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Dissociations between Conscious and Unconscious Influences of Memory for Object Location

by

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B.A., Simon Fraser University, 1992
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A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

in the Department of Psychology

We accept this Dissertation as conforming to the required standard

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This study used the process dissociation procedure to investigate the effects of three variables on conscious and unconscious influences of memory for object location. The purpose was not only to provide insight into conscious and unconscious influences of memory for object location, but also to obtain support for the assumption that the two influences operate independently. Such support can be obtained by demonstrating that a manipulation affects one component of memory but leaves the other invariant. The three variables used in the present study included dividing attention at study and test, the age of the participants, and habit strength. In the first experiment, when attention was divided at study, the conscious estimate was significantly reduced under conditions of divided attention. This result was also found when attention was divided at test, although the effect only approached significance. Moreover, when attention was divided at study, there was a tendency for the unconscious estimate to be greater under full attention than under divided attention. When attention was manipulated at test, however, the unconscious estimate did not vary across the two attention conditions. The results of Experiment 1, therefore, did not provide strong evidence for the assumption of independence. Such evidence, however, was obtained in Experiments 2 and 3 where a double dissociation between conscious and unconscious influences of memory for object location was observed. Specifically, in Experiment 2 it was found that age affected the conscious component but left the unconscious component invariant, whereas in Experiment 3 it was found that manipulating habit strength affected the unconscious influence of memory for spatial location but not the conscious influence. The results of these experiments are discussed in terms of their importance for research on memory and aging and systems theories of memory, as well as
for the assumption that conscious and unconscious influences of memory operate independently.

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Introduction

When an individual searches for an object they have recently placed in a particular location, they may do so based on two memory processes. First, they may search in a location based on the conscious recollection of that location. For example, the individual may remember that they left their keys hanging on a hook by the door and will therefore go to that location to retrieve the keys. Second, the individual may search for an object based on an unconscious influence of memory for the object's location. Such unconscious influences will likely lead the person to search for the object in its most common location, for example, searching for the keys on the hook. If, however, the object has been placed in an unlikely location, for instance, the individual left their keys in their coat pocket, then an unconscious influence of memory will likely lead the person to search in the wrong location.

The present set of experiments examined these two influences of memory. Specifically, it used the process dissociation procedure to investigate the effect of three variables on conscious and unconscious influences of memory for object location. These three variables included full versus divided attention, age, and habit strength. The purpose was to gain a further understanding of conscious and unconscious influences of memory for location by investigating dissociations between these two memory processes.

This paper begins with a brief summary of the dissociations that have been obtained between conscious and unconscious influences of memory. This summary is followed by a discussion of research investigating memory for spatial location as well as a review of research involving the three variables used in the present study. The experiments conducted in this study are then described, and the results of those experiments discussed. The importance of the findings for the process dissociation procedure and the assumption of independence between conscious and unconscious influences of memory is then discussed, as are the implications of the results for systems theories of memory and research on memory and aging.
Dissociations between Conscious and Unconscious Influences of Memory

Investigations of conscious and unconscious influences of memory have traditionally involved the use of two kinds of memory measures. The first group of tests, which have been referred to as explicit or direct tests of memory, require an individual to consciously recollect a prior episode and then to respond based on that recollection. Such tests have been used to assess conscious influences of memory. Examples of direct tests of memory include recall and recognition. In contrast to direct tests of memory, implicit or indirect tests of memory do not require an individual to consciously recollect a previous experience. Performance on such tests, however, is affected by those experiences. Such tests have been used to assess unconscious influences of memory. Examples of indirect tests include word stem completion, word fragment completion, and masked word identification.

Dissociations between these two kinds of memory measures have been used as evidence in favor of the existence of conscious and unconscious influences of memory. Examples of variables that have been found to affect direct test performance but not indirect test performance include dividing attention (Eich, 1984; Parkin, Reid, & Russo, 1990), levels of processing (Jacoby & Dallas, 1981), age (Light & Albertson, 1989; Light & Singh, 1987; Schacter, Cooper, & Valdiserri, 1992), and presentation duration during encoding (Jacoby & Dallas, 1981; Kunst-Wilson & Zajonc, 1980; Seamon, Marsh, & Brody, 1984). Amnesia has also been found to affect direct but not indirect test performance. That is, amnesic patients typically demonstrate intact performance on indirect tests of memory but impaired performance on direct tests (Warrington & Weiskrantz, 1968, 1970).

Manipulations that have shown the reverse dissociation, demonstrating an effect on indirect test performance but not on direct test performance, typically reveal that performance on indirect tests is highly specific. For example, indirect test performance has
been found to be affected by changes in physical features between study and test (Srinivas, in Roediger & Srinivas, 1993; Weldon & Roediger, 1987) and by changes in modality between study and test (Roediger & Blaxton, 1987).

Another area in which dissociations have been found between direct and indirect test performance involves newly acquired associations. Such dissociations were uncovered in a series of experiments conducted by Graf and Schacter (1985; 1987; Schacter & Graf, 1986; 1989). The basic paradigm used by these researchers was as follows. In a study phase, subjects were presented with unrelated cue word/target word pairs, and were asked to generate a sentence that incorporated both words. Associative memory was then tested by presenting subjects with cue word/word stem pairs. The word stems could be completed with target words presented during study. Moreover, the cue word presented at test was either the same cue word with which the target word was paired during study or was a new word. Subjects were required to complete the stem under indirect or direct test instruction. The results indicated that for both the direct and indirect tests, the proportion of study items used to complete the stem was higher in the same cue condition than in the different cue condition. Dissociations between the tests were obtained in a later series of experiments where it was found that proactive and retroactive interference affected performance on a direct test of memory for new associations but not on an indirect test (Graf & Schacter, 1987), and shifts in modality between study and test affected performance on an indirect test of memory for new associations but not a direct test (Schacter & Graf, 1989).

Although examination of dissociations between direct and indirect test performance has provided insight into underlying memory processes, there is a potential drawback to using such measures to assess conscious and unconscious influences of memory. The problem arises when dissociations between direct and indirect tests are used to make conclusions about conscious and unconscious influences of memory. Such conclusions
assume that the memory measures are process pure. That is, they assume that direct tests assess conscious influences of memory and indirect tests assess unconscious influences of memory. Jacoby (1991), however, has argued that memory tasks are not necessarily process pure in that direct test performance may be contaminated by unconscious influences of memory and indirect test performance may be contaminated by conscious influences. For this reason he developed the process dissociation procedure.

Process Dissociation Procedure

The process dissociation procedure avoids the problem of contamination by searching for dissociations between conscious and unconscious influences of memory within a single task, rather than searching for dissociations between tasks, and it does so by using both a facilitation paradigm and an opposition paradigm. In the facilitation paradigm, both conscious and unconscious influences of memory lead to the same response, whereas in the opposition paradigm conscious and unconscious influences of memory lead to different responses.

To describe the procedure, an experiment conducted by Jennings and Jacoby (1993, Experiment 1) will be discussed. In that experiment, subjects were presented with a list of nonfamous names to be read aloud. Memory for those names was then assessed using two fame judgment tests in which the subject decided whether each name was famous. For each test, three kinds of names were presented; old nonfamous names (i.e., names presented in the study phase), new nonfamous names (i.e., names not presented at study), and new famous names. In the first test, the inclusion test, subjects were wrongfully informed that the names they read in the study phase of the experiment were famous so if they recognized a name from that phase they should call it famous. In this test, conscious (recollection) and unconscious (automatic) influences of memory act in concert in that both influences of memory will lead a subject to call an old nonfamous name famous. The inclusion instruction condition, therefore, serves as the facilitation task. In
the exclusion test, which followed the inclusion test, subjects were correctly informed that
the names presented in the first phase were nonfamous, so if they recognize a name from
that phase they should call it nonfamous. In this test, conscious and unconscious
influences of memory are placed in opposition in that the conscious recollection of an old
nonfamous name would lead a subject to say a name is not famous, whereas an
unconscious influence of memory, that is unopposed by conscious recollection, would lead
a subject to call an old nonfamous name famous.

Equations were then used to obtain estimates of conscious and unconscious
influences of memory for the names presented in the study phase, based on the subjects' performance on the inclusion and exclusion tests. It is important to note that an assumption was made when using these equations, which is that conscious and unconscious influences of memory independently contribute to performance. Once this assumption was made, the following equations were used to estimate conscious and unconscious influences of memory in the fame judgment task.

For the inclusion test, both conscious and unconscious influences of memory would result in a subject calling an old nonfamous name famous. In this instruction condition, the probability that a subject called an old nonfamous name famous is equal to the probability that the old name was consciously recollected (C) plus the probability that the old name came forward due to an unconscious influence (U), minus their product given the two processes operate independently. Thus, \( P(\text{calling an old name famous} \mid \text{incl}) = C+U-CU \), or to simplify, \( P(\text{calling an old name famous} \mid \text{incl}) = C+U(1-C) \).

In the exclusion condition, conscious and unconscious influences of memory were placed in opposition, that is, an old nonfamous name would be called famous if there was an unconscious influence of memory operating that was not opposed by conscious recollection. In this instruction condition, the probability that a subject called an old nonfamous name famous was equal to the probability that name came forward
unconsciously without a conscious influence, \( P(\text{calling an old name famous} \mid \text{excl}) = U(1-C) \).

An estimate of conscious and unconscious influences of memory was then computed from the proportions of trials in which a subject called an old nonfamous name famous in the inclusion and exclusion instruction conditions. The estimate of the conscious influence of memory was obtained by subtracting the probability of calling an old name famous in the exclusion instruction condition from the probability of calling an old name famous in the inclusion instruction condition, \( C = I - E \). Once this value was obtained, the estimate of the unconscious influence of memory was computed, \( U = E/(1-C) \).

In the experiment discussed above, Jennings and Jacoby (1993) estimated conscious and unconscious influences of memory for the studied names in both young and old subjects. They found that the estimate for conscious recollection was reliably lower for the older group than for the younger group. The estimate of unconscious influences of memory, however, did not differ as a function of age.

Rationale for the Present Study

The benefit of using the process dissociation procedure is that it allows one to observe dissociations between conscious and unconscious influences of memory without having to assume that measures are process pure. The present study, therefore, used this procedure to investigate conscious and unconscious influences of memory for object location. The rationale for investigating memory for spatial location was twofold. First, little research has been conducted examining unconscious influences of memory for spatial location, so the present set of experiments would provide insight into such processes. Second, the present study was conducted for the purpose of determining whether memory for object location operates by the same principles as other kinds of memory. Specifically, it attempted to separate conscious and unconscious influences of memory within a single
task and to examine whether these two influences operate independently. Each of these reasons will now be discussed in turn.

**Direct Tests of Memory for Spatial Location**

The first reason for investigating unconscious influences of memory for object location stemmed from the lack of research on such processes. Most studies investigating memory for spatial location have used direct tests of memory to assess conscious influences of memory. Such studies have typically been conducted for the purpose of testing a model proposed by Hasher and Zacks (1979). By that theory, when an individual attends to an event, certain aspects of that event are encoded automatically, such as location, time, and frequency information. Hasher and Zacks argued that because such information is encoded automatically, it should not be affected by incidental versus intentional learning instructions, practice, or developmental trends.

The results of experiments investigating the criteria proposed by Hasher and Zacks have been equivocal. Consistent with the predictions of the Hasher and Zacks model, a number of studies have demonstrated that subjects could remember the location of objects even when not instructed to remember those locations. For example, Mandler, Seegmiller, and Day (1977) found that subjects could remember the location of 16 toys placed on a matrix of 36 locations under incidental instructions. Moreover, there was no cost in remembering the identity of the toys when subjects were asked to remember both the toys and the locations. Likewise, Shadoin & Ellis (1992) found that subjects could remember the locations of drawings of objects when placed on matrices of varying sizes (4, 9, or 16 locations), and that intention to remember the locations did not improve performance over incidental instructions. Further support for the position that location information is encoded automatically was found by McCormack (1982) who demonstrated that young and older subjects performed similarly on a memory test for the locations of words presented on cards.
Other studies, however, do not support the model proposed by Hasher and Zacks (1979). For example, a number of researchers have found that intention to remember location information leads to superior recall over incidental learning instructions (Park & Mason, 1982; Naveh-Benjamin, 1987, 1988). Furthermore, Naveh-Benjamin (1987, 1988) found that memory for location information was higher when the demands of a competing task were low rather than high, when subjects were given the opportunity to practice, and when subjects had an encoding strategy.

