition $F(1, 60) < 1$. However, type of automatic measure did have a significant effect, $F(1, 60) = 13.28$, $MSe = .005$, such that guessing scores were higher than estimates of habit (means of .76 and .71 respectively). This difference between habit and guessing did not replicate across Experiments 5 and 6 and therefore, will not be considered further. The interactions did not approach significance. As shown in earlier experiments, estimates of habit and guessing approximated the actual probability with which participants saw the typical items during training and thus probability matching was apparent in the automatic component for both young and elderly adults.

The results of Experiment 4 demonstrated that aging produces deficits in recollection but estimates of habit and guessing were not affected by age. These findings support results from other studies that have shown aging affects recollection but leaves automatic processing unchanged (Jacoby & Hay, 1993; Jacoby, et al., 1996; Jennings & Jacoby, 1993, in press). It was demonstrated that elderly adults committed more memory slips than young adults on opposition trials *and* performed more poorly than the young when habit and recollection acted in concert (congruent trials). Inhibition accounts of age-related deficits in memory do not expect age differences in both of these situations but rather, predict that elderly adults will have difficulties inhibiting the effects of habit only in the opposition condition, where habit leads to errors in performance. Alternatively, these findings suggest that elderly adults have deficits in recollective processing, which also impairs their ability to make use of distinctive contextual information.

For the young adults it was revealed that recollection was higher in the distinctive condition in which typical and atypical responses reflected different meanings of the stimulus word, as compared to the non-distinctive condition where the same meaning was maintained for both responses. These results suggest that young adults elaborate the associative relation between the stimulus and response words to enhance recollection. If participants were less able to elaborate contextual information then there would be no advantage afforded by the distinctive materials and recollection estimates would not differ across distinctiveness conditions. Indeed, this was the pattern of responding observed for older adults. In line with previous aging research (e.g., Burke & Light, 1981; Craik & Byrd, 1982; Craik & Simon, 1980), the results of Experiment 4 support the hypothesis that elderly adults have difficulties elaborating information and thus do not effectively exploit contextual information to assist their memory performance. Instead, it is possible that older adults encoded information in a more general manner that involved less associative processing (e.g., Craik & Simon, 1980).

Experiment 5

It is possible that the recollection estimates of older adults did not differ across distinctiveness conditions in Experiment 1 because the older adults simply did not have enough time to elaborate the associative relation between the stimulus and response words at encoding. The use of consciously controlled processes requires time and attentional resources as shown by the reduction in recollection when young participants study under conditions of divided attention (Jacoby et al., 1993) or respond within a short deadline (Experiment 3). The purpose of Experiment 5 was to focus only on the performance of elderly adults to help them take advantage of distinctive contextual information in the materials. General slowing hypotheses (e.g., Salthouse, 1994), suggest that age differences can be eliminated if elderly adults are given additional time to process information. Based on a slowing account of age differences in memory, elderly adults should be able to exploit distinctive contextual information when they receive more processing time at encoding. If older adults are able to exploit the distinctive associative relations in the materials, then a difference in recollection should emerge between distinctiveness conditions at a long presentation rate. Automatic influences of memory should not be affected by presentation rate manipulations.

Method

Participants and materials. The participants were 32 elderly volunteers over the age of 60 years who were alumni of either McMaster University or the University of Toronto. Participants were randomly assigned to a distinctiveness condition with the constraint that participants in both groups be approximately equal in age. In the non-distinctive condition, the mean age of participants was 71.9 years whereas in the distinctive condition, the mean age was 72.7 years. Data from two elderly adults were discarded due to difficulties completing the task. The materials and details of list construction were identical to Experiment 4.

Design and procedure. The initial training session of Experiment 5 was identical to Experiment 4 but the following changes were made to the study-test sessions: Presentation rate of the items in the study lists was manipulated within-participants such that all participants received eight study lists at a slow rate (3000 ms) and eight study lists at a fast rate (1000 ms) maintained from Experiment 4. A random ordering of fast and slow lists was determined and then divided into two blocks of eight, with four at each rate appearing in each set of eight study-test blocks. The position of the fast and slow lists was counter-balanced across participants. All other details of the procedure were the same as Experiment 4, as were the analyses of results.

Results and Discussion

During the training session, the intention was again to create a habit strength of 75% by presenting typical items as responses on 75% of the trials. The mean probability of responding with a typical item in the final block of training was .60 in the non-distinctive condition and .59 in the distinctive condition. An analysis of typical responses produced across training blocks and distinctiveness conditions revealed improved performance across blocks $F\ (2, 60) = 165.63$, $MSe = .004$. No other effects approached significance.

The mean probability of responding with a typical item on congruent trials was investigated across presentation rate manipulations and distinctiveness conditions (see Table 5). There was a significant effect of presentation rate, $F\ (1, 30) = 5.54$, $MSe = .004$, as participants were more likely to correctly produce a typical response when items were studied at a slow presentation rate as compared to a fast rate. The interaction was not significant $F\ (1, 30) < 1$.

The mean probability of incorrectly responding with a typical item on incongruent trials across fast and slow presentation rates and both distinctiveness conditions was investigated (see Table 5). This analysis revealed a significant effect of presentation rate $F(1, 30) = 28.41$, $MSe = .016$, as more memory slips were produced when items were studied at a fast rate. Again, there was no significant interaction $F(1, 30) < 1$.

Insert Table 5 about here

Estimates of recollection and automatic influences. An analysis of recollection estimates across presentation rate manipulations and distinctiveness conditions showed that recollection was higher when items were presented at a slow versus fast presentation rate $F(1, 30) = 48.05$, $MSe = .014$. The interaction did not approach significance $F(1, 30) < 1$ (see Table 5).

