ARE RECOVERED MEMORIES ACCURATE?

A Dissertation

by

DAVID GERKENS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2004

Major Subject: Psychology

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Approved as to style and content by:

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ABSTRACT

Are Recovered Memories Accurate? (May 2004)

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Research in our laboratory has demonstrated blocked and recovered memories within the context of a controlled experiment. The comparative memory paradigm allows for comparisons of recovered memories, continuous memories, and false memories. Additional research in our laboratory has shown two distinct types of memory errors; semantic based errors which occur due to pre-existing category knowledge, and episodic based errors in which the source of details (list members) are misattributed. Independently, these two lines of research have illuminated basic memory processes, however, they have not been combined previously. That is, the experiments in the present study explore the susceptibility of recovered memories to semantic and episodic based errors relative to continuous memories.

Experiment 1 replicated the large blocking and recovery effects previously found by our laboratory. Additionally, it demonstrated that recovered memories were no more prone to semantic based errors than were continuous memories. These errors occurred very infrequently despite the use of materials chosen specifically to induce such errors. Experiment 2 again replicated the large

blocking and recovery effects. The equivalent low rate of semantic based errors was also replicated. However, Experiment 2 also revealed that recovered memories were more susceptible to episodic based errors than were continuous memories. This was especially true when the memory block occurred in an interference treatment condition. Finally, post-recall source recognition tests failed to improve memory accuracy. In fact, numerically both semantic based and episodic based errors increased on the source recognition test relative to the cued recall test. Findings are discussed in relation to the source monitoring and fuzzy-trace theories of memory as well as the legal and clinical recovered memory controversy.

For Monkey, Zuzu, & Zane -

the reasons any of it matters.

ACKNOWLEDGEMENTS

I would like to thank Dr. Steven Smith for his advice throughout every stage of this dissertation and my graduate career. I also want to thank Drs. Heather Bortfeld, Robert Hall, and Mark Packard for acting as committee members and providing valuable feedback about the research and ideas for future projects. I would also like to thank Dr. Thomas Ward for his influence during my graduate career.

Without the support and encouragement of my family and the Robles family I would not have been able to complete this dissertation. This is especially true of my wife, Leslie, who endured my highs and lows with me here in Texas.

Finally, I would like to thank all of my colleagues in graduate school that helped me in ways ranging from study groups, to commiserating, or just going to Northgate. All of which were essential activities for completing graduate school with sanity intact.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Overview

The accuracy, and in some cases even the possibility, of recovered memories has been a divisive issue between clinical and cognitive psychologists for over a decade (Bass & Davis, 1988; Hyman & Billings, 1998; Hyman, Husband, & Billings, 1995; Hyman & Pentland, 1996; Lief, 2003; Loftus, 1993; Loftus & Ketchem, 1994; Loftus & Pickrell, 1995; Mack, 1994; Terr, 1991; 1994). The publication of the self-help book, *The Courage To Heal* (Bass & Davis, 1988) caused alarms to ring in the minds of cognitive psychologists. In the book, a variety of ambiguous symptoms (e.g., depression, sexual dysfunction, sleep disturbances) are identified as potential indicators of "repressed" memories of trauma (e.g., childhood sexual abuse). Loftus (1993) responded with an article addressing the myriad issues concerning claims of accurate recovered memories. Among these are: the lack of empirical evidence, alternate sources of information provided in allegedly recovered memories, consideration of simple forgetting rather than a special "repression" mechanism, and therapeutic practices that may implant memories or distort existing memories. Memories recovered in therapy and legal cases involving recovered memories continue to be reported (Lief, 2003; Leavitt, 2001; Mack, 1994; Porter, Campbell, Birt, & Woodworth, 2003; Schooler, 2001) and cognitive psychologists continue to produce implanted memories and false memories in the laboratory (Hicks & Marsh, 2001; Hyman & Billings, 1998; Hyman, Husband, & Billings, 1995; Hyman & Pentland, 1996; Lief,

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This dissertation follows the style and format of *Memory.*

2003; Loftus, 1993; Loftus & Ketchem, 1994; Loftus & Pickrell, 1995; Roediger & McDermott, 1995; Smith, Gerkens, Pierce, & Choi, 2002; Smith, Tindell, Pierce, Gilliland, & Gerkens, 2001).

Despite the controversy, however, little empirical work has examined the accuracy of blocked and subsequently recovered memories (for exceptions see, Basden, Basden, & Morales, 2003; Sahakyan & Kelley, 2002; Smith, Gleaves, Pierce, Williams, Gilliland, & Gerkens, 2003). Although the debate centers on recovered memories of emotional events, initially it is important to establish the effects of blocking and recovery on memory for emotionally neutral episodes. That is, a comprehensive analysis of recovered memories requires an exploration of how basic cognitive processes might account for memory blocking and recovery in addition to considerations of how emotional arousal may influence these processes. Current understanding of the neural substrates of memory implicates multiple memory systems that may cooperate or compete in the encoding of memories in different circumstances (Packard & Cahill, 2001; Poldrack & Packard, 2003). Emotional arousal mediates amygdalar modulation of the role of these different memory systems. However, these memory systems are still the same systems underlying basic stimulus-response and declarative learning and memory rather than some special system for emotional memories. Thus there is reason to believe that basic cognitive processes may be the mechanisms underlying memory blocking and recovery effects. The present paper reports two experiments conducted to investigate the accuracy of emotionally neutral recovered memories relative to continuously accessible

memories as an essential first step to understanding the recovered memory

phenomenon.

Blocking Memories in the Laboratory

One reason little laboratory work has been conducted on the accuracy of

recovered memories is the difficulty in producing functional amnesia and

subsequent recovery in a controlled laboratory setting. Functional amnesia has

been defined as "memory loss that is attributable to an instigating event or

process that does not result in insult, injury, or disease affecting brain tissue, but

that produces more forgetting than would normally occur in the absence of that

instigating event or process" (Schacter & Kihlstrom, 1989). Procedures such as

the list method of directed forgetting generally produce memory deficits of less

than 15% (e.g., Basden, Basden, Morales, 2003) and also don't provide an easy

way to induce memory recovery without re-presenting memory targets. The

suppression procedure followed by the independent probe technique (e.g.,

Anderson & Green, 2001) could potentially create memory blocks and

subsequent recovery. However, in the Anderson and Green study, for example,

the independent probe for suppressed items only produced approximately 5%

better recall than the original probe, which elicited only about 7% fewer items after

suppression than baseline recall performance. That is, the entire blocking effect

is less than 15% and the independent probe produced little recovery. Cox and

Barnier (2003) note that post-hypnotic amnesia shares the major features of

functional amnesia and thus, may be an effective method for studying functional

amnesia. However, this method is limited in that it only works on highly hypnotizable participants.

Smith et al. (2003) developed the comparative memory paradigm (CMP) which allows direct comparison of continuous memories, recovered memories, and false memories within a single experiment. In the CMP, interference is created by providing extra exposure to a majority of the originally learned material (word lists of taxonomic categories) leaving a small subset (critical lists) of the material that does not receive extra exposure less accessible. On a free recall test participants in the interference condition displayed 35% worse recall of the critical lists than participants in a control condition (Smith et al., 2003). Importantly, participants in both conditions are only exposed to the critical items once and have the same delay between encoding and test. Like post-hypnotic amnesia, the effects of the interference manipulation in the CMP share the major features of functional amnesia. Recovery of the blocked lists is achieved by providing the category names as retrieval cues for the studied category members. Recovered memories on the cued-recall test were not distinguishable from continuous memories in terms of percent correct recall or on a variety of meta-cognitive judgments.

The proposed mechanism underlying the blocking effect found by Smith et al. (2003) is that, for the interference group, the output dominance of the critical lists is diminished by the extra exposure to the other lists. Output dominance refers to the likelihood a particular item will come to mind when asked to generate items to a given cue. In this case, the likelihood the critical lists are produced

given the cue: The set of lists learned at the beginning of the experiment.

During recall, output interference builds up from the retrieval of categories with

higher output dominance (e.g., categories that received extra-exposure) making

previously recalled categories more likely to come to mind and the critical

categories less likely to be retrieved consistent with the Rundus (1973) and

Mensink and Raaijmakers (1988) models of word list free recall (see Figure 1).