Further difficulty for the Hasher and Zacks (1979) model was obtained in studies demonstrating age related changes in memory for spatial location. For example, Perlmutter, Metzger, Nexworski, and Miller (1981) and Light and Zelinski (1983) found that older adults did not remember the location of objects on a map as well as younger adults. Moreover, Park, Puglisi, & Lutz (1982) demonstrated that younger subjects were superior to older subjects in their ability to remember whether line drawings of objects appeared on the left or right hand side of slides.

Pezdek (1983) also found that older subjects did not remember the location of items as well as their younger counterparts. In that experiment, young and older subjects were presented with 16 small objects or verbal labels on a 6 by 6 matrix and asked to remember the display for a memory test. For the test, subjects were first required to recall the objects presented in the display. Following the free recall task, subjects were presented with the objects and asked to re-place the objects in their original locations. The results indicated that performance of the younger subjects was superior to the older individuals in both the free recall task and in the placement task. Similarly, Naveh-Benjamin (1987, 1988) found that older subjects did not perform as well as their younger counterparts when asked to remember the location of 20 drawings of objects presented on a 6 by 6 matrix.

Although the results of the studies discussed above do not provide strong evidence for the assumption that spatial information is encoded automatically, they do demonstrate
that subjects can remember the locations of objects under certain conditions. In these experiments, however, memory for object location was tested using direct measures that required the subjects to consciously recollect the locations. Very few studies have been conducted investigating memory for location information using indirect tests.

**Indirect Tests of Memory for Spatial Location**

One experiment that demonstrated an unconscious influence of memory for location was conducted by Treisman and Hayes (in Treisman, 1992). These researchers asked subjects to detect the presence or absence of one of four targets embedded in a set of eight distractors. All items were displayed simultaneously in a circular array. The number of times a target occurred in a particular location in the array was manipulated so that two of the four targets occurred in the same spatial location on 75% of the target present trials and the remaining two targets occurred in random locations. Subjects demonstrated a benefit in detecting the targets when they appeared in the consistent location, which was revealed in the lower response latencies compared to latencies for randomly located targets, and a cost when they appeared in a different location, which was revealed in the higher response latencies compared to latencies for randomly located targets. The subjects in this experiment, however, said they were not aware of the consistent locations. These results suggest an existence of an unconscious influence of memory for location in the absence of a conscious influence for that information.

Musen (1993) also demonstrated an unconscious influence of memory for location. In that experiment, 9 letters appeared in various locations on the computer screen and the subject's task was to identify the location of each letter as it appeared. The letters were presented in the same locations over 10 blocks of trials and then on the eleventh trial block the locations of the letters were changed. The results indicated a decrease in response latencies over the initial 10 trial blocks, and then an increase in latency on the eleventh trial block. The subjects, however, were not able to report the consistent location for each
letter. As in the Treisman and Hayes study, these results indicate an unconscious influence of memory for the location of the letters in the absence of conscious recollection.

Due to the lack of research on unconscious influences of memory for spatial location, Caldwell and Masson (1998, Experiment 6) investigated such influences. In that experiment, an unconscious influence of memory for an object's spatial location was revealed using Jacoby's process dissociation procedure. In the study phase of that experiment, subjects were presented with drawings of household objects on a computer screen and were asked to place those objects in specified locations in rooms of a house. In the test phase, subjects were asked to search for those objects under inclusion and exclusion instructions. In the inclusion instruction condition, subjects were told that each object was in the same location in which they placed it in the study phase and so they should look for the object in that location. If they could not remember that location, they were to search for the object in the first location that came to mind. In the exclusion condition, subjects were told that the objects were located in locations different from where they placed them in the study phase, so they were to search for the objects in new locations. The results from that experiment indicated a reliable conscious influence of memory for the locations of the objects, and more importantly for present purposes, subjects also demonstrated a reliable unconscious influence of memory for the locations.

Systems Theories of Memory

The Declarative/Nondeclarative Distinction

The results of the study conducted by Caldwell and Masson (1998) suggest that there is a reliable unconscious influence of memory for spatial location. Such a finding may have important implications for systems views of memory. For instance, by the systems theory proposed by Squire (1992), a distinction is made between two memory systems, declarative and nondeclarative. Squire argued that the declarative memory system is involved in episodic memory and is, therefore, implicated in direct test performance.
The declarative system is also said to be responsible for semantic memory, which is memory for general knowledge. The area of the brain that has been implicated in declarative memory abilities is the hippocampal system. It is argued that this system plays an important role in the development of new relationships between events, "such as those established when associating stimuli with their spatial and temporal context (thus representing a new episode) or those established when associating a fact with the semantic context to which it belongs (thus representing a new concept)" (Squire, 1992, p. 208).

The second memory system discussed by Squire (1992) is the nondeclarative system, which has been implicated in such memory abilities as priming, conditioning, and skilled performance. Such abilities are revealed on indirect tests of memory. The nondeclarative system, therefore, is implicated in unconscious influences of memory. Squire suggested that the brain system involved in nondeclarative memory operates independently of the hippocampal formation.

Evidence in favor of Squire's model has been obtained in studies of amnesic subjects who have suffered damage to their hippocampal formation. These patients demonstrate impaired performance on tests that tap declarative memory abilities and normal performance on tests that assess nondeclarative memory abilities. For example, Squire and McKee (1992) exposed amnesic patients and control subjects to a list of famous and nonfamous names. A fame judgment task was then administered which contained old famous and nonfamous names as well as new famous and nonfamous names. After the fame judgment task, subjects were given a recognition test for the names in the study list. The results indicated that for both amnesic and control subjects old famous names were more likely to be called famous than new famous names. The same was true for old nonfamous names, that is, they were more likely to be called famous than new nonfamous names. In the recognition test, however, the amnesic subjects performed reliably worse than the control subjects. Squire and McKee (1992) concluded that amnesic patients
performed at a normal level on the fame judgment task because performance on that task relies on a system that is not impaired in amnesia, i.e., the nondeclarative system.

Further evidence that amnesic patients with hippocampal damage perform normally on indirect tests of memory was obtained by Musen and Squire (1991). These researchers found that both amnesic and normal control subjects read lists of repeated words and repeated nonwords faster than lists of non repeated words and nonwords. Furthermore, this benefit of repetition persisted over a 10 minute delay for both groups of subjects. A test of recognition for the same material, however, demonstrated impaired performance in the amnesic group.

Additional evidence for the declarative/nondeclarative distinction has also been obtained in research involving elderly subjects. These adults demonstrate a similar pattern of memory loss to amnesic patients, that is, they demonstrate impaired performance on direct tests of memory and intact performance on indirect tests (Howard, Fry, & Brune, 1991; Light & Albertson, 1989; Light & Singh, 1987; Schacter, et al., 1992). Moreover, older adults show a decrease in the number of neurons in the hippocampus when compared to their younger counterparts, and the neurons of the older adults demonstrate abnormalities that are not present in younger adults (Squire, 1987). Such findings suggest that the hippocampus plays a similar role in the loss of declarative memory abilities in both amnesic patients and elderly adults.

Squire has also obtained evidence for his theory by demonstrating that the declarative system is responsible for establishing new associations. In an experiment conducted by Shimamura and Squire (1989), the paired-associate paradigm of Graf and Schacter (1985; 1987; Schacter & Graf, 1986; 1989) was used to determine whether amnesic subjects demonstrated intact priming for new associations. In that experiment, amnesic patients and control subjects were presented with critical word pairs embedded within sentences and were asked to rate how well each sentence related the two words. A
stem completion task then followed, which consisted of the presentation of word-word stem pairs. Subjects were asked to complete the stem with the first word that came to mind, and were told that the cue word may help them think of a completion. There were two conditions of interest; the same context condition, in which the stem was paired with its original context word, and the different context condition, in which the word stem was paired with a word not presented before in the experiment. The results revealed that normal subjects showed a context effect in that they completed the stems with studied words more often in the same context condition than in the different context condition. Amnesic patients, however, demonstrated similar performance in the two context conditions. That is, the amnesic patients did not demonstrate priming for new associations. Shimamura and Squire (1989) concluded that declarative memory contributes to priming of new associations. In contrast to the results obtained with new associations, Shimamura and Squire (1984) have demonstrated that amnesic patients perform well on paired-associate priming tasks that involve highly related word pairs (for example, table-chair).

Contrary to the results of Shimamura and Squire (1989), Gabrieli, Keane, Zarella, & Poldrack (1997) have demonstrated reliable priming for novel word pairs in a group of amnesic patients. In that experiment, amnesic and control subjects were given unrelated word pairs to read in a study phase. In the test phase, subjects were asked to identify briefly presented word pairs. For this test, three types of word pairs were presented; old (the original pair from the study phase), recombined (the first member of the pair was presented with a second member from a different pair presented in the study phase), and new (the first member of the pair was presented with a new word not presented in the study phase). The results indicated that old pairs were identified more accurately than recombined pairs, which were more accurately identified than new pairs. The type of word pair, however, did not interact with group, demonstrating similar levels of priming across
amnesic and control subjects. Recognition for the original pairs, however, was impaired in
the amnesic patients.

The Perceptual Representation System

A second system theory was proposed by Tulving and Schacter (1990). Unlike
Squire's dual system theory, however, these researchers distinguish four memory systems;
1) procedural memory, which is responsible for learning skilled actions, 2) semantic
memory, which is involved in the acquisition and storage of general knowledge, 3)
episodic memory, which is responsible for representing events as they occur in a particular
space and time, and 4) the perceptual representation system, which is responsible for
performance on indirect tests such as stem completion and word fragment completion.

Procedural, episodic, and semantic memory were carried over from an earlier
classification proposed by Tulving (1985). The perceptual representation system,
however, is a relatively new addition to the model (Tulving & Schacter, 1990). Evidence
in favor of the existence of the perceptual representation system as distinct from the other
memory systems was obtained by Schacter, Cooper, and Delaney (1990). In that
experiment, subjects were presented with possible and impossible objects (possible objects
are those that can exist in the real world whereas impossible objects cannot because of
certain lines and angles) and were asked to either judge whether they faced left or right or
whether they had more vertical or horizontal lines. Subjects were then given an object
decision task (i.e., they had to classify the object as possible or impossible) and a
recognition task. The results demonstrated reliable facilitation on the object decision task
for the left/right encoding task but not for the horizontal/vertical task. Furthermore,
facilitation was obtained for possible objects only, impossible objects did not demonstrate
an effect of prior exposure. Performance on the recognition test, however, was not
affected by the encoding manipulation. In a second experiment, elaborative processes were
used during encoding, and this manipulation affected recognition performance but did not
improve object decision performance. Schacter et al. (1990) argued that such dissociations between object decision and recognition support the distinction between an episodic memory system and a perceptual representation system.

Based on the evidence, Schacter and his colleagues (Schacter, et al., 1990; Tulving and Schacter, 1990) have suggested that the perceptual representation system operates as follows. When an item is presented to the subject, and they are required to process its global structure, a structural description of that object is created in the perceptual representation system. When the object is presented at a later point in time, access to this structural description facilitates performance. This facilitation, however, occurs only on priming tasks; it does not occur on episodic memory tasks because creation of the structural description does not provide the kinds of contextual (space and time) information that is necessary for episodic memory (Schacter, et al., 1990).

The results of Caldwell and Masson (1998) may have important implications for the system views of memory discussed above. For example, by the account proposed by Squire (1992), the declarative memory system mediates episodic memory and is therefore responsible for conscious influences of memory. This declarative system exists independently of the memory system that mediates unconscious influences of memory (the nondeclarative system). This theory would predict that the system responsible for episodic memory (which is memory for events occurring in a particular context) i.e., the declarative system, should be sensitive to spatial information whereas the nondeclarative system should not be sensitive to such information, that is, there should not be an unconscious influence of memory for spatial location. Contrary to such a prediction, however, Caldwell and Masson (1998) demonstrated an unconscious influence of memory for spatial location.

The finding of an unconscious influence of memory obtained by Caldwell and Masson (1998) could be accommodated by the system theory proposed by Squire (1992), however, if one were to argue that the location information acquired in that experiment
involved paired-associate learning. Specifically, in the Caldwell and Masson experiment, subjects learned to place objects in specific locations (for example, the brush on the vanity). One way subjects could process such information is simply to associate the object with the location, so rather than learning a location in space, per se, the subject simply learns to associate two objects. Moreover, because the locations used in that experiment consisted of typical locations for the objects, the associations would already be established. Squire, therefore, could accommodate the Caldwell and Masson result by arguing that memory performance in that experiment was based on pre-existing associations between the objects and locations. As discussed previously, nondeclarative memory can support performance on paired associate tasks that involve related pairs of objects.

The finding of an unconscious influence of memory for object location may not be as easily accommodated by the system theory proposed by Tulving and Schacter (1990). By that theory, the system responsible for unconscious influences of memory (the perceptual representation system) does not retain contextual information. This theory, therefore, would predict that there should not be an unconscious influence of memory for an object's location.

