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An Assessment of Cross-Category Inhibition Following Within-Category Similarity Encoding

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AN ASSESSMENT OF CROSS-CATEGORY INHIBITION FOLLOWING WITHIN-CATEGORY SIMILARITY ENCODING

by

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Dedication

I would like to dedicate this research to my parents, Paul and Joan Ladny, for they have helped make furthering my education possible.

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Abstract

Current research in the field of forgetting indicates that interference arises during recall due to competition between memories. To reduce interference an inhibitory mechanism impairs the undesired interfering memories so that the desired memory can be retrieved. This phenomenon is known as the theory of retrieval-induced forgetting (RIF; Anderson, 2003). The current study proposed to demonstrate a dissociation between the RIF effect and cross-category inhibition during recall and recognition through explicitly instructing participants to study similar exemplars together (Anderson, Green, & McCulloch, 2000). Use of the similar-study strategy attenuated RIF, whereas an individual-study strategy facilitated the effect. However, no difference between study strategies was observed for cross-category inhibition. Results of this study hold implications for the sometimes transient nature of RIF.

Introduction

Forgetting is the inability to recover information stored in memory through the process of either recall or recognition (Smith & Kosslyn, 2007). A greater understanding of the mechanics behind this phenomenon can have a significant impact on the assessment and improvement of memory functioning in clinical and normal populations. Current research in the field of forgetting indicates that remembering certain memories can inhibit the ability to recall other similar memories (Bajo, Gómez-Ariza, Fernandez, & Marful, 2006; MacLeod & Saunders, 2005; Nestor, Piech, Allen, Niznikiewicz, Shenton, & McCarley, 2005). For example, retrieving the memory for the year World War I began (i.e., 1914) could cause potential forgetting for the year America entered World War II (i.e., 1941). The similarity of the dates can lead to retrieval competition that requires selective-memory inhibitory mechanisms to resolve the competition. The inhibitory mechanisms indirectly operate to reduce the uncertainty and confusion that accompanies memory loss by impairing similar memories interfering with the retrieval of the single desired memory (Anderson, 2003; Anderson, Bjork, & Bjork, 1994).

Through understanding the mechanics behind inhibitory mechanisms of forgetting it becomes possible to develop study strategies that reduce interference and permit greater retrieval access to similar memories that would otherwise become impaired. For example, grouping items based on similarity, integration, or other forms of mnemonic techniques, permit a person to retrieve a larger number of similar memories than if they had not used a study strategy designed to reduce similar-memory interference (Anderson, Green, & McCulloch, 2000; Smith & Hunt, 2000). Strategies such as these are used everyday to help remember grocery lists, character's lines, students' names, and telephone numbers. As a result, not only is it important to know how memory impairment occurs, but it is important to know how the use of study-strategy can reduce impairment.

Theories on the Mechanism of Forgetting

It is unequivocal that the passage of time negatively correlates with the ability to retrieve previously learned information (see Jobe, Tourangeau, & Smith, 2000). Time itself, however, is not a cognitive mechanism. The processes operating across time that influence retrieval fall into one of three categories: 1) change in the type of processes used between study and retrieval, 2) decay, and 3) interference. A change in information processing is based on the encoding specificity hypothesis that attributes forgetting to a mismatch between the strategy used to study information and the strategy used to retrieve information (Tulving & Thompson, 1973). Generally, a mismatch of strategies leads to a mismatch between study and retrieval cues that subsequently lead to forgetting. For example, if the category-exemplar TOOL FILE were to be studied orthographically (i.e., all the letters are capitalized), but were to be retrieved semantically (i.e., a FILE is a TOOL used to smooth rough edges), then the encoding cue 'capitalize' would not be a part of the retrieval cue set because the capitalization of the letters in TOOL are an orthographic feature of the word rather than semantic. On the other hand, early theories on the nature of forgetting emphasized decay of the memories and treated forgetting as a passive process occurring over time due to physiological decay (Fuchs & Melton, 1974; Hellyer, 1962; Murdock, 1961; Peterson & Peterson, 1959). Nevertheless, modern interference-based theories of forgetting no longer support decay hypotheses as reasons for daily forgetting (Duncan & Lewandowsky, 2005; Lewandowsky, Duncan, & Brown, 2004). Rather, current theorizing places more emphasis on active processes that are a result of interference between learning, storage, or retrieval. The current study is designed to examine the effects of interference that arise during retrieval processing.

Three components are involved in the process of memory retrieval: a retrieval-cue, an association, and a target-memory (McGeoch, 1932). For example, relating back to previous information that 'World War II began in 1941', *World War* II would serve as the retrieval-cue that initiates the search for *1941* (the target-memory). *Began* then serves to define the association (i.e., the relationship) between the retrieval-cue and target-memory, so that the statement concludes 'World War I *began* in 1941' rather than it *continued through* or *ended* in that year. Forgetting will occur if any one of the components is not accessible during the retrieval process.

Theories Emphasizing Inappropriate Retrieval Cues

Theories of forgetting that do no accredit retrieval failure to the active suppression of undesired memories, generally reflect retrieval-cue biases (Anderson & Bjork, 1994) that are explained in terms of the encoding-specificity hypothesis (Tulving & Thompson, 1973). Sometimes a person may be unable to retrieve a memory because the cues used at retrieval do not match the cues used when the memory was encoded. Since the current study only examines retrieval processing, the extent of the discussion about the encoding-specificity hypothesis will be limited to the bias (i.e., a change in strategy) that occurs to a cue during retrieval. For example, retrieving memories such as *baseball, football, and basketball*, can bias the semantic meaning of the retrieval-cue *sport* to associate only with games that are played using a ball (e.g., swimming would not be subsequently retrieved as a sport). Changes in retrieval strategy may occur not only because the meaning of word has become biased, but may also result from changes in context (Anderson & Bjork, 1994). If in the physical context of a sports arena, it is likely that sports played there will be recalled before a sport such as skeet shooting. Godden and Baddeley (1975) demonstrated the effects of environmental change between study and recall by having two groups of divers memorize dive tables either on land or underwater. Results showed that a context-congruent environment during learning and test led to greater recall than when a change in context took place between encoding and recall, demonstrating the effect of context bias.

Interference Theories

The core assumption of interference-based theories of forgetting is that memory loss is a result of impedimentary competition between the target-memory and similar undesired memories. Two factors determining the amount of competition causing the interference are the formation of more recent and thus more easily recalled associations, and the similar features that the memories themselves share. In order to eliminate interference, a mechanism must operate on the undesired memory or on the association between the undesired memory and retrieval-cue to enable retrieval of the target-memory (See Figure 1). Interference arising from competition at the retrieval-cue itself is not possible since the cue serves as the initiator for memory retrieval. Ironically, the mechanism that allows for successful retrieval is also responsible for subsequent retrieval failure, since interfering similar memories become impaired during retrieval of the target memory (Anderson, Bjork, & Bjork, 2000). Therefore, although a memory may be impaired because initially it is not the target memory, the memory might later be the target memory yet will have been previously impaired, thus forgotten.

Association-Strength Theories

Three primary theories propose impairment due to changes in association-strength: occlusion, resource diffusion, and associative decrement. The theories are based on the assumption that impairment of an undesired memory should only occur if the association between the retrieval-cue and target-memory is practiced. That is, impairment of the undesired

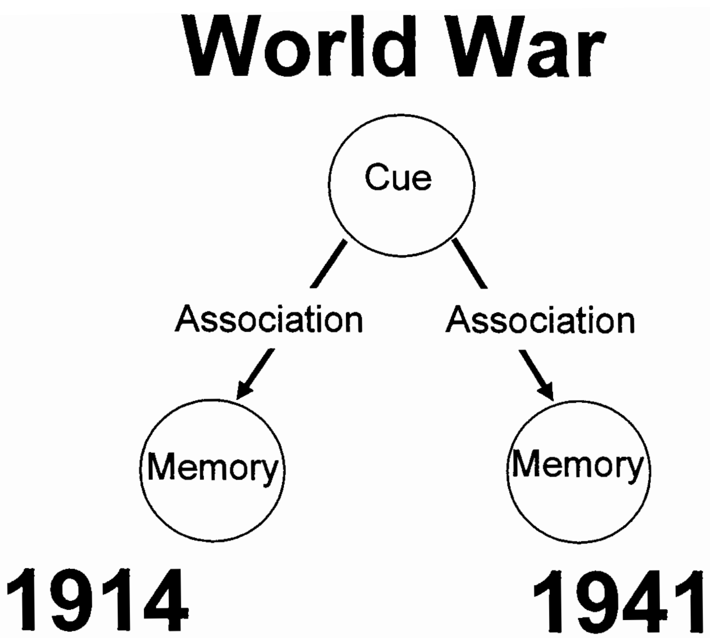


Figure 1. Forgetting of 1941 can result from a change in cue meaning (e.g., end of the World Wars), change in association (e.g., World War – 1941 is impaired), or memory impairment (i.e., inhibition of 1941).

memory relies upon the successful retrieval and subsequent increased strength of the association between the retrieval-cue and the desired target-memory. Therefore, experimental paradigms that rely on retrieval practice, due so in order to introduce interference, which alters the memory associations leading to new forms of impairment.

Occlusion refers to the blocked retrieval of a target-memory from a retrieval-cue, due to the formation of a new association between the cue and another memory. The formation or reformation of a new memory eliminates the old association between the retrieval-cue and previous target-memory. The theory as it stands, however, has the problem of explaining how retrieval of previous target-memories is still possible, as it does not permit a means for unblocking of the previous target memories (Anderson, 1983; Raaijmakers & Shiffrin, 1981). For example, the category *sport* is associated with *baseball.* If *sport – hockey* were to be learned, then according to occlusion theory the association between *sport – baseball* would be blocked and forgotten. That is, only *hockey* would be retrieved as a type of *sport,* yet normal recall assures us that we are still able to retrieve *baseball*. Therefore, there exists the need for the formation of multiple associations between a retrieval-cue and potential target-memories to account for the subsequent retrieval of temporarily undesired target-memories. Additionally, a mechanism is needed to control for interference that will arise between the multiple associations as they compete for access during the retrieval process.

Resource diffusion theory fulfills both of the requirements just mentioned (Melton & Irwin, 1940). Multiple associations are permitted between retrieval-cue and potential target-memories, and a weighting process that affects the association-strength of the individual associations mitigates interference. Therefore, old associations are not destroyed, and the retrieval of previous target-memories remains possible. According to the theory, the total associative-strength capacity for a retrieval-cue is limited and divided across associations, which forces an upper and lower bound on an association's weight (Mensink & Raaijmakers, 1988). For example, using the same set of category-exemplar pairs, the category *sport* has a hypothetical total associative-strength capacity of 100, *sport-baseball* has an initial association weight of 60, and *sport-hockey* has an association weight of 40 (weights are theoretically derived from memory salience and prior retrieval rate). At this point, *baseball* will be the target-memory recalled since its association weight of 60 is greater than *hockey*'s association weight of 40. However, the next time *sport-hockey* is retrieved, its association weight will increase to 60, and *sport-baseball*'s association weight will decrease to 40. Now, *hockey* will be the target-memory that is recalled, even though both *baseball* and *hockey* were dominant target-memories for the retrieval-cue *sport* at a prior point. The addition of a weighting process and multiple associations to the theory allows for the preservation of previously formed memory associations despite lost dominant-association status to specific retrieval-cues.

Finally, associate decrement theory is similar to the theories of occlusion and resource diffusion, except the limited associative-strength capacity restriction for the retrieval-cue no longer exists, and decrements in association-strength for individual associations occur only if there is interference, unlike resource diffusion theory where decrements are unconditional (Melton & Irwin, 1940). Continuing with the previous category-exemplar pairs example, if the pair *sport-hockey* has an association-strength of 60 and the target-memory *hockey* is recalled, then its association-strength will increase to 80, and *sport-baseball*'s association-strength will remain at 40. However, should the memory *baseball* have produced interference when *hockey* was the target-memory, then *sport-baseball*'s association-strength would be decremented to 20 and *sport-hockey*'s association-strength would still be incremented to 80. The key difference from previous interference theories is that decrements in association-strength only result when there is direct interference between competing memories during recall. Therefore, the anniversary date between you and your significant other will only be impaired if perhaps you were trying to retrieve your in-laws' anniversary date, but impairment of your anniversary date would not likely result from trying to remember your mother-in-law's birthday.

Executive-Control Theories

Two additional interference-based theories of forgetting help to explain retrieval failure; search termination (Raaijmakers & Shiffrin, 1981) and reporting bias (Tulving & Thomson, 1973). Unlike the previous theories that attributed forgetting to a primarily unconscious mechanism, search termination and reporting bias are processes consciously controlled by the central executive system of working memory (Baddeley, 2003), a metacognitive phenomenon. They do not lead to impairment, but are decisions made by a person to end the retrieval process. Search termination occurs when a person stops trying to recall a desired target-memory after experiencing the feeling of being unable to find the memory after searching for a subjective length of time. Similarly, reporting bias is the inability to distinguish a desired target-memory from an array of similar memories, which results in the subjective feeling and subsequent report of forgetting.