That is, there are two mechanisms working in concert to produce the blocking

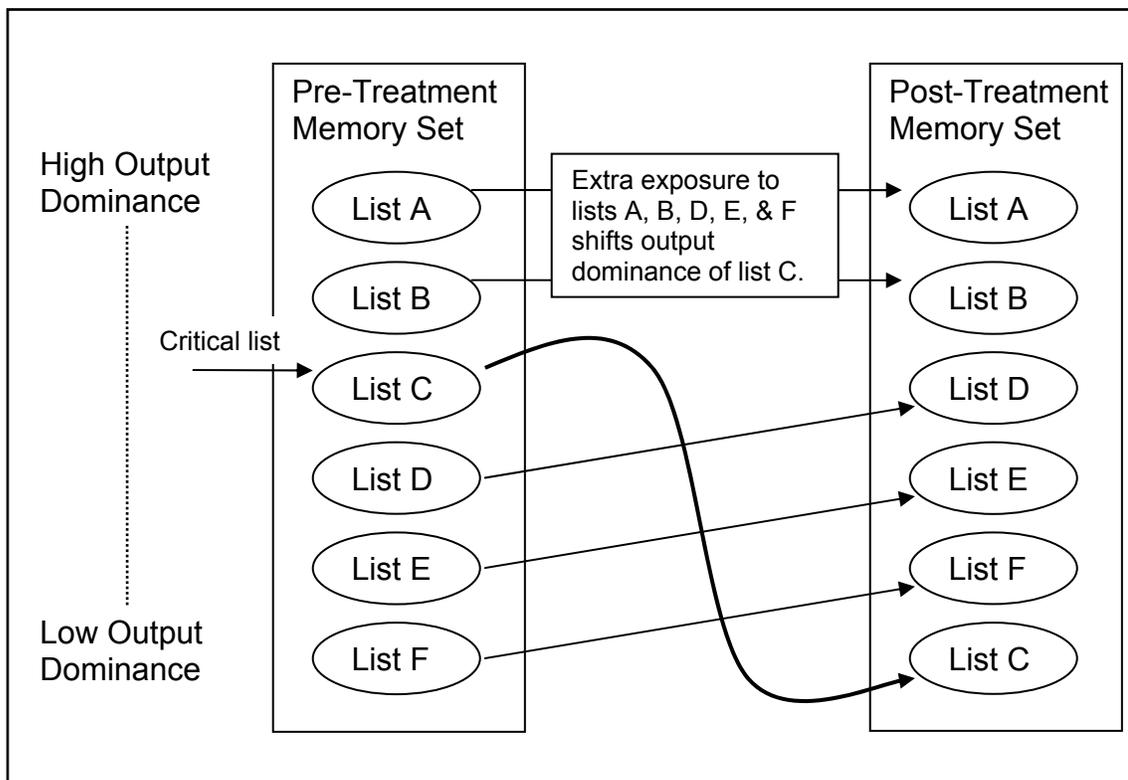effect; the shift in output dominance and output interference.

Figure 1. Depiction of the shift in output dominance of a critical list
within a memory set given the interference treatment. Note: Based on
figure originally published in Smith et al. (2003).

This blocking at the level of the category may be analogous to cases of functional amnesia where entire episodes are inaccessible to conscious recall. For example, one theory of psychogenic amnesia of recurring abuse is that the victim adaptively learns to forget episodes of abuse (Terr, 1991). That is, as a coping mechanism, a victim of abuse may selectively retrieve memories that compete with memories of abuse. Avoiding the pain of the traumatic memory acts as negative reinforcement thereby increasing the likelihood that the competing memories are retrieved and consequently decreasing the probability that the painful memories are retrieved (Bowers & Farvolden, 1996; Cloitre, 1992; Cloitre, Cancienne, Brodsky, Dulit, & Perry, 1996; Smith, et al., 2003). Similarly, each category can be conceptualized as a separate episode. Blocking may occur at the level of the category name, effectively blocking recall of the entire episode. However, given the category name as a retrieval cue, recall of presented category members is possible.

In addition to the blocking mechanism of the CMP resembling some explanations of blocked memories for trauma, the category name recovery cue method in the CMP resembles certain clinical practices. Specifically, one therapeutic technique used to explore a patient's personal history involves asking him or her to recall categories of events. For example, a patient may be asked to recall all the episodes of abuse that they can, or all of the episodes involving a particular individual. Despite the innocuous nature of the stimuli used in the CMP, the same hierarchical representation cognitive model can be used to map the

structure of both the experimental materials and clinically relevant events (Smith, et al. 2003).

False Memories in the Laboratory

Comparing false memories with recovered and continuous memories in the CMP revealed that on average false memories were given lower confidence ratings and were more likely to be rated as "known" rather than "remembered" than either recovered or continuous memories. In the CMP false memories are elicited by having participants recall items to category names during cued recall that had not been presented during the study episode. Participants were instructed to write down only items from the category being tested (i.e., not to include items from other categories), but that they could guess at category members. After recalling category members participants performed the meta-memory judgments. Items given confidence ratings greater than zero were counted as false memories. This method of producing false memories resembles some memory implantation studies in the literature (e.g., Hyman & Billings, 1998; Hyman, Husband, & Billings, 1995; Hyman & Pentland, 1996; Loftus & Ketcham, 1994; Loftus & Pickrell, 1995). It also parallels the circumstance in which a therapist asks a client to recall an event category that does not correspond to the client's autobiographical history. Although this procedure produces interesting false memory effects, it is limited in that the false memories that are created are independent of the blocked and recovered memories produced by the paradigm. That is, the memories created are for new episodes (i.e., non-studied taxonomic categories) rather than for details (i.e., category members of studied lists) within

memories of episodes that are either recovered or have been continuously accessible.

The principle question of interest in the present study is the accuracy of the memory for an episode (i.e., categorized lists) that had been blocked, but has subsequently been recovered. One hypothesis is that, because the blocking occurs at the level of the episode, the details within that episode may be relatively unaffected by the memory block. That is, cued recall of the episode should be just as accurate for memory of a recovered episode as memory for an episode continuously available to recall. An alternative hypothesis is that blocking at the level of the category may also influence accuracy of the details within an episode. For example, blocking may create a greater reliance on constructive processes during retrieval of the episode details because the link between the episode label and episode details has been degraded.

Assessment of the accuracy of recovered memories (and continuous memories for that matter) should include a measure of correct recall and a measure of false recall. Furthermore, false recall can be broken down into errors based on semantic information (e.g., schemas, category knowledge) and errors based on episode confusions (e.g., misattributing details from one event into memory of a separate event). These two types of errors can be classified as reality monitoring failures (see Johnson & Raye, 1981) and source monitoring failures (see Johnson, Hashtroudi, & Lindsay, 1993) respectively. Reality monitoring failures refer to cases in which a rememberer is unable to accurately identify whether a given memory is for an internally generated event, or an

externally experienced event. In contrast, source monitoring failures refer to an inability to accurately attribute a given memory to the correct external source. In a variety of studies it has been shown that both semantic and episodic based errors in recall or recognition can be greatly reduced if participants are instructed to think about the source of their memories (e.g., Lindsay & Johnson 1989; Smith, et al., 2001; Zaragoza & Koshmider, 1989; Zaragoza & Lane, 1994). That is, reality and source monitoring are meta-memorial judgments made about memories either during or after recall or recognition that typically improve memory accuracy.

However, in many cases, reality or source monitoring instructions do not completely eliminate memory errors (e.g., Chandler, Gargano, & Holt, 2001; Smith et al., 2001; Zaragoza & Lane, 1998). For example, Smith et al. (2001) conducted a series of experiments that produced both semantic based errors and episodic based errors in recall of categorized lists. Participants studied several categorized lists comprised of the category members with the highest output dominance with the exception that the member with the highest output dominance was left off each list. The highest output dominant members were used as critical items. Half of the critical items appeared in an incidental task at the beginning of the experiment and the other half were not presented during the experimental session. Nonpresented critical items provided the potential for semantic based errors and incidentally presented critical items allowed for episodic based errors. On a cued recall test semantic errors occurred on an average of 25% of the lists and episodic errors occurred on 39% of the lists on average. After a cued recall

test, participants were instructed to look over their responses and determine the source of each item. For semantic confusion errors (i.e., non-studied items recalled because they were members of studied categories) participants almost always attributed the items to the studied lists. In contrast, for episodic confusion errors (i.e., items encountered in an incidental task, but not on the studied lists), participants were frequently able to correctly identify items as having been presented on an incidental task. However, the majority also incorrectly believed the items had also appeared in the studied lists.

The present experiments used the basic CMP paradigm, but incorporated aspects of the Smith et al. (2001) false recall experiments to explore the accuracy of blocked and subsequently recovered memories compared to the accuracy of memories continuously accessible to recall. Participants incidentally learned a number of taxonomic categories, half were then exposed to interference and the other half performed spatial tasks, and finally memory was assessed for all participants. Memory was tested three times. First, a free recall test of presented category names was given to determine which categories had become inaccessible. Second, a cued recall test in which category names were provided as retrieval cues was given to show the extent to which the members of both previously accessible and previously blocked categories could be remembered. Finally, a source recognition test was given for category members to establish whether errors within recovered and continuous memories would be identified at different rates given source monitoring instructions.

EXPERIMENT 1

First, based on the theoretical mechanism of output dominance shifting combined with output interference and the findings of Smith et al. (2003) it is predicted that the free recall test will reveal a large blocking effect on the critical lists. Second, it is predicted that the cued recall test will produce memory recovery by guiding participants to a starting point within the memory search that bypasses the effects of output interference. The structure of the learned categories is designed to provide multiple opportunities for semantic confusion errors, however, because the blocking occurs at the level of the category name it is predicted that continuous and recovered lists will show equivalent high error rates in cued recall. Different predictions concerning source recognition performance are derived from the source monitoring framework (used generally here to refer to the theory behind both reality and source monitoring) and fuzzy-trace theory.

The source monitoring framework describes source decisions as occurring in one of two ways. First, a memory may be automatically and unconsciously imputed to a source. Second, one may go through a deliberate judgment process weighing available characteristics of the memory trace to attribute a memory to a source (Johnson et al., 1993). The source monitoring framework does not directly address the issue of blocking, however, it is implied that many memory errors result from source being attributed automatically and that instructions to monitor memory source should reduce these errors. Given similar encoding and retrieval conditions, memory performance should be equivalent regardless of intervening

task. That is, similar to the way in which source instructions virtually eliminate misinformation effects (e.g., Lindsay & Johnson, 1989), they should reduce errors (especially episode based) regardless of treatment condition (interference or control) or memory type (recovered or continuous) because the source information is assumed to be intact, but simply not utilized unless motivation is provided to monitor for source.