The type of automatic measure (habit estimates and guessing scores) at each presentation rate and in each distinctiveness condition was analyzed but did not reveal significant effects for type of automatic measure $F(1, 30) = 1.22$, $MSe = .007$, presentation rate $F(1, 30) < 1$ or distinctiveness condition $F(1, 30) < 1$, and there were no significant interactions (see Table 5). These results support the proposal that habit estimates and guessing scores both reflect the same underlying processes and for both measures, probability matching was again apparent.

The results of Experiment 5 produced a process dissociation such that manipulations of presentation rate affected recollection performance of elderly adults but did not influence estimates of habit or guessing (automatic influences of memory). Comparing results across Experiments 4 and 5, recollection performance of elderly participants improved by giving them additional time for study. The effect of study rate on recollection is consistent with several different interpretations of the effects of aging on memory. An inhibitory deficit view (e.g., Hasher & Zacks, 1988) would suggest that because of their difficulties inhibiting irrelevant thoughts, elderly participants have less working memory capacity left to engage in encoding processes and consequently, benefit from additional study time. Salthouse (e.g., 1991) would explain the same result by appealing to a general slowing of information processing in older adults. Alternatively, a processing resource view of aging (e.g., Craik & Simon, 1980) would suggest that due to the reduced processing capacity of elderly participants, they require more time to process meaning than do young adults and therefore, their performance improves when study time is increased.

The results of Experiment 5 showed that decreasing presentation rate reduced the probability of a memory slip but also increased the probability of a correct response on congruent trials. This pattern of results shows an influence of presentation rate on recollection but is not readily understood by arguing that memory slips reflect a deficit in inhibitory processes. Instead, it is important to consider effects in both facilitation and opposition conditions in order to interpret effects of aging on memory. Doing so reveals effects of aging on recollection.

Although the elderly demonstrated that they can improve their overall level of recollection if they are given additional time to process information at encoding, this manipulation did not allow them to exploit distinctive semantic information in a manner similar to the young. The lack of difference between distinctiveness conditions suggests that a global slowing hypothesis (e.g., Salthouse, 1991) may be insufficient to explain age differences in memory. That is, even when more time was allowed at study, older adults did not process the associative relation between the stimulus and response words thus suggesting that in addition to quantitative deficits in recollection, there are qualitative differences in the nature of recollective processing performed by young and elderly adults.

Experiment 6

Rather than focus on encoding deficits, several researchers have suggested that older adults are more affected by difficulties experienced at the time of retrieval (e.g., Burke & Light, 1981). Further, Craik (1983, 1986) suggested that age decrements in memory can be reduced to the extent that the task environment supports retrieval processes. In Experiment 6, I attempted to guide the retrieval as well as encoding so as to help older adults take advantage of distinctive information. To start, participants were given an unlimited deadline to respond at test to allow them more time to retrieve information. However, elderly adults may also have difficulties *spontaneously* initiating elaborative strategies (e.g., Craik & Byrd, 1982), and therefore, reliance on self-initiated processing was reduced by explicitly describing the semantic relation between the stimulus and response words to participants in both distinctiveness conditions and by encouraging them to elaborate the associative information. My intention was to guide the processing of elderly adults in the distinctive condition by having them focus on the different meanings associated with the typical and atypical responses. If older adults are able to elaborately process distinctive contextual information, then they should show higher recollection in the distinctive condition compared to the non-distinctive condition under these supportive task conditions. Again, automatic influences of memory should not be affected by amount of time to respond at test or distinctiveness manipulations.

Method

Participants and materials. Thirty-two elderly adults over the age of 60 who were alumni of McMaster University or the University of Toronto, volunteered to participate in the study. Participants were randomly assigned to a distinctiveness condition, with the constraint that participants in both groups be matched in age. In the non-distinctive condition, the mean age of participants was 71.1 years whereas in the distinctive condition, the mean age was 71.9 years. Data from one elderly adult were discarded because the participant was not able to complete the task. The materials and details of list construction from Experiments 4 and 5 were maintained.

Design and procedure. The training and study-test sessions of Experiment 6 were identical to Experiments 4 and 5 with the following exceptions: Presentation rate of study list items in Phase 2 was maintained at a slow rate (3000 ms) for all lists but the amount of time allowed for responding was manipulated within-participants. The 16 study-test sessions were divided into two sets of 8 sessions, with one set having a 3000-ms deadline, and the other having an unlimited deadline. The ordering of response deadlines (short, long) was counter-balanced across participants.

Before the training session was initiated, all participants were informed that two semantically related responses would appear with each stimulus word and in addition, the relation between the stimulus and response words was explicitly described. Participants in the distinctive condition were told that each stimulus word would be paired with responses that reflected different interpretations of the stimulus word, while participants in the non-distinctive condition were informed that both responses would reflect the same meaning of the stimulus word. Participants were especially encouraged to think about the semantic interpretations of the responses when they encoded the items during the study-test sessions. Focusing on the different meanings of the responses in the distinctive condition was expected to make the two responses more unique, leading to better recollection for these items. In contrast, responses in the non-distinctive condition were more similar to each other due to their shared meaning and therefore recollection of these items was expected to be similar or reduced compared to performance in Experiment 5. More importantly, it was expected that recollection estimates would be significantly higher in the distinctive versus the non-distinctive condition.

Results and Discussion

During the training session the intention was to again create a habit strength of 75% by presenting typical items as responses on 75% of the trials. The mean probability of giving a typical item as a response in the final block of training for elderly participants in the non-distinctive and distinctive conditions was .68 and .60, respectively. Analysis of typical responses produced in the training phase across blocks and distinctiveness conditions revealed a significant effect of blocks $F\ (2, 60) = 128.40$, $MSe = .004$. No other effects approached significance.