The Inhibitory Retrieval-Induced Forgetting Theory

The retrieval-induced forgetting (RIF) theory differs from the previous theories that explain retrieval failure in terms of retrieval-cue bias and association-weighting, by attributing the source of forgetting to the target-memories themselves (Anderson & Bjork, 1994). Relating back to our previous category-exemplar example of *sport-baseball;* the memory for *baseball* is believed to become impaired and not the association between *sport* and *baseball* or the type of games thought of as *sports.* Additionally, the mechanism operating to impair similar target-memories (e.g., *hockey*) to overcome interference is hypothesized as inhibitory (i.e., analogous to weighting decrements).

Evidence supporting the existence of an inhibitory mechanism has been observed in physiological and behavioral studies of attention. For example, a lateral inhibition process is shown to exist that suppresses the excitation of parallel neurons during activation, so that selective attention can be made possible (Walley & Weiden, 1973). Behavioral evidence comes from stroop-task studies where participants are shown words denoting colors that are themselves depicted in different hues. The participants are then told they must name the hue they see and not the lexical-color word. This task requires selective attention to the hue of the word while inhibiting the impulse to read the printed word. Completion of the stroop-task is accounted for by the operation of inhibitory mechanisms of attention (Houghton & Tipper, 1996, Reynolds, Chelazzi, & Desimone, 1999).

The retrieval-practice paradigm (RPP). Anderson et al. (1994) developed the retrieval-practice paradigm to test for interference effects between word sets during retrieval, where forgetting was based on an association-strength model. Similar paradigms (e.g., the A-B-A-D and part-set cuing paradigms) were designed to test more broadly for the effects of interference itself. Anderson and colleagues however, were interested in the effects that repetitive retrieval of less-often recalled target-memories (i.e., weaker memories) have on the later recall of more-often recalled memories (i.e., stronger memories), a narrower observation of memory competition leading to interference. The RPP consists of four separate phases (see Figure 2). The first phase is a learning phase, in which participants memorize a series of category-exemplar pairs such as FLY KITE, FLY BUTTERFLY. This phase is immediately followed by a retrieval-practice

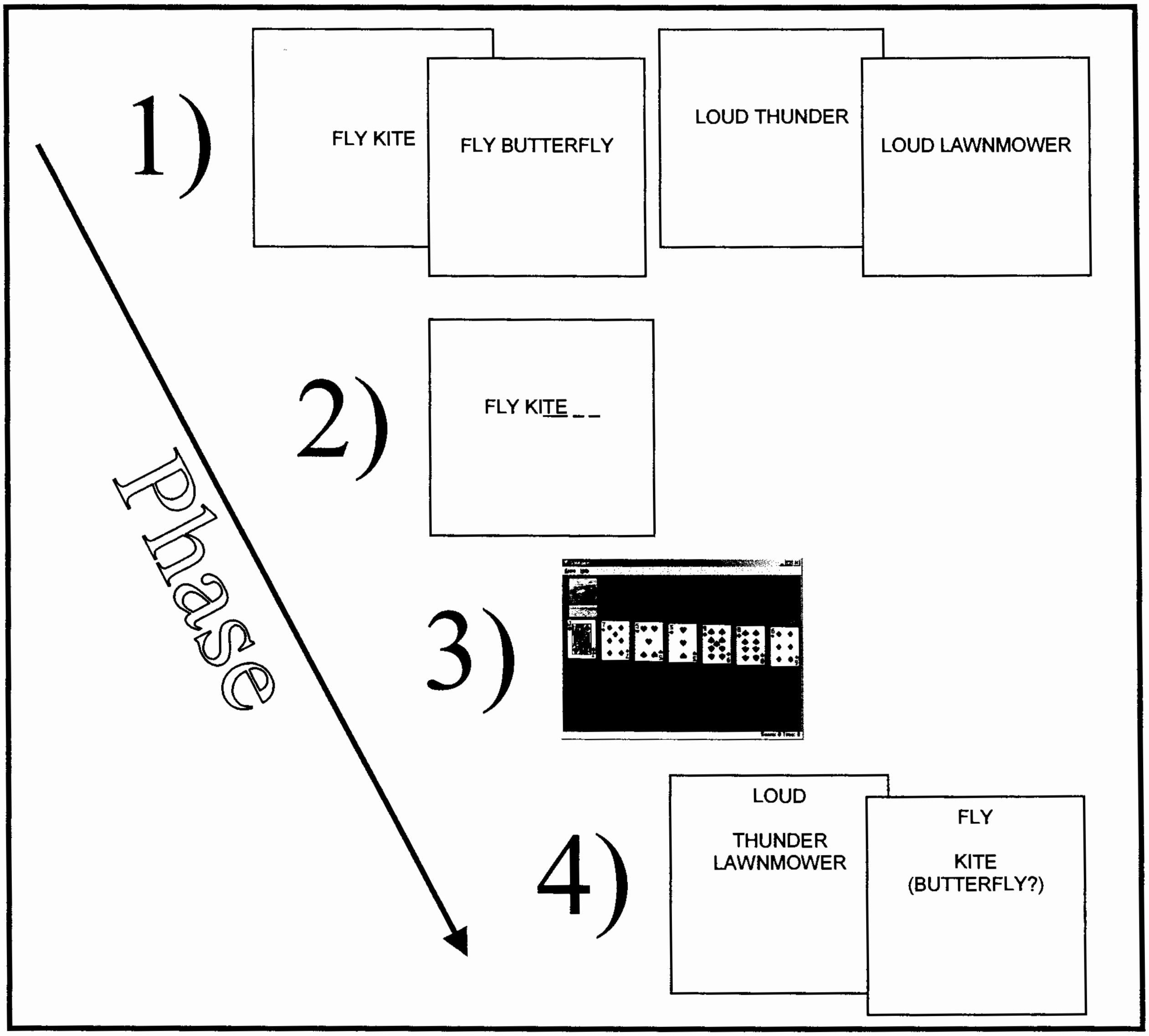


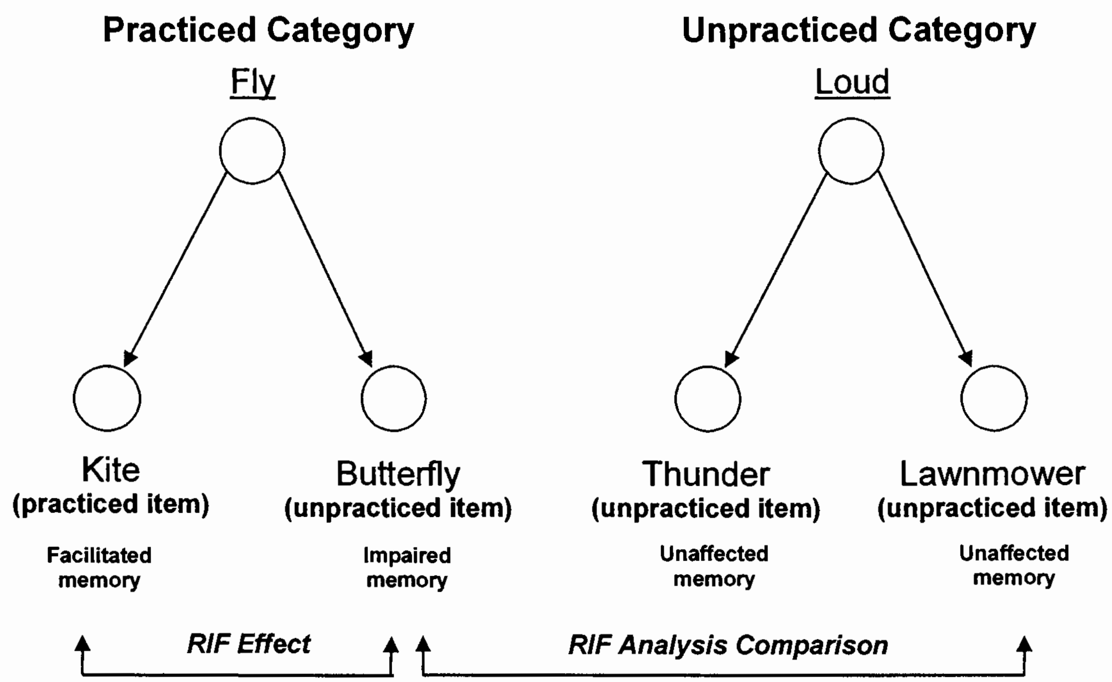
Figure 2. The standard retrieval-practice paradigm consists of four phases: 1) study of category-exemplar pairs; 2) retrieval-practice using stem-completion; 3) distracter task (e.g., solitaire); 4) category-cued recall (*Note:* The recognition phase of Experiments 2 and 3 is not pictured, but immediately follows the recall phase).

phase, in which participants practice retrieving a subset of the exemplar portion of the pairs using a stem-completion task (e.g., FLY KI_ _ _). A distracter phase then follows to ensure participants are unable to mentally rehearse (i.e., 'thinking aloud') both the studied and retrieved exemplars. Finally, participants complete a test phase in which a category-cued recall test is standard. The test consists of providing participants with the names of the categories sequentially and asking them to recall all previously studied exemplars from each category.

The phenomenon of retrieval-induced forgetting is demonstrated when retrieval practice of a subset of exemplars impairs recall for unpracticed exemplars within the same category. The investigative comparison assessing this impairment is made between the unpracticed exemplars from a practiced category and the unpracticed exemplars from an unpracticed category (see Figure 3A for the locus of RIF and comparison example). RIF is apparent when the unpracticed item from the practiced category is remembered at a lesser rate than the unpracticed item from the unpracticed category. For example, within the category FLY, retrieving the exemplar KITE should later facilitate recall for KITE, but impair recall for the exemplar BUTTERFLY. An important implication is that forgetting cannot be due to retrieval-cue bias because all category-exemplar pairs were learned and recalled at the same time while using the same form of processing. Thus, differences in retrieval processing cannot explain why some exemplars from a category are impaired while others are not. Retrieval practiced items show facilitation during subsequent recall, and unpracticed items within the same category show impairment. Therefore, there is no basis to attribute forgetting to semantic or context biasing of the retrieval-cue. Instead, an effect analogous to a change in association-strength is observed that is similar to resource diffusion theory and the associative decrement theories of forgetting.

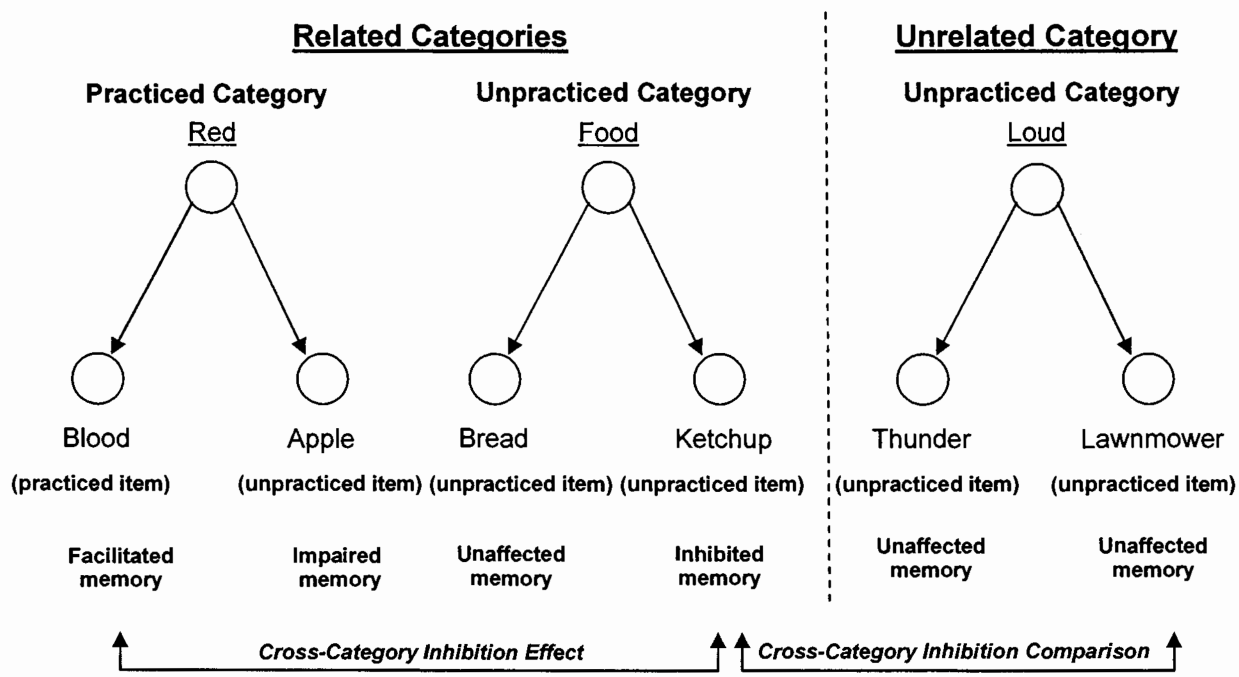
Figure 3. (A) Retrieval practice of a subset of category-exemplar pairs impairs recall for unpracticed exemplars within the same category. For example, retrieval of Kite impairs Butterfly. Since retrieval practice facilitates recall for practiced items and impairs recall for unpracticed items in the same category; recall for Butterfly is compared to recall for Lawnmower, which is not affected by retrieval practice. (B) Retrieval practice of a subset of related category-exemplar pairs impairs recall for unpracticed related-exemplars within a different category. For example, retrieval of Blood impairs Ketchup. Since retrieval practice impairs unpracticed related-exemplars, the comparison to determine an inhibitory effect occurs between unpracticed related-exemplars and unpracticed unrelated-exemplars.