In contrast, Fuzzy-trace theory attributes different properties to different characteristics of a memory (Brainerd & Reyna, 1993; Reyna & Brainerd, 1995). According to Fuzzy-trace theory, verbatim and gist memory traces are formed simultaneously for every event. Verbatim traces are thought to contain the characteristics associated with making source decisions whereas gist traces contain the semantic content. Additionally, verbatim traces are prone to interference and decay rapidly whereas gist traces are relatively resistant to interference and are stable over time (e.g., Brainerd, Reyna, & Brandse, 1995; Reyna & Brainerd, 1995). Given these constraints, the interference treatment of the CMP should impair accurate source monitoring. That is, given the proposed interference based mechanism underlying the blocking effect, one might infer that the treatment should disrupt the verbatim representation of the blocked lists but leave the gist representation unscathed by the interference. If this is the case, only the gist representation of the blocked lists remains accessible and consequently source instructions will be ineffective.

Method

Participants

Seventy-one undergraduate student volunteers participated in the experiment. Students received credit toward their research requirements in their introductory psychology courses. Students had multiple options from which to choose.

Materials

Forty-eight lists of words belonging to 24 different taxonomic categories were used as the primary stimuli. These lists are modifications of those used in Smith et al. (2000) and Smith et al. (2001). The modification involved changing the list structure. Instead of presenting items that ranged from second to eleventh in output dominance (OD) for each category, two counterbalancings (CB) of the same category were created by using alternating items (i.e., OD rankings of 1, 3, 5, 7 … were used in one CB and 2, 4, 6, 8 … were used in the other CB; see Table 1). This modification was made for two reasons. First, it created more opportunity for participants to produce false recall on the cued recall test. Second, it provided highly plausible items to use as foils on the recognition test. Additional materials included a variety of perceptual tasks used as non-interfering, but attention demanding tasks for the control conditions. These tasks consisted of mazes, mental rotation figures, and a random character string search.

Design & Procedure

A treatment (interference/control) x list type (critical/control/misinformation) x CB (A/B) 3 factor mixed design was used. CB, and treatment were between-

TABLE 1

Examples of list structures used in Experiments 1 & 2.

Experiment 1		Experiment 2
Sports		Sports
CB 1	CB2	OD Ranking / Item
OD Ranking / Item	OD Ranking / Item	*2 / football*
1 / basketball	2 / football	3 / baseball
3 / baseball	4 / soccer	4 / soccer
5 / swimming	6 / tennis	5 / swimming
7 / track	8 / hockey	7 / track
9 / volleyball	10 / golf	8 / hockey
11 / polo	12 / racquetball	9 / volleyball
13 / rugby	14 / softball	10 / golf
15 / skiing	16 / boxing	11 / polo
17 / diving	18 / gymnastics	12 / racquetball
19 / lacrosse	20 / handball	*1 / basketball

Note: * Item not present in initial incidental learning episode,
but was presented in the affect rating task in CB1 providing a source for
episodic confusion errors.

participants factors and list type was a within-participant factor. Free recall of

category names, cued recall of category items, and item recognition performance

were dependant measures. Two different CBs were created by using half even

OD lists and half odd OD lists for each list type. Table 2 illustrates the basic

experimental design.

TABLE 2

Basic experimental procedure.

Phase	Treatment		
	Control	Interference	
Study	Learn 22 lists	Learn 22 lists	
Delay	Spatial tasks	Interfering tasks	
Free Recall	Category recall	Category recall	Blocking effect observed here
Cued Recall	Category member recall	Category member recall	Recovery observed here
Source Recognition	Source attribution	Source attribution	Source memory observed here

Regardless of conditions, all participants began the experiment by viewing

22 categorized lists (including category names) one item at a time in a large easy

to read font on a computer screen. Category names were on the screen for 4

seconds each and items were on the screen for 3 seconds each (followed by a 3

s blank screen). During this presentation, participants copied down the category

names and items and rated each item for typicality on a 1 to 5 scale in their response packets.

In the control (no interference) treatment, this task was followed by a maze-solving task. Participants were instructed that differences between males and females had been found in spatial processing and that these differences were being explored in the next few tasks. Each participant had a number of mazes in their response packets to solve during the time given. In addition, they were asked to rate how difficult each maze was on a 1 to 7 scale once they had completed it. Following this task, control participants completed a mental rotation matching task. The task involved mentally rotating three two-dimensional figures to determine if they were identical to, or mirror images of, a given probe. Participants were given 25 probes that became increasingly complex as they progressed through the task. For each set (probe and 3 figures to match), participants were instructed that anywhere from zero to three of the figures matched the probe thus forcing them to check all the figures for a match. They were also told to rate each set for difficulty on the same 1 to 7 scale used on the maze task. Finally, participants in the control condition completed the random character string search. This task is just like a word search, but rather than words, participants search for given strings of randomly grouped alphanumeric characters. There were 12 strings ranging from 4 to 9 characters in length to find in a 20 x 20 matrix. Strings could be vertical, horizontal, diagonal, forward, or backward. Participants were given 6.5 minutes for each of these tasks and it was rare for anyone to complete a task before time expired. These tasks equated the

interval between encoding and retrieval for the control and interference treatment conditions. The tasks required cognitive effort, but only involved non-verbal materials so as to avoid introducing interference.

For participants in the interference treatment the typicality-rating (incidental learning) task was followed by a memorability-rating task. For this task, participants were given a page containing 20 categorized lists. Eighteen of these lists were the same lists presented in the typicality-rating task (though the order of the lists and the order of the items within the lists were different). The other two lists were new categories and thus resemble misinformation. Importantly, four lists that had been presented did not appear in the interference task. These four lists are the critical lists of the blocking manipulation. Participants were instructed to rate how memorable (i.e., would they recall it on a later test if one were given) each item in the categories was. Ratings were done on a 1 to 7 scale. The next task was a size-ranking task. The same lists (including the two misinformation lists) were once again presented (again, both list and item order were changed) and participants were instructed to rank order the members of each category by size. Five of the categories could not be ranked by size. Four of these (sports, dwellings, metals, and officials) were to be ranked in terms of prestige and one category (diseases) was to be ranked by seriousness. The final interference task was a typicality-ranking task. The same 20 lists were presented (in another new order) and participants ranked category members from most typical to least typical.

Following either the spatial tasks or interference tasks, all participants were given a free recall test. Participants were asked to think back to the original typicality-rating task when the categories were presented on the computer screen (none of the intervening tasks involved presentation of materials on the computer screen) and to recall as many of the category names from that presentation as they could. Following the free recall test, all of the participants were given a cued recall test. For the cued recall test, participants were asked to recall as many category members from the original presentation on the computer screen as possible. Category names were presented one at a time as cues. The category names of ten of the originally presented, plus the two misinformation lists were given as cues. Participants were instructed to recall category members for lists shown during the original task, but that if a category name was given during the test that did not appear in the original task they were to mark the list with an asterisk and list the first ten members that came to mind. Each category name was shown for 90 s and participants recalled members for a category only during its presentation. Response forms had space for the category name and ten category members per list. The cued recall test provided a measure of recovered memories.

Following the cued recall test, all participants took an 80-item source monitoring recognition test. The recognition test included ten categories (all had been on the cued recall test) presented in blocks. Of the eight items for each category, four were from the CB the participant experienced and four were from the other CB (i.e., foils). Of the ten categories tested, four were the critical lists of

the blocking manipulation (i.e., the lists that did not appear on the memorability

and ranking tasks for the interference condition), two were the categories added

in on the interfering tasks (i.e., the misinformation lists), and four were categories

that had been presented on both the original incidental learning procedure and on

the interference tasks (i.e., control lists). Items were presented one at a time on a

computer screen for 5 s each. During this time, participants in the interference

condition indicated whether the item was presented only during the incidental

learning procedure, only on the interference tasks, on both, or if it was a new

item. The control (no interference) group was instructed to identify if each item

was presented during the incidental-learning task only, if they had generated it on

the cued recall test, but it hadn't been presented during the experiment, or if it

was a new item.

Results

Unless otherwise specified, all statistically significant analyses reported

have a value of $p < .05$.

Free Recall

 As predicted, the interference condition did significantly worse recalling the

critical lists than the control condition, i.e., there was a 28% blocking effect (see

Table 3). In addition, the interference group outperformed the control group on

the control lists, i.e., there was an 11% extra practice effect. These effects were

revealed with the following analysis: A 2 (Item Type) x 2 (Treatment) x 2 (CB)

mixed ANOVA was performed on proportion of category names recalled. Item

TABLE 3

Mean proportion of category names recalled by list type and treatment,
Experiment 1.

	Item Type	
Treatment	Critical Items	Control Items
Interference	.27 (.04)	.75 (.02)
Control	.55 (.04)	.64 (.02)

Note: Standard errors appear in parentheses.

type was either critical lists or control lists and treatment was either interference

or control. There was a significant main effect of item type [$F(1, 67) = 99.95$,

$MSE = .03$, partial $\eta^2 = .60$] and a significant treatment main effect [$F(1, 67) =$

7.36, $MSE = .04$, partial $\eta^2 = .10$], but these were qualified by an item type by

treatment interaction [$F(1, 67) = 49.59$, $MSE = .03$, partial $\eta^2 = .43$]. There was

also an item effect causing significantly greater correct recall of control items over

critical items for the control group, [$F(1, 34) = 5.52$, $MSE = .02$, partial $\eta^2 = .14$].