The probability of responding with a typical item on congruent trials was examined for both short and long (unlimited) deadline conditions and each distinctiveness condition (see Table 6). This analysis did not reveal a significant effect of distinctiveness condition $F\ (1, 30) < 1$, or response deadline $F\ (1, 30) < 1$ and the interaction was not significant $F\ (1, 30) = 3.35$. The probability of incorrectly producing a typical response on incongruent trials was greater in the non-distinctive than in the distinctive condition $F\ (1, 30) = 5.5$, $MSe = .02$, demonstrating that memory slips were more likely to occur when the task materials were less distinctive. There was no significant interaction with deadline condition $F\ (1, 30) < 1$ (see Table 6).

Insert Table 6 about here

Estimates of recollection and automatic influences. An analysis of estimates of recollection was carried out for both distinctiveness conditions and response deadlines (see Table 6). This investigation revealed that recollection estimates were greater in the distinctive condition than in the non-distinctive condition $F(1, 30) = 5.84$, $MSe = .03$. There was no significant interaction $F(1, 30) = 2.22$, $MSe = .03$. Further analyses of recollection estimates showed that participants recollected more in the distinctive than the non-distinctive condition when given an unlimited deadline $F(1, 30) = 7.76$, $MSe = .024$ but performance did not differ between distinctiveness conditions at the shorter response deadline $F(1, 30) = 1.40$, $MSe = .022$. Therefore, elderly adults were only able to exploit distinctive associative information to assist recollection if they had an unlimited amount of time to respond at test, a sufficient amount of time to encode information at study, and if they were instructed as to how they should process the distinctive information presented to them.

An analysis of habit and guessing estimates across distinctiveness and deadline conditions was performed but did not reveal any significant effects for type of automatic measure $F(1, 30) < 1$, response deadline $F(1, 30) < 1$, or distinctiveness condition $F(1, 30) < 1$. The interactions did not approach significance. Further, estimates of automatic influences again approximated the probability of having seen typical items during the training session (Table 6).

The pattern of recollection performance for elderly adults in Experiment 6 replicated performance of young adults in Experiment 4 in that recollection estimates were now higher in the distinctive versus the non-distinctive condition. These results demonstrated that elderly adults are capable of exploiting distinctive associative information to the same extent as young adults, however, this finding only emerged under very specific, supportive task conditions. It was only by guiding the processing of the older adults *and* by allowing them to respond within an unlimited deadline that this pattern emerged in the recollection estimates and performance improved to levels comparable to the young in Experiment 4. Although recollection estimates were influenced by instructional/deadline manipulations in Experiment 6, habit was unaffected by these variables and again reflected the probability with which typical items had been presented during the training phase.

In summary, older adults were more likely than young adults to commit memory slips due to effects of habit in the absence of recollection, however, older adults were also disadvantaged in a facilitation condition. Combining results from a memory slip and facilitation condition by using Jacoby's (1991) process-dissociation procedure, it was revealed that elderly adults have significant deficits in recollection in the presence of preserved automatic responding. This result is consistent with previous research using different versions of the process-dissociation procedure (Hay, Nordlie, & Jacoby, in press; Jacoby & Hay, 1993; Jacoby, et al., 1996; Jennings & Jacoby, 1993, in press). Further, results of Experiments 4-6 revealed that there are qualitative differences in recollective processing between young and elderly adults such that the elderly are less able to take advantage of distinctive contextual information to enhance recollection performance. However, these age differences were eliminated when older adults performed under supportive task conditions.

Chapter 4

Subjective and Objective Measures of Memory in Young and Elderly Adults

Experiment 7 was designed to investigate the relation between memory performance and subjective awareness of memory in young and elderly adults. The process-dissociation procedure compares performance in a memory slip and a facilitation condition, providing an objective means of evaluating conscious recollection. In contrast, the probability of correctly completing a fragment and saying "recall" when an item is specifically remembered serves as a subjective measure of recollection. As discussed earlier, the subjective report procedure used here is very similar to the remember/know procedure used by Gardiner and his colleagues (Gardiner, 1988; Gardiner & Java, 1991; Gardiner & Parkin, 1990) in which they ask participants to report "remember" when specific details about an item's presentation can be recollected, or report "know" if an item seems familiar but it cannot be consciously remembered. Other researchers (e.g., Donaldson, 1996; Donaldson, et al., 1996) have argued that "remember" and "know" responses reflect a difference in response criteria rather than a difference in memory processes, with "remember" responses having a higher response criterion than "know" responses. However, such a single process model of memory has difficulties accounting for findings of dissociations in which variables affect one type of response while leaving the other unchanged and vice versa (e.g., Jacoby & Hay, in press; Jacoby, et al., 1997).

The original remember/know procedure made the assumption that intentional and automatic memory processes are mutually exclusive, however, evidence supporting the assumption of independence over exclusivity has been reported (Jacoby, et al., 1997). In Experiment 7, an independence assumption was combined with a modified version of the remember/know paradigm so that the probability of subjective recollection could be obtained (R'= "recall"), and automatic influences of memory could be calculated as the proportion of correct responses not "recalled"/(1-R').

Using the independence version of the remember/know procedure as a measure of subjective report, young adults demonstrate a similar pattern of responding across subjective and objective measures of memory (Jacoby, et al., 1997; Yonelinas, 1995). Although the correspondence between awareness and performance has been less clear for elderly adults (see Lovelace, 1990 for a review), it has been shown that aging reduces "remember" responses in tests of recognition memory (Parkin & Walter, 1992) and cued recall (Mantyla, 1993), paralleling age-related deficits in recollection that have been demonstrated using the process dissociation procedure (e.g., Jennings & Jacoby, 1993). The purpose of Experiment 7 was to compare objective and subjective measures of memory within the habit paradigm used in earlier experiments, to assess the relation between subjective awareness and memory performance in young and elderly adults within the same experiment.