Like Squire (1992), however, Tulving and Schacter, could argue that the unconscious influence of memory for object location obtained by Caldwell and Masson (1998) simply reflected memory for preexisting associations. Performance on that task, therefore, would have been supported by the semantic memory system and not the perceptual representation system, because it is the semantic system that is concerned with the storage of general knowledge such as the relationship between concepts.

**The Independence Assumption**

The second source of motivation for the current set of experiments was an attempt to determine whether conscious and unconscious influences of memory for object location operate independently. Jacoby and his colleagues (Jacoby, Toth, & Yonelinas, 1993;
Toth, Reingold, & Jacoby, 1994) have argued that one way to provide support for this assumption is to demonstrate that a manipulation affects one influence of memory but leaves the other invariant. To obtain dissociations between conscious and unconscious influences of memory for object location in the present experiment, the process dissociation procedure was used to examine the effect of three variables on these two influences of memory. The three variables used were attention, age, and the strength of habit for placing objects in particular locations. Previous research investigating the effects of these variables on conscious and unconscious influences of memory will now be discussed.

Variables Used in the Present Study

Attention

A number of studies have obtained dissociations between conscious and unconscious influences of memory by manipulating the subjects' attention either at study or test. The results of such experiments have typically demonstrated that dividing attention decreases conscious influences of memory but leaves unconscious influences invariant. For instance, Parkin, et al. (1990) investigated the effect of dividing attention on direct and indirect test performance. In the study phase, subjects were presented with target words embedded in sentences. These sentences were either sensible or nonsensical and subjects had to report whether the sentence made sense or not. During this sentence verification task, half of the subjects also performed a tone monitoring task in which they had to report whether a tone was high, medium, or low. In the test phase, subjects performed multiple recognition and fragment completion tasks. The results indicated that subjects in the full attention condition performed better on the recognition task than did those in the divided attention condition. The attention factor, however, did not affect performance on the fragment completion task.

Jacoby, Woloshyn, and Kelly (1989) also examined the effect of dividing attention on conscious and unconscious influences of memory. In the first experiment of that study,
subjects were presented with lists of famous and nonfamous names in a study phase and asked to pronounce the names out loud. Half of the subjects performed a second task during the encoding of the names. This second task involved listening to a series of numbers and reporting when they heard three odd digits in a row. Subjects then performed two tests. The first test was a fame judgment task in which old and new famous and old and new nonfamous names were presented and they had to determine whether the name was famous or not. The second test was a recognition test.

The results indicated that old famous and nonfamous names were identified as famous more often than were new famous and nonfamous names, respectively. More importantly, the increase in judging an old name as famous (familiarity) was not affected by the divided attention manipulation. The results of the recognition test, however, demonstrated that performance was superior when subjects encoded the names under full attention than when they encoded them under divided attention. Jacoby et al. concluded that dividing attention at study affected one's ability to consciously recollect a name from the study list but had no effect on the familiarity of those names in a fame judgment task.

Jacoby, et al. (1993) also investigated the effect of dividing attention on conscious and unconscious influences of memory using a stem completion task. In that experiment, the process dissociation procedure was used. In the first phase of that experiment, words were presented auditorially and subjects were asked to remember them for a memory test. In the second phase, a second list of words was presented visually. Half of the subjects were instructed to read the words aloud and remember them for a memory test. The remaining subjects also read the words aloud but simultaneously performed a second task, which was the number task used by Jacoby et al. (1989).

In the test phase of the experiment, subjects were asked to complete word stems under two sets of instructions. For the inclusion condition (in which case the word stem would appear in the colour green) subjects were asked to complete the stem with a word
presented earlier in the experiment, either read or heard. In the exclusion condition (in which case the word stem would appear in the colour red) subjects were told to complete the stem with words that were not presented in the first part of the experiment. The process dissociation procedure equations were then used to estimate conscious and unconscious influences of memory based on the subjects' performance on the inclusion and exclusion trials. The results indicated that dividing attention did not affect the unconscious component. This manipulation did, however, affect the conscious estimate, causing it to drop to zero in the divided attention condition.

Debner and Jacoby (1994, Experiment 2) also demonstrated a dissociation between conscious and unconscious influences of memory on a stem completion task using a divided attention manipulation. For that experiment, a series of three words were presented very briefly on the screen, one at a time, and were then followed by a word stem. The second word in the series (the sandwiched word) was flanked by two digits, as was the word stem. In the inclusion instruction condition, subjects were asked to complete the word stem with the sandwiched word, or failing that to complete the stem with the first word that came to mind. In the exclusion condition, subjects were asked to complete the word stem with a word other than the sandwiched word.

For the divided attention condition, subjects had to report the sum of the two numbers flanking the sandwiched word before completing the word stem. It was argued that this was a divided attention task because subjects could not fully attend to the sandwiched word since attention had to also be directed to the flanking numbers. For the full attention condition, subjects had to report the sum of the numbers flanking the word stem before completing the stem. In this condition, because subjects did not have to sum the numbers flanking the sandwiched word, full attention could be directed toward that word.
The results of this experiment indicated that in the exclusion condition, when attention was divided, subjects completed the stem with the sandwiched word more often than they did in the baseline condition. For the full attention condition, however, the opposite pattern was found in that subjects were less likely to complete the stem with the sandwiched word when compared to baseline performance. Moreover, as in the other experiments discussed above, the estimates revealed that dividing attention reduced the conscious estimate but did not influence the unconscious estimate.

The results of the experiments discussed above suggest that dividing attention influences the conscious estimate but leaves the unconscious estimate invariant. The first manipulation used in the present set of experiments was a divided attention manipulation. Specifically, attention was divided either at study or test to determine its effect on conscious and unconscious influences of memory for an object's spatial location. Based on the research discussed above, it was expected that dividing attention would affect conscious influences of memory for spatial location but not unconscious influences.

Age

The second variable investigated in this study was age. A common complaint among elderly adults is that they do not remember as well as they did when they were younger. This complaint has led to a great deal of research investigating age-related differences in memory performance. Many of these studies have compared young and elderly adults on direct and indirect tests of memory. The findings of such studies typically demonstrate that older adults perform at a comparable level to their younger counterparts on indirect tests but perform at a lower level than younger subjects on direct tests. The following section will review research investigating the performance of elderly subjects on direct and indirect tests of memory.

Most studies investigating memory in the elderly have used tests that assess episodic memory abilities. Episodic memory is memory for personally experienced events
as they occur in a particular temporal/spatial context (Tulving, 1985). Examples of episodic memory tests include direct tests such as recognition and recall. As discussed earlier, such tests require a subject to consciously recollect a previous episode. Studies that have investigated episodic memory abilities in older adults have typically demonstrated that these individuals do not perform as well as their younger counterparts. For example, it has been consistently found that older subjects perform at a lower level than younger subjects on tests involving the free recall of information; older subjects demonstrate impaired performance in free recall for words (Erber, 1974; Perlmutter, 1978; White & Cunningham, 1982) and prose (Gordon and Clark, 1974), as well as in cued recall for paired associates (Rabinowitz, 1984).

The findings for recognition have not been as consistent. For example, early studies investigating recognition in the elderly did not demonstrate a decline (Schonfield & Robertson, 1966), whereas more recent evidence has shown that recognition is impaired in older subjects (Erber, 1974; Gordon & Clark, 1974; Rabinowitz, 1984). In these latter studies, however, performance in recognition is often superior to that of recall (Craik & McDowd, 1987; Perlmutter, 1978; White & Cunningham, 1982).

The impaired performance of older adults on tasks assessing episodic memory have not only been observed in the laboratory but is also prevalent in situations representing real life experiences. For example, older individuals demonstrate difficulty in remembering information on medicine labels (Morrell, Park, & Poon, 1989), recalling the information in written passages (Gordon & Clark, 1974), and remembering activities they have performed (Kausler & Lichty, 1988). Older adults are also impaired in their ability to recognize and name tunes (Maylor, 1991), to identify faces (Maylor, 1990), to recognize proper names (Cohen & Faulkner, 1986), and to identify the source of information (Dywan & Jacoby, 1990; Janowsky, Shimamura, & Squire, 1989; McIntyre & Craik, 1987).
The results of the studies discussed above suggest that older subjects are impaired on direct tests assessing episodic memory abilities. In contrast to direct test performance, however, older subjects have been found to perform similarly to younger subjects on indirect tests of memory. Performance on many of these indirect tests has been associated with semantic memory abilities. Unlike episodic memory, semantic memory is memory for factual knowledge, and does not rely on knowledge of the temporal/spatial context in which the information was acquired (Tulving, 1985). A paradigm that has been widely used to assess semantic memory abilities is semantic priming. In this paradigm, a stimulus (the prime) is presented prior to a target stimulus, and is either related to the target, unrelated to the target, or neutral. The target is then presented for response (for example, the task may be a lexical decision task in which case the subject must decide whether a string of letters is a word or it may be fragment completion in which case the subject must complete a word fragment that is missing a number of letters). The typical result is enhanced performance (improved accuracy and decreased latency) when the prime is related to the target. Research using the semantic priming paradigm has demonstrated comparable performance in young and old subjects. For example, older subjects have been found to perform at normal levels in semantic priming when the task is lexical decision (Bowles & Poon, 1985; Burke, White, & Diaz, 1987) and fragment completion (Light, Singh, & Capps, 1986). Additional evidence suggesting that semantic memory abilities are intact in older subjects was obtained by Cerella & Fozard (1984) who found that older and younger subjects demonstrated similar levels of priming on a naming task. Moreover, these results were found under both normal and degraded viewing conditions.

Older adults have also been found to perform similarly to younger adults on tasks involving word stem completion and masked word identification (Light & Singh, 1987). Moreover, Light and Albertson (1989) showed that older subjects demonstrated intact performance on an indirect test of memory for categories, whereas performance on a direct
test for the same information was impaired. In that experiment, subjects were presented with members from a number of categories. These members were embedded in a list of words to prevent awareness of category membership. For the indirect test of memory, subjects were presented with the category names and asked to provide members of that category. For the direct test, subjects were also given the category names but were instead asked to report the members that were provided in the study list. The older subjects provided fewer category exemplars than younger subjects on the direct test, but performed at a comparable level to their younger counterparts on the indirect test.

Schacter, et al. (1992) examined indirect test performance in young and older subjects using nonverbal stimuli. In the encoding phase of that experiment, subjects were presented with possible and impossible objects and the task was to decide whether the objects faced primarily to the left or right. Subjects were then given an indirect and a direct test of memory. For the indirect test, old and new objects were presented briefly and subjects were to decide whether they were possible or impossible (the object decision task). For the direct test of memory a recognition task was administered. In the object decision task, old and young subjects demonstrated enhanced performance due to prior exposure for possible objects. Furthermore, the degree of enhancement in this task was similar across the two age groups. Impossible objects, however, did not demonstrate an effect of prior exposure in either age group. Unlike performance on the indirect test, older subjects demonstrated poorer recognition performance than did the younger subjects.

Howard, et al. (1991) demonstrated similar performance across young and old subjects on an indirect test measuring memory for new associations. The performance was similar in the two groups only when encoding conditions were optimal (i.e., when subjects were asked to generate a sentence that related the critical pair of words). When encoding conditions were less than optimal (i.e., subjects had a limited amount of time in which to expand on sentences that contained the critical pair of words), older subjects demonstrated
poorer memory for the new associations than did younger subjects. Consistent with other findings, these researchers found that the older subjects demonstrated poorer performance than their younger counterparts on a cued recall test.

One explanation for why older subjects' perform poorly on direct tests of memory but not on indirect tests is that older subjects fail to encode detailed information about the to be remembered events (Light & La Voie, 1993; Rabinowitz & Ackerman, 1982). This line of reasoning stems from the distinction between two kinds of memory processes. The first process, activation or fluency, is thought to support performance on priming measures, whereas the second process, which is more elaborative in nature, serves to integrate an event with its context and supports performance on tests of recognition and recall (Graf & Mandler, 1984; Jacoby & Dallas, 1981). By this position then, the process of activation is spared in older subjects, whereas elaborative processes are impaired. Evidence has been obtained to support this position. For example, Kausler and Puckett (1981a, 1981b) demonstrated an age-related decrement in the ability to recall whether information was presented in a male or a female voice. The same researchers also demonstrated that older subjects have difficulty remembering whether written information was presented in upper or lowercase letters (Kausler & Puckett, 1980, 1981a). Additional research has shown that older adults have difficulty determining the colour in which pictures and words were presented (Park & Puglisi, 1985), in recalling whether a word was simply read or was generated from a cue (Rabinowitz, 1989), or whether words were presented auditorially or visually (Lehman & Mellinger, 1984, 1986).