This appears to be an item effect because controlling for item position during

learning did not reduce the difference and in Experiment 2 when different

categories are used as critical lists the effect is reversed. No other effects were

statistically significant.

Another way to illustrate the effectiveness of the interference manipulation

is to consider the number of participants that failed to recall any critical lists.

Every participant in the control condition (35 of 35) recalled at least one critical list

whereas 36% (13 of 36) of the interference condition participants failed to recall

any of the critical lists. Descriptively, there was a 47% false recall (episodic

confusion error) rate of the misinformation lists for the interference group,

whereas no one in the control group falsely recalled those categories. There

were only two intrusions of non-presented categories, both of which occurred in

the control group.

Cued Recall

 Multiple analyses were performed on the cued recall data in order to consider

different aspects of the data separately. First, the effect of blocking and recovery

on false and correct recall compared to continuous memory is presented (i.e., the

memory type effect). Second, the effect of the interference treatment on correct

recall is examined collapsing across memory type. Finally, analyses of false

recall and the effect of misinformation, again collapsing across memory type, are

presented.

False & Accurate Recall in Recovered vs. Continuous Lists

A 2 (Memory Type) x 2 (Treatment) x 2 (CB) mixed ANOVA was performed

on proportion of category members recalled comparing cued recall accuracy of

blocked and recovered memory with continuous memory. Making a within-

participant comparison of recovered and continuous memories resulted in

dropping some participants because not everyone had both continuous and

recovered memories. This comparison failed to reveal a difference between

recovered and continuous false memories (i.e., there were no significant effects).

There were low false recall rates overall (approximately half an item per list).

However, the control condition recalled more correct items than the interference

condition for both recovered and continuous lists [treatment main effect, $F(1, 52)$ = 8.88, MSE = 2.20, partial η^2 = .15, no other effects were significant]. This result indicates that it is something about the interference manipulation rather than the process of being blocked and recovered that caused the reduction in correct recall for the interference treatment group (see Table 4).

TABLE 4

Mean proportion of correct category members recalled by memory type and treatment.

	Memory Type	
Treatment	Recovered Lists	Continuous Lists
Interference	.55 (.03)	.58 (.03)
Control	.63 (.03)	.67 (.03)

Note: Standard errors appear in parentheses.

Correct Recall of Critical Lists & Control Lists

 A 2 (List Type) x 2 (Treatment) x 2 (CB) mixed ANOVA was performed on proportion of category members recalled. Consistent with the memory type analysis, participants in the control condition recalled more items from the critical lists than the participants in the interference condition (see Table 5). The practice effect (interference condition greater than control condition) on control lists was again observed in the cued recall test (see Table 5). The preceding effects were revealed by a significant main effect of list type [$F(1, 67)$ = 287.55, MSE = .43, partial η^2 = .81], qualified by a list type by treatment interaction [$F(1, 67)$ = 62.03,

MSE = . 43, partial η² = .48], with follow-up t-tests [*t*(69) = 2.68 and *t*(69) = 5.12]

comparing treatment conditions on critical lists and control lists respectively.

There was also a slightly larger difference between critical and control lists across

counterbalancings [*F*(1, 67) = 5.26, *MSE* = .43, partial η² = .03], but mean recall of

each list type did not differ across counterbalance [*t*(69) = 1.50, *M* = 6.3 versus

5.9, and *t*(69) = 0.29, *M* = 7.9 versus 8.0] for the critical lists and control lists

respectively.

TABLE 5

Mean proportion of correct category members recalled by list type and treatment,
Experiment 1.

	List Type	
Treatment	Critical Lists	Control Lists
Interference	.57 (.02)	.85 (.01)
Control	.65 (.02)	.75 (.01)

Note: Standard errors appear in parentheses.

False Recall & Misinformation

 Overall, there was very little false recall (less than one item every three lists). A

2 (Item Type) x 2 (Treatment) x 2 (CB) mixed ANOVA was performed on number

of non-presented category members recalled.   There was a significant main

effect of list type on false recall [*F*(1, 67) = 4.01, *MSE* = .08, partial η² = .06], with

more false recall on the critical lists (*M* = .35, *SE* = .05) than on the control lists (*M*

= .25, *SE* = .04; note these are not proportions). No other effects were significant. Most notably, the effect did not interact with the interference manipulation.

Everyone in the control condition identified both misinformation lists as new on the cued recall test and no control condition participants claimed a presented list was new. In contrast, only 25% of the interference condition participants correctly identified the misinformation lists as new and two participants claimed other lists were new as well. A 2 (CB) x 3 (list type) mixed ANOVA comparing the cued recall of the misinformation lists with the interference and control lists for the interference treatment group (list type main effect [$F(1, 34)$ = 6.91, *MSE* = .53, partial η^2 = .17] and list type by CB interaction [$F(1, 34)$ = 5.79, *MSE* = .53, partial η^2 = .15]) revealed greater false recall in the misinformation lists than in the critical and control lists [$t(18)$ = 2.50, *M* = 1.11, *SE* = .27 > *M* = .42, *SE* = .11; and $t(18)$ = 3.09, *M* = 1.11, *SE* = .27 > *M* = .30, *SE* = .09 respectively] in CB 2. No differences in CB 1 were detected.

The same ANOVA performed on correct recall revealed significantly better recall on the control lists (*M* = 8.48, *SE* = .15) than either the critical (*M* = 5.72, *SE* = .20) or misinformation (*M* = 5.65, *SE* = .46) lists which did not differ [$F(1, 34)$ = 263.48, *MSE* = .51, partial η^2 = .89]. That is, the effect of extra practice is visible in item recall, as it was in category name recall. A manipulation check done to ensure participants were recalling category members rather than generating them was to have them generate items for those lists if they identified them as new. It is clear this is the case because participants in the no interference condition

generated an average of 5.76 items that would be incorrect for their CB condition and only 3.59 items that would be correct.

Source Recognition

On the critical lists, the control group had a much higher hit rate than the interference group (M = .95, SE = .04; M = .33, SE = .04 respectively), but on the control lists both groups had high hit rates (CB1 was reliably lower than CB2 for the interference group; M = .83, SE = .03; M = .97, SE = .03) as revealed by a 2 (probe type) x 2 (treatment) x 2 (CB) mixed ANOVA [probe type main effect: F(1, 67) = 80.09, MSE = .03806, partial η^2 = .54; treatment main effect: F(1, 67) = 169.01, MSE = .03, partial η^2 = .72; probe type by treatment interaction: F(1, 67) = 64.11, MSE = .04, partial η^2 = .49; probe type by treatment by CB interaction: F(1, 67) = 4.05, MSE = .04, partial η^2 = .06; followed by a simple treatment by CB interaction analysis: treatment main effect: F(1, 67) = 8.74, MSE = .02, partial η^2 = .12; treatment by CB interaction: F(1, 67) = 5.21, MSE = .02, partial η^2 = .07]. The difference in hit rates for the critical lists is because participants in the interference group made more source misattributions for items related to the critical lists than the control group [F(1, 67) = 114.14, MSE = .05, partial η^2 = .63; M = .58, SE = .04; M = .004, SE = .04, respectively].

Comparing hits for recovered memories with continuous memories did not reveal an effect of memory type, but there was a treatment main effect [F(1, 52) = 131.78, MSE = .08, partial η^2 = .72; M = .95, SE = .04; M = .32, SE = .04, for control and interference groups respectively]. There was also a treatment by CB interaction [F(1, 52) = 4.78, MSE = .08, partial η^2 = .08] which showed the

difference was larger in CB2 than in CB1 mostly due to differences in the interference groups. As with the list comparison analysis, an analysis of recovered versus continuous source misattributions revealed that the difference appears to be due to increased source monitoring errors for the interference group than the control group, regardless of whether the lists were recovered or continuous [$F(1, 52) = 109.45$, $MSE = .08$, partial $\eta^2 = .68$; $M = .01$, $SE = .04$; $M = .59$, $SE = .04$, for control and interference groups respectively]. False alarms ranged from 12% - 32% but did not vary reliably in any theoretically meaningful way (there was an item effect of approximately 9% as seen in a memory type by CB interaction effect [$F(1, 52) = 5.66$, $MSE = .04$, partial $\eta^2 = .10$]).

Concerning the misinformation lists, the interference group (the control group never attributed misinformation items to the original task) on average made source monitoring errors 65% ($SE = .04$) of the time, hits 30% ($SE = .04$) of the time, and false alarms 14% ($SE = .03$) of the time. Paired t-tests failed to reveal differences between rates of hits, source monitoring errors, and false alarms for the misinformation lists and the recovered critical lists, or the misinformation lists and the recovered control lists.

<div align="center">**Discussion**</div>

Free Recall

 The predicted blocking effect was seen on the free recall test. It was comparable to the blocking effect found by Smith et al. (2003; 28% vs. 34% - averaging their three experiments). As expected, the extra exposure to the control lists conferred an advantage in recall of those lists for the interference

group. Despite the large amount of material learned in a very brief period of time, recall was good. Also, despite the lack of overt implication and the fact that they were entirely new taxonomic categories, misinformation acceptance was high (47%).