Experiment 7

Method

Participants and materials. The young participants were 16 introductory psychology students at McMaster University who participated in the experiment for course credit. The elderly participants were 16 volunteers over the age of 60 (mean age of 72.0 years), who were alumni of McMaster University or the University of Toronto. The materials, word lists, randomized orders and counterbalancing conditions were maintained from Experiments 2 and 3.

Design and procedure. The procedure was the same as in Experiments 2 and 3 except that there was no manipulation of presentation rate or response deadline during the study-test session. Typical items were again presented on 67% of trials in training. In addition to the task instructions used in Experiments 2 and 3, participants were asked to subjectively report on their memory experience. After responding at test, participants were instructed to say "recall" if they could specifically remember that a item brought back a particular association, image, or something more personal from the time of study on the immediately preceding study list. Participants were cautioned that items in the study list would be very familiar to them and therefore, it would be easy to mistakenly believe that they recalled a certain response when in fact they did not. After a 3000 ms display of each test item, the computer beeped and then the screen went blank. All participants were asked to respond before the beep sounded if possible, but were allowed to take as much time as they needed to give a response and subjectively report on their memory experience. Pressing the spacebar on the computer advanced the test items at a self-paced rate. The study lists were presented at a 1 s rate for all participants.

Results and Discussion

During the training session, the intention was to create a habit strength of 67% by presenting typical items as responses on 67% of trials. In line with expectations, the probability of responding with a typical response in the final block of training was .63 and .60 for young and elderly adults, respectively. Analysis of typical responses produced in the training phase across blocks and age revealed a significant effect of blocks $F(2, 60) = 18.44$, $MSe = .005$. No other effects approached significance.

Performance estimates using the process-dissociation procedure. The mean probability of responding with a typical item on congruent and incongruent trials was examined for young and elderly adults, and a significant interaction emerged, $F(1, 30) = 9.52$, $MSe = .009$ (see Table 7). Further analyses showed that young adults were more likely to correctly respond with a typical item on congruent trials than were older adults, $F(1,30) = 5.048$, $MSe = .006$. In contrast, the probability of erroneously responding with a typical item on incongruent trials (the likelihood of a memory slip) was greater for the older adults, $F(1, 30) = 4.60$, $MSe = .013$, thus supporting earlier findings that showed older adults are more susceptible to memory slips than are younger adults.

An analysis of recollection estimates (Table 7) confirmed that young adults were better able to recollect than were older adults, F (1, 30) = 9.52, MSe = .018. The effect of aging on recollection was similar to the effect of varying presentation rate and response deadline observed in Experiments 2-3.

An analysis of habit and guessing estimates demonstrated that automatic influences were not affected by age, F (1, 30) < 1, type of automatic measure F (1, 30) = 2.97, MSe = .003 and the interaction did not approach significance F (1, 30) < 1. Probability matching was again approached in the automatic component, as estimates of habit and guessing reflected the proportion of typical items presented during the training session (67%).

Insert Table 7 about here

Subjective report comparisons. Subjective report estimates of recollection and habit were calculated using the same data that were used to derive the performance estimates. Applying the independence assumption to the remember/know procedure allows one to estimate recollection and automaticity in a manner similar to that used in the process-dissociation procedure. "Recall" responses map directly onto recollection because participants are told to respond "recall" only if they recollect specific information about an item. The proportion of test items correctly "recalled" provided a measure of subjective recollection for both the typical and atypical items. To derive estimates of subjective habit, the proportion of correct responses that was not "recalled" was calculated for typical and atypical items. These responses were similar to "know" responses because they were familiar enough to be given as correct answers yet were not subjectively remembered (H(1-R)). However, "know" responses do not map directly onto automatic influences estimated by the process-dissociation procedure, but instead, resemble performance on incongruent trials (Incongruent = H(1-R)). Therefore, an estimate of subjective habit (H') can be calculated as the proportion of correct responses not 'recalled' divided by a failure in recollection: H = correct responses not "recalled"/(1 - R'). The mean estimates of subjective recollection and subjective habit for young and elderly adults (based on typical items) have been presented in Table 8.

Insert Table 8 about here

An analysis of recollection estimates (subjective and objective measures) for young and elderly adults was carried out. This analysis revealed that recollection was higher for young versus elderly adults, F (1, 30) = 17.46, MSe = .044, however, there was no difference between subjective and objective measures, F (2, 60) = 2.577, MSe = .005 and the interaction was not significant, F (2, 60) = 1.206, MSe = .005, p =.306.

Estimates of subjective and objective recollection were also significantly correlated for both groups, with coefficients of .71 and .81 for the young and elderly, respectively.

An analysis of the type of automatic measure (habit estimates, guessing scores, typical and atypical subjective estimates) was performed for young and elderly adults. As expected, this analysis revealed an effect of the type of automatic measure, F (3, 90) = 38.74, MSe = .011, but there were no age differences, F (1, 30) < 1 and the interaction did not approach significance F (3, 90) < 1.

Further analyses were performed on the different types of automatic measures. A Student-Newman-Keuls Multiple Range Test revealed that there were no differences between automatic estimates derived with the process-dissociation procedure, guessing scores and subjective report estimates based on typical items (means of .62, .64 and .65 respectively). However, all three of these estimates differed from the subjective report estimates calculated on the atypical items (mean of .41). This result was expected because subjective habit calculated for the atypical items reflected automatic influences for items that were only presented on 33% of training trials whereas the other automatic estimates all reflected the typical habits from the training session (67%). Estimates of habit derived with the process-dissociation equations were highly correlated with subjective habit estimates for typical items, with coefficients of .80 and .81 for young and elderly adults, respectively.

The false recall rate to items that did not appear on the study list (across congruent and incongruent trials) was .05 for the elderly adults and .07 for the young adults, suggesting that participants were following instructions and that there were no differences in response bias across the groups.