(A)



Practiced Category
Fly
Unpracticed Category
Loud
Kite
(practiced item)
Butterfly
(unpracticed item)
Thunder
(unpracticed item)
Lawnmower
(unpracticed item)
Facilitated memory
Impaired memory
Unaffected memory
Unaffected memory
RIF Effect
RIF Analysis Comparison

(B)



Related Categories
Unrelated Category
Practiced Category
Red
Unpracticed Category
Food
Unpracticed Category
Loud
Blood
Apple
Bread
Ketchup
Thunder
Lawnmower
(practiced item)
(unpracticed item)
(unpracticed item)
(unpracticed item)
(unpracticed item)
(unpracticed item)
Facilitated memory
Impaired memory
Unaffected memory
Inhibited memory
Unaffected memory
Unaffected memory
Cross-Category Inhibition Effect
Cross-Category Inhibition Comparison

Output interference could possibly provide an alternative explanation for the results obtained from the RPP where the presentation of a subset of items from a list causes impaired retrieval for the remaining items on a list. Since the set of retrieval-practice exemplars are the most recently studied items; they are more likely to be recalled during the category-cued recall test than the unpracticed set of items. Using a cued-category-plus-stem recall test identical to the type used during the retrieval practice phase allows individual control over the output order of the studied items. Results from studies that have implemented this type of task during the test phase still demonstrate the RIF effect (Anderson & Bell, 2001; Anderson et al., 1994; Macrae & MacLeod, 2001). Therefore, retrieval-induced forgetting is not due to output interference.

However, RPP boundary conditions and limitations similar to those demonstrated within association theories of impairment have been observed. Studies using the RPP have shown that retrieval practice and not just additional learning exposure during phase one is crucial in eliciting impairment (Bäuml, 2002; Ciranni & Shimamura, 1999). Anderson and Bell (2001) did observe impairment when retrieval practice was replaced with an extra study presentation, but when the authors divided participants into high and low "covert" retrieval-practice groups they no longer observed impairment in the low covert-retrieval-practice group. Thus, the observed impairment may have been the result of participants subjectively performing retrieval-practice during the extra-study presentation.

Furthermore, control-condition retrieval-practice experiments have been performed with practice taking place for unrelated items (Macrae & MacLeod, 2001) and where participants had to try to generate exemplars for category-exemplar-stems that did not have a possible vocabulary response (e.g., FRUIT LY_____; Storm, Bjork, Bjork, & Nestojko, 2006). Impairment was found in the impossible stem-completion condition (Storm, Bjork, Bjork, & Nestojko), but not when the items were categorically unrelated (Macrae & MacLeod). A possible reason for the occurrence of impairment occurred in the "impossible" retrieval-practice condition is that covert retrieval of exemplars that almost fit the category-stem (e.g., LEMON, LIME, LINGONBERRY) was performed while attempting to successfully complete the task. Thus, retrieval-practice is still a key aspect in memory impairment, but retrieval of unstudied related exemplars may be enough to cause forgetting.

Macrae and MacLeod (1999) also explored repetitive retrieval-practice by varying the number of practice-stem presentations by one, three, or six, while holding overall retrieval-practice time constant at 150 seconds. Thus, completion time for single-repetition practice-stems was 30 seconds, three-repetition practice-stems was 10 seconds, and six repetition practice-stems was five seconds. Although a trend towards greater facilitation for practiced items and greater impairment for unpracticed items from practiced categories was observed, there was no significant increase in RIF. Therefore, a greater number of retrieval-practice repetitions does not necessarily cause greater impairment. However, results may have been different if trial time was held constant across conditions, although Bäuml (1996) found no difference in impairment by increasing "covert" retrieval-practice time.

An upper bound of impairment duration has also been observed, although the results are slightly mixed. The original study performed by Anderson and colleagues (1994), and subsequent studies using a slightly modified paradigm (Anderson & Spellman, 1995; Macleod & Saunders, 2005; Nestor et al., 2005; also see Levy & Anderson, 2002) have relied upon a delay ranging from 5 to 20 minutes between retrieval-practice and test. Macleod & Macrae (2001) were the first to specifically test impairment duration. They used the original RPP paradigm and manipulated delay between practice and test by 20 minutes and 24 hours between-participants.

The standard RIF effect was observed in the 20-minute group, but was not observed after 24 hours. On the other hand, Storm, Bjork, Bjork, and Nestojko (2006) found RIF after one week using a modified RPP paradigm with an impossible stem-completion retrieval-practice task (as previously described) and a category-plus-one-letter-stem cued-recall test (e.g., FRUIT O_____). Therefore, under some conditions impairment can last for long periods of time.

The independent-probe technique (IPT). The RPP was designed to examine interference effects from repetitive retrieval practice, whereas the IPT modifies the RPP to test for the locus of impairment. The IPT was designed to clarify whether memory inaccessibility is due to a change in association between the retrieval-cue and memory, or the memory itself. Results using the IPT show that impairment is a product of inhibition of the target memory rather than a decrement in the association (Anderson & Spellman, 1995). Within the modified paradigm, the phases and type of stimuli used remain the same, but some of the exemplars are now semantically cross-categorized (e.g., RED APPLE / FOOD APPLE, RED KETCHUP / FOOD KETCHUP). During retrieval-practice a subset of the category-exemplar pairs are practiced from one related category and one unrelated category. The additional factor of cross-category exemplar-relation separates the standard RPP from the IPT-modified RPP (see Figure 3B). In such designs, impairment effects similar to those related to associative-strength are found, however, cross-category impairment can also be observed between related exemplars. That is, practicing a subset of exemplars in one related category can impair recall of unpracticed exemplars in an unpracticed related-category. Therefore, if the category-exemplar pairs RED APPLE and FOOD KETCHUP were learned, where RED APPLE was from a practiced category and FOOD KETCHUP was from an unpracticed category, an IPT model would predict that

KETCHUP would be less likely to be recalled than an unpracticed-unrelated-pair from an unpracticed category (e.g., LOUD LAWNMOWER).

The standard RPP was shown to eliminate retrieval-cue bias as the possible form of memory impairment, and with the addition of the IPT, the observation of cross-category impairment eliminates associative weighting as the second possible form of impairment. As previously mentioned, association theories of interference state that impairment can only occur if the association between the cue and target-memory is practiced. Anderson & Spellman (1995) demonstrated that unpracticed memories in an unpracticed related-category still suffer impairment, even though no practice had taken place between the cue and memory (e.g., KETCHUP *is* a FOOD is not practiced). Therefore, impairment must be localized to the memories themselves, and not retrieval-cue bias or changes in association-strength. Furthermore, the mechanism of impairment is the result of an inhibitory process since participants demonstrate decreased recall for unpracticed related-memories compared to unpracticed unrelated-memories, thereby showing suppression of competing memories—rather than excitation of the target-memory.

Memory recognition testing. If impairment is a result of memory inhibition, then an effect of impairment should still be observed regardless of whether testing involves recognition or recall. That is, since impairment affects the memories themselves, then visually presenting the initially studied material should still be sufficient to observe an inhibition effect through reduced recognition rates; assuming that inhibition reduces familiarity for the inhibited exemplars. So far however, the results have been mixed (see Table 1 for a summary of results). The RIF effect has been observed in both explicit (i.e., the participant is aware of the nature of the test) and implicit tests (i.e., the participant is not aware of the nature of the test) of recognition memory. It has also

Table 1

Summary of Results from Studies Examining Retrieval-induced Forgetting with Recognition Tests

Type of test	Recognition task	Type of task	Dependent measure	RIF effect
Explicit	Stem-cued completion	Semantic	Recognition Proportions	No[1]
Explicit	Category-stem-cued completion	Semantic	Recognition Proportions	No[1]
Explicit	Category-stem-cued completion	Semantic	Recognition Proportions	Yes[2,3]
Explicit	Category-word-fragment-cued completion	Semantic	Recognition Proportions	No[1]
Explicit	Category-cued with elaboration completion	Semantic	Recognition Proportions	No[4]
Explicit	Old/New item decision	Semantic	Recognition Proportions	Yes[5]
Explicit	Old/New item decision	Semantic	Response Time	Yes[6]
Implicit	Yes/No category verification	Semantic	Response Time	Yes[7]
Implicit	Stem-cued completion	Lexical	Recognition Proportions	No[1,7]
Implicit	Stem-cued completion	Lexical	Recognition Proportions	Yes[8]
Implicit	Nonsense-word identification	Lexical	Response Time	Yes[6]
Implicit	Perceptual word-identification	Perceptual	Response Time	No[7]

References

[1](Butler, Williams, Zacks, & Maki, 2001)
[2](Anderson, Bjork, & Bjork, 1994)
[3](Anderson, Bjork, & Bjork, 2000)
[4](Koutstaal, Schacter, Johnson & Galluccio, 1999)
[5](Hicks & Starns, 2004)
[6](Veling & Knippenberg, 2004)
[7](Perfect, Moulin, Conway, & Perry, 2002)
[8](Anderson & Bell, 2001)

been observed in semantic recognition tasks that require participants to think about the meaning of the stimulus, and in lexical decision tasks that rely upon participants' knowledge of their native language. The effect has also been observed when measuring either response times, or the standard measure of mean proportion of words correctly identified. However, as also can be seen in Table 1, contrary findings have been observed for experiments using the same style of test and task. Therefore, a recognition test following the standard recall test was administered in our Experiments 2 and 3 using an old/new decision task in order to assist in identifying the necessary conditions to observe impairment effects, as well as to examine the durability of impairment.

Strategic encoding and impairment reduction. Memory impairment through interference can be generated by competition among memory targets. As a result, the use of mnemonics or item-integration techniques lead to a decrease in interference; causing elimination of the RIF effect (Anderson & McCulloch, 1999). Mnemonics reduce interference since items come to be associated as a group, rather than perceived as separate items that compete among each other during the retrieval process. In effect, by manipulating participants' study strategies (i.e., so they incorporate exemplars during the first phase of the RPP), the RIF effect is eliminated (Anderson & McCulloch).

Category-exemplar stimuli allow for at least two types of incorporation strategies, categorization and integration (Anderson & McCulloch, 1999; Smith & Hunt, 2000). Categorization occurs when exemplars are similarly grouped to the respective categories in which they belong, for example, studying BLOOD, APPLE, and CHERRY as collectively belonging to the category RED. Integration involves similarly grouping all exemplars regardless of category membership. For example, memorizing studied exemplars by creating a sentence such as the following given by one participant, "The hand GLIDER escaped the CEDAR TREE that was struck by lightning and dripped [*sic*] RED BLOOD by going to PARIS and eating BREAD and CRACKERS amidst LOUD TRAFFIC and had to YELL over [*sic*, capitalization added]." The critical difference in strategies is that categorization groups exemplars within categories, whereas integration groups exemplars across categories. These study strategies may differentially affect RIF and cross-categorization inhibition because the RIF effect is elicited within categories whereas the cross-category inhibition effect is elicited across categories. Therefore, in order to test for a dissociation of impairment between the RIF effect and the cross-category inhibition effect it is necessary to ensure participants only categorize category-exemplars and not integrate them. This is contrary to the standard assumption that participants use an individual-study strategy as illustrated by the instructions given to participants and through the individual presentation of each category-exemplar pair (Anderson & Spellman, 1995; Bäuml & Hartinger, 2002; Butler et al., 2001; Dunn & Spellman, 2003; Williams & Zacks, 2001).