Cued Recall

There was considerable recovery shown by the 57% recall rate of critical list items. However, recall rates were significantly lower for the interference group than for the control group. Further inspection revealed that the control group had higher recall rates for both recovered and continuous memories. One could infer that differences in recall rates are due to exposure to interference rather than the process of being blocked and recovered. It is also interesting to note that recovered list correct recall rates are considerably lower in the current experiment than in Smith et al. (2003). This is likely due to the list structure. In Smith et al. the lists were comprised of the most typical members of the categories whereas in the present experiment, the lists ranged in member output dominance. In the Smith et al. study, participants could simply generate the first category members that came to mind and then make a judgment about them. Most members that would be generated would be accurate recall making the judgment process easy. In the present experiments both the processes of generating correct items and of making judgments was more difficult. This difficulty was then exacerbated by the interference treatment. One possible explanation is that the interference tasks may have made interference group participants more aware that typical category members were missing from each list causing a stricter acceptance criterion to be

used by the interference group than the control group. Another possibility is that a stricter criterion was used simply because there was a potential second source for items that had to be excluded by the interference treatment group.

Source Recognition

A limitation of Experiment 1 was that it did not allow for determining whether the observed source monitoring errors resulted from the interference manipulation, or simply the fact that the source test was harder for the interference group. Experiment 2 addressed this issue by including a second source that was independent of the interference manipulation, and that occurred for both treatment conditions. In addition, Experiment 2 used a different list structure in an attempt to increase levels of semantic based false recall.

EXPERIMENT 2

The addition of the second source for items that fit presented categories provided an opportunity for episodic confusion errors to occur for both treatment conditions (control or interference), as well as both memory types (continuous or recovered). That is, episode based errors could occur in all conditions of Experiment 2. The structure of the lists used in Experiment 2 was changed to more closely resemble those used by Smith et al. (2000) and Smith et al. (2001) that reliably produced semantic based errors. The new lists were comprised of high output dominance items, but did not include all of the high output dominance members. The change in list structure was made to increase the instances of semantic confusion errors regardless of treatment and memory type. The large blocking effect is again predicted. The recovery of correct items is expected to be larger than in Experiment 1 because of the change in list structure. The addition of the second source for category members regardless of treatment will allow for a test of the source monitoring framework and fuzzy-trace theory predictions.

Method

Participants

One hundred and forty-three undergraduate student volunteers participated in the experiment. Students received credit toward their research requirements in their introductory psychology courses. Students had multiple options from which to choose.

Materials

 The stimuli were very similar to those of Experiment 1. The same lists were used except that the members were changed to include items with the output dominance rankings of 2-5 and 7-12 (see Table 1). That is, all presented items had high output dominance scores and for each list there were two high (items with output dominance scores of 1 and 6) output dominance items that were not presented. These two items (critical items) were presented in an incidental affect rating task for half of the lists.   The critical items, as well as category members with output dominance scores of 13 and 14 were used as foils in the recognition test. These lists are similar to those used by Smith, et al. (2001) and Smith, et al. (2002) which both reliably produced semantic based false recall. The critical lists were changed from fish, tools, instruments, and flowers, to weapons, tools, sports, and fruit. This change was made because previous studies have found these lists to elicit high levels of false recall (e.g., Smith, et al., 2001; Smith, et al., 2002). Because of these changes, list members were not counterbalanced, however, which lists the critical items used to create episodic confusion errors belonged to was counterbalanced. These items were introduced in a 24 item pleasantness rating task composed of 20 filler items (all common nouns from 3 to 11 letters in length), the highest output dominance item from two critical lists, and the highest output dominance item from two control lists. That is, one counterbalance group saw knife, basketball, sock, and carrot in the pleasantness rating task and the other group saw hammer, orange, truck, and clarinet.

Design & Procedure

The design was a 2 (list type) x 2 (treatment) x 2 (CB) mixed factorial. As in Experiment 1, there were 3 separate memory tests, free recall, cued recall, and source recognition.

Results

Free Recall

The predicted blocking effect was replicated, with 34% fewer critical list names recalled in the interference condition than in the control condition. The interference group again, outperformed the control group on the control lists (9%). A difference between the present experiment and Experiment 1 (as noted in the Experiment 1 results) is that the control group had reliably greater recall of the critical lists than the control lists (Table 6) reaffirming the explanation that this difference is merely an item effect. These effects were revealed by a 2 (List Type) x 2 (Treatment) x 2 (CB) mixed ANOVA on proportion of category names recalled. There was a significant main effect of list type [$F(1, 142) = 43.89$, $MSE = .03$, partial $\eta^2 = .24$] and a significant treatment main effect [$F(1, 142) = 23.84$, $MSE = .04$, partial $\eta^2 = .14$], qualified by an list type by treatment interaction [$F(1, 142) = 113.79$, $MSE = .03$, partial $\eta^2 = .45$]. The ANOVA was followed up with paired t-tests of list type within treatment condition [$t(69) = 2.94$, $SE = .03$ and $t(75) = -12.07$, $SE = .03$, for the control and interference groups respectively].

TABLE 6

Mean proportion of category names recalled by list type and treatment, Experiment 2.

	Item Type	
Treatment	Critical Lists	Control Lists
Interference	.37 (.03)	.72 (.01)
Control	.71 (.03)	.63 (.02)

Note: Standard errors appear in parentheses.

Considered another way, 100% of the participants in the control group recalled at least one critical list (the majority recalled 3), whereas 17% of the participants in the interference treatment failed to recall a single critical category name (the majority only recalled 1). Again, no one in the control group falsely recalled a misinformation list compared to 52% of the participants recalling at least one of the misinformation lists in the interference group, 34% of the misinformation lists were recalled by the interference group overall.

Cued Recall

 As in Experiment 1, multiple analyses were performed on the cued recall data. These analyses are presented in two sets. First, analyses comparing recovered and continuous memories are presented. This is followed by analyses of the treatment collapsing across memory type, but including a comparison of critical and control lists. Within each set of analyses, semantic confusion errors, episodic confusion errors, and correct recall are reported separately.

Recovered vs. Continuous Memories

Comparing recovered and continuous memories within-subjects resulted in some participants being dropped from the analysis as in Experiment 1.

Semantic Confusion Errors

Using proportion of semantic confusion errors as the dependent measure, a 2 (memory type) x 2 (treatment) x 2 (counterbalance) mixed ANOVA revealed a main effect of counterbalance [$F(1, 111) = 9.66$, *MSE* = .04, partial η^2 = .08]. The counterbalance effect shows the same item effect as in the list type analysis. Lists in CB 2 (*M* = .12, *SE* = .02) were more likely to generate semantic confusion errors than those in CB 1 (*M* = .04, *SE* = .02).

Episodic Confusion Errors

The findings concerning episodic confusion errors are somewhat complex. The general finding is that there were more episodic confusion errors in recovered lists than in continuous lists (see Table 7). This can be seen from a 2 (memory type) x 2 (treatment) mixed ANOVA using proportion of episodic confusion errors as the dependent measure [memory type main effect: $F(1, 87) = 6.61$, *MSE* = .24 , partial η^2 = .07; recovered, *M* = .52, *SE* = .05, continuous, *M* = .33, *SE* = .05]. No other effects were significant in this analysis.

The more comprehensive analysis that includes counterbalance along with memory type and treatment using proportion of episodic confusion errors as the dependent measure revealed a counterbalance main effect [$F(1, 85) = 6.62$, *MSE* = .19, partial η^2 = .07], a memory type main effect [$F(1, 85) = 7.11$, *MSE* = .22, partial η^2 = .08], and a memory type by counterbalance by treatment interaction

[$F(1, 85) = 8.57$, *MSE* = .22, partial η^2 = .09]. Simple interaction analyses for each

counterbalance revealed a memory type by treatment interaction in CB 1 [$F(1, 41)$

= 10.72, *MSE* = .20 , partial η^2 = .21], but only a memory type main effect in CB 2

[$F(1, 44) = 4.77$, *MSE* = .23, partial η^2 = .10]. Follow-up paired t-tests in CB 1

revealed more episodic confusion errors in recovered lists than continuous lists in

the interference treatment condition, whereas no difference was found in the

control treatment condition. In CB 2 there were more episodic confusion errors in

recovered lists than in continuous lists regardless of treatment condition. Table 7

shows mean proportion of episodic confusion errors by memory type and

treatment.

TABLE 7

Mean proportion of episodic confusion errors by memory type and treatment.

	Memory Type	
Treatment	Recovered Lists	Continuous Lists
Interference	.63 (.07)	.33 (.06)
Control	.41 (.08)	.32 (.08)

Note: Standard errors appear in parentheses.

Correct Recall

Performing the 2 (memory type) x 2 (treatment) x 2 (CB) mixed ANOVA

using correct recall as the dependent measure revealed a counterbalance main

effect [$F(1, 111) = 4.43$, *MSE* = .03, partial η^2 = .04]. There was greater correct

recall in CB 2 (*M* = .75, *SE* = .02) than in CB 1 (*M* = .70, *SE* = .02). No other effects were significant.

Critical Lists vs. Control Lists

Semantic Confusion Errors

 Using proportion of semantic confusion errors as the dependent measure in a 2 (list type) x 2 (treatment) x 2 (CB) mixed ANOVA revealed significant main effects of list type [$F(1, 142) = 5.31$, *MSE* = .01, partial η^2 = .04] and counterbalance [$F(1, 142) = 8.48$, *MSE* = .03, partial η^2 = .06]. No other effects were significant. The 10% (*SE* = .01) semantic confusion error rate on critical lists was greater than the 7% (*SE* = .01) semantic confusion error rate on the control lists. The counterbalance effect shows that the lists in CB 2 (*M* = .11, *SE* = .01) were more likely to generate semantic confusion errors than those in CB 1 (*M* = .06, *SE* = .01).