Further evidence that older subjects do not encode contextual information as well as their younger counterparts was obtained by Micco and Masson (1992). In that experiment, young and older subjects were presented with target words as well as one clue word that was either a strong or a weak associate of the target word. Subjects were asked to provide six additional clue words that were related to the target word so that another individual
would be able to guess the target from those clue words. A second group of elderly and young subjects were then presented with the clue words, one at a time beginning with the associates, and were asked to guess the identity of the target word. The clue generation task was considered to be analogous to the process of encoding whereas target generation was analogous to the process of retrieval. The results indicated that, in the strong associate condition, the age of the subjects generating the clues did not influence target identification. In the weak associate condition, however, the clues generated by older subjects made target identification more difficult than the clues generated by the younger subjects. These findings suggest that older adults were not as successful at encoding contextually appropriate information that aids retrieval processes. This finding, however, was true only when the stimulus did not provide this kind of information (i.e., the weak association condition). When the stimulus does provide more support (i.e., the strong associate condition) the encoding of this information is similar across older and younger subjects.

In contrast to the number of studies that have shown older subjects to perform at a level similar to their younger counterparts on indirect tests of memory, a small number of studies have found older subjects to perform worse than their younger counterparts on a number of indirect tests of memory. For example, Chiarello and Hoyer (1988) demonstrated that older subjects did not perform as well as younger subjects on a stem completion task or a cued recall task. Furthermore, the difference between young and old subjects on these tests was reliable on an immediate test of memory, after a 13 minute delay, and after a 46 minute delay. Likewise, Davis, Cohen, Gandy, Colombo, Van Dusseldorp, Simolke, and Romano (1990), Hultsch, Masson, and Small (1991), and Small, Hultsch, and Masson (1995) also found that older subjects did not perform as well as their younger counterparts on a stem completion task.

It is also important to note that when elderly and young subjects do not show a reliable difference in performance on indirect tests, there is often a trend that favors young
adults. For instance, Light and Singh (1987) stated that although they did not obtain a reliable difference between old and young subjects in two experiments investigating stem completion performance, the differences between the two groups was marginally significant when the data from the two experiments were combined. A number of other studies have also found nonreliable differences that favor the young on indirect tests of memory (Light & Albertson, 1989). Such trends suggest that there may be a true difference between young and old subjects on indirect tests, but the difference is so small that many experiments do not have enough power for its detection (Chiarello and Hoyer, 1988; Hultsch, et al., 1991).

Another explanation for the trend favoring the young is that it may reflect contamination of indirect tests by conscious recollection. Specifically, subjects can use conscious recollection on indirect tests of memory to improve their performance even though such tests do not require them to do so. Because younger subjects demonstrate recollection that is superior to that of older adults, their indirect test performance will benefit when conscious recollection is involved.

It is important to determine, therefore, whether the difference sometimes obtained between young and elderly subjects on indirect tests is real or whether it is due to contamination of those tests by conscious recollection. As mentioned earlier in this paper, use of the process dissociation procedure avoids the problem of contamination. An experiment conducted by Jennings and Jacoby (1993), which was discussed previously, used the process dissociation procedure to investigate conscious and unconscious influences of memory in young and elderly adults. The task used in that experiment involved fame judgment. The results demonstrated comparable unconscious influences of memory across young and older adults. The conscious estimate, however, was reliably lower for older subjects. These findings suggested that the age differences in unconscious
influences of memory obtained in a number of experiments may have resulted from contamination by conscious influences.

The second experiment of the present study investigated conscious and unconscious influences of memory for location across young and elderly adults, and it did so using the process dissociation procedure to avoid the effects of contamination. The results of this experiment have important implications for research investigating memory in elderly subjects. For example, it has been demonstrated that older subjects show impaired performance on tests assessing memory for contextual information. Those studies, however, have typically used direct tests that assess conscious influences of memory. Older subjects, however, have been found to perform at a lower level on direct measures than younger subjects. Very few studies have examined unconscious influences of memory for contextual information in elderly adults using indirect tests of memory.

One exception is a study conducted by Light, La Voie, Valencia-Laver, Owens, Albertson, and Mead (1992) that investigated memory for modality using an indirect test. The results of that study suggested that unconscious influences of memory for contextual information remain stable across young and old subjects. In the first experiment of that study, subjects either read or heard words. They then received a masked word identification task in which old words (those read and heard) and new words were presented. Identification performance was superior for both kinds of old words (i.e., those read and heard) when compared to the new items. Furthermore, the words that were read were identified better than those that were heard, and this was true for both older and younger subjects. A recognition task was also given in which subjects were presented with the words and were asked to respond whether each word was seen or heard in the study phase, or whether it was new. In this recognition task, the younger group performed reliably better than the older group. The complementary result was also obtained when the test was auditory in nature. Specifically, items that were previously heard were identified
better than those that were previously seen, yet both read and heard words demonstrated a higher rate of identification than new items, and this was true for both young and older subjects. The results of the Light et al. (1992) experiments suggest that contextual information is available to older adults when this knowledge is tested using an indirect measure. Older subjects, therefore, may also demonstrate an unconscious influence of memory for spatial location in the second experiment of the present study.

If older adults do show a reliable unconscious influence of memory for an object's spatial location, such a result would have important implications for the view that spatial information is encoded automatically. Hasher and Zacks (1979) argued that because spatial information is encoded automatically it should not be affected by developmental trends. A consistent finding, however, is that older subjects perform more poorly than younger subjects on tests that assess memory for spatial location. Such findings, however, have typically been obtained using direct tests which assess conscious influences of memory. The interesting question, therefore, is whether older individuals will show impaired performance on a test assessing unconscious influences of memory for spatial location. It is possible that older subjects are not able consciously to access spatial information that is automatically encoded, yet have this information available to unconsciously influence behaviour. If this is the case, older subjects may demonstrate a reliable unconscious influence of memory for spatial location that is comparable to that found among younger adults.

The purpose of the second experiment was to use the process dissociation procedure to compare conscious and unconscious influences of memory for object location across young and older adults. Based on the research demonstrating that older adults perform at a level comparable to younger adults on indirect tests of memory, yet perform at a lower level than their younger counterparts on direct tests, it was predicted that the conscious influence of memory for spatial location would be lower for older adults than for
younger adults, but the unconscious influence would remain invariant across the two age
groups.

**Habit Strength**

The third and final experiment in this study examined the effect of habit strength on
estimates of conscious and unconscious influences of memory. In this experiment,
subjects were asked to place objects in particular locations numerous times in a training
phase, and the occurrence of memory slips for those locations was then assessed. The
purpose was to determine whether varying habit strength (the number of times an object
was placed in a particular location) would affect conscious and unconscious influences of
memory on a recall task.

The paradigm used in this experiment was similar to that used by Hay & Jacoby
(1996). In that study, subjects were presented with word-word fragment pairs (e.g. knee-
b_n_). The fragment could be completed with two words, both of which were related to
the first word (e.g., bone and bend), and the subject's task was to guess the word that fit
the fragment. After the subject made their response, the correct completion was provided.
The subject was presented with the same word-word fragment pair a number of times in a
training phase. Two different proportion conditions were used. For one condition (the
75% condition), one completion for the fragment was correct on 75% of the trials (the
typical completion) and the other completion was correct for 25% of the trials. For the
second proportion condition (the 50% condition), each of the two completions were correct
50% of the time. Once the training was complete, subjects were given a series of study-test
lists. For the study lists, word-word pairs were presented. Each of these pairs consisted
of an initially studied word and one of its related words that was a completion for the
fragment in the training phase. The subject was told to remember the pair for a memory
test. In the test, the words were again paired with the fragments, as in the training phase,
and subjects were asked to complete the fragments with the words from the study list.
Estimates of conscious and unconscious influences of memory were then obtained based on the subjects' performance on the memory test. Trials in which the typical completion was given in the study list served as the facilitation condition. Specifically, the subject would respond with the typical completion in this condition if they consciously recollected the word from the study list or if they responded based on habit created during the training phase, $R + H(1-R)$. Trials in which the atypical completion was given in the study list served as the opposition condition. That is, the subject would respond with the typical response in this condition if the typical response came forward automatically due to the habit created during training, but conscious recollection was not available to oppose that unconscious influence, $H(1-R)$. These equations were then used to compute estimates of conscious recollection and habit in the same way that conscious and unconscious influences of memory were computed with the process dissociation procedure equations discussed above. The advantage of using this procedure is that it does not use the inclusion and exclusion instructions, which some researchers have argued are difficult to follow (Curran & Hintzman, 1995).

Hay and Jacoby found that the estimate of habit was reliably greater in the 75% condition than in the 50% condition. Conscious recollection, however, did not reliably differ across the two proportion conditions. Moreover, these researchers found that the obtained values of habit closely approximated the actual proportions used in the training phase.

The results of Hay and Jacoby (1996) are consistent with a result obtained by Caldwell and Masson (1998). In that experiment, subjects were asked to place the objects in particular locations in a study phase and were then asked to search for the objects under inclusion and exclusion instructions in the test phase. In the study phase, the number of times each subject was exposed to the objects and their locations was manipulated. Half of the subjects placed the objects in the cued locations once, whereas the remaining subjects
placed the objects twice. Caldwell and Masson found that for those subjects who placed the objects twice, the unconscious estimate was enhanced compared to those who placed the objects only once. This manipulation, however, did not affect the conscious estimate. This result suggests that two exposures to the objects and their locations was enough to increase the habit for placing the objects in those locations over that achieved with one exposure, thereby enhancing the unconscious estimate.

The results of Caldwell and Masson (1998) suggest that if a paradigm similar to that used by Hay and Jacoby (1996) were used to investigate memory for the location of objects, the unconscious influence of memory for object locations would be affected by a proportion manipulation but the conscious influence of memory would not. The third experiment in this study, therefore, manipulated the number of times objects were placed in particular locations to determine the effect of repetition on conscious and unconscious influences of memory.

Overview of Experiments

The current study used the process dissociation procedure to examine the effect of three variables on conscious and unconscious influences of memory for object location. The first two experiments used a paradigm similar to that of Caldwell and Masson (1998). Experiment 1 investigated the effect of dividing attention on conscious and unconscious influences of memory for location. It was predicted that dividing attention would decrease the conscious influence of memory but leave the unconscious component invariant. Such a finding would be consistent with previous research (for example, see Jacoby, et al., 1993) and would provide support for the assumption of independence between conscious and unconscious influences of memory.

The second experiment compared conscious and unconscious influences of memory for an object's location across young and older subjects. Based on previous research demonstrating age related declines in performance on direct tests but little or no decline on
indirect tests of memory, it was expected that age would influence the conscious component but would not affect the unconscious component.

The final experiment used a paradigm similar to that of Hay and Jacoby (1996). The purpose was to develop habits for placing objects in particular locations and then to examine whether memory slips occurred for those locations. Specifically, strength of habit was manipulated to determine its effect on conscious and unconscious influences of memory on a recall task. It was predicted that the number of times an object was placed in a particular location would affect the unconscious estimate but not the conscious estimate. Such a finding would be consistent with the findings of Hay and Jacoby (1996), and would provide further support for the assumption that conscious and unconscious influences of memory independently contribute to performance.

Experiment 1

The first experiment was conducted for the purpose of investigating the effect of dividing attention on conscious and unconscious influences of memory for spatial location. In this experiment, subjects were presented with a number of drawings of household objects and were asked to place them in specified locations in background rooms. In the test phase, subjects were asked to find the objects under two sets of instructions. In the inclusion instruction condition, subjects were told that the objects occupy the same location in which they placed them in the study phase, so they should search for them in those locations. In the exclusion instruction condition, subjects were told that the objects occupy different locations from where they placed them in the first part of the experiment so if they remember the old location they should search in a different location. For half of the subjects attention was manipulated at study, and for the remaining subjects it was manipulated at test. Estimates of conscious and unconscious influences of memory for the target locations were then computed using the process dissociation procedure equations. Based on the findings by others (Debner and Jacoby, 1994; Jacoby, et al., 1993) it was
expected that dividing attention would decrease the conscious component but leave the automatic component invariant.

**Method**

**Subjects.** Seventy-eight subjects participated in the first experiment. Six of these subjects were excluded from the analyses due to floor performance in the exclusion condition. The ages of the remaining 72 subjects ranged from 18 to 26 years with a median age of 18 years. The subjects were obtained from the subject pool at the Psychology Department at the University of Victoria. Thirty-six of the subjects were randomly assigned to the divided attention at study condition and the remaining subjects were assigned to the divided attention at test condition.

**Design.** This experiment consists of a 2X2X2 mixed factorial design with inclusion/exclusion instruction condition and divided versus full attention within subject factors and divided attention at study or at test a between subject factor.