In summary, the results from Experiment 7 showed older adults are more likely to make memory slips than are young adults when automatic and intentional responding are in opposition. It was also demonstrated that older adults performed more poorly in a facilitation condition in which both processes act in concert. Using Jacoby's (1991) process-dissociation procedure to combine responding in both conditions, it was apparent that intentional memory processes decline with age but automatic processes remain intact. These results replicated findings reported in Experiment 4 and are consistent with other research using the process-dissociation procedure (e.g., Jennings & Jacoby, 1993).

Deriving estimates with the process-dissociation procedure provided an objective measure of memory performance that could be compared to subjective report estimates to assess the extent to which young and elderly adults are aware of their memory abilities. The correspondence between subjective and objective measures of recollection revealed very similar results for both age groups. In addition, objective and subjective measures were significantly correlated, suggesting that both young and elderly participants are very accurate in their ability to assess when they are recollecting. Subjective estimates of automatic influences also converged with performance estimates and revealed probability matching.

Chapter 5

General Discussion of Results

Using the process-dissociation procedure devised by Jacoby (1991) I was able to separate the contributions of automatic and consciously controlled processes within a single task. Based on the estimates derived from this procedure, it was shown that some factors affect automatic influences of memory (habit) but do not have an impact on consciously controlled memory processes (recollection) and vice versa. Further, it was demonstrated that the effects of aging on memory are selective to recollection, as estimates of habit did not differ across young and elderly adults. Such functional dissociations support a dual-process model of memory in which consciously controlled and automatic processes make *independent* contributions to memory performance (Jacoby, 1991).

Memory Slips and Facilitation

Memory slips occur in situations in which the influence of habit and recollection act in opposition. These errors emerge when failures in recollection leave the effects of habit unopposed, leading to an outcome that was not intended. The results of Experiment 1 demonstrated that the probability of committing a memory slip was influenced by habit strength. That is, participants made more memory slip errors when habit was strong (75% condition) than when it was weak (50% condition), suggesting that strong habits are sometimes very difficult to overcome. Indeed, the stronger the habit the more likely it was to interfere with one's intention.

Previous research on memory slips has focused on the errors that occur when the effects of habit are evident in the absence of recollection. However, habit is not always a source of error; there are also situations in which habit can facilitate performance. The results from the congruent condition demonstrated that participants showed a higher probability of correctly remembering typical items in the 75% condition when habit was strong, as compared to the 50% condition when habit was weaker. In situations where both habit and recollection lead to the same outcome, relying on habit can assist performance. By combining results from facilitation and opposition conditions using the process-dissociation procedure, I demonstrated results that are consistent with the assumption that automatic and intentional processes operate independently.

Automatic Influences as Probability Matching

Strength of word-pair associations was manipulated such that participants saw typical items with varying probabilities (50%, 67% and 75%) during the training phase in Experiments 1-7. Estimates of habit derived with the process-dissociation equations and the guessing scores, closely reflected the actual probability of having seen typical items during training. As mentioned earlier, these results reflect probability matching.

Similar demonstrations of probability matching in the automatic component have been reported by Yonelinas and Jacoby (1995). In their study, the process-dissociation procedure was used to examine automatic and controlled processes within a Sternberg memory search task. Results of their experiments revealed process dissociations such that memory-set size influenced recollection (controlled memory search) but left automatic influences invariant. Yonelinas and Jacoby argued that the observed probability matching qualified as implicit learning. Such results and others (Jacoby, et al., 1993; Yonelinas, 1994) have led to the suggestion that automatic influences reflect a strength-like component in memory. The probability matching observed in habit estimates across the 7 experiments presented here, lend further support to the idea that a strength-like property is characteristic of the automatic memory component.

There exists a large literature on probability matching dating back to the 1930s. As an analogue of classical conditioning, early studies used a binary task that asked participants to predict which of two lights would be illuminated on each of a series of trials (e.g., Humphreys, 1939). Other probability learning paradigms have used paired-associate learning tasks in which two response words are probabilistically paired with one stimulus word. Participants are asked to predict the response that would be paired with each presentation of a stimulus, and in doing so, typically produce each response with a rate that matches its probability of occurrence (e.g., Voss et al., 1959). The task used in Phase 1 of the experiments reported here and the observed results, are representative of this type of paradigm. Probability matching is a particularly striking phenomenon because it is not the optimal solution to a task when participants are trying to maximize the accuracy of their predictions. The best strategy would be to predict that the more frequent event would be presented on every trial, but humans and animals are extremely resistant to abandoning probability matching.

Reber (e.g., 1989) has argued that such probability matching reflects implicit learning of an event sequence that is acquired independently of a conscious effort to learn, and without people employing intentional strategies. Research in implicit learning using artificial grammars has many parallels with probability matching experiments (see Reber, 1993 for a review). Artificial grammar studies have participants work with rule-based exemplars of a novel grammar in the first phase of the experiment and then in a later test phase, the participants are given novel stimulus strings, and are asked to discriminate whether or not the novel strings violate the recently presented grammar. People are typically able to make such discriminations, demonstrating implicit learning (Reber, 1993).

Conscious Contamination in Probability Learning Paradigms

An important question arises from previous probability learning studies: To what extent is probability learning consciously controlled and to what extent is it automatic? A common weakness of both probability matching paradigms and artificial grammar experiments is that researchers who use these paradigms, assume participants are unaware of stimuli patterns across presentations but this may not be so. Previous studies have tried to prevent participants from becoming aware of stimuli patterns by presenting information at rapid rates and in complex sequences, but there is no way of determining if conscious processes were entirely eliminated.

Knowlton, Squire and Gluck (1994) described probability learning as a task that relies primarily on the form of memory preserved by amnesics. However, they found that amnesics show evidence of probability learning, but perform more poorly than people with normally functioning memory. Knowlton, et. al. suggested the reason for amnesics' poorer probability learning is that they lack the ability to recollect (declarative memory), a type of memory used by normals to supplement more automatic, unconscious processes (procedural memory) that are fully relied on by amnesics for probability learning tasks.