Episodic Confusion Errors

 The same analysis for episodic confusion errors revealed a list type main effect [$F(1, 142) = 33.55$, *MSE* = .09, partial η^2 = .19], a treatment main effect [$F(1, 142) = 15.27$, *MSE* = .14, partial η^2 = .10], a list type by treatment interaction [$F(1, 142) = 26.90$, *MSE* = .09, partial η^2 = .16], and a counterbalance by treatment interaction [$F(1, 142) = 6.11$, *MSE* = .14, partial η^2 = .04]. No other effects were significant. The list type by treatment interaction shows that the extra practice on control lists greatly reduced the amount of episodic confusion errors (Table 8). The counterbalance by treatment interaction reflects a larger reduction in episodic confusion errors due to extra practice for CB 1 (28%) than CB 2 (7%).

TABLE 8

Mean proportion of episodic confusion errors by list type and treatment.

	List Type	
Treatment	Critical Lists	Control Lists
Interference	.52 (.04)	.12 (.04)
Control	.50 (.04)	.48 (.04)

Note: Standard errors appear in parentheses.

Correct Recall

 The same analysis using proportion correct recall as the dependent measure revealed a list type main effect [$F(1, 142) = 69.99$, $MSE = .01$, partial $\eta^2 = .33$], a treatment main effect [$F(1, 142) = 28.01$, $MSE = .02$, partial $\eta^2 = .17$], and a list type by treatment interaction [$F(1, 142) = 63.24$, $MSE = .01$, partial $\eta^2 = .31$]. No other effects were significant. The list type by treatment interaction shows the extra practice effect for the control lists in the interference treatment condition (Table 9). Overall, correct recall was good and did not differ (with the exception of the extra practice effect) due to the treatment.

TABLE 9

Mean proportion of correct category members recalled by list type and treatment,
Experiment 2.

	List Type	
Treatment	Critical Lists	Control Lists
Interference	.74 (.01)	.90 (.02)
Control	.73 (.01)	.73 (.02)

Note: Standard errors appear in parentheses.

Source Recognition of Critical List Critical Items

Recovered vs. Continuous Memories

Semantically Based Errors

   False alarms signify semantic based errors on the recognition test because

these items were not presented within the experimental procedure. No significant

effects were found for correct rejections or false alarms by treatment or

counterbalance condition, or as a function of being recovered or continuous.

Overall, there were more correct rejections (M = .63, SE = .03) than false alarms

(M = .37, SE = .03) [$F(1, 64)$ = 16.86, MSE = .29, partial η^2 = .11]. However, it is

clear the task was difficult given the high false alarm rate (any positive response,

regardless of source attribution was considered a false alarm).

Source Monitoring Errors, Hits, & Incorrect Rejections

   Proportions of source monitoring errors, hits, and incorrect rejections for

recovered and continuous memories were also compared using three 2

(treatment) x 2 (counterbalance) x 2 (memory type) mixed ANOVAs. Because not

all participants had recovered and continuous memories some participants were dropped from the analysis.

Source Monitoring Errors

Overall, the proportion of source monitoring errors (i.e., episodically based errors) was greater for recovered memories (M = .71, SE = .08) than for continuous memories (M = .39, SE = .08). Analysis for source monitoring errors revealed a significant main effect of memory type [$F(1, 42)$ = 12.28, MSE = .16, partial η^2 = .23], a significant memory type by counterbalance interaction [$F(1, 42)$ = 5.46, MSE = .16, partial η^2 = .12] and a significant memory type by treatment interaction [$F(1, 42)$ = 4.08, MSE = .16, partial η^2 = .09].   The memory type by CB interaction indicates that the advantage of continuous memories over recovered memories was significant in CB 1 (54% fewer source attribution errors) [$t(15)$=3.42], but not in CB 2 (11% fewer source attribution errors). However, in both counterbalancings there was a lower rate of source monitoring errors for continuous memories than recovered memories. The memory type by treatment interaction shows that the interference treatment greatly increases the source attribution error rate for continuous memories compared to the control treatment (see Table 10). Specifically, there were significantly more source monitoring errors for recovered memories than for continuous memories in the control treatment [$t(18)$=2.69], but source monitoring error rates did not significantly differ in the interference treatment. No other effects were significant.

TABLE 10

Mean proportion of source monitoring errors by memory type and treatment.

	Memory Type	
Treatment	Recovered Lists	Continuous Lists
Interference	.66 (.09)	.53 (.09)
Control	.76 (.13)	.25 (.12)

Note: Standard errors appear in parentheses.

Hits

For hits (correct attribution of critical items to the pleasantness rating task), there was a significant main effect of memory type [$F(1, 42) = 6.15$, $MSE = .11$, partial $\eta^2 = .13$] and a significant memory type by treatment interaction [$F(1, 42) = 4.27$, $MSE = .11$, partial $\eta^2 = .09$]. Following up the interaction with paired t-tests comparing recovered and continuous memories for the control and interference treatments independently revealed that in the control group there were significantly more hits for continuous memories ($M = .48$, $SE = .12$) than for recovered memories ($M = .14$, $SE = .10$) [$t(18)=2.88$]. Hits did not significantly differ across memory types in the interference treatment ($M = .23$, $SE = .09$, continuous memories) and ($M = .20$, $SE = .07$, recovered memories) respectively. No other effects were significant.

Incorrect Rejections

There was a significant memory type by CB interaction for incorrect rejections [$F(1, 42) = 6.96$, $MSE = .11$, partial $\eta^2 = .14$] indicating that the pattern

of incorrect rejections reversed across CBs. In CB1 there were significantly more incorrect rejections for continuous lists (M = .27, SE = .11) than recovered lists(M = .05, SE = .10) [t(15)=2.61], whereas for CB2 they did not significantly differ (M = .13, SE = .08) for continuous lists and (M = .20, SE = .07) for recovered lists.

Critical List Critical Items – (collapsing across memory type)

 Concerning the incidentally presented critical items, proportions of hits, source monitoring errors, and incorrect rejections were compared across counterbalance and treatment conditions using 2 x 2 ANOVAs. No differences were found, all Fs < 1, all partial η^2s < .01. A 2 (treatment) x 2 (counterbalance) x 3 (response type) mixed ANOVA using proportion of responses to critical items as the dependent measure revealed a significant main effect of response type [F(2, 278) = 44.69, MSE = .16, partial η^2 = .24]. Follow-up paired t-tests showed that there were more source monitoring errors (M = .58, SE = .03) than hits (M = .26, SE = .03) [t(142) = 5.97] or incorrect rejections (M = .15, SE = .02) [t(142) = 9.84]. Furthermore, there were more hits than incorrect rejections [t(142) = 2.52]. That is, participants were more likely to make a source monitoring error than a hit, and more likely to make a hit than an incorrect rejection for critical items regardless of treatment condition or counterbalance.

Source Recognition of Control List Critical Items

Treatment Effects – (collapsing across memory type)

Semantically Based Errors

Overall, there were more correct rejections (M = .77, SE = .03) than false alarms (M = .53, SE = .03) [F(1, 139) = 25.90, MSE = .16, partial η^2 = .16].

However, rates of correct rejections and false alarms interacted with treatment and counterbalance [$F(1, 139) = 31.69$, $MSE = .16$, partial $\eta^2 = .19$ and $F(1, 139) = 4.85$, $MSE = .16$, partial $\eta^2 = .03$, respectively]. Simple main effect analyses failed to reveal a difference between correct rejection and false alarm rates for the control treatment group [$F<1$], but did reveal a higher correct rejection rate than false alarm rate for the interference treatment group [$F(1, 72) = 79.64$, $MSE = .12$, partial $\eta^2 = .53$; $M = .83$, $SE = .03$ and $M = .33$, $SE = .04$, respectively]. This is another indicator of the extra practice effect. That is, the interference group participants were less likely to attribute new items to the lists they had been exposed to four times than the control group whom had a single exposure to the lists. The interaction with counterbalance simply reflects a larger difference between correct rejection and false alarm rates in counterbalance 1 than in counterbalance 2.

Episodically Based Errors

A 2 (treatment) x 2 (CB) univariate ANOVA using proportion of source monitoring errors as the dependent measure [$F(1, 136) = 34.67$, $MSE = .13$, partial $\eta^2 = .20$] revealed fewer source monitoring errors for control list critical items (i.e., high output dominant items presented in the pleasantness rating task that fit control lists, but that were not presented with the lists) in the interference treatment group ($M = .29$, $SE = .04$) than in the control treatment group ($M = .64$, $SE = .04$) indicating that the benefit of extra practice on control lists for the interference treatment group continued on the recognition source test.

Hits

The extra practice benefit can also be seen in the same analysis using proportion of hits on control list critical items, treatment main effect [$F(1, 136)$ = 4.50, *MSE* = .12, partial η^2 = .03] (*M* = .40, *SE* = .04 and *M* = .27, *SE* = .04, for the interference and control groups respectively).

Incorrect Rejections

Part of the advantage seen in the lower source monitoring errors may be due to the adoption of a stricter response criterion. Consistent with this explanation there was a treatment main effect running the same analysis on incorrect rejections [$F(1, 136)$ = 19.87, *MSE* = .09, partial η^2 = .13]. The interference treatment group had a higher rate of incorrect rejections (*M* = .32, *SE* = .04) than the control treatment group (*M* = .09, *SE* = .04).