**Apparatus.** The stimuli and instructions were generated by a Macintosh II computer with an 11" Apple monochrome monitor.

**Materials.** The stimuli were the same as those used by Caldwell and Masson (1998) and consisted of 84 drawings of household objects (see Appendix A for examples). Twelve of these objects were used for practice trials and the remaining 72 were used for the critical trials. The critical objects were divided into six blocks of 12 for counterbalancing purposes. Each block of 12 was assigned to one of six conditions; full inclusion (FI), full exclusion (FE), divided inclusion (DI), divided exclusion (DE), new inclusion (NI), and new exclusion (NE). The assignment of the blocks to the six conditions was counterbalanced across subjects, with every block being assigned to each condition equally often. For the divided attention at test condition, half of the items in the NI block and half in the NE block were randomly assigned to be presented under conditions of full attention.
and the remaining items in those two blocks were presented under conditions of divided attention.

The background consisted of six line drawings of rooms in a house (bedroom, bathroom, kitchen, den, living room, and garage; see Appendix B for an example). A drawing of a floor plan was also used, which contained the six rooms corresponding to those used as backgrounds (see Appendix C). Each room in the floor plan was labeled with its name (e.g., kitchen).

A pilot study was conducted to determine a target location for each object. In the pilot study, 10 subjects were presented with the line drawings of the objects, and asked to choose the three most typical locations for each object within the target room. The target location for each object was chosen based on the following two criteria. First, the target location received agreement across the 10 subjects, that is, each of the 10 subjects picked the location as one of their three choices. Second, the target location was chosen in such a way that as many locations as possible within each room contained objects.

Two practice objects and twelve critical objects were assigned to each of the six rooms. The number of locations used within the rooms ranged from 8 to 14, with a maximum of two objects occupying each location.

Procedure. The subjects were tested individually in the presence of the experimenter. The experiment consisted of two phases, study and test. In the study phase, the items assigned to the FI, FE, DI, and DE were presented.

For those subjects in the divided attention at study condition, the presentation of items in the study phase were blocked such that the items in the two full attention blocks were presented in random order, followed by the presentation of the two divided attention blocks, also presented in random order. The blocks of items presented first, i.e., full or divided, was counterbalanced across subjects. The items in the FI and FE conditions were presented under conditions of full attention and the items in the DI and DE condition were
presented under conditions of divided attention. Each of the two blocks of critical items was preceded by four practice items.

The secondary task the subject performed during divided attention was an auditory one in which a tape recording of a series of single-digit numbers was presented. The subject's task was to tap on the table when they heard three odd numbers in a row (e.g., 3, 9, 7).

For the subjects in the divided attention at test condition, the items in the FI, FE, DI, and DE were mixed and presented in random order in the study phase. These critical items were preceded by 8 practice items. All of the items at study were presented under full attention.

For each trial in the study phase, the drawing of the household object was presented at the bottom of the subject's monitor, followed by the drawing of the floor plan. The name of the room that contained the target location for that object was then highlighted. The subject was first asked to name the household object aloud and then to click on the highlighted room. Upon this click, the floor plan was erased and the drawing of the room was displayed on the screen. The subject then clicked on the object, which was still presented at the bottom of the screen. With this click, a cue (X) flashed twice in the target location and then remained on the screen. The subject was then required to click on the cued location. The object was then erased from the bottom of the screen and re-drawn in the target location. The room and object were then erased and the next trial began. Subjects were asked to remember the locations for a memory test.

In the test phase, all of the critical items were presented. For those subjects in the divided attention at study condition, the 12 practice items were presented followed by the 72 critical items, which were mixed and presented in random order. For this group, all items at test were presented under conditions of full attention.
For those subjects in the divided attention at test condition, the items assigned to the divided attention condition, i.e., the items in the blocks assigned to DI and DE conditions, were presented in one block as well as half of the items from the NI condition and half from the NE condition. These items were presented in random order under conditions of divided attention. In the other block, the full attention items were presented, i.e., the items in the FI and FE conditions, as well as the remaining items in the NI and NE conditions. These items were presented in random order under conditions of full attention. Each block of critical items was preceded by 6 practice items. The block of items presented first (i.e., full or divided attention) was counterbalanced across subjects. The same auditory number task used for the divided attention at study condition was used for the divided attention task at test.

In the test phase, subjects were required to search for the objects under inclusion and exclusion instructions. For those items assigned to the inclusion instruction condition (i.e., DI, FI, and NI) subjects were told that each object occupied the same location in which they placed it in the study phase, so if they remember the old location they should search in that location. If they could not remember the old location, they were told to search for the object in the first location that came to mind. For those items assigned to the exclusion condition (i.e., DE, FE, and NE), subjects were told that the object was in a different location from where they placed it in the study phase, so if they remember where they placed it, they should search for the object in another location. Again, they were told that if they could not remember the location in which they placed it in the study phase, they should search for it in the first location that came to mind. The location they chose, however, had to be a likely location for that object.

The trials in the test phase were very similar to those in the study phase. Specifically, the object was presented at the bottom of the screen, the floor plan was then presented, and the name of the target room was highlighted. The subject clicked on the
highlighted room, which erased the floor plan and displayed the drawing of the room. The word "SAME" or "DIFFERENT" was presented beside the drawing of the object. This indicated whether the trial was an inclusion or an exclusion one, respectively. The subject moved the cursor around the drawing of the room, which caused the locations within the room to become highlighted. The subject made their choice by clicking on a location when it was highlighted. Only three of the locations accepted the click of the mouse, one of which was the old location. The two additional locations were chosen based on performance on new items in the Caldwell and Masson (1998) experiment. Specifically, these two additional locations were the two most common locations (next to the target location) selected in the inclusion new and exclusion new conditions across all of the subjects in that experiment.

Results

Divided Attention at Study. Separate analyses were conducted for the divided attention at study and divided attention at test conditions. Table 1 shows the inclusion and exclusion scores under full and divided attention for those subjects in the divided attention at study condition.

The type I error rate used in this and the remaining experiments in this study was .05. A one way Analysis of Variance (ANOVA) was conducted to determine whether the values in the inclusion new and exclusion new conditions differed. The purpose of this analysis was to determine whether the subjects' criterion for responding differed in the two instruction conditions. This test was not reliable, $F < 1$.

The probability of choosing the old location in the inclusion condition was then compared across conditions of full and divided attention. This comparison was reliable, $F(1, 35) = 33.76$, $MSE = .03$, demonstrating that subjects were more likely to choose the old location when instructed to do so under conditions of full attention than under conditions of divided attention. This result is consistent with Jacoby et al. (1993) who
found that dividing attention decreased the probability of using an old word as a completion for a word stem in the inclusion instruction condition. For the exclusion trials, a comparison across full and divided attention was not reliable, $F < 1.14$. This result was not consistent Jacoby et al. (1993) who found that dividing attention increased the probability of using an old word to complete a word stem in the exclusion condition. This lack of an effect of attention on exclusion performance suggests that subjects may not have been engaging in recall when performing the exclusion task. A more likely explanation is that potential locations came to mind automatically and subjects did a recognition check to decide if a location was an old one, and then excluded a location if they had a sense the location was old.

Table 1

Mean Proportions (and Standard Deviations) of Target Locations Chosen and Estimates of Conscious and Unconscious Influences in Experiment 1 when Attention was Divided at Study

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Full Attention</th>
<th>Divided Attention</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inclusion</td>
<td>.57 (.17)</td>
<td>.35 (.16)</td>
<td>.26 (.11)</td>
</tr>
<tr>
<td>Exclusion</td>
<td>.24 (.13)</td>
<td>.27 (.13)</td>
<td>.26 (.11)</td>
</tr>
<tr>
<td>Estimate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conscious</td>
<td>.34 (.23)</td>
<td>.08 (.21)</td>
<td></td>
</tr>
<tr>
<td>Unconscious</td>
<td>.35 (.15)</td>
<td>.29 (.12)</td>
<td></td>
</tr>
</tbody>
</table>

The process dissociation procedure equations were then used to obtain estimates of conscious and unconscious influences of memory for spatial location based on the subjects'
performance on the inclusion and exclusion trials. These estimates for the full and divided attention conditions are presented in Table 1. Separate ANOVAs were conducted to determine whether the conscious and unconscious influences of memory varied across conditions of full versus divided attention. For the conscious component the ANOVA was reliable, $F(1, 35) = 28.49, \text{MSE} = .04$, demonstrating that dividing attention reliably decreased the conscious estimate. For the unconscious estimate, the difference between full and divided attention was not reliable, although there was a trend for the estimate to be greater under full attention, $F(1, 35) = 3.25, \text{MSE} = .02, p < .08$.

The next set of analyses was conducted to determine whether there was a reliable unconscious influence of memory for spatial location. For these analyses the unconscious estimate was compared to baseline performance. The rationale for doing these comparisons stems from an assumption that is made when using the process dissociation procedure formulas which is that the unconscious value obtained encompasses both unconscious influences of memory as well as guessing performance. One must therefore determine whether the unconscious value is reliably greater than baseline. In this experiment, baseline performance was the average of the inclusion new and exclusion new trials. The comparison of the unconscious value to baseline was done separately for the full and divided attention conditions. In the full attention condition, the unconscious estimate was reliably greater than baseline, $F(1, 35) = 10.05, \text{MSE} = .01$. This analysis, however, was not reliable in the divided attention condition, $F < 1.1$.

In this experiment, the conscious value obtained in the divided attention condition was not numerically large. It was important, therefore, to determine whether this value was significant, that is, was a reliable conscious influence of memory obtained in that condition. To this end, a $t$-test was conducted that compared the conscious value in the divided attention condition to zero. This test was reliable, $t(35) = 2.32, SE = .03$, 

demonstrating a reliable conscious influence of memory under conditions of divided attention.

**Divided Attention at Test.** Table 2 shows the average inclusion and exclusion performance for the full and divided attention conditions when attention was divided at test. In the divided attention at test condition there were four values obtained for the new objects, inclusion versus exclusion crossed with full versus divided attention. The first analysis compared the new values for the full and divided attention conditions in the inclusion instruction condition. This analysis was not reliable, $F < 1$. The same analysis in the exclusion instruction condition was not reliable, $F < 1$. The new values were therefore collapsed across full and divided attention and compared across the inclusion and exclusion conditions. This analysis was also not reliable, $F < 2.7$.

Comparisons were then conducted to examine the probability of choosing the old location in the inclusion and exclusion instruction conditions across conditions of full and divided attention. This comparison was not reliable for the inclusion condition, $F < 1$. This lack of effect of dividing attention on inclusion performance suggests that subjects may not have been engaging in recall in the inclusion condition; if subjects were attempting to recall the locations in the inclusion condition performance should have been greater under full attention than under divided attention. Instead, subjects may have been relying on the automatic coming to mind of potential locations. In the exclusion condition, the probability of choosing the old location was greater under divided attention than under full attention, $F(1, 35) = 4.57$, MSE = .02.

Estimates of conscious and unconscious influences of memory for location obtained in the divided attention at test condition are presented in Table 2. An ANOVA was conducted to compare the conscious value across conditions of full and divided attention. Although this analysis was not reliable, it approached significance, $F(1, 35) = 3.78$, MSE = .03, $p < .07$, demonstrating that there was a trend for the conscious estimate to be
reliably greater in the full attention condition. For the unconscious estimate, the comparison across full and divided attention was not reliable, F < 2.7.

Table 2

Mean Proportions (and Standard Deviations) of Target Locations Chosen for Old and New Objects and Estimates of Conscious and Unconscious Influences in Experiment 1 when Attention was Divided at Test

<table>
<thead>
<tr>
<th>Performance Measure Attention</th>
<th>Full Attention</th>
<th>Divided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inclusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>.58 (.18)</td>
<td>.58 (.15)</td>
</tr>
<tr>
<td>New</td>
<td>.23 (.13)</td>
<td>.23 (.19)</td>
</tr>
<tr>
<td>Exclusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>.22 (.12)</td>
<td>.30 (.13)</td>
</tr>
<tr>
<td>New</td>
<td>.27 (.23)</td>
<td>.28 (.18)</td>
</tr>
<tr>
<td>Estimate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conscious</td>
<td>.36 (.21)</td>
<td>.28 (.21)</td>
</tr>
<tr>
<td>Unconscious</td>
<td>.35 (.16)</td>
<td>.41 (.13)</td>
</tr>
</tbody>
</table>

To determine whether there was a reliable unconscious influence of memory in the full and divided attention conditions, separate ANOVAs were conducted which compared the unconscious value in each of the attention conditions to baseline. The baseline value used in these comparisons was the average of the four new values. For both the full and divided attention conditions the unconscious value was reliably greater than baseline, F(1,
$F(1, 35) = 10.06, \text{ MSE} = .02$ and $F(1, 35) = 38.43, \text{ MSE} = .01$, for the full and divided attention conditions, respectively.