To avoid the possibility of conscious strategies contaminating performance, I used Jacoby's (1991) process-dissociation procedure to separately examine consciously controlled and automatic memory processing. In Phase 2 of the experiments reported here, probability learning was not the focus, yet the form of memory responsible for probability matching was observed. By using this procedure, I was able to separate the contributions of habit and recollection to performance and thereby examine effects of habit uncontaminated by recollection. In doing so, it was found that only the automatic component, or habit, reflected the actual probability of having seen the typical items earlier in the training session. Further, the differential "habit strength" of typical responses did not influence recollection, nor did factors that influenced recollection affect the contribution of habit.

It is still possible for one to argue that the estimates of habit in the current experiments did not reflect automatic or implicit influences, but rather, reflected strategic processes in which participants became aware of the presentation probabilities from training and intentionally used that knowledge, thereby inflating the estimates of automatic influences. This possibility seems quite unlikely, however, unless one assumes that participants were not only aware of the probabilities with which items appeared in training but were also able to control their responding in such a way that allowed the estimates to closely approximate the objective probabilities of items' occurrence. Further, if conscious guessing sometimes occurs, it might be expected to be a relatively slow basis for responding. If so, then requiring fast responding in Experiment 3 should have reduced the contribution of habit relative to the longer deadline condition in which conscious guessing could occur. The lack of change in the contribution of habit across the manipulation of response deadline makes it likely that habit served as an unaware, unintentional basis for responding. In contrast to the results for habit, manipulating response deadline had a large influence on recollection, as did the effects of aging in Experiments 4 and 7, thus suggesting that habit estimates were not consciously mediated.

Convergence with the Inclusion/Exclusion Procedure

For most of the experiments using the process-dissociation procedure, in concert and opposition conditions have been created by manipulating instructions given at the time of test (e.g., Jacoby et al., 1993). Participants are told to report remembered items for an inclusion test (in concert condition) but to withhold remembered items for an exclusion test (opposition condition). In contrast, when conditions are created by manipulating congruency with prior learning, participants are always instructed to give remembered items as responses. Using this new version of the process-dissociation procedure allowed me to separate the contribution of habit from recollection for specific events. Kelley and Jacoby (1993) used a variant of the procedure that is similar to the one used in the experiments reported here, and showed that general knowledge and recollection can make functionally independent contributions to performance on a cued-recall test of memory. Similarly, Yonelinas and Jacoby (1995) used a manipulation of congruency to separate automatic and controlled processes within a memory search task.

The two ways of implementing the process-dissociation procedure produce parallel results. Using the inclusion/exclusion procedure, manipulating factors that are traditionally treated as important for conscious control have produced process dissociations. For example, divided attention at study reduces recollection but leaves automatic influences invariant, as do the effects of aging (for a review, see Jacoby, et al., 1997; Jennings & Jacoby, 1993). Using a short response deadline to require fast responding also reduces recollection without changing the contribution of automatic influences (Yonelinas & Jacoby, 1994). In the experiments reported here, I showed parallel effects by manipulating congruency with prior training, and further, I found convergence with subjective report estimates (Experiment 7).

Some critics of the process-dissociation procedure have argued that inclusion/exclusion instructions are too complicated for people to comprehend and further, that they may produce differential biases in responding across the two conditions (Graf & Komatsu, 1994). However, the findings reported here provide support for conclusions based on manipulations of instructions because parallel results are demonstrated when conditions are created by manipulating congruency with prior learning thereby making it unnecessary to vary instructions across in concert and opposition conditions.

An assumption underlying the process-dissociation procedure is that automatic influences are the same for in concert and opposition conditions. There is some reason to question whether this assumption was satisfied by the procedure used for the experiments reported here. It is possible that the magnitude of habit was slightly greater for congruent trials than for incongruent trials, as typical items had an additional presentation in the study list for congruent trials only (atypical responses were presented in the study list for incongruent trials). The additional presentation at study may have boosted the habit present for congruent trials above that present for incongruent trials.

However, there are several reasons to suggest that any difference in habit across congruent and incongruent trials was minimal. Typical items were presented in training on 12 - 18 separate occasions, with an additional six presentations during testing in Phase 2, making it likely that habit was already at a level where one additional presentation had a negligible impact. This seems especially likely given that estimates of habit closely reflected the actual probabilities of items being presented in training. Further, "guessing" items which were not presented for study (similar to typical items in the incongruent condition) produced a probability of responding that was very close to the derived estimates of habit. This convergence suggests that any difference between congruent and incongruent trials was unimportant for estimating the contribution of habit.

Age-Related Deficits in Recollection

Using Jacoby's (1991) process-dissociation procedure to separate recollection and habit in young and elderly adults, I found significant deficits in recollection yet estimates of habit were not influenced by the effects of aging (Experiments 4 and 7). Previous research using different versions of the process-dissociation procedure has shown similar age-related impairments in recollection in the presence of preserved automatic responding (Hay, et al., in press; Jacoby & Hay, 1993; Jacoby, et al., 1996; Jennings & Jacoby, 1993, in press). These results demonstrated that elderly adults are more likely than young adults to commit memory slips. The increased likelihood of older adults committing memory slips can be interpreted as reflecting the effects of habit in the absence of recollection.