Recovered vs. Continuous Memories

The basic findings involving correct source attribution of the incidentally presented items that match control lists are a greater hit rate for the interference treatment condition (*M* = .23, *SE* = .03) than the control treatment condition (*M* = .14, *SE* = .03) [marginally significant treatment main effect: $F(1, 56)$ = 3.70, *MSE* = .06, partial η^2 = .06, *p* = .060]. Also, there were more source attribution errors for items corresponding to recovered lists (*M* = .30, *SE* = .03) than items related to continuous lists (*M* = .19, *SE* = .03) [significant memory type main effect: $F(1, 56)$ = 15.32, *MSE* = .06, partial η^2 = .22]. However, these effects were found performing a 2 (memory type) x 2 (treatment) mixed ANOVA. The inclusion of the counterbalance factor complicates matters considerably.

The findings concerning incidentally presented items that fit control lists are complex due to memory type by treatment by counterbalance interactions for both hits [$F(1, 54) = 9.77$, $MSE = .04$, partial $\eta^2 = .15$] and source monitoring errors [$F(1, 54) = 5.50$, $MSE = .04$, partial $\eta^2 = .09$]. Simple interaction analyses for the interference and control treatment groups are presented below. A treatment main effect [$F(1, 54) = 6.31$, $MSE = .03$, partial $\eta^2 = .11$] was the only significant effect found for incorrect rejections. The interference group had more incorrect rejections ($M = .10$, $SE = .02$) than the control group ($M = .02$, $SE = .02$).

For the interference treatment group a 2 (memory type) x 2 (CB) mixed ANOVA using proportion of hits as the dependent measure revealed a marginally significant main effect of memory type [$F(1, 28) = 3.48$, $MSE = .06$, partial $\eta^2 = .11$, $p = .073$]. The hit rate was lower for recovered list items ($M = .17$, $SE = .05$) than for continuous list items ($M = .29$, $SE = .05$). The same analysis using source monitoring errors as the dependent measure revealed a significant main effect of memory type [$F(1, 28) = 5.50$, $MSE = .05$, partial $\eta^2 = .16$] with a higher source attribution error rate for recovered list items ($M = .24$, $SE = .05$) than continuous list items ($M = .09$, $SE = .04$). No other effects were significant (including the same analyses for incorrect rejections).

Performing the same 2 (memory type) x 2 (CB) analyses on hit rate for the control group revealed a significant memory type by counterbalance interaction [$F(1, 26) = 14.50$, $MSE = .03$, partial $\eta^2 = .36$]. In CB1 hit rates were lower for recovered list items ($M = .03$, $SE = .04$) than for continuous list items ($M = .18$, $SE = .06$), but in CB 2 the pattern was reversed ($M = .33$, $SE = .06$ and $M = .11$, $SE =$

.08, for recovered and continuous list items respectively). The complementary pattern was seen for source monitoring error rates. For CB1 there were more source attribution errors for recovered list items (M = .45, SE = .04) than for continuous list items (M = .26, SE = .06), but in CB2 recovered list items had a lower source attribution error rate (M = .17, SE = .06) than continuous list items (M = .39, SE = .08). This was a significant interaction [F(1, 26) = 15.79, MSE = .03, partial η^2 = .38]. There were no other significant effects (again including analysis of incorrect rejections).

Discussion

Free Recall

As expected, the large blocking effect (34%) seen in Experiment 1 and Smith et al. (2003) was replicated. The extra-exposure effect (9%) seen in Experiment 1 was also replicated.

Cued Recall

Semantic Confusion Errors

Despite changing the list structure in an attempt to produce more semantic based errors the error rate remained low (8.5%) compared to previous studies (e.g., around 21% in Smith et al., 2001). As is typical in false memory studies some lists produced more false recall than others as seen by the list type and CB effects. However, the rate of semantic confusion errors on critical lists was not affected by either the treatment manipulation or the processes of being blocked and recovered. For control lists, the extra encoding experienced by the

interference group reduced the likelihood of semantic based intrusions relative to the control group.

Episodic Confusion Errors

The finding of primary interest is that there was a higher rate of episodic confusion errors in memory for lists that had been blocked and recovered (52%) than for lists that had been continuously accessible (33%). This effect occurred in both the treatment group and control group indicating that it resulted from the processes of being blocked and recovered rather than from the interference manipulation. However, at least in some instances, the interference treatment exacerbated the effect. The theoretical implications of this finding will be the main topic of the general discussion.

Correct Recall

The result of interest concerning correct recall is that recall rates were high regardless of condition. The recall rates of over 70% in Experiment 2 are more similar to those found by Smith et al. (2003; 69% averaging across condition in their Experiment 1). This is consistent with the interpretation that the guided retrieval and judgment processes were more difficult for the more general categories resulting in a lower (61% averaging across conditions in the current Experiment 1) recovery rates. That is, although taxonomic categories are used in all cases, in Smith et al. (2003) and Experiment 2, these categories are comprised entirely of typical category members whereas in Experiment 1 some presented members were not highly typical. During learning then, participants may have implicitly added the qualifier "typical" to the category names while they

studied in the former cases, but not the latter. This would narrow the search space making the retrieval task easier. Of course extra-exposure should and did enhance recall resulting in the exceptional recall rate of 90% for the control lists by the interference treatment group.

Source Recognition

Semantically Based Errors

There was a striking increase in semantically based errors from the cued recall test (8.5%) to the source recognition test (37%). This can be interpreted to indicate that during cued recall participants were not generating the critical items in the retrieval process rather than generating them and subsequently rejecting them through a decision process. Another explanation is that participants were simply fatigued by the time they performed the source recognition test. Additionally, at least part of this increase may be attributed to a liberal shift in acceptance criteria. Hicks and Marsh (2001) found that false recognition rates for critical items in the DRM paradigm were higher given a source recognition test compared to an old-new recognition test. This difference was primarily driven by a shift in acceptance criterion. This demonstrates that although source decisions are generally thought to be a post-recognition or recall judgment process, the task still influences the old-new decision component of recognition. Despite the increase in error rate, it should be noted that participants were more likely to correctly reject (63%) semantically related foils than to false alarm to them.

Episodically Based Errors

Given a source monitoring test the detrimental effect of blocking and recovery on source errors was increased compared to the cued recall test. This is somewhat inconsistent with previous research that has shown that source recognition tests reduce errors in misinformation studies compared to old-new recognition tests (e.g., Lindsay & Johnson, 1989; Zaragoza & Koshmider, 1989; Zaragoza & Lane, 1994). Of course cued recall differs from recognition in that it includes a retrieval component and much of this increase could be driven by this difference. That is, participants simply may not have generated the critical items during cued recall. However, the liberal shift in acceptance criterion for a source recognition test may also contribute (Hicks & Marsh, 2001). Whereas much of the source confusion effect in cued recall was driven by the interference groups high error rate on recovered lists, the effect is largely due to the control groups high error rate on recovered lists and low error rate on continuously remembered lists (the interference group had high error rates in for both memory types) on the source recognition test.

Correct Recognition

Participants failed to correctly attribute critical items to the pleasantness rating task only most of the time. This was especially true for items corresponding to recovered lists, but also for continuously remembered lists in the interference group. That is, the best performance was by the control group for items corresponding to continuously remembered lists. However, this was still less then 50% accurate.

GENERAL DISCUSSION AND SUMMARY

The major finding of the present study is that the process of blocking and recovery makes a memory more susceptible to source confusions. Whether participants were tested on cued recall or source recognition, they were more likely to claim that incidentally presented items had appeared in an original event (even though they had not) when memory for the original event had been temporarily inaccessible as compared to cases when the original event was continuously remembered. These results have both theoretical and applied implications.

The importance of these errors, however, should be placed in context; correct recall and recognition of presented items from the original event was quite good. For example, in Experiment 2, correct cued recall was over 70% and recognition was over 90% regardless of treatment condition (interference or control) or memory type (recovered or continuous). Additionally, although the materials were designed to elicit semantically based errors, these occurred infrequently and did not vary as a function of memory type. That is, despite the increased proneness of recovered memories to episodic based errors, in some ways recovered memories were shown to be just as accurate as continuous memories.

The results are consistent with the proposed memory blocking mechanism presented in Smith et al. (2003). That is, the prediction of a large blocking effect for the interference group was confirmed on the free recall test and, subsequently providing category names on a cued recall test virtually eliminated the blocking

effect. This is precisely the pattern of results expected if blocking occurs at the level of the category name through output dominance shifting and output interference. The high rate of accurate recall and recognition of category members is also consistent with this blocking mechanism.

Concerning episodic based errors, the most noteworthy finding is the higher error rate for items corresponding to recovered lists relative to continuously remembered lists. This comparison has not been made experimentally in prior research, but may have serious implications for legal issues surrounding the recovered memory debate, and will be covered in detail later in the discussion. The episodic confusion errors revealed on the cued recall tests, though important and interesting, do not separate the predictions of the source monitoring framework and fuzzy-trace theory. Consistent with fuzzy-trace theory source memory was impaired by the interference manipulation. That is, interference disrupts verbatim memory traces which contain source memory. However, the recall instructions did not focus participants on source, and consequently a more automatic and less stringent source attribution process may have been utilized so the source monitoring explanation cannot be ruled out. The source recognition test makes this separation by partially supporting the fuzzy-trace prediction, but not the source monitoring prediction. The incidentally presented items that corresponded to the critical lists were more likely to be attributed to the wrong source (either the initial learning task alone or both the initial learning task and the pleasantness rating task) than to the correct source (the pleasantness rating task only). Because participants were performing a source test they should have used

source memory if it was available, as suggested by the source monitoring framework (Johnson, Hashtroudi, & Lindsay, 1993). In contrast to this prediction, accuracy of memory source attributions was poor. If source information is part of a memory trace that is disrupted by interference, source instructions should not, and did not in the present study, reduce episodic based errors, consistent with fuzzy-trace theory. That is, the disruptive influence of the interference treatment on accurate source attribution was predicted by fuzzy-trace theory (Brainerd & Reyna, 1993). What is unclear is how the theory can account for the impaired performance of the control group on recovered list items. Speculatively, it is possible that the processes of blocking and recovery exacerbate the assumed rapid decay of verbatim memory traces (Brainerd & Reyna, 1996; 1998). Another possibility is that the blocking and recovery processes have a similar consequence as interference.