Further suggestions for the possible dissociation come from the two-factor theory of similarity affecting RIF (Anderson, Green et al., 2000). First, as previously mentioned categorization of practiced exemplars and unpracticed exemplars within categories during study eliminates the RIF effect (e.g., BLOOD-APPLE). Second, categorization of unpracticed exemplars within categories facilitates the RIF effect (e.g., APPLE-CHERRY). Therefore, when viewing the effect of cross-category inhibition as a form of higher-order RIF, categorization of a practiced related-category should inhibit an unpracticed related-category, demonstrating a 'higher order' effect of RIF (see Figure 4). That is, since RIF is no longer seen for exemplars within categories, retrieval of exemplars from the practiced category should cause impairment for unpracticed related exemplars in a related category since the unpracticed related exemplars

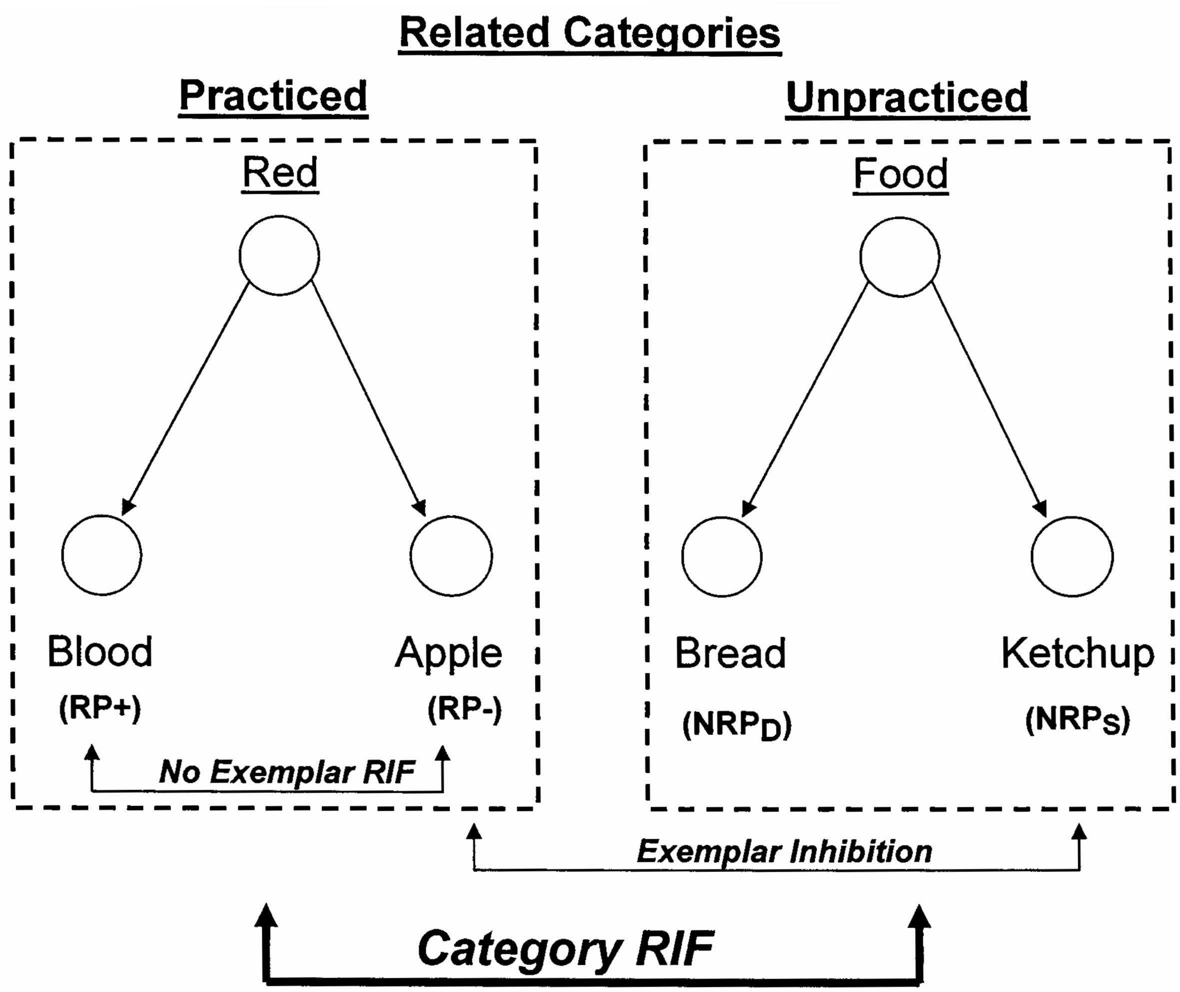


Figure 4. Studying items within categories together based on similarities should produce a higher order RIF effect for the related categories. Cross-category inhibition of exemplars should still be seen, but RIF for exemplars should be eliminated.

are no longer impaired and should be subject to interference. At the same time, categorization should eliminate the RIF effect for exemplars within the practiced category itself thereby demonstrating the dissociation from cross-category inhibition. Therefore, an effect of cross-category inhibition but not RIF would be expected for exemplars, whereas a higher-order effect of RIF would be expected between related categories.

A discovered confound possibly affecting most RIF studies is that participants often perform categorization even without explicit experimenter instruction (Anderson & McCulloch, 1999). The subjective use of these different study strategies may explain why the RIF effect can at times appear transient, and why RIF and cross-category inhibition may not always be observed in results. The purpose of the present study was to examine these possibilities and discover how study-strategy use more specifically affects the observation of RIF and cross-category inhibition. In Experiment 1, we sought to replicate the typical effect of RIF and cross-category inhibition. In Experiment 2, we sought to replicate the dissociation between RIF and cross-category inhibition found in Experiment 1 and see if we could extend these findings to recognition testing. Finally, in Experiment 3 we specifically tested for an effect of higher-order category RIF by manipulating study-strategy instructions, with the hopes of observing cross-category exemplar inhibition without an effect of RIF for exemplars.

Experiment 1

The goal of Experiment 1 was to establish the basic RIF and cross-category inhibition effect using the RPP with the IPT. More specifically, we examined the effects of retrieval-practice on recall for newly formed episodic memories of category-exemplar pairs (e.g., RED BLOOD; see Appendix A for all categories and exemplars), adopting the materials and procedure of Anderson and Spellman (1995, Experiment 1). Participants studied a series of category-exemplar pairs, practiced retrieving a subset of the exemplars, and were then asked to recall all of the exemplars (see Figure 2 for the basic design).

Commensurate with results from previous studies of RIF we expected that first, participants would display a greater ability to remember practiced exemplars than unpracticed exemplars, since retrieval practice is a method of learning and subsequently enhances recall memory. Second, we also expected that participants would more frequently forget unpracticed exemplars from practiced categories than unpracticed words from unpracticed categories. This would be the result of impairment arising from competition between semantically similar exemplars within a category during memory retrieval. Finally, we expected that participants would display a decrease in remembering for unpracticed *similar* (i.e., semantically related) exemplars from an unpracticed category, compared to unpracticed *dissimilar* exemplars from a different unpracticed category. Consistent with theory, we would predict this impairment arises from the competition between semantically similar exemplars *across* related categories, despite that the similar exemplars are members of an unpracticed category. This type of impairment would be demonstrative of memory inhibition and not retrieval-cue bias or association weighting. In general, we would expect that retrieval-practice would cause facilitation for practiced exemplars and memory inhibition for unpracticed similar exemplars, for at least a twenty-minute duration.

Method

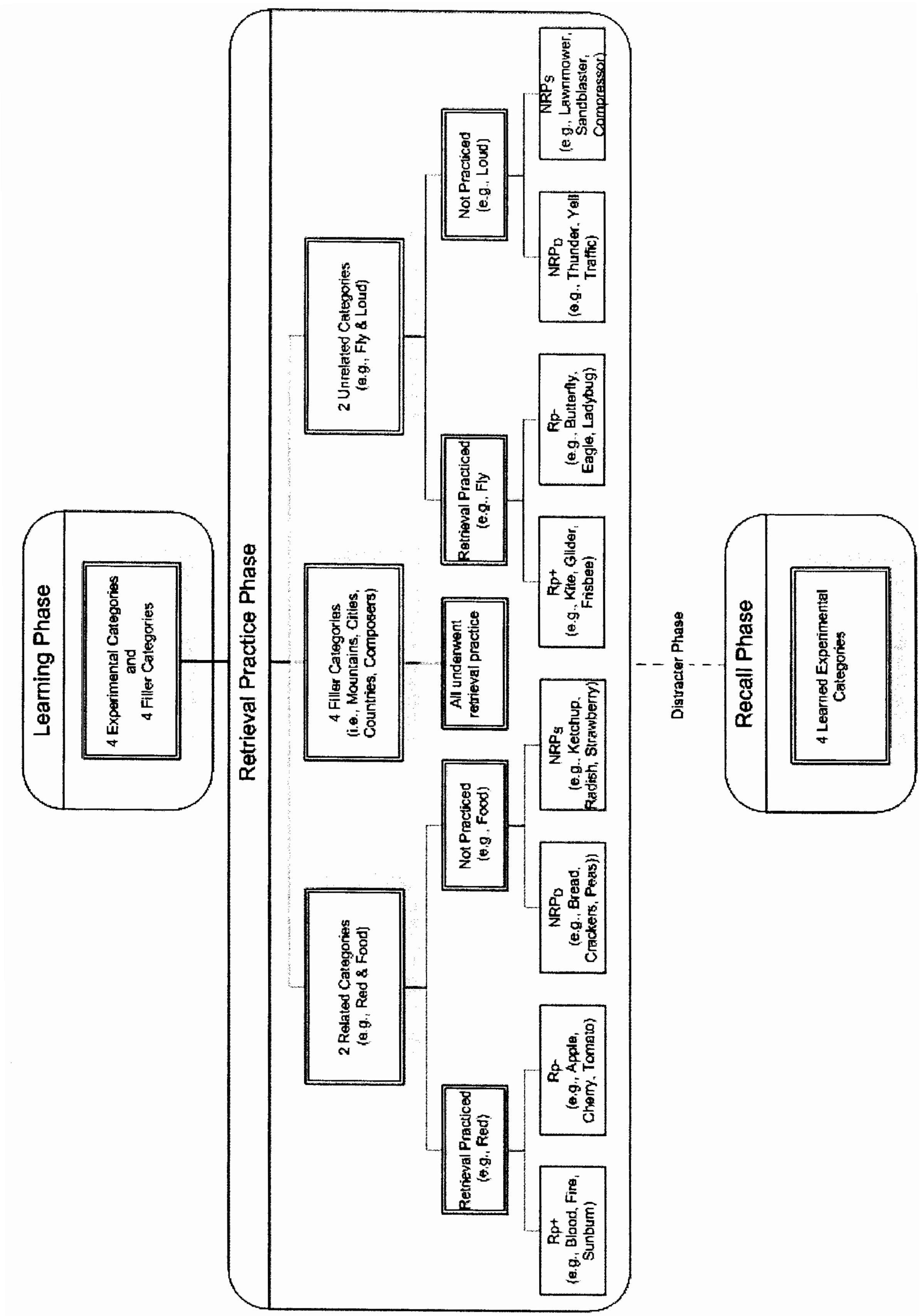
Participants

A total of 41 undergraduate students (aged 18 to 28) from the psychology participant pool at Seton Hall University participated in the study either to fulfill a course requirement or to earn extra credit. Students over the age of 28 were excluded to avoid extraneous variability due to memory decline, which begins in the early twenties (Salthouse, 2003). Additionally, because retrieval practice is necessary for RIF and serves as a measure for the successful encoding of the associates (Anderson, Bjork, & Bjork, 2000, Bäuml, 2002; Ciranni & Shimamura, 1999), participants who failed to get at least two-thirds of the retrieval practice items correct were excluded from the analysis (n = 18), leaving 23 participants.

Design

The experiment design was 2 x 4 within-subjects, with category relation (related vs. unrelated) and retrieval-practice status of exemplars (RP+, RP-, NRP_D, NRP_S) as factors. The dependent measure was the proportion of words correctly recalled and identified at test. See Figure 5 for a depiction of the primary design components of the retrieval practice paradigm. There were six experimental categories, and all categories consisted of six exemplars. Appendix A provides a list of all categories and exemplars that were used. In the related condition, three exemplars from each of two categories were semantically similar across the two categories; the remaining exemplars were semantically related only to their respective category. In the dissimilar condition, all exemplars were related to only their respective category. The

Figure 5. Participants learn 8 categories with 6 exemplars each. Perform retrieval practice on one related category, one unrelated category, and all filler categories. Complete a distractor task. Then, participants complete a cued-recall test of all four experimental categories. (*Note:* the recognition phase of Experiments 2 and 3 is not pictured, but immediately follows the recall phase).


Learning Phase
4 Experimental Categories and 4 Filler Categories
Retrieval Practice Phase
2 Related Categories (e.g., Red & Food)
4 Filler Categories (i.e., Mountains, Cities, Countries, Composers)
2 Unrelated Categories (e.g., Fly & Loud)
Retrieval Practiced (e.g., Red)
Not Practiced (e.g., Food)
All underwent retrieval practice
Retrieval Practiced (e.g., Fly)
Not Practiced (e.g., Loud)
Rp+ (e.g., Blood, Fire, Sunburn)
Rp- (e.g., Apple, Cherry, Tomato)
NRPD (e.g., Bread, Crackers, Peas))
NRPS (e.g., Ketchup, Radish, Strawberry)
Rp+ (e.g., Kite, Glider, Frisbee)
Rp- (e.g., Butterfly, Eagle, Ladybug)
NRPD (e.g., Thunder, Yell Traffic)
NRPS (e.g., Lawnmower, Sandblaster, Compressor)
Distracter Phase
Recall Phase
4 Learned Experimental Categories

manipulation took place during the learning phase when participants were presented with two related and two unrelated categories.

To create the second factor, retrieval-practice status of exemplars, exemplars from the retrieval practice (RP) categories (four of the six experimental categories were randomly chosen per participant, two of which became RP categories) were equally divided so that half of the exemplars were practiced by the participant (RP+ items), and the other half were not (RP- items). See Appendix B for a representation of exemplars that received retrieval practice. None of the exemplars from the categories that did not receive retrieval-practice (NRP categories) were practiced (i.e., NRP_D and NRP_S items; $_D$ refers to dissimilar or unrelated and $_S$ refers to similar or related).

RP+ items and NRP_D items were semantically related to only their respective RP and NRP categories. In the similar category condition, RP- items and NRP_S items were semantically related to both their respective RP and NRP categories. That is, they could be cross-categorized such that the exemplar APPLE could have been categorized with either FOOD or RED. However, in the dissimilar category condition, the RP- and NRP_S items were representative only of their respective categories, such that there was only one category to which they were associated, such as RED BLOOD.