Alternatively, one of the most popular accounts of age-related deficits in the aging literature currently is that elderly adults have difficulties inhibiting non-target information in memory (e.g., Hasher & Zacks, 1988). In the experiments presented earlier, performance on incongruent trials measured the proportion of memory slips committed by participants when they failed to suppress typical responses, making this condition similar to tasks used by other researchers investigating inhibitory mechanisms (e.g., Hasher & Zacks, 1988; Tipper, 1991; Gernsbacher & Faust, 1991). Performance on incongruent trials in Experiments 4 and 7 could be taken as evidence to support an inhibition account of age differences in memory, as older adults failed to inhibit typical responses more often than young adults. But if age-related memory deficits arise from impaired inhibitory mechanisms, then performance of older adults should not differ from young adults on congruent trials (in concert condition) where recollection and habit work together to produce the same outcome. However, the results of Experiments 4 and 7 revealed age differences in the facilitation condition. These findings cannot be explained by an inhibition account of aging, but by a dual-process account, the elderly perform more poorly than the young because they have deficits in conscious recollection in the presence of intact automatic responding, or habit.

Qualitative Age Differences in Memory

The results of Experiments 4 demonstrated that young adults elaborate distinctive semantic information to assist recollection as shown by their higher recollection estimates in the distinctive versus the non-distinctive condition. In contrast, the performance of elderly adults did not differ between distinctiveness conditions. These results suggest that aging contributes to qualitative, as well as quantitative differences, in how recollective processing is carried out. Such findings are consistent with research suggesting that older adults are less likely to elaborate associative information in memory and instead, encode items in a more general manner (e.g., Craik & Byrd, 1982; Craik & Simon, 1980; Rabinowitz et al., 1982). Craik has claimed older adults have a reduction in cognitive resources required for elaborative encoding of distinctive contextual information and therefore do not process information as richly or deeply as young adults.

A similar interpretation of memory impairments has been proposed by Blaxton (1992), who makes a distinction between the types of processing required by different tasks. Blaxton argues that memory-impaired populations such as amnesics have difficulties engaging in conceptually driven processing, but their ability to perform data-driven-processing remains intact. The distinction between conceptually driven and data driven processing was used by Jacoby (1983), who suggested that the former reflects meaningful analysis of information while the latter reflects analysis of physical characteristics and perceptual features. Deficits in conceptual processing demonstrated by populations such as elderly adults, similar to deficits in elaborative processing, might better be interpreted as reflecting a more general deficit in consciously controlled processes.

The difference between impaired inhibition and impaired conscious control as explanations of age-related deficits in memory is important because these two views lead to very different approaches for memory rehabilitation. An inhibition account emphasizes teaching older adults to resist interfering information (habit) by training them to suppress information that is off the goal path. Rather than teach the elderly to inhibit extraneous information, the research presented here suggests that a better goal for rehabilitation is to enhance recollective abilities in older adults by examining memory performance in a facilitation condition as well as an inhibition condition. In Experiments 5 and 6, attempts were made to repair deficits in recollection in older adults by focusing on their difficulties elaborating and integrating associative information. It was found that older adults are able to elaborate materials to exploit distinctive information to the same extent as young adults, when supportive task conditions were created. By targeting this type of processing, my approach clearly differed from one that would be taken if it was believed that older adults had impaired inhibitory mechanisms. Experiments 4-6 were guided by the view that age-related impairments in elaborative processing reflect deficits in consciously controlled uses of memory.

Aging and the Frontal Lobes

Although the frontal lobes are complex and diverse in nature, it is often assumed that they primarily perform a supervisory, "executive" role in controlling cognition and behaviour (e.g., Norman & Shallice, 1980; Stuss & Benson, 1986). Moscovitch and colleagues have referred to the frontal lobes as a 'working-with-memory' structure because they mediate the strategic, self-initiated aspects of memory which include organizing and coordinating information to and from the hippocampal system, as well as performing activities such as inferencing, planning and elaborative processing (e.g., Moscovitch, 1992, 1994; Moscovitch & Winocur, 1992). Deficits in these cognitive abilities are signature traits of patients with frontal lobe damage but they are frequently reported for elderly adults as well. Such observations are not surprising given that age-related memory decline is often linked to frontal dysfunction (e.g., Craik, Morris, Morris, & Loewen, 1990; Moscovitch & Winocur, 1992; Parkin, in press).

Findings from Experiments 4 and 5 can be viewed as evidence for deficits in strategic processing in older adults. However, when task conditions were made more supportive to facilitate and guide recollective processing, older adults demonstrated that they could elaborate distinctive information to enhance recollection in a manner similar to the young. Although young adults can initiate elaborative strategies on their own, older adults may be less able to perform such processing unless guided by external sources (e.g., Hulicka & Grossman, 1967; Treat & Reese, 1976). Craik (1983, 1986) suggested elderly adults have deficits in *spontaneously* initiating memorial processing, especially in unstructured situations. Although results from Experiments 4-6 support conclusions of age impairments in self-initiated processing, I find it promising that older adults are able to engage in elaborative, strategic processing if they are guided to do so.

Correspondence Between Objective and Subjective Measures

The results of Experiment 7 revealed that both young and elderly adults are very accurate in reporting their memory processing. That is, self-report estimates of recollection were almost identical to the estimates derived with the process-dissociation procedure. Although a similar convergence between objective and subjective measures has been demonstrated previously across experiments (Jacoby, et al., 1996; Yonelinas & Jacoby, 1995), such convergence has never been shown by young and elderly participants within a single experiment, performing a common task. Comparing different measures within the same participants, it was found that objective and subjective measures of recollection were highly correlated (correlation coefficients of .71 and .81 for young and elderly, respectively) suggesting that both age groups are accurately able to report that they are recollecting, when they are doing so. The results of Experiment 7 support studies in the aging literature that have found no age differences in metamemory (see Lovelace, 1990 for a review; Lovelace & Marsh, 1985).

Jennings and Hay (1994) extended these findings by comparing subjective estimates of recollection in the lab with self-reports of everyday memory failures in a questionnaire filled out by young and elderly adults. It was found that the frequency of everyday memory failures correlated highly with subjective recollection estimates ($r = .-56$), but not subjective estimates of automatic influences of memory ($r = .08$). Therefore, not only is there correspondence between objective and subjective memory measures in the lab, it appears that these measures of recollection also correlate with self-report measures in the real world.