The prediction that there would be a high rate of semantic confusion errors regardless of treatment condition or memory type was not supported. Given the structure of the lists and the delay between learning and test this is rather surprising. Previous studies (e.g., Smith et al., 2000; Smith et al., 2001) found that nonpresented, category consistent high output dominance items are often falsely recalled, around 18% and 25% respectively (averaging across all experiments and conditions using high output dominance items in which proportion of critical intrusions were reported). Given the longer retention interval in the current experiments it was expected that accurate memory would be diminished making recall more susceptible to semantic intrusions. For example,

Roediger, Watson, McDermott and Gallo (2001) found a negative relationship between accurate recall and false recall in a multiple regression analysis of DRM lists. The greater rate of semantic confusion errors in Experiment 2 relative to Experiment 1 implicates list structure as an important factor in this type of false recall. Specifically, semantic based false recall is unlikely unless the learned lists are predominantly comprised of high output dominance category members. However, even in Experiment 2, the semantic confusion error rate was less than half that found by Smith et al. (2001), indicating that some other factor suppressed semantic based false recall in the present study. It can also be inferred that the low false alarm rate in recall is partly due to the retrieval component of recall. That is, the semantic lures are not being retrieved and rejected during recall, but simply are not retrieved. This inference is based on the considerably higher semantic based error rate on the source recognition test (ranging from 12% to 32% across all conditions of both experiments) that eliminates retrieval and leaves only a decision process. Another explanation for this increase (or perhaps a contributing factor) is the liberal criterion shift on source tests first reported by Hicks and Marsh (2001).

Applied Implications

Before addressing the clinical and legal applications of the present findings it should be made clear that despite the reported memory errors, accurate recovered memories were commonly observed in the present experiments and in prior research (Smith et al., 2003). The current findings show that recovered and continuous memories are similar in many respects. What is also shown,

however, is that extra care should be taken in evaluating the source of details within recovered memories when there are important consequences concerning memory source.

Regardless of the theoretical mechanism, behind the observed deficit in source monitoring ability for items related to recovered memories, those who argue that recovered memories provide an accurate portrayal of an original episode should be concerned. In many of the legal cases involving recovered memories there is a lengthy interval between the original event and the time of recovery. During this interval the rememberer is likely to have been exposed to a multitude of information related to the recovered event (Loftus, 1993). Prior research has shown that exposure to related material between the original event and a memory test may produce errors. This occurs when the exposure is incidental (e.g., Allen & Lindsay, 1998; Gerkens, Pierce, & Smith, unpublished manuscript), or presented within the context of the original event (e.g., Loftus, Miller, & Burns, 1978; Mitchell & Zaragoza, 1996; Zaragoza & Lane, 1994). Findings of studies like those listed above have already brought considerable scrutiny of eyewitness testimony. The findings of the present study demonstrate that there is an even greater chance these types of errors can occur in cases of recovered memories. As a result, in legal settings where the content of these memories is likely to have serious implications, and if accepted as accurate, extensive consequences, it is important that all parties are aware of the potential for fallibility.

In many cases memories are claimed to have been recovered in therapy (e.g., Lindsay & Read, 1994; Loftus, 1993). The current findings in conjunction with previous research should inform therapeutic practices concerning "memory work" (techniques used to help clients recover more details from memory). Specifically, it has been demonstrated that the implantation of an entire event is possible within a couple experimental sessions (Hyman & Billings, 1998; Hyman, Husband, & Billings, 1995; Hyman & Pentland, 1996; Loftus & Ketchem, 1995; Loftus & Pickrell, 1995). Furthermore, factors that increased the acceptance of new episodes as memories resemble techniques used by therapists (Hyman & Pentland, 1996). For example, guided imagery, and encouragement from trusted authority have both been used to increase the likelihood of implanting memories. In a therapy session devoted to memory recovery the therapist can be seen as a trusted and encouraging authority. Guided imagery may be one technique used in such a session, or even hypnotic regression. Using experimental sessions that resembled regression, Spanos, Menary, Gabora, DuBreuil, and Dewhirst (1991) identified three factors that contribute to memory distortion. The factors were expectation, intensity of recovered memory, and authority endorsement, all of which are likely to occur in a memory work therapy session. Given the current findings that recovered memories are more susceptible to source confusions, e.g., visualizing something in therapy versus the original event, therapists need to take even greater care in evaluating recovered memories.

The effects seen in the current study, and many other studies involving false memories, occurred for innocuous materials. A major issue in the recovered

memory debate is the effect of emotion on memory. It is clear that the role of emotion in memory needs to be investigated further. However, there are several reasons to expect that recovered memory for emotional events (e.g., childhood sexual abuse) is similar to recovered memory for non-emotional events.

First, in some cases an event that is emotional at recovery may not have been encoded as an emotional event. That is, although a child being sexually abused may find the episode peculiar and uncomfortable, if the abuser is a trusted adult they may not realize what is occurring is wrong. This does not apply to all cases of childhood sexual abuse, but in cases it does apply, the event would be encoded and stored like other non-emotional memories.

Second, although not traumatic, studies of flashbulb memories have shown that these vivid and seemingly accurate memories for emotional events are just as prone to distortion as memories for non-emotional events if tested after 32 months (e.g., Neisser & Harsch, 1993; Schmolck, Buffalo, & Squire, 2000). That is, phenomenologically participants experience these memories as vivid and accurate, but they do not correspond with initial reports of the events.

Third, current understanding of the neurophysiology of memory (gained primarily through non-human animal studies) does not support the notion that there is a special memory system for emotional memories. Instead, emotion appears to modulate which of two regularly used memory systems is primarily used to encode an event (Packard & Cahill, 2001; Poldrack & Packard, 2003). That is, there is a hippocampal based system implicated in declarative memory and a caudate putamen based system active during stimulus-response learning.

Stress appears to result in preferential use of the caudate system and impairs performance on tests reliant on the hippocampal system (Kim, Lee, Han, & Packard, 2001). The hippocampus has also been implicated in consolidation of episodic memory in humans (Squire & Zola, 1998). Contrary to the claim that traumatic events produce an indelible memory of the episode, one may infer from the neurophysiological evidence that stress impairs episodic encoding and increases the likelihood that the event will be encoded using the stimulus-response system. As such, it is possible that a declarative style recollection of a traumatic event may utilize more constructive processes than recall of non-emotional events. This is consistent with studies that show that memory of stressful situations often produce strong memories of a central detail (e.g., the stimulus), but poor memory of peripheral details (e.g., the context of the event; Lindberg, Jones, McComas Collard, & Thomas, 2001). This effect is often presented as weapon focus, wherein an individual that experiences a threatening event involving a weapon has difficulty remembering things other than the weapon (e.g., Loftus, Loftus, & Messo, 1987).

Of course the role of emotion in recovered memories needs to be investigated further and more directly if possible, but this does not mean that studies using non-emotional materials should not be used to inform clinical and legal practices. In addition to emotion, several other aspects of recovered memories should be investigated. These factors include the effects of the length of delay, distinctiveness of material, complexity of material, expectations, how well the initially blocked item fits the schema of the event, and the circumstances

of the retrieval episode. Although much of the discussion has focused on the possibilities of distortion of recovered memories, it is important to remember that correct recall and semantic based error rates were similar for recovered and continuous memories in the present study. In sum, despite the finding that recovered memories are more prone to episodically based errors than continuous memories, in some ways recovered memories appear to be very similar to continuous memories.

Summary

The present experiments demonstrate a laboratory version of memory blocking and recovery. Blocked memories were of particular taxonomic categorized lists that participants were unable to recall when given a free recall test for presented categorized lists. Prior research suggests that when participants are unable to recall category names after learning categorized lists, they are also unable to recall members of those categories (e.g., Smith et al., 2003; Tulving & Pearlstone, 1966). That is, regardless of whether participants are asked to recall names of categorized lists or list members, the number of categorized lists recalled is equivalent. It was found that the accuracy of the details of these subsequently recovered memories (i.e., categorized lists for which members could be given when the category name was provided as a cue) was similar to that of categorized lists continuously recalled (i.e., recalled on both tests) in two ways. First, correct recall did not vary as a function of memory type. Second, the number of semantically based errors was low and equivalent across memory type. However, it was also found that recovered memories are more

susceptible to episodic based errors than continuous memories. That is, category members presented in an incidental task were more likely to be incorrectly attributed to the original list learning session if the categorized list to which they corresponded had previously been blocked and subsequently recovered than if it had been continuously available to memory. It appears that the processes of blocking and recovery have detrimental affect on source memory, but not on memory for items.

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