Performance on the auditory number task was then examined for both the divided attention at study and at test conditions. For each subject, the proportion of 3 odd digit strings correctly detected was determined. For subjects in the divided attention at study condition, the average proportion of strings detected was .64. For those in the divided attention at test condition, the mean was .60. An ANOVA conducted on these data was not significant, $F < 2.34$. 

**Discussion**

The purpose of Experiment 1 was to obtain evidence for the assumption of independence between conscious and unconscious influences of memory using a divided attention manipulation. The importance in demonstrating such independence arises because use of the process dissociation procedure equations relies on the assumption that conscious and unconscious influences of memory independently contribute to performance. Jacoby and his colleagues (Jacoby, et al., 1993; Toth, et al., 1994) have suggested that to provide support for such independence one could demonstrate that a manipulation affects one component of memory but leaves the other invariant. The divided attention manipulation was used in this experiment because previous research has demonstrated that such a manipulation decreases the conscious component but leaves the unconscious component invariant.

In the present experiment, when attention was divided at study, the conscious component did demonstrate the predicted decrease across the two attention conditions, demonstrating a reliably greater value in the full than in the divided attention condition. The unconscious component, however, also showed a trend in that direction. This pair of results does not provide support for the independence assumption because it suggests that both conscious and unconscious influences of memory for spatial location were influenced
by dividing attention at study. It is important to note, however, that failure to obtain this
dissociation does not provide evidence against the assumption of independence.

Stronger support for the independence assumption was obtained when attention
was divided at test. For that condition, the effect of full versus divided attention
approached significance for the conscious component but was not reliable for the
unconscious estimate.

There is an alternative explanation for the pattern of results obtained in the divided
attention at test condition, which is that subjects may have had difficulty following the
inclusion and exclusion instructions under conditions of divided attention. An indication
that this explanation is unlikely can be observed in the pattern of results obtained in the
inclusion and exclusion instruction conditions. This pattern suggests that subjects were
able to follow the instructions. Specifically, subjects were more likely to choose the old
location when asked to do so (in the inclusion condition) than when asked not to do so (in
the exclusion condition). To determine whether this difference was reliable, an ANOVA
was conducted on these values and the result of this test was significant, $F(1, 35) = 64.83,$
$MSE = .02.$ Such a pattern would not be expected if subjects could not follow, or simply
ignored, the test instructions.

A second important set of findings obtained in Experiment 1 was the demonstration
of a reliable unconscious influence of memory for spatial location. Specifically, in the
divided attention at study condition, the unconscious value in the full attention condition
was reliably above performance on the new items. Likewise, in the divided attention at test
condition, the unconscious estimates in both the full and divided attention conditions were
reliably greater than baseline. These findings suggest that there is a reliable unconscious
influence of memory for location and thus replicate the results obtained by Caldwell and
Masson (1998). Moreover, the results of this experiment extend the findings of Caldwell
and Masson by demonstrating a reliable unconscious influence of memory for object location under conditions of divided attention when attention was divided at test.

In summary, the results of Experiment 1 replicate and extend the work of Caldwell and Masson (1998) by demonstrating a reliable unconscious influence of memory for object location. The results of this experiment, however, provide only weak support for the assumption that conscious and unconscious influences of memory independently contribute to performance.

**Experiment 2**

Experiment 2 attempted to obtain stronger support for the assumption of independence by investigating potential age-related differences in conscious and unconscious influences of memory for object location. To this end, young and older subjects were compared in a paradigm similar to that used in Experiment 1. It was predicted that, because older adults often demonstrate normal performance on indirect tests of memory and impaired performance on direct tests, the conscious estimate would decrease with increasing age, whereas the unconscious estimate would remain invariant.

**Method**

**Subjects.** Sixty subjects participated in this experiment. Thirty of these subjects were recruited from the same subject pool as those in the first experiment, and constituted the group of young adults. Their ages ranged from 18 to 25 years, with a median age of 19 years. The remaining 30 subjects constituted the older group. These subjects were community-dwelling adults recruited through a subject pool established by Dr. Roger A. Dixon at the Department of Psychology at the University of Victoria. The ages of this group ranged from 60 to 82 years with a median age of 70 years.

**Design.** This experiment consisted of a 2X2 mixed factorial design with inclusion/exclusion instruction condition a within subject factor and age a between subject factor.
Materials and Procedure. The materials and apparatus were the same as those used in the first experiment. In addition, the vocabulary subtest of the Nelson-Denny Reading Test was also used in this experiment for the purpose of screening for cognitive impairment in the older subjects. This test was given prior to the experimental session and took approximately 10 minutes to complete.

The procedure was similar to that used in Experiment 1, with the exception that attention was not manipulated. As Experiment 1, this experiment consisted of two phases, study and test. In the study phase, 48 critical items were presented in random order and subjects were asked to place the objects in cued locations. Each trial in the study phase proceeded in the same manner as the study trials in Experiment 1.

For the test phase, the 72 critical items were presented in random order and subjects were asked to search for the objects under inclusion and exclusion instructions. For the inclusion trials, subjects were told that the objects occupy the original locations from the study phase, so if they remember those locations they should search there. For the exclusion trials, subjects were told the objects occupy different locations, so if they remember the old location they should search elsewhere. As in Experiment 1, the items presented for the inclusion instruction condition were accompanied by the word "SAME" and those presented in the exclusion instruction condition were accompanied by the word "DIFFERENT." Each trial in the test phase proceeded in the same manner as those in Experiment 1.

Results

Performance on the vocabulary test was the first set of data to be analyzed. The older subjects obtained an average score of 87.47 on this measure, with a standard deviation of 2.38. The scores for this group ranged from 48 to 100 percent. The younger subjects did not score as well as the older group, and obtained a mean of 60.23, with a standard deviation of 20.61. The scores for the younger subjects ranged from 12 to 92
percent. An ANOVA on these data revealed a reliably higher average score for the older subjects, $F(1, 58) = 37.40$, $MSE = 297.43$.

The inclusion and exclusion values obtained for the young and older subjects are presented in Table 3, as are the conscious and unconscious estimates computed from these values. An ANOVA was conducted on the new items with age as a between subject factor and instruction condition (inclusion versus exclusion) a within subject factor. None of the effects were reliable, $F$'s $< 1$.

Separate ANOVAs demonstrated that the younger subjects chose the old location more often than older subjects in the inclusion condition, $F(1, 58) = 18.24$, $MSE = .02$, and less often than older subjects in the exclusion condition, $F(1, 58) = 18.20$, $MSE = .01$.

An ANOVA was then conducted which compared the conscious estimate across young and older adults. This analysis was reliable, $F(1, 58) = 26.12$, $MSE = .04$. The same analysis conducted on the unconscious estimate was not reliable, $F < 1$.

Table 3

Mean Proportions (and Standard Deviations) of Target Locations Chosen and Estimates of Conscious and Unconscious Influences in Experiment 2

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Young Studied</th>
<th>Young New</th>
<th>Old Studied</th>
<th>Old New</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inclusion</td>
<td>.63 (.15)</td>
<td>.27 (.13)</td>
<td>.48 (.13)</td>
<td>.26 (.10)</td>
</tr>
<tr>
<td>Exclusion</td>
<td>.18 (.07)</td>
<td>.26 (.10)</td>
<td>.29 (.12)</td>
<td>.28 (.11)</td>
</tr>
<tr>
<td>Estimate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conscious</td>
<td>.45 (.18)</td>
<td></td>
<td>.19 (.22)</td>
<td></td>
</tr>
<tr>
<td>Unconscious</td>
<td>.33 (.12)</td>
<td></td>
<td>.34 (.10)</td>
<td></td>
</tr>
</tbody>
</table>
To determine whether the unconscious estimate obtained in the two age groups was above baseline, an ANOVA was conducted with age as a between subject factor and unconscious versus baseline a within subject factor. The only reliable effect was the main effect of the unconscious value versus baseline, $F(1, 58) = 13.03, \text{MSE} = .01$. The effect of age and the interaction were not reliable, $Fs < 1$.

Analyses were then conducted separately for the young and older subjects to determine whether the unconscious value obtained was reliably greater than baseline. The results of these analyses were significant for both groups of subjects, $F(1, 29) = 5.69, \text{MSE} = .01$ and $F(1, 29) = 7.60, \text{MSE} = .01$ for the young and older subjects, respectively.

**Discussion**

The results of Experiment 2 extend the findings of Caldwell and Masson (1998) by demonstrating a reliable unconscious influence of memory for an object's spatial location in elderly as well as younger subjects. The results also provide support for the assumption that conscious and unconscious influences operate independently. Specifically, it was found that the conscious influence of memory for an object location was affected by age but the unconscious influence was not. This finding is consistent with previous research that has shown that older adults perform similarly to their younger counterparts on tests that assess unconscious influences of memory (i.e., indirect tests) but perform worse than younger subjects on tests that assess conscious influences of memory (i.e., direct tests).

The results of this experiment, however, are inconsistent with a number of other experiments that have demonstrated that older adults perform more poorly than younger adults on indirect tests of memory (Chiarello & Hoyer, 1988; Davis, et al., 1990; Hultsch, et al., 1991; Small, et al., 1995). These studies typically increase the power to detect a
difference by testing a large number of participants. The results of such studies suggest that there is a true difference between the two age groups on indirect tests but that most studies do not have the power to detect this difference. Consistent with this view is the typical finding of a numerical difference favoring the young on indirect tests in experiments that do not obtain a reliable difference between the age groups (Light & Albertson, 1989; Light & Singh, 1987). The results of the current experiment, however, suggest that when differences between young and older subjects are obtained on indirect tests of memory they may arise because of contamination of those tests by conscious influences of memory. When the process dissociation procedure was used in the present experiment to avoid the problem of contamination, an age difference in the unconscious estimate was not obtained. This result is consistent with the finding of Jennings and Jacoby (1993) who used the process dissociation procedure and found that conscious influences of memory for nonfamous names presented in a study phase decreased across age but unconscious influences remained invariant.

The second experiment was successful in demonstrating a dissociation between conscious and unconscious influences of memory for object location by showing that conscious influences of memory are affected by age but unconscious influences of memory are not. The third experiment attempted to demonstrate the opposite dissociation. Specifically, it attempted to show that a manipulation can affect the unconscious component while leaving the conscious component invariant. Such a finding would establish a double dissociation between conscious and unconscious influences of memory, providing even stronger evidence that the two processes operate independently.

Experiment 3

The third experiment in this study used a paradigm that was different from that used in the first two experiments. The paradigm was taken from Hay and Jacoby (1996) and involved creating habits for putting objects in particular locations in a training phase and
then observing whether memory slips occur for those locations in a test phase. Specifically, in Experiment 3 subjects underwent a training phase in which each target object was associated with two locations. These associations were created by having the subject place the object in each of the two locations a certain number of times. For one condition (the 75% condition), subjects placed the object in one of the two locations on 75% of the trials, creating a strong association between the object and that location (this will be referred to as the typical location), and in the other location on 25% of the trials, creating a weaker association (the atypical location). For the other condition (the 50% condition), subjects placed the object in the two locations an equal number of times, creating the same strength of association for the two locations. The location labeled typical and atypical in this condition was arbitrary. Subjects then received a series of short study-test lists. For the study lists, the objects were presented on the screen in particular locations, and subjects were asked to remember those locations for a memory test. On some of the study trials, the object appeared in its typical location (congruent trials), and on other trials it appeared in its atypical location (incongruent trials). Subjects were then tested for the locations in which the objects appeared in the short study lists. The process dissociation procedure was then used to determine the contribution of unconscious (habit) and conscious (recollection) influences in a location memory task.

Method

Subjects. Thirty subjects participated in Experiment 3. These subjects were recruited from the same subject pool as those in Experiment 1. Two subjects were not used in the analyses due to floor performance on incongruent trials; i.e., they never chose the typical location in that condition. The ages of the remaining 28 subjects ranged from 18 to 24 years with a median age of 19 years.
Design. This experiment consisted of a 2X2 factorial design with trial type (congruent versus incongruent) and proportion of training trials (75% versus 50%) within subject factors.

Materials. The stimuli used in this experiment consisted of the 6 background rooms and a subset of 18 objects from the original set of 72 objects used in Experiments 1 and 2. The 18 critical objects were chosen from the original set such that there were three objects per room. The objects were divided into two blocks of 9 objects, one block was assigned to the 75% condition and the other to the 50% condition. No more than two objects from the same condition occupied the same room. The assignment of the two blocks of objects to conditions was counterbalanced across subjects. Two additional items were included and were used as practice items for the training phase.