Materials

Categories. Category-exemplar pairs were adopted from Anderson and Spellman (1995, Experiment 1), which were created from several published norms of participants' familiarity with examples of category membership (Battig & Montague, 1969; Marshall & Cofer, 1970; Shapiro & Palermo, 1970; see Overschelde, Rawson, & Dunlosky, 2004 demonstrating generational stability). There were ten categories: six experimental (i.e., analysis was performed for recall of exemplars from these categories) and four filler (i.e., recall was not performed for these categories). The six experimental categories were grouped into three pairs of related categories, in which half of the exemplars from each category could be cross-categorized. However, each category was counterbalanced to be presented equally often in the related and unrelated conditions. Unrelated category pairs were formed by choosing categories across different related pairings. The filler categories were used to control for primacy and recency effects in learning (i.e., first studied items and last studied items are more likely to be remembered than those in the middle of a list; Baddeley & Hull, 1979; Healy, Havas, & Parker, 2000), and for maintaining separation of experimental pairs during the counterbalancing.

Learning Item Sets. A sample of two learning sets with exchanged similar-exemplars (for counterbalancing purposes) appears in Table B1. In total, there were six learning sets made up of eight categories; two related, two unrelated, and four filler categories. All six exemplars from each category were presented to the right of their respective category titles (e.g., LOUD YELL) to create the pairings. The six sets were derived from the three pairs of related categories, with similar exemplars exchanged between categories (e.g., RED KETCHUP and FOOD KETCHUP were study items interchanged between-subjects).

The presentation sequence of the pairings was generated pseudo-randomly with the following restrictions: First, the exemplars from the same category did not appear adjacently (e.g., RED BLOOD, RED TOMATO was a prohibited construction). Second, exemplars from related categories did not appear adjacently (e.g., RED KETCHUP, FOOD RADISH was a prohibited construction). Finally, exemplars from unrelated categories did not appear adjacently more than once (e.g., FLY KITE, LOUD THUNDER, FLY GLIDER was a prohibited construction because FLY and LOUD were categories in the unrelated condition). In addition to controlling for primacy and recency effects, filler categories were used in maintaining separation between experimental categories to minimize possible mnemonic effects from exemplar integration within and between categories. The process of interrelating exemplars is a link-word mnemonic technique (Neath & Surprenant, 2003), which as mentioned earlier, has been demonstrated to increase recall and reduce the RIF effect (Bäuml & Hartinger, 2002; MacLeod & Macrae, 2001).

Retrieval-practice Item Sets. There were 10 retrieval-practice sets created using a pseudo-random expanding-sequence order (Landauer & Bjork, 1978; Verkoeijen, Rikers, & Schmidt, 2005) and counterbalanced twice (i.e., yielding two sets per list). Organizing repeated study-pairs with an increasing inter-repetition study position (e.g., XOXOOX) enhances recall. This results from unconscious memorization of contextual variability between inter-repetitions that serve as elaborative retrieval cues (Verkoeijen, Rikers, & Schmidt).

Each of the six learning sets had four corresponding retrieval-practice sets. Participants performed practice by completing a cued-category-plus-stem recall task. Provided with the first two letters of a learned exemplar (i.e., an exemplar stem), they were expected to complete the predicate (e.g., RED TO<u>MATO</u> _ _).

The retrieval-practice sets were derived from four (of six) exemplars from each of the filler categories, half of the exemplars from one of the learned related categories, and half of the exemplars from one of the learned unrelated categories. Furthermore, practice of the exemplars from the two experimental categories was always performed on the dissimilar exemplars (i.e., the RP+ items). To control for material effects, each of the six experimental categories was practiced and unpracticed equally often in the related and unrelated condition across retrieval-practice sets (see Table B2 for an example with the category *Red*).

Each set contained 22 distinct cued-category-plus-stem items, 16 from the filler categories and six from the experimental categories. Each experimental item received practice three times in expanding sequence ($M = 3.7$ items between the first and second exposures to each item, $M = 7$ items between the second and third). Each filler item received practice twice, in random order. Furthermore, retrieval-practice sets were counterbalanced with experimental items appearing in an RP-NRP and NRP-RP order and filler items were newly randomized. Additionally, the same exemplar-stems were prohibited from appearing adjacently, and the same categories were prohibited from appearing adjacently more than once, these prohibited constructions were similar to those previously defined for the learning sets.

Distractor Task. The purpose of the distractor was to control for additional extraneous learning that can either inhibit or facilitate the memory associations acquired in the experiment, such as selective rehearsal of the words. Windows® solitaire was used as the task because of its strategic nature requiring minimal memory retrieval beyond simple arithmetic.

Recall Item Sets. There were six recall sets, which consisted of the names of the four experimental categories that participants became familiarized with. Each learning set corresponded to two counterbalanced recall sets. Counterbalancing of the RP and NRP categories followed two presentation patterns: RP, NRP, RP, NRP, and RP, NRP, NRP, RP, in which the first and third categories were always members of the related condition, and the second and fourth categories were always members of the unrelated condition. The positions of the categories ensured that no two categories from the same condition were presented adjacently.

Post-Experiment Questionnaire. The questionnaire consisted of nine open-ended questions (see Appendix C). The first four demographic questions determined age, cumulative G.P.A., and variability in previous hours slept. The fifth question required the participant to rank their motivational performance in the experiment using a 7-point Likert scale. The next set of three questions determined if participants might have used a mnemonic technique to remember the material, and if the design of the experiment allotted too much time for study or completion of the tasks. Again, this was to determine if participants had the opportunity to integrate exemplars, subsequently affecting observed performance. In their own study, Anderson & Bell (2001) posed questions similar to these. The final item was a general question in which participants were encouraged to give feedback about the experiment overall.

Procedure

Participants were asked to sign an informed consent form. Afterwards, data was collected in groups of up to four, using standard IBM® desktops computers running the E-Prime® software suite. Participants were told they were being tested on their ability to remember examples from various categories, and it was stressed they must memorize the pairings as they were displayed on the screen. The experiment itself was conducted in four phases, a learning phase, retrieval-practice phase, distractor phase, and a recall-test phase, followed by a post-experiment questionnaire. Participants were asked to fill out the questionnaire in Microsoft Word ® regarding their performance in the experiment in order to determine if they had used a learning strategy during study, which could have affected the study results.

Learning Phase. Participants took a seat in front of one of four available computers, which already had the current phase instructions displayed on the screen. The instructions informed the participants they would be presented with a series of category-example pairs, and that their task was to study each example in relation to its category. Participants were also informed they had five seconds to memorize the current item before the next pairing was going to be presented. Once the participants were ready, they hit the 'enter' key to begin the experiment. Each pair was presented one at a time in the middle of the computer screen.

Retrieval-Practice Phase. Upon completion of the learning phase, a new screen was displayed informing participants they had completed the previous phase of the experiment and that instructions for the next task would be displayed in five seconds. The retrieval-practice phase instruction screen informed participants they would be presented with a series of category-example word-stems (i.e., "only the first two letters") taken from the list of pairings they studied. Their task was to complete each word-stem with one of the words that they had studied. Furthermore, participants were informed that some pairs might be seen more than once. They had ten seconds to complete each stem before the next one was presented or the possibility to hit the 'enter' key after responding. Once the participants were ready, they hit the 'enter' key to begin the phase. Each cued-category-plus-stem item was then presented individually in the middle of the computer screen, with the cursor placed right of the stem ready to record and display all responses.

Distractor Phase. Upon completion of the learning phase, a new screen was displayed informing participants they had completed the second phase of the experiment and would play Windows® solitaire for twenty minutes. They were told that the researcher will open the program for them and that if they do not know how to play solitaire the experimenter will go over the rules of the game with them. Once twenty minutes had passed, the researcher closed the solitaire program and presented the next set of phase instructions to them on the computer screen. Time was kept using the Microsoft WindowsXP® system clock.

Recall-Test Phase. The recall-test phase instructions informed participants they would be presented with a series of only the category labels from the previous list of category-exemplar pairs they had studied, and their task was to type all of the words they could recall for each category with *only* words they had previously studied. Additionally, participants were informed they were allotted thirty seconds per category before the next label would be presented (participants were not given the option to hit 'enter' to advance to the next label so they could not 'quit' attempting to recall all of the words). Finally, once participants were ready, they hit the 'enter' key to begin. Each category label was presented singly and top-centered on the screen, with the cursor placed bottom-centered of the label ready to record and display all responses.

Post-Experiment. Upon completion of the recognition-test phase, a new screen was displayed informing participants they completed the main portion of the experiment. The researcher then opened Microsoft Word® containing the brief questionnaire. After the participant completed the questionnaire, the experimenter thanked the participant for their time and handed them a debriefing sheet while answering any questions they had concerning the experiment.

Results

As mentioned previously, because retrieval practice is necessary for RIF and can serve as a measure for the successful encoding of the associates (Anderson, Bjork, & Bjork, 2000, Bäuml, 2002; Ciranni & Shimamura, 1999), participants who failed to get at least two-thirds of the retrieval practice items correct were excluded from the analysis (n = 18), leaving 23 participants. Analyses performed on the full data set can be found in Appendix E.

On average, participants correctly completed 80.2% (*SD* = 8.5%) of the word stems with exemplars they had initially studied. During the recall phase, the rate of intrusion of words not presented at study was 4.4% (*SD* = 6.8%) and the rate of intrusion of words studied for other categories was 2.8% (*SD* = 5.0%). Planned comparisons were performed to identify the effects of retrieval-induced facilitation, RIF, and cross-category inhibition. Criterion for significance for all analyses was set at $\alpha = .05$ unless otherwise noted.

Retrieval-Induced Facilitation

It was predicted that retrieval practice of exemplars would facilitate later recall of the practiced items. As expected, a dependent samples t-test comparing RP+ and NRPd items revealed that the mean recall for RP+ items was significantly greater than NRPd items (see Table 2 for recall rates), $t(22) = 6.56$, $MSE = .050$, $p < .001$, $d = 1.64$. Therefore, exemplars that underwent retrieval practice were more likely to be remembered at recall.

Table 2

Experiment 1 Proportion of Exemplars Correctly Recalled

Retrieval-Induced Forgetting

	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.71 (.23)	.29 (.27)	.36 (.28)	.41 (.25)
Related	.61 (.29)	.32 (.24)	.30 (.24)	.19 (.28)

Note. Numbers in parentheses represent standard deviations.

Retrieval practice of half of the exemplars from a category should impair recall for the unpracticed half, thus, unrelated RP- and unrelated NRPs items were compared using a dependent samples t-test. The analysis for RIF was performed within the unrelated condition only, due to possible confounding of cross-category inhibition within the related condition (i.e., cross-category inhibition predicts reduced recall for related NRPs items). Although the mean unrelated RP- score was less than the unrelated NRPS score, we failed to see a significant difference (see Table 2), $t(22) = 1.50$, $MSE = .078$, $p = .148$, $d = .45$, $1 - \beta = .54$. Therefore, the expected RIF effect was not observed.

Cross-Category Inhibition

Cross-Category Inhibition was predicted to occur, as demonstrated by reduced recall for related NRPs items compared to unrelated NRPs items. Even though RIF was not observed, a dependent samples t-test comparing the mean recall rates of related and unrelated NRPs items revealed cross-category inhibition, $t(22) = 2.63$, $MSE = .083$, $p = .015$, $d = .82$. Therefore, retrieval practice of half of the exemplars in one related category impaired the recall of unpracticed exemplars in a second related category.

Control Comparisons

To ensure that exemplars in the related and unrelated conditions were equally retrieved during retrieval practice, a paired-samples t-test was performed on RP+ items between the two relation conditions. The analysis failed to show a significant difference in retrieval rate between the sets of items. (related: 77.3%, $SD = 18.5\%$; unrelated: 82.6%, $SD = 17.7\%$), $t(22) = .84$, $MSE = .063$, $p = .41$, $d = .29$, $1 - \beta = .27$.

Further control analyses assessed the effects of the stimulus materials on RIF and cross-category inhibition. Because of the number of comparisons required by the control analyses (7), significance levels were adjusted using the Bonferroni correction: pair-wise comparisons were assessed at an alpha of 0.007. To assess the effect of learning list, a 6 x 2 (learning list: A, B, C, D, E, F x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVA was performed for RIF, and a similar 6 x 2 (learning list: A, B, C, D, E, F x item status: related NRPs, unrelated NRPs) repeated measures ANOVA was performed for cross-category inhibition. No effects of learning list were observed (Fs < .912, ps > .691 for RIF; Fs < .579, ps > .714 for cross-category inhibition). To assess the effect of retrieval practice list, 2 x 2 (retrieval-practice list: A, B x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVAs were performed for RIF, and similar 2 x 2 (retrieval-practice list: A, B x item status: related NRPs, unrelated NRPs) repeated measures ANOVAs were performed for cross-category inhibition for each of the individual learning lists. These multiple analyses were required due to the nesting of different retrieval-practice lists within each learning list. No effects of retrieval-practice lists were observed (Fs < 9.219, ps > .055 for RIF; Fs < 3.001, ps > .181 for cross-category inhibition), although there were not enough cases to perform analyses for retrieval-practice within learning lists *E* and *F*.