Subjective estimates of habit were also derived for young and elderly adults, based on the assumption that recollection and habit make independent contributions to performance. This self-report measure was also compared to estimates derived with the process-dissociation procedure, showing a strong convergence between the estimates and high correlations between the two types of measures. Further, probability-matching was revealed in habit estimates regardless of the type of measure. These findings suggest that young and elderly adults are not only aware of their memory processing in situations where they are recollecting, but also in situations where they are relying on automatic influences of memory.

Conclusions

The goal of separating the contribution of processes within a task seems particularly important given that in most natural situations both automatic and consciously controlled processes are simultaneously in play. In the experiments presented in this thesis, I was able to separate out memory processes as they occurred together by manipulating congruency with prior learning. This extension of Jacoby's (1991) process-dissociation procedure offers a useful method for investigating automatic and consciously controlled influences on memory and serves well to answer some of the criticisms aimed at earlier versions of the inclusion/exclusion procedure.

Memory slips emerge in situations in which habit and recollection act in opposition. However, habit is not always a source of error; automatic responding and recollection sometimes work together to produce the same outcome. Unlike previous work on memory slips that has focused on opposition conditions, the research presented here also investigated facilitation conditions. By combining performance from in concert and opposition conditions, it was demonstrated that habit and recollection were differentially affected by various experimental manipulations, thus supporting the assumption that the two bases of responding can operate independently of each other.

Due to deficits in recollection, effects of habit are often left unopposed in older adults, increasing the likelihood that they will produce memory slips. However, elderly adults also have memory impairments in a facilitation condition. To better understand the nature of age-related deficits in memory requires consideration of both an opposition and facilitation condition. By examining performance in both conditions, it is evident that elderly adults have deficits in recollection but automatic influences, or habit, are preserved. This same pattern of results emerged in subjective report measures.

A dual-process view of memory differs from inhibition accounts of aging (e.g., Hasher & Zacks, 1988), which suggest that older adults have difficulties suppressing interfering information. In contrast, the focus here has been on helping elderly adults process information in a more elaborate, integrative fashion to increase recollective abilities. Although the elderly showed deficits in their ability to exploit distinctive contextual information, when task conditions were made more supportive, performance improved to a level comparable to young adults. That such abilities are not lost entirely and can actually be improved under some conditions, is encouraging for future work aimed at rehabilitating memory deficits associated with aging.

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Table 1

Probabilities of responding with a typical item and mean estimates of recollection and automatic influences, as a function of the proportion of typical items seen during training in Experiment 1

Proportion of typical items	*Trial Type* Congruent	Incongruent	*Estimates* Recollection	Habit	Guessing
75%	.82	.37	.45	.67	.71
50%	.71	.28	.43	.48	.53

Table 2

Probabilities of responding with a typical item and mean estimates of recollection and automatic influences, as a function of presentation rate in Experiment 2

Pres. Rate	*Trial Type*		*Estimates*		
	Congruent	Incongruent	Recollection	Habit	Guessing
Slow	.79	.32	.47	.62	.68
Fast	.74	.48	.27	.65	.66

Table 3

Probabilities of responding with a typical item and mean estimates of recollection and automatic influences, as a function of response deadline in Experiment 3

Response Deadline	*Trial Type*		*Estimates*		
	Congruent	Incongruent	Recollection	Habit	Guessing
Long	.77	.37	.41	.62	.66
Short	.71	.45	.26	.61	.62

Table 4

Probabilities of responding with a typical item and mean estimates of recollection and automatic influences, as a function of age and distinctiveness condition in Experiment 4

	Trial Type		*Estimates*		
Age	Congruent	Incongruent	Recollection	Habit	Guessing
Young					
Non-Distinctive	.84	.41	.44	.72	.77
Distinctive	.88	.29	.60	.70	.77
Elderly					
Non-Distinctive	.80	.51	.29	.72	.76
Distinctive	.80	.50	.30	.72	.74

Table 5

Probabilities of responding with a typical item and mean estimates of recollection and automatic influences for elderly adults, as a function of presentation rate and distinctiveness condition in Experiment 5

	Trial Type		*Estimates*		
Pres. Rate	Congruent	Incongruent	Recollection	Habit	Guessing
Fast					
Non-Distinctive	.82	.60	.22	.76	.75
Distinctive	.82	.56	.26	.75	.73
Slow					
Non-Distinctive	.85	.41	.44	.72	.79
Distinctive	.87	.41	.46	.75	.77

Table 6

Probabilities of responding with a typical item and mean estimates of recollection and automatic influences for elderly adults, as a function of response deadline and distinctiveness condition in Experiment 6

	Trial Type		*Estimates*		
Response Deadline	Congruent	Incongruent	Recollection	Habit	Guessing
Short					
Non-Distinctive	.87	.45	.42	.77	.77
Distinctive	.86	.38	.48	.72	.73
Long					
Non-Distinctive	.84	.41	.41	.72	.75
Distinctive	.89	.31	.58	.73	.74

Table 7

Probabilities of responding with a typical item and mean estimates of recollection and automatic influences for young and elderly adults in Experiment 7

	Trial Type		*Estimates*		
Age	Congruent	Incongruent	Recollection	Habit	Guessing
Young	.87	.35	.44	.63	.66
Elderly	.86	.44	.29	.62	.64

Table 8

Mean estimates of subjective recollection and subjective habit for typical items, for young and elderly adults in Experiment 7

	Estimates	
	Recollection'	Habit'
Age		
Young	.44	.64
Elderly	.24	.65

IMAGE EVALUATION TEST TARGET (QA-3)

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6"

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