For each critical object, two locations were chosen, and for each subject, one of these target locations was randomly chosen to be the typical location and the other was the atypical location. The two locations chosen for each object were unique such that they were not shared with any other object in the experiment.

Procedure. This experiment consisted of two phases. The first phase was a training phase in which the 18 critical objects were presented numerous times. For each trial the subject was asked to place the object in one of two locations. For the items assigned to the 75% condition, the subject was asked to place the object in one location 75% of the time (the typical location) and in the other location 25% of the time (the atypical location). For those items in the 50% condition, subjects placed the object in the typical location 50% of the time and in the atypical location 50% of the time. For this condition, the typical-atypical distinction was arbitrary.

The trials in the training phase of Experiment 3 were very similar to the trials in the study phase of Experiments 1 and 2. The only exception was that the drawing of the floor plan was presented once, after the instruction screen, and was not presented again
throughout the training phase. For each trial of the training phase, the drawing of the object and the room appeared on the subject's monitor. The subject's first task was to name the object out loud. The subject then clicked on the object, and the cue (X) appeared in the target location. The subject then clicked on the cued location, which caused the object to be erased and re-drawn in the target location. Subjects were instructed that they would see each of the objects numerous times and that they were to continue placing them in the cued locations. They were further told that the purpose of the training phase was to provide them with practice in placing the objects in the locations.

For the training phase, the objects were presented in 5 blocks of 72 trials. For each block of 72 trials, each of the 18 objects was presented four times; for those objects assigned to the 75% condition, each object was placed in its typical location three times and in its atypical location once, and for those in the 50% condition, each object was placed in its typical location twice and in its atypical location twice. The objects were presented in random order for each block of 72 trials. Across the 5 blocks of 72 trials, each object was presented 20 times. For the 75% condition, each object was placed in its typical location 15 times across the 5 blocks of trials and in its atypical location 5 times. For those objects in the 50% condition, each was placed in its typical and atypical location 10 times across the 5 blocks trials. The presentation of the 5 blocks of training trials was preceded by two practice trials. The objects used for the practice trials were not used again in the experiment.

The training phase was followed by a series of 18 study-test lists where each study list was presented to the subject, followed by its corresponding test list. For the trials in the study list, an object appeared on the screen in either its typical location (congruent trial) or its atypical location (incongruent trial). On each trial, the drawing of the room was presented on the screen. The target location was then cued by the presentation of an "X". The "X" was then erased and the drawing of the object appeared in that location. The
object remained on the screen for approximately 1 second and was then erased. The next trial then began automatically. Subjects were instructed to remember where each object appeared for a memory test.

Each study list contained 8 items from training; four of these items were from the 75% condition and four were from the 50% condition. For the items in the 75% condition, three of these appeared in the typical location and one appeared in the atypical location. For those in the 50% condition, two appeared in the typical location and two in the atypical location. For the 18 study lists, each of the 18 critical items appeared 8 times; an object assigned to the 75% condition appeared in its typical location six times across the 18 lists and in its atypical location twice, whereas an object assigned to the 50% condition appeared in its typical and its atypical location four times across the 18 lists.

After each study list, there was a short distractor task. For the distractor task, a number between 30 and 100 appeared on the screen for one second and was then erased leaving a blank screen. The subject was asked to count backward by three from that number until the test trials began. The screen remained blank for approximately 8 seconds and then the test trials began. For each test, subjects were presented with 10 objects; 8 of these objects were from the study list and two were not presented in the study list (these items will be referred to as guessing items). One of the guessing items was from the 75% condition and one was from the 50% condition. Each object appeared as a guessing item twice across the 18 study-test lists. The purpose of including these items was to provide converging evidence for the unconscious estimates computed from the process dissociation procedure equations, that is, performance on the guessing items could only reflect habit and guessing and not conscious recollection.

For the test lists subjects were asked to choose the location in which the objects appeared in the study list. They were further instructed that if they could not remember the location in which the object appeared in the study list, they should choose the first location
that came to mind. Subjects were also warned that some objects presented in the test did not appear in the study list and for these objects they should also choose the first location that came to mind.

The trials for the test lists proceeded in the same manner as they did in the test phase of Experiments 1 and 2. Specifically, for each trial the drawing of the room appeared, followed by the presentation of the object at the bottom of the screen. To make their response, a subject moved the cursor around the room to highlight the active locations. Unlike Experiments 1 and 2, only two locations became highlighted and accepted a click of the mouse; the typical and atypical locations. The subject made their choice between these two locations.

The presentation of objects in the study-test list proceeded as follows. The objects for each trial were selected from a randomly ordered list of the 18 critical objects. The first 9 objects on the list were assigned to one proportion condition and the next 9 objects on the list were assigned to the other condition. Assignment of objects to conditions was counterbalanced across subjects. For the first study list, the first four objects in each condition were presented in random order. For the corresponding test, the 8 objects from the study list were presented as was the next object in each of the two conditions. These two objects served as the guessing items for that test list. The 10 objects in the test list were presented in random order. For the second study list, the next four objects in each of the two conditions were presented in random order (these were the last four items in each condition in the ordered list). For the corresponding test, the 8 objects from study were again presented, as were the two objects at the top of each condition in the ordered list. That is, the selection of objects from the ordered list looped back to the first item in each condition once all items in the ordered list had been presented once. For the third study list, the next four objects in each condition were presented. For the test, the 8 objects from study were presented, as was the next object in each of the two conditions. Presentation of
objects in the study-test lists proceeded in this manner for the first 9 study-test lists. For the remaining 9 study-test lists, the same study-test lists from the first set of 9 lists were presented, but these lists appeared in a different order from the first set.

Results

The probability of choosing the typical location on congruent (i.e., the typical location in training was the one presented in the study-test list) and incongruent (i.e., the atypical location in training was the one presented in the study-test list) trials for the 75% and 50% conditions are presented in Table 4.

An ANOVA was conducted on the probability of choosing the typical location with trial type (congruent versus incongruent) and proportion condition (75% versus 50%) as within subject factors. This ANOVA demonstrated a main effect of proportion condition, $F(1, 27) = 29.01$, $\text{MSE} = .01$ as well as a main effect of trial type, $F(1, 27) = 783.75$, $\text{MSE} = .02$. The interaction between these two factors was not reliable, $F < 1$.

Table 4
Mean Proportions (and Standard Deviations) of Typical Locations Chosen on Congruent and Incongruent Trials and Estimates of Recollection and Habit in Experiment 3

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>75%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congruent</td>
<td>.94 (.06)</td>
<td>.86 (.07)</td>
</tr>
<tr>
<td>Incongruent</td>
<td>.21 (.13)</td>
<td>.15 (.08)</td>
</tr>
<tr>
<td>Guess</td>
<td>.54 (.13)</td>
<td>.51 (.13)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimate</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Recollection</td>
<td>.73 (.17)</td>
<td>.71 (.12)</td>
</tr>
<tr>
<td>Habit</td>
<td>.78 (.14)</td>
<td>.49 (.15)</td>
</tr>
</tbody>
</table>
Separate comparisons were then conducted examining the probability of choosing the typical location in the two proportion conditions for the congruent and incongruent trials. For the congruent trials, subjects were more likely to choose the typical location in the 75% condition than in the 50%, $F(1, 27) = 47.81$, MSE = .002. Likewise, for the incongruent trials, subjects were more likely to choose the typical location in the 75% condition than in the 50% condition, $F(1, 27) = 8.17$, MSE = .01. It is this latter comparison which shows that memory slips are more prevalent when habit is stronger (i.e., in the 75% condition).

The equations used by Hay and Jacoby (1996) were then used to estimate recollection and habit based on the subjects' performance on the congruent and incongruent trials. In applying these equations it is assumed that recollection and habit operate independently. A subject would place the object in the typical location on congruent trials if the subject consciously recollected the typical location from the study list or based on habit created during the training phase, $P(\text{placed in typical location for congruent trial}) = R+H-RH$, or to simplify, $R+H(1-R)$. For incongruent trials, subjects would place the object in the typical location if they failed to recollect the atypical location from the study list and relied on habit created during training, $P(\text{placed in typical location for congruent trial}) = H(1-R)$. To estimate recollection, the probability of placing the object in the typical location for incongruent trials was subtracted from the probability of placing the object in the typical location on congruent trials. The estimate for habit was then computed by dividing the probability of placing the object in the typical location on incongruent trials by $1-R$. The estimates of recollection and habit obtained in Experiment 3 are shown in Table 4.

Separate ANOVAs were conducted on these values to determine whether recollection and/or habit varied as a function of the proportion of training trials (75% versus 50%). The estimate of recollection did not differ across the two proportion conditions, $F<$.
1. The estimate of habit, however, was reliably greater in the 75% condition than in the 50% condition, $F(1, 27) = 60.14, \text{MSE} = .02$. Moreover, the estimates of habit obtained in the two probability conditions closely approximated the proportions used in the training phase. An ANOVA was then conducted to determine whether performance on the guessing items differed across the two probability conditions. The effect was not reliable, $F < 1.2$.

Additional analyses were conducted to determine whether the subjects' performance varied across the 18 study-test lists. To this end, ANOVAs were conducted which examined performance on the congruent and incongruent trials, as well as the estimates of recollection and habit, across the first and second blocks of 9 study-test lists. The results indicated that accuracy declined across the two blocks of 9 study-test lists. This decrease in performance most likely stemmed from proactive interference which resulted in an increase in errors due to typical location intrusions across the two blocks of 9 study-test lists.

**Discussion**

Experiment 3 successfully demonstrated a dissociation between recollection (a conscious influence of memory) and habit (an unconscious influence of memory). Specifically, it was observed that manipulating the proportion of trials in which the object was placed in the typical location during training influenced the estimate of habit but not the estimate of recollection. This finding is consistent with that of Hay and Jacoby (1996).

The dissociation between recollection and habit obtained in Experiment 3 is particularly important when viewed in combination with the dissociation obtained in Experiment 2 where it was found that age affected the conscious estimate but not the unconscious estimate. Specifically, these two findings reveal a double dissociation between conscious and unconscious influences of memory providing strong support for the assumption that these two processes operate independently.

Another important finding in Experiment 3 was the observation that the estimates of habit obtained in the 75% and 50% conditions approximated the actual proportion of trials
in which subjects placed the objects in the typical location in the training phase. This result is consistent with research on probability matching which has demonstrated that subjects tend to make choices that reflect rates of prior occurrence (for example, see Voss, Thompson, & Keegan, 1959).

It is interesting to note, however, that performance on the guessing items in the 75% condition did not closely approximate the estimate of habit obtained in that condition. The purpose of including the guessing items was to provide converging evidence for the estimate of habit. Guessing items were not presented in the study list so performance on those items could not reflect conscious recollection; performance on such items could reflect only habit created during training or guessing. Unlike the present experiment, Hay and Jacoby (1996) demonstrated that subjects were more likely to guess the typical completion in the 75% condition than in the 50% condition. It is suggested that in that experiment, where the stimuli consisted of word fragments, subjects were less likely to remember whether an item was presented in the study list, and would therefore rely on habit when making their response. In Experiment 3 of the present study, subjects would be more likely to remember whether an object appeared in the study list. That is, they would know whether an item was a new one or not. For this reason, they would not need to rely on memory when choosing a location for a new object in the test and could instead rely on other information, such as where they keep the object in their own home. Habit, therefore, would be less likely to influence performance on the guessing items in the present experiment.

To summarize the results of Experiment 3, the estimate of habit, which is an unconscious influence of memory, varied as a function of training proportions whereas the estimate of conscious recollection did not. This result provides additional support for the assumption that conscious and unconscious influences of memory for an object's location independently contribute to performance.
General Discussion

Summary of the Results

The series of experiments reported here investigated dissociations between conscious and unconscious influences of memory for an object's spatial location using Jacoby's (1991) process dissociation procedure. The purpose was not only to provide insight into conscious and unconscious influences of memory for an object's spatial location by demonstrating dissociations between these two memory processes, but also to provide support for the assumption that the two memory processes operate independently.