Post-Experiment Questionnaire

All participants completed the open-ended post-experimental questionnaire. Two independent judges coded the responses with an interscorer reliability of greater than 70%. Disagreements in response categorization were re-evaluated and fit into one of the categories. Response tallies show that most participants (82.6%) explicitly used a memory encoding strategy during the experiment, with studying exemplars within categories together as the most common method (36.8%). Participants also reported using a combination of rehearsal, personalization (i.e., making exemplars self-relevant), and integration (i.e., grouping exemplars between categories together based on similarities).

Discussion

It was expected that retrieval practice of category-exemplar pairs would facilitate their recall during test. However, the retrieval-practice of only half the exemplars in a category was predicted to cause impaired recall for the unpracticed exemplars, demonstrating a RIF effect. In addition, unpracticed exemplars that were semantically related to the practiced category-exemplar pairs—yet in a different category—were also expected to show a reduced level of recall, demonstrating cross-category inhibition.

Cross-Category Inhibition without RIF

Our results confirm that retrieval practice does facilitate recall for practiced exemplars at recall. However, contrary to our expectations RIF was not seen for the unpracticed set of exemplars belonging to the same category as the retrieval-practiced set. On the other hand, cross-category inhibition was observed for the unpracticed—yet related—set of exemplars belonging to a different category. Therefore, impairment did not occur for unpracticed related-exemplars within the practiced category, although there was impairment for unpracticed related-exemplars within a separate category. Thus, there was no effect of RIF, but there was a cross-category inhibition effect.

A reverse dissociation of cross-category inhibition without a demonstration of the RIF effect has not been previously seen in the experimental literature. Studies thus far have been successful in replicating the standard RIF effect (Anderson, Bjork, & Bjork, 1994; Ciranni & Shimamura, 1999; Dunn & Spellman, 2003; Koustaal, Schacter, & Johnson, 1999; MacLeod & Macrae, 2001; however, see Butler, Williams, Zacks, & Maki, 2001), as well as demonstrating RIF along with cross-category inhibition (Anderson & Bell, 2001; Anderson & Spellman, 1995; MacLeod & Saunders, 2005; Saunders & MacLeod, 2006; however, see Perfect et al., 2004;

Williams & Zacks, 2001), but there have been no reported studies displaying cross-category inhibition without first demonstrating the standard RIF effect.

Theoretically, cross-category impairment is believed to operate by the same inhibitory mechanism as within-category impairment of RIF (Anderson & Spellman, 1995). As mentioned earlier however, an effect of RIF does not preclude a non-inhibitory account of impairment, whereas cross-category impairment does necessitate an inhibitory mechanism. Consequently, although we assume that RIF and cross-category inhibition occur through the same mechanism, this is not necessary in a broader theoretical sense. An alternative explanation for the dissociation between the two effects may lie in possible differences in the stimuli used or in differences in study strategies used by the participants.

Possible Explanations for Cross-category Inhibition without RIF

Comparable levels of successful retrieval practice were seen for exemplars belonging to related and unrelated conditions. Thus, the dissociation between RIF and cross-category inhibition was not due to differential levels of practice leading to different levels of recall impairment. In addition, analyses ruled out effects of learning list and retrieval-practice lists. Furthermore, due to the counterbalancing design, unpracticed related-exemplar sets serve equally often in the unrelated RP- (reflecting RIF) and related NRPs conditions (reflecting cross-category inhibition), with similar levels of impairment observed for the item sets when in the unrelated RP- (12.3%, *SD* = 38.8%) and related NRPs (21.1%, *SD* = 41.9%) conditions. Therefore, the dissociated observation of RIF and cross-category inhibition does not appear to be due to the nature of the stimuli.

The number of exemplar intrusions made during recall by participants does not affect the measures of RIF and cross-category inhibition because intruding exemplars do not belong to the same set as the tested exemplars. Conversely however, significant cross-categorization of exemplars may affect measures of RIF and cross-category inhibition because the test exemplar was successfully recalled (i.e., not inhibited), but associated with the wrong category. However, the observed proportion of incorrectly categorized exemplars as previously reported is small compared to the number of exemplars correctly categorized.

A further possibility of merit that may explain the dissociation between RIF and cross-category inhibition is that participants may have used an encoding strategy based on similarity for exemplars within but not between categories. The use of similarity encoding has been demonstrated to eliminate RIF (Anderson, Green et al., 2000; Smith & Hunt, 2000), which may account for the lack of observed RIF in this experiment. The post-experimental questionnaire confirmed that the majority of participants did use some form of explicit study strategy, with grouping similar exemplars together as the most common technique. Nonetheless, no study has yet to explore the effect of similarity encoding on cross-category inhibition using the standard retrieval-practice paradigm (see Anderson & McCullough, 1999 for the use of a modified version). Therefore, this possible explanation for the observed dissociation should be cautiously accepted, yet not ruled out.

Experiment 2 in this study sought again to try to replicate the standard RIF and cross-category inhibition effects, except we used a 10-minute distractor task instead of 20-minutes, and we introduced a recognition test immediately following recall. The addition of the recognition test allowed for the examination of RIF and cross-category inhibition from a different measure of memory-retrieval, as well as testing for the robustness in exemplar impairment.

Experiment 2

The purpose of Experiment 2 was to replicate the effect of cross-category inhibition, and to establish the effect of RIF, having been unable to do so in Experiment 1. The methodology of Experiment 2 was similar to that of Experiment 1, except the distractor length between retrieval practice and test was shortened to 10 minutes, and we administered a recognition test immediately after recall. We hoped that shortening the distractor time might elicit the RIF effect; possibly by means of increasing overall recall levels so that the specific impairment of RIF would be observed. The purpose of the recognition test was to test for the robustness of impairment under the condition of familiarity and recollection, as well as to possibly detect an effect of impairment not observed during recall. Thus, following successful retrieval-practice we expected to observe effects of memory facilitation for practiced exemplars, RIF for unpracticed exemplars within categories, and inhibition for semantically unpracticed related-exemplars across categories.

Method

Participants

A total of 50 undergraduate students (aged 18 to 28) from the psychology participant pool at Seton Hall University participated in the study either to fulfill a course requirement or to earn extra credit. Additionally, 15 participants failed to get at least two-thirds of the retrieval-practice items correct and were subsequently excluded from the analysis, leaving 35 participants.

Design

The design of Experiment 2 was similar to Experiment 1. However, distractor time was shortened from 20 minutes to 10 minutes, and a recognition test was administered immediately following recall. Thus, the design of the experiment was still 2 (category relation: related, unrelated) x 4 (item status: RP+, RP-, NRP_D, NRP_S) within-subjects, but consisted of five phases; learning, retrieval practice, distractor, recall, and recognition.

Materials

In addition to the materials used in Experiment 1, thirty-six lure exemplars were selected for the recognition test. Half of the lures were taken from the previously mentioned published norms pool (e.g. Overschelde et al., 2004) and half were derived by the principal investigator. The 36 lure exemplars were chosen to equate for the six experimental categories (6 lures per category) and cross-categorization half of the time. The purpose was to ensure similarity between experimental exemplars and lure exemplars within the design of the study. However, the recognition test consisted only of exemplars and they were therefore presented to participants without explicit relation to particular categories.

There were six recognition sets. Each set consisted of 24 learned experimental exemplars and 24 lure exemplars, which corresponded to the four experimental categories from the learning set previously presented to the participant. Presentation order in the recognition sets was random. No other change in materials was made between Experiment 1 and Experiment 2.

Procedure

The procedure in Experiment 2 was similar to Experiment 1, except for the addition of the recognition-test phase. Upon completion of the recall-test phase, a new screen was displayed informing participants they completed the previous phase of the experiment and the instructions for the next task will be displayed in five seconds. Participants were then informed they would see a series of words on their screens (e.g., PENNSYLVANIA) and that some of them would be novel whereas others were previously learned. They were told to respond as *accurately and quickly* as possible, by pressing the 'N' key if the word was new or 'M' key if the word was one they had memorized. Finally, once participants were ready, they hit the 'enter' key to begin. Each word was presented individually in the middle of the computer screen.

Results

Due to the importance of successful retrieval practice, participants who failed to get at least two-thirds of the retrieval practice items correct were excluded from the analysis (n = 15), leaving 35 participants. These participants correctly completed 81.9% (*SD* = 11.6%) of the word stems with exemplars they had initially studied. Analyses performed on the full data set can be found in Appendix E. Planned comparisons were performed to identify the effects of retrieval-induced facilitation, RIF, and cross-category inhibition for both recall and recognition. Criterion for significance for all analyses was set at $\alpha = .05$ unless otherwise noted.

Recall

The rate of intrusion of words not presented at study was 9.8% (*SD* = 18.8%) and the rate of intrusion of words studied for other categories was 2.9% (*SD* = 6.2%).

Retrieval-Induced Facilitation. It was predicted that retrieval practice of items would facilitate later recall of the practiced exemplars. As expected, a dependent samples t-test comparing RP+ and NRPd items revealed that the mean recall for RP+ items was significantly greater than NRPd items (see Table 3 for recall rates), $t(34) = 7.35$, $MSE = .036$, $p < .001$, $d = 1.37$. Therefore, exemplars that underwent retrieval practice were more likely to be remembered at recall.

Retrieval-Induced Forgetting. Retrieval practice of half of the exemplars from a category should impair recall for the unpracticed half, thus, unrelated RP- and unrelated NRPs items were compared using a dependent samples t-test. The analysis for RIF was performed within the unrelated condition only, due to possible confounding of cross-category inhibition within the

Table 3

Experiment 2 Proportion of Exemplars Correctly Recalled

	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.65 (.30)	.33 (.27)	.39 (.26)	.37 (.31)
Related	.66 (.27)	.20 (.22)	.38 (.26)	.22 (.20)

Note. Numbers in parentheses represent standard deviations.

related condition (i.e., cross-category inhibition predicts reduced recall for related NRPs items). Contrary to our hypothesis however, mean recall of the unrelated RP- items did not show significant impairment compared to mean recall of the unrelated NRPs items (see Table 3), $t(34) = .751$, $MSE = .051$, $p = .46$, $d = .13$, $1 - \beta = .16$. Therefore, the expected RIF effect was not observed.

Cross-Category Inhibition. Cross-Category Inhibition was predicted to occur; as demonstrated by reduced recall for related NRPs items compared to unrelated NRPs items. Even though RIF was not observed, a dependent samples t-test comparing the mean recall rates of related and unrelated NRPs items revealed cross-category inhibition, $t(34) = 2.76$, $MSE = .055$, $p = .009$, $d = .56$. Therefore, retrieval practice of half of the exemplars in one related category impaired the recall of unpracticed exemplars in a second related category.

Control Comparisons. To ensure that exemplars in the related and unrelated conditions were equally retrieved during retrieval practice, a paired-samples t-test was performed on RP+ items between the two relation conditions. The analysis failed to show a significant difference in retrieval rate between the sets of items. (related: 79.7%, *SD* = 19.1%; unrelated: 84.1%, *SD* = 19.7%), $t(34) = .85$, $MSE = .052$, $p = .40$, $d = .23$, $1 - \beta = .31$.

Further control analyses assessed the effects of the stimulus materials on RIF and cross-category inhibition. Because of the number of comparisons required by the control analyses (7), significance levels were adjusted using the Bonferroni correction: pair-wise comparisons were assessed at an alpha of 0.007. To assess the effect of learning list, a 6 x 2 (learning list: A, B, C, D, E, F x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVA was performed for RIF. There was no main effect of learning list for RIF, $F(5, 29) = 2.36$, $MSE = .243$, $p = .065$, $\eta_p^2 = .29$, $1 - \beta = .67$, nor an interaction with RIF, $F(5, 29) = 1.38$, $MSE = .059$, $p = .26$, $\eta_p^2 = .19$, $1 - \beta = .42$. A similar 6 x 2 (learning list: A, B, C, D, E, F x item status: related NRPs, unrelated NRPs) repeated measures ANOVA was performed for cross-category inhibition. No main effect was observed for learning list for cross-category inhibition, $F(5, 29) = 1.14$ $MSE = .092$, $p = .36$, $\eta_p^2 = .16$, $1 - \beta = .35$, but there was a significant interaction between learning list and cross-category inhibition, $F(5, 29) = 5.74$ $MSE = .181$, $p < .001$, $\eta_p^2 = .50$. A post-hoc analysis revealed that learning list *B* tended to produce a greater amount of cross-category inhibition than the other lists, but the difference between individual lists was not significant following Bonferroni correction ($\alpha = .002$).

To assess the effect of retrieval practice list, 2 x 2 (retrieval-practice list: A, B x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVAs were performed for RIF, and similar 2 x 2 (retrieval-practice list: A, B x item status: related NRPs, unrelated NRPs) repeated measures ANOVAs were performed for cross-category inhibition, for each of the individual learning lists. These multiple analyses were required due to the nesting of different retrieval-practice lists between each learning list. No effects of retrieval-practice lists were observed (*F*s < 4.799, *ps* > .115 for RIF; *F*s < 9.599, *ps* > .053 for cross-category inhibition).

Recognition

Participants demonstrated an overall mean hit rate of 84.4% (*SD* = 8.1%), recognizing 81.6% (*SD* = 13.0%) of the critical exemplars and 87.3% (*SD* = 8.6%) of the filler exemplars.