Three variables were used in this study to examine their differential effects on conscious and unconscious influences of memory for location. The first experiment examined whether dividing attention at study or test affected the conscious and/or unconscious influence of memory for location. The results indicated that when attention was divided at study, the conscious estimate was reliably greater under full attention than under divided attention. This pattern was also obtained when attention was divided at test, although this effect only approached significance. For the unconscious estimate, there was a trend for the value to be greater in the full attention condition than in the divided attention condition when attention was divided at study. When attention was divided at test, the unconscious value did not vary across the two attention conditions. These results did not provide strong support for the assumption that conscious and unconscious influences of memory independently contribute to performance. An important finding was obtained in Experiment 1, however, which was a reliable unconscious influence of memory for an object's location. This influence was reliable in the full attention condition when attention was divided at study, and in both the full and divided attention conditions when attention was divided at test. These findings replicate the results of Caldwell and Masson (1998) and suggest that there is a reliable unconscious influence of memory for an object's spatial location.
In Experiment 2, the effect of age on conscious and unconscious influences of memory for an object's location was investigated. The results of that experiment demonstrated that conscious influences of memory for location were weaker for older than for younger adults, whereas unconscious influences remained stable. These results provide strong support for the assumption that conscious and unconscious influences operate independently. A second important result obtained in Experiment 2 was the demonstration of reliable unconscious influences of memory for location in both young and older subjects.

The final experiment in this study used the habit paradigm introduced by Hay and Jacoby (1996). In Experiment 3, habit strength was manipulated by varying the proportion of trials in which an object was placed in a particular location during a training phase. In the second phase of the experiment, the objects from training were presented in locations and subjects were instructed to remember those locations for a memory test. The effect of habit strength on conscious (recollection) and unconscious (habit) influences of memory was then examined. The results of that experiment indicated that the proportion of training trials influenced the estimate of habit but not recollection, providing support for the assumption of independence.

The current set of experiments demonstrated a reliable unconscious influence of memory for an object's spatial location. Such a finding not only replicates the results of Caldwell and Masson (1998), but also serves to extend those results by demonstrating that an unconscious influence of memory for an object's spatial location can be obtained under conditions of divided attention (Experiment 1), can be demonstrated in an older population (Experiment 2), and can be observed when a different paradigm is used that involves creating habits for putting objects in particular locations (Experiment 3).

The results of the present experiments also have important implications for memory systems theories and for research on memory and aging, as well as importance for the
assumption that conscious and unconscious influences of memory operate independently. These implications will now be discussed in turn.

Implications for Systems Theories of Memory

The findings of the current set of experiments may have important implications for systems theories of memory. Specifically, the finding of a reliable unconscious influence of memory for an object's spatial location is not easily accommodated by a theory which assumes that separate areas of the brain are responsible for different memory processes. For instance, by the systems theory proposed by Squire (1992), episodic memory is mediated by the declarative system. This declarative system operates independently of the system that mediates unconscious influences of memory. Because memory for location is an episodic memory, it is the declarative system that should be sensitive to spatial information, the nondeclarative system should not be sensitive to such information. This theory, therefore, would predict that there should not be an unconscious influence of memory for location.

The system theory proposed by Tulving and Schacter (1990) may also have difficulty accounting for the finding of a reliable unconscious influence of memory for spatial location demonstrated in the current study. By that theory, the perceptual representation system is responsible for unconscious influences of memory. That system, however, does not retain information concerning the context in which an event occurs. This theory, therefore, would predict that there should not be an unconscious influence of memory for location.

As discussed in the introduction, however, systems theories could account for the finding of an unconscious influence of memory for object location by arguing that subjects did not remember the locations of objects per se, but instead remembered an association between the object and its location (for example, the hair brush and the vanity). Squire (1992), argued that the nondeclarative system can support performance on priming tasks
involving preexisting associations, and because the locations used in the present experiment were common locations for the objects, the nondeclarative system should be able to support performance on this task. Likewise, Tulving and Schacter (1990) could accommodate the finding of an unconscious influence of memory for location in the present study by arguing that performance in those experiments relied on the activation of preexisting associations between the objects and their locations in semantic memory.

The argument that subjects in the present set of experiments simply learned associations between objects and locations could be tested by conducting an experiment similar to those used in the present study but instead of using typical locations for the objects, atypical locations could be used (for example, the weed eater in the refrigerator). Such atypical object and location pairs would not have preexisting associations. Such pairs, therefore, would be analogous to the unrelated word pairs used by Shimamura and Squire (1984; 1989). These researchers found that amnesic patients with impaired declarative memory abilities did not show priming for unrelated pairs of words. Based on that finding, they concluded that declarative memory is required for priming with new associations. If subjects demonstrated an unconscious influence of memory for object location in an experiment using atypical pairs of objects and locations, it would not be easily accommodated by Squire's declarative/nondeclarative distinction. That is, Squire would have to argue either that the nondeclarative system can support performance on a task involving novel pairs of items, or that under some circumstances the declarative system mediates unconscious influences of memory.

Moreover, a finding of an unconscious influence of memory for atypical locations would not be easily accommodated by the system theory proposed by Tulving and Schacter (1990). Specifically, unconscious influences of memory for atypical locations could not be supported by the perceptual representation system because that system does not retain information concerning the context in which an event occurs. Likewise, such influences of
memory could not be supported by the semantic memory system because the atypical object/location pairs used in that experiment would not have preexisting associations.

Implications for Research on Memory and Aging

The results of Experiment 2 in the present study also have important implications for research on memory and aging. A number of studies have shown that older individuals do not remember contextual information as well as younger subjects. Most of those studies, however, have used direct tests to assess memory performance. Older adults, however, do not perform as well as their younger counterparts on tests that rely on the conscious recollection of past experiences. The important question not answered by these earlier studies is whether unconscious influences of memory for context decline with age. The purpose of Experiment 2 in the present study was to answer this question and it did so by examining both conscious and unconscious influences of memory for one aspect of contextual memory, namely spatial location. The results of that experiment demonstrated a decline in the conscious estimate with age, which is consistent with previous research. The unconscious influence, however, remained invariant across the two age groups. These results suggest that the decline in memory for context, and in particular spatial location, that is observed in older subjects may be observed only when direct tests of memory are used which assess conscious influences of memory; unconscious influences of memory for contextual information may remain stable across the life span. Consistent with this conclusion are the results obtained by Light, et al. (1992) who demonstrated an unconscious influence of memory for modality in older subjects.

The findings of Experiment 2 also have important implications for the activation/elaboration explanation for why older adults perform poorly on direct tests of memory. That theory would have difficulty accounting for a reliable unconscious influence of memory for location demonstrated by older adults in Experiment 2. By that view, older subjects perform poorly on direct memory tasks because they fail to integrate an event with
its context. That is, their ability to process information elaboratively is impaired. Older subjects, however, perform at a comparable level to young adults on indirect tests of memory because performance on such tests is supported by the process of activation, which is intact in older subjects. The difficulty for the activation/elaboration position arises in the demonstration of an unconscious influence of memory for location by older adults which suggests that these individuals can and do integrate an event with its context, and this information can be accessed using an indirect measure.

The activation/elaboration position could account for the finding of an unconscious influence of memory for object location by suggesting that performance on that task relied on activation of the preexisting association between the object and the location. As discussed in the previous section, however, this explanation could be tested by using atypical object/location pairs.

The results of Experiment 2 also present difficulty for other researchers who argue that older subjects do not perform as well as their younger counterparts on direct tests of memory because they do not encode contextual information to the same extent as do younger individuals (Light & La Voie, 1993; Rabinowitz & Ackerman, 1982). The findings of the second experiment in this study suggest that older subjects do encode contextual information, and whether subjects demonstrate memory for such information depends on the manner in which it is tested. In the case of spatial memory, if conscious influences of memory are assessed, older subjects do not perform as well as their younger counterparts. If however, unconscious influences of memory are assessed, older subjects do perform at a comparable level to younger subjects.

The results of Experiment 2 also have important implications for the position that spatial information is encoded automatically (Hasher and Zacks, 1979). Hasher and Zacks (1979) argued that because spatial information is encoded automatically, it should not be affected by developmental trends. A consistent finding, however, is that older subjects do
perform worse than younger subjects on tasks that assess memory for spatial location. This evidence, however, has been obtained using direct tests which assess conscious influences of memory. The demonstration that unconscious influences of memory for location were comparable across young and older subjects suggests that older subjects are successful at encoding spatial information, and that this information can be accessed given the appropriate testing conditions.

The results of Experiment 2 are consistent with previous research demonstrating that older subjects perform at a level comparable to younger subjects on indirect tests of memory but not on direct tests. The findings of this experiment suggest that the small number of studies that have demonstrated a reliable difference between young and older subjects on indirect tests obtained that result because of contamination of the indirect tests by conscious influences of memory. When the process dissociation procedure is used to avoid the problems associated with contamination, age differences in unconscious influences of memory are not obtained (see also Jennings & Jacoby, 1993).

**Implications for the Process Dissociation Procedure**

The findings of the current set of experiments also have important implications for the process dissociation procedure. Jacoby (1991) introduced this procedure so one can avoid the problems of contamination that arise when using direct and indirect memory measures. The procedure allows the separate assessment of conscious and unconscious influences of memory within a single task, rather than searching for dissociations across tasks. When using this procedure, however, an important assumption is made, which is that conscious and unconscious influences of memory operate independently. To provide evidence for this assumption, Jacoby and his colleagues (Jacoby, et al., 1993; Toth, et al., 1994) have suggested that one could demonstrate that a manipulation influences one component of memory but leaves the other invariant.
Evidence in favor of this assumption was obtained in the current set of experiments. In Experiment 2 it was found that age affected the conscious estimate but not the unconscious estimate. In Experiment 3, the opposite dissociation was observed, where it was demonstrated that manipulating habit strength affected unconscious influences of memory for location but not conscious influences. Moreover, the results of these two experiments together provide particularly strong support for the independence assumption by demonstrating a double dissociation between conscious and unconscious influences of memory for object location.

Limitations and Future Directions

Although the current set of experiments provide insight into conscious and unconscious influences of memory for object location, it is important to discuss how location information was represented in these experiments. As discussed earlier, one could argue that subjects did not learn the location of objects in space, but instead learned an association between two objects (for example, the hair brush and the vanity). It is important to note however, that this kind of paired associate learning between an object and its location may also be what individuals learn in real world situations. For example, when an individual leaves their keys on the hook by the door, and later go back to the hook to retrieve them, are they remembering the location in space in which the keys were left or are they simply remembering the association between the keys and hook? The spatial information presented in this real life example is very similar to the location information subjects learned in the present study.

It is also important to note, however, that the location information represented in the present set of experiments is different from location information represented in real world situations in at least one important respect, which is that in the real world people maneuver through a three dimensional environment and manipulate real objects. Such an environment is very different from what was used in the current study. It would be
interesting, therefore, to conduct a similar set of experiments to those in the present study but instead of presenting objects and locations on a computer screen, one could use actual rooms, locations, and objects. For such an experiment, subjects could maneuver through the actual rooms and place objects in real locations, and could then search for those objects by walking back through the rooms. If similar results to those obtained in the present study were obtained in such an experiment it would suggest spatial information was represented similarly in both cases.

Another important issue to consider when investigating memory for spatial location concerns the relative positions of objects. Many earlier studies investigating memory for location used spatial arrays that consisted of numerous objects presented simultaneously (for example, Mandler, et al., 1977; Shadoin & Ellis, 1992). The problem with such a procedure is that the absolute location of the objects is confounded with the relative locations of the objects. In the present study, however, each object was presented individually, so subjects could not observe relative locations. Subjects could, however, when placing an object, recall a previously studied object, and then encode the relative locations of these objects by using this recalled information. Subjects could then use such information to aid performance when searching for the objects in the test phase.

To investigate whether subjects encoded relative positions of objects in the present set of experiments, one could use the priming paradigm of McNamara, Ratcliff, and McKoon (1984). In that experiment, subjects learned the locations of numerous cities on a map. They were then given a recognition test for those cities. It was found that subjects recognized a city faster if it was preceded by a close city than if it was preceded by a far city. The paradigm used by McNamara et al. (1984) could be used with the present set of materials to determine whether objects placed close to one another within a room would result in greater priming than objects placed far apart within the same room, or objects placed in different rooms. Moreover, objects simply situated within the rooms for
background effects could also be used in the recognition task. If objects placed or situated close together do prime one another more than those farther apart, it would provide insight into how subjects represent the spatial information presented in the experiment.

Conclusions

To conclude, the present set of experiments used the process dissociation procedure to investigate the effect of three variables on conscious and unconscious influences of memory for object spatial location. The results of the experiments demonstrated a number of dissociations between the two components of memory. Specifically, age was found to affect the conscious estimate but not the unconscious estimate, whereas habit strength influenced the unconscious component but not the conscious component. Manipulating attention at study or test, however, did not result in clear dissociations between conscious and unconscious influences of memory for object location. The results of these experiments have important implications for research on memory and aging, as well as for the assumption that conscious and unconscious influences of memory operate independently.
References


Appendix A

Examples of drawings of household objects.
Appendix B

Drawing of one of the background rooms (kitchen).
Appendix C

Drawing of the floorplan.