Retrieval-Induced Facilitation. It was predicted that retrieval practice of items would facilitate later recognition for the practiced exemplars. As expected, a dependent samples t-test comparing RP+ and NRPd items revealed that RP+ items were recognized significantly more often than NRPd items (see Table 4 for hit rates), $t(34) = 3.66$, $MSE = .040$, $p < .001$, $d = .76$.

Table 4

Experiment 2 Proportion of Exemplars Correctly Recognized

	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.94 (.15)	.79 (.27)	.85 (.26)	.86 (.26)
Related	.92 (.16)	.68 (.33)	.72 (.32)	.76 (.24)

Note. Numbers in parentheses represent standard deviations.

Therefore, exemplars that underwent retrieval practice were more likely to be recognized when the stimuli were presented alone.

Retrieval-Induced Forgetting. Retrieval practice of half of the exemplars from a category should impair recognition for the unpracticed half, thus, unrelated RP- and unrelated NRPs items were compared using a dependent samples t-test. The analysis for RIF was performed within the unrelated condition only, due to possible confounding of cross-category inhibition within the related condition (i.e., cross-category inhibition predicts reduced memory for related NRPs items). Contrary to our hypothesis however, the unrelated RP- items did not show significant recognition impairment compared to the unrelated NRPs items (see Table 4), $t(34) = 1.23$, $MSE = .054$, $p = .23$, $d = .25$, $1 - \beta = .36$. Therefore, the expected RIF effect was not observed.

Cross-Category Inhibition. We hypothesized an effect of cross-category inhibition would be established through the reduced recognition for related NRPs items compared to unrelated NRPs items. However, a dependent samples t-test comparing hit rates of related and unrelated NRPs items failed to display a significant difference, $t(34) = 1.77$, $MSE = .054$, $p = .086$, $d = .38$, $1 - \beta = .61$. Therefore, we did not observe significant inhibition following retrieval practice for unpracticed related exemplars in an unpracticed category.

Control Comparisons. Control analyses assessed possible effects of the stimulus materials on RIF and cross-category inhibition. Because of the number of comparisons required by the control analyses (7), significance levels were adjusted using the Bonferroni correction: pair-wise comparisons were assessed at an alpha of 0.007. To assess the effect of learning list, a 6 x 2 (learning list: A, B, C, D, E, F x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVA was performed for RIF, and a similar 6 x 2 (learning list: A, B, C, D, E, F x item status: related NRPs, unrelated NRPs) repeated measures ANOVA was performed for cross-category inhibition. No effects of learning list were observed (Fs < 1.481, ps > .226 for RIF; Fs < 1.385, ps > .258 for cross-category inhibition). To assess the effect of retrieval practice list, 2 x 2 (retrieval-practice list: A, B x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVAs were performed for RIF, and similar 2 x 2 (retrieval-practice list: A, B x item status: related NRPs, unrelated NRPs) repeated measures ANOVAs were performed for cross-category inhibition, for each of the individual learning lists. These multiple analyses were required due to the nesting of different retrieval-practice lists within each learning list. No effects of retrieval-practice lists were observed (Fs < 1.801, ps > .271 for RIF; Fs < 1.430, ps > .285 for cross-category inhibition).

Post-Experiment Questionnaire

All participants completed the open-ended post-experimental questionnaire. Two independent judges coded the responses with an interscorer reliability of greater than 75%. Disagreements in response categorization were re-evaluated and fit into one of the categories. Response tallies show that most participants (88.6%) explicitly used a memory encoding strategy during the experiment, with studying exemplars together within categories as the most common method (38.7%). These rates are similar to those obtained in Experiment 1. Participants also reported using a combination of rehearsal, personalization (i.e., making exemplars self-relevant), and integration (i.e., grouping exemplars between categories together based on similarities).

Discussion

As originally hypothesized for Experiment 1, it was expected that retrieval practice of category-exemplar pairs would facilitate their recall during test. However, the retrieval-practice of only half the exemplars in a category was predicted to cause impaired recall for the unpracticed exemplars, demonstrating a RIF effect. In addition, unpracticed exemplars that were semantically related to the practiced category-exemplar pairs—yet in a different category—were also expected to show a reduced level of recall, demonstrating cross-category inhibition.

Recall

Our results confirm that retrieval practice does facilitate recall for practiced exemplars at recall. However, contrary to our original hypothesis, RIF was not seen for the unpracticed set of exemplars belonging to the same category as the retrieval-practiced set. On the other hand, cross-category inhibition was observed for the unpracticed—yet related—set of exemplars belonging to a different category. Therefore, impairment did not occur for unpracticed related-exemplars within the practiced category, although there was impairment for unpracticed related-exemplars within a separate category. Thus, even with a 10-minute retention-interval there was no effect of RIF, but there was an effect cross-category inhibition. These results replicate those found in Experiment 1.

Recognition

Although similar to the results of the recall test, the recognition results failed to reach significance. We did find facilitated recognition for retrieval-practiced items. However, there was no RIF impairment, and only a marginal effect of cross-category inhibition was observed, which might have reached significance with a larger sample size. Thus, although a significant observation of cross-category inhibition was not observed, there does appear to be a trend of robust impairment across recall and recognition tests. The finding of a marginal effect within the current design of the experiment is somewhat surprising in itself, given the immediacy of the recognition test following recall.

Possible Explanations for Cross-category Inhibition without RIF

The same control analyses from Experiment 1 were performed to rule out methodological flaws causing the observed dissociation between RIF and cross-category inhibition. We did observe an interaction of learning list by cross-category inhibition for recall, with list *B* leading to greater overall inhibition levels. However, due to the counterbalancing design of the experiment, unpracticed related item-sets served equally often in the unrelated RP- (reflecting RIF) and related NRPs conditions (reflecting cross-category inhibition), and similar levels of impairment were observed for the item sets when in the unrelated RP- (3.8%, *SD* = 30.0%) and related NRPs (15.2%, *SD* = 32.7%) conditions. Thus, the greater inhibition of NRPs items seen from list *B* may be do to chance, since greater impairment for the same exemplars when in the RP- condition of list *B* was not also seen.

The control analyses further revealed comparable levels of successful retrieval practice for items belonging to related and unrelated conditions. Thus, the dissociation between RIF and cross-category inhibition is not due to different levels of successful retrieval practice. Taken together, the dissociated observation of RIF and cross-category inhibition does not appear to be due to the stimuli used.

The number of exemplar intrusions made during recall by participants was more than double that in Experiment 1 (4.4% vs. 9.8%). However, the number of intrusions does not affect the measures of RIF and cross-category inhibition since intruding exemplars do not belong to the same set as the tested exemplars, although it may imply participants are willing to follow experiment instructions. Conversely however, significant cross-categorization of exemplars may affect measures of RIF and cross-category inhibition because the test exemplar was successfully recalled (i.e., not inhibited), but associated with the wrong category. However, the observed proportion of incorrectly categorized exemplars is small compared to the number of exemplars correctly categorized, and is similar to that seen in Experiment 1.

As mentioned in our previous discussion, a further possibility that may explain the dissociation between RIF and cross-category inhibition is that participants may have used an encoding strategy based on exemplar similarity for exemplars within but not between categories. Our post-experimental questionnaire again confirmed that the majority of participants did use some form of explicit study strategy, with grouping similar exemplars together as the most common technique. Nonetheless, no study has yet to explore the effect of similarity encoding on cross-category inhibition using the standard retrieval-practice paradigm (again, see Anderson &

McCullough, 1999 for the use of a modified version). Therefore, Experiment 3 was designed to test the effect that manipulating study strategy has on recall and recognition of related retrieval-practice exemplars. Specifically, we instructed participants to memorize category-exemplar pairs individually or to memorize exemplars from the same category as a group.

Experiment 3

In Experiment 3 the same three general questions were posed (i.e., memory facilitation, impairment, and inhibition), but a fourth critical question inquired about how grouping exemplars based on category influences impairment and inhibition. We manipulated the instruction sets displayed to participants prior to the learning phase. The experiment had two goals. First, we planned to demonstrate cross-category inhibition in participants that were instructed to memorize exemplars from the same categories together, and also in participants that were instructed to memorize category-exemplar pairs individually. Second, we did not expect to observe within-category RIF when participants were instructed to memorize the exemplars together, but did expect to see an effect when instructed to memorize the pairs individually. Thus, we proposed that RIF and cross-category inhibition would be observably dissociable events under the factor of study-instruction manipulation.

Method

Participants

A total of 55 undergraduate students (aged 18 to 28) from the psychology participant pool at Seton Hall University participated in the study either to fulfill a course requirement or to earn extra credit. Additionally, 27 participants (Individual: n = 14, Similar: n = 13) failed to get at least two-thirds of the retrieval-practice items correct and were subsequently excluded from the analysis, leaving 28 participants (Individual: n = 13, Similar: n = 15).

Design

The design of Experiment 3 was similar to Experiment 2. However, memorization instructions were manipulated between-subjects prior to the learning phase. This factor was broken down across two levels, similarity and individual study strategies. Therefore, the design of the experiment was 2 x 4 x 2 mixed, with the first two factors within-subjects (category relation and item status) and the last between (instruction set).

Materials

There were several material changes between Experiment 2 and Experiment 3. First, participants in the similarity condition were presented with the following instructions during learning:

> During the first phase of this experiment, you are required to stare at the screen and memorize a series of category-example word pairs. Each pair will be presented in random order, but there will be six categories containing several examples each. When memorizing a given category-example pair, you should think about all of the previously seen examples for that category while thinking about the similarities that exist between them. For example, if you're presented with TIME SECONDS and then later see TIME MINUTES you should think about how SECONDS and MINUTES are a similar way of keeping TIME.

However, participants in the individual condition received the following set of instructions:

> During the first phase of this experiment, you are required to stare at the screen and memorize a series of category-example word pairs. Category names may appear several times but your task is to memorize only the category-example word pair that is currently on the screen. For every word pair you should think about how that example is representative of the presented category. For example, if you are presented with TIME MINUTES you should think about how MINUTES is an example of a way of keeping TIME.

All other instructions presented throughout the experiment were the same across conditions.

Second, retrieval-practice sets were counterbalanced once rather than twice due to a reduced number of participants, as determined by power analyses. Third, Tetris® instead of Solitaire® served as the distractor task. Tetris® provided participants with an increasing level of difficulty, which we felt would keep them better stimulated for the full twenty-minute duration, therefore leaving them more interested while in the lab and more motivated to perform well during the remaining portion of the study. Fourth, the questionnaire was moderately revised to consist of fourteen questions (see Appendix D). The first four demographic questions remained the same, but items five through eight were designed to better determine the type of mnemonic techniques participants may have used during study; items specifically asked about individual, similarity, integration, and general study-strategies. Each question required a yes or no response as well as further explanation by the participant. We used a Likert scale in questions nine through twelve to assess the amount of effort participants put into their performance in the experiment, and question thirteen inquired about the length of time allotted to participants during each phase of the experiment. The final question requesting general comments remained the same.

Procedure

The procedure in Experiment 3 was similar to Experiment 2, except that all instructions were presented on the computer to control for presentation variability. In addition, participants randomly self-assigned themselves to the different instruction conditions based upon their appointment time. However, participants were only run in groups under the same condition in the event that further verbal instruction-clarification by the participant was needed. In addition, condition and time-of-day that participants were ran was randomly varied.

Results

As done with the prior experiments in this study, participants who failed to get at least two-thirds of the retrieval practice items correct were excluded from the analysis (Individual: n = 14, Similar: n = 13), leaving 13 participants in the individual-study condition and 15 in the similar-study condition. Subsequently, individual-study participants successfully completed 82.1% (*SD* = 11.1%) of the word stems, and similar-study participants correctly completed 78.2% (*SD* = 9.7%). Analyses performed on the full data set can be found in Appendix E. Criterion for significance for all analyses was set at $\alpha = .05$ unless otherwise noted.

Recall

In the individual-study condition, the rate of intrusion for words not presented at study was 13.5% (SD = 23.7%) and the rate of intrusion for words studied for other categories was 2.3% (*SD* = 4.3%). For the similarity condition, the rate of intrusion of words not present at study was 15.2% (SD = 18.8%) and the rate of intrusion of words studied for other categories was 6.6% (*SD* = 10.1%). Mean recall rates for the critical items for both instruction conditions can be found in Table 5.

Table 5

Experiment 3 Proportion of Exemplars Correctly Recalled

Individual Strategy				
	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.72 (.27)	.23 (.25)	.41 (.31)	.41 (.24)
Related	.72 (.18)	.13 (.17)	.44 (.21)	.26 (.28)

Similarity Strategy				
	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.69 (.29)	.33 (.31)	.33 (.22)	.29 (.31)
Related	.71 (.28)	.16 (.25)	.42 (.34)	.22 (.27)

Note. Numbers in parentheses represent standard deviations.

Retrieval-Induced Facilitation. A 2 x 2 (instructions: similar, individual x item status: RP+, NRPd) mixed repeated-measures ANOVA was performed in order to assess whether manipulating study instructions would have a differential effect on item facilitation (RP+ - NRPd). There was no main effect of study instructions, $F(1, 26) = .28$, $MSE = .014$, $p = .60$, $\eta_p^2 = .01$, $1 - \beta = .08$, but there was a predicted main effect of item status, $F(1, 26) = 50.41$, $MSE = 1.33$, $p < .001$, $\eta_p^2 = .66$. Follow-up dependent-sample t-tests confirmed facilitated recall of previously practiced exemplars in both the individual-study, $t(12) = 6.88$, $MSE = .042$, $p < .001$, $d = 1.84$, and similar-study, $t(14) = 4.49$, $MSE = .072$, $p < .001$, $d = 1.45$, conditions. As was further expected, there was no significant interaction between facilitation and instruction set, $F(1, 26) = .10$, $MSE = .003$, $p = .76$, $\eta_p^2 < .01$, $1 - \beta = .06$.

Retrieval-Induced Forgetting. A 2 x 2 (instructions: similar, individual x item status: unrelated RP-, unrelated NRPs) mixed repeated-measures ANOVA was performed to assess if RIF would be found under both study-instruction conditions. There were no main effects (instructions: $F(1, 26) = .01$, $MSE = .001$, $p < .92$, $\eta_p^2 < .01$, $1 - \beta = .05$; item status: $F(1, 26) = 1.57$, $MSE = .064$, $p < .22$, $\eta_p^2 = .06$, $1 - \beta = .23$), but there was an instruction by item-status interaction, $F(1, 26) = 4.31$, $MSE = .175$, $p = .048$, $\eta_p^2 = .52$. Follow-up dependent-sample t-tests using the Bonferroni correction (alpha set at 0.025) revealed marginal significance for RIF in the individual condition, $t(12) = 2.01$, $MSE = .089$, $p = .068$, $d = .73$, $1 - \beta = .80$, whereas in the similarity condition, an effect of RIF did not approach significance, $t(14) = .70$, $MSE = .064$, $p = .50$, $d = .14$, $1 - \beta = .13$.

Cross-Category Inhibition. A 2 x 2 (instructions: similar, individual x item status: related NRPs-, unrelated NRPs) mixed repeated-measures ANOVA was performed to assess possible differences for cross-category inhibition between instruction sets. There was no main effect for either instruction set, $F(1, 26) = .95$, $MSE = .084$, $p = .34$, $\eta_p^2 = .04$, $1 - \beta = .16$, or item status, ($F(1, 26) = 2.67$, $MSE = .169$, $p = .12$, $\eta_p^2 = .09$, $1 - \beta = .35$, nor an interaction, $F(1, 26) = .42$, *MSE* = .026, *p* = .52, η_p^2 = .02, 1 - β = .10. Therefore, cross-category inhibition was not detected at the current power level and the study instructions given to participants did not produce different effects on cross-categorizable exemplars.

Recognition

Participants in the individual-study condition demonstrated an overall mean hit rate of 85.1% (SD = 4.9%), with a 77.2% (SD = 10.3%) hit rate for critical exemplars and a 93.0% (SD = 5.5%) hit rate for filler exemplars. Those in the similar-study group had an overall mean hit rate of 81.4% (SD = 5.8%), with a 70.3% (SD = 14.8%) hit rate for critical exemplars and a 92.5% (SD = 9.3%) hit rate for filler exemplars. Hit rates based on critical-exemplar status between instruction conditions can be found in Table 6.

Retrieval-Induced Facilitation. A 2 x 2 (instructions: similar, individual x item status: RP+, NRPd) mixed repeated-measures ANOVA was performed in order to assess whether or not manipulating study instructions would have a differential effect on facilitating exemplar recognition. There was no main effect of study instructions, *F*(1, 26) = 2.47, *MSE* = .129, *p* = .13, η_p^2 = .09, 1 - β = .33, but there was a predicted main effect of item status, *F*(1, 26) = 36.65, *MSE* = 1.24, *p* < .001, η_p^2 = .59. Follow-up dependent-sample t-tests using the Bonferroni correction (alpha set at 0.025) confirmed facilitated recognition for previously practiced exemplars in both the individual-study, *t*(12) = 5.20, *MSE* = .044, *p* < .001, *d* = 1.32, and similar-study, *t*(14) = 4.40, *MSE* = .083, *p* = .001, *d* = 1.20,conditions. As was further expected, there was no significant interaction between facilitation and instruction set, *F*(1, 26) = 1.90, *MSE* = .064, *p* = .18, η_p^2 = .07, 1 - β = .26.

Table 6

Experiment 3 Proportion of Exemplars Correctly Recognized

Individual Strategy				
	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.92 (.15)	.54 (.29)	.67 (.38)	.79 (26)
Related	1.0 (.00)	.69 (.35)	.79 (.22)	.77 (.32)

Similarity Strategy				
	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.91 (.15)	.71 (.25)	.51 (.38)	.64 (.29)
Related	.96 (.12)	.62 (.33)	.62 (.42)	.64 (.32)

Note. Numbers in parentheses represent standard deviations.

Retrieval-Induced Forgetting. A 2 x 2 (instructions: similar, individual x item status: unrelated RP-, unrelated NRPs) mixed repeated-measures ANOVA was performed to assess if RIF would be found under both study instruction conditions. There were no main effects (instructions: $F(1, 26) = .03$, $MSE = .002$, $p = .87$, $\eta_p^2 < .01$, $1 - \beta = .05$; item status: $F(1, 26) = 1.44$, $MSE = .125$, $p = .24$, $\eta_p^2 = .05$, $1 - \beta = .21$), but there was a marginal instruction by item-status interaction, $F(1, 26) = 4.179$, $MSE = .363$, $p = .051$, $\eta_p^2 = .14$, $1 - \beta = .50$. Follow-up dependent-sample t-tests revealed marginal significance for an effect of RIF in the individual-study condition, $t(12) = 2.03$, $MSE = .126$, $p = .065$, $d = .93$, $1 - \beta = .94$, whereas in the similarity condition RIF was not observed, $t(14) = .68$, $MSE = .099$, $p = .51$, $d = .24$, $1 - \beta = .23$; instead, unrelated RP- items displayed a higher recognition rate than unrelated NRPs items (see Table 6).

Cross-Category Inhibition. A 2 x 2 (instructions: similar, individual x item status: related NRPs-, unrelated NRPs) mixed repeated-measures ANOVA was performed to assess possible differences in cross-category inhibition between study instruction sets. There were no main effects for either instruction set, $F(1, 26) = 2.35$, $MSE = .264$, $p = .14$, $\eta_p^2 = .08$, $1 - \beta = .32$, or item status, ($F(1, 26) = .04$, $MSE = .002$, $p = .85$, $\eta_p^2 < .01$, $1 - \beta = .05$, nor an interaction, $F(1, 26) = .035$, $MSE = .002$, $p < .85$, $\eta_p^2 < .01$, $1 - \beta = .05$. Therefore, cross-category inhibition was not detected at the current power level and the study instructions given to participants did not produce different effects on cross-categorizable exemplars.

Control Comparisons

Dependent sample t-tests showed no difference in retrieval practice rates between related and unrelated items in either the individual-study condition, $t(12) = .84$, $MSE = .081$, $p = .42$, $d = .36$, $1 - \beta = .34$, or the similarity condition, $t(14) = .78$, $MSE = .086$, $p = .45$, $d = .35$, $1 - \beta = .32$. A one-way ANOVA also revealed no significant difference in the proportion of items correctly retrieved between the two study-instruction conditions, $F(1, 26) = .98$, $MSE = .019$, $p = .33$, $d = .37$, $1 - \beta = .61$.

Further control analyses assessed possible stimulus effects for RIF and cross-category inhibition within each of the instruction conditions for both recall and recognition tests. Because of the number of comparisons required (4) by the control analyses for each instruction condition within both tests, significance levels were adjusted using the Bonferroni correction; pair-wise comparisons were assessed at an alpha of 0.0125. To assess the effect of learning list, a 6 x 2 (learning list: A, B, C, D, E, F x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVA was performed for RIF, and a similar 6 x 2 (learning list: A, B, C, D, E, F x item status: related NRPs, unrelated NRPs) repeated measures ANOVA was performed for cross-category inhibition; the analyses were first performed for the recall test than for the recognition test. No effects of learning list were observed (Fs < 3.583, ps > 0.015). We were unable to assess possible effects of retrieval-practice lists because of too few retrieval-practice list cases within each learning list were obtained.

Manipulation Check. All participants in the similar-study condition, and 11 of the 13 participants in the individual-study condition completed the post-experimental questionnaire. The questions were partially close-ended that required yes-no answers, but in addition asked participants to elaborate on their answers. Response tallies of the yes-no responses show that most participants (92.0%) explicitly used an encoding strategy as instructed during study. In the individual-study condition 50% of participants reported using a similarity-based strategy, whereas only 20% also reported studying exemplars in an individual fashion. In the similar-study condition, 67% of participants reported studying exemplars together based on similarity and 40% reported studying the exemplars individually. 20% of participants who reported using a study strategy said they used both similar and individual strategies. Thus, based on the difference in RIF between groups, it appears that not only did subjective reports of study strategies differ from the objective reports, but participants indicated using multiple types of strategies. Perhaps participants initially performed individual-study and then switched to similar-study as a greater number of items were introduced.

Discussion

It was expected that instructing participants to study exemplars together based on their category similarity would attenuate an effect of RIF, but produce no extraneous influence on cross-category inhibition. Conversely, participants that were instructed to study each category-exemplar pair in an isolated individual-fashion were expected to demonstrate the standard RIF effect and cross-category inhibition. Thus, between instruction conditions it was expected that the similar-study and individual-study groups would show a significant difference in RIF, but show no difference for cross-category inhibition.

Recall

As was expected, both the individual-study and similar-study groups displayed facilitated recall for practiced exemplars with no significant difference based on instruction set. More importantly however, there was a significant difference in RIF-based impairment between the two study conditions. The individual-study group displayed marginal significance of the traditional RIF effect, whereas the similar-study group actually demonstrated slight facilitation for RP- items—an effect opposite that of RIF, thus supporting our hypothesis.

However, cross-category inhibition was not detected across instruction conditions, which does not support our hypothesis. An examination of the effect of instruction-set manipulation on cross-category inhibition revealed no difference between the two groups, which is consistent with our prediction, but we had anticipated to observe cross-category inhibition in both groups. The main effect of inhibition did approach marginal significance and a significant difference in recall might have been detected with more power.

Recognition

Results of the recognition test parallel the expected results of the recall test. Significant facilitated recognition was observed for both the individual-study and similar-study groups, with no difference in group results based on instruction set. However, there was a marginally significant difference between the two instruction groups for the RIF effect. Specifically, the individual-study group displayed a marginally significant effect of RIF, whereas the similar-study group displayed an opposite trend of facilitated recognition for RP- items. Thus, the impairment and facilitation seen during recognition is comparable to that observed during recall; demonstrating the robustness of both effects.

However, parallel to recall—we failed to detect cross-category inhibition across instruction conditions. No difference between instruction conditions for cross-category inhibition was observed, but we had predicted to observe cross-category inhibition in both conditions. Thus, we did not find support for our hypothesis of the dissociation of cross-category inhibition without a RIF effect in the similar-study condition, but instead observed the dissociation of the RIF effect without cross-category inhibition in the individual-study condition.

The RIF Effect and Cross-Category Inhibition Effect

The current results lend partial support to our hypothesis of covert strategy-use as the possible cause for the dissociation between RIF and cross-category inhibition seen in Experiments 1 and 2. Participants' self-report of studying exemplars in categorized groups might have caused the attenuation of an RIF effect, but had no influence on the production of cross-category inhibition, as demonstrated in the current experiment. However, one caveat to this conclusion was the lack of a main effect of cross-category inhibition across both instruction conditions.

An interesting general observation is that in both Experiment 1 and Experiment 2, no effect of RIF was found—yet cross-category inhibition was observed—whereas in Experiment 3, an effect of RIF was observed in the individual-study condition—yet cross-category inhibition was not found. In addition, recognition test results across experiments showed parallel trends of the dissociated effects observed with recall. Therefore, within the current study we saw a double dissociation in the observation of RIF and cross-category inhibition for both recall and recognition. Furthermore, the stimuli used between experiments were identical, with explicit instructions for study strategy during Experiment 3 as the only change in manipulation. Based on the critical role that study strategy plays in the observation of either effect, a closer and more controlled exploration of strategy effects should be explored.

Although participants were auditorily and visually instructed on how they should memorize the category-exemplar pairs in the current experiment, the post-experimental questionnaire revealed that overall, less than half studied the exemplars as instructed. Behaviorally however, the differential observation of RIF between the two instruction conditions supports the belief that participants followed the instructions as told. It is possible that participants did not fully understand the intent of the questions, but the wording between questions and study-instructions was similar, so that participants in either instruction condition should have at least answered *yes* to using the respective type of strategy with which they were informed to use. Furthermore, most participants gave accurate explanations of the type of strategy that they used, which would imply they understood the nature of the strategy that they were being questioned about. Nevertheless, while not surprising to see disagreement between behavioral and subjective measures, a more controlled and precise method of analysis is required to understand the interplay between study strategy-use and the attenuation of forgetting.

Possible Explanations for Cross-category Inhibition without RIF

Failure to observe cross-category inhibition in the current experiment may be the result of lack of power (i.e., 1 - β) to detect the possible effect. This is primarily a reflection of the low number of participants in the current data set, which is the principal consequence of attrition. Thus, a main effect of cross-category inhibition may have been detected with the presence of additional participants.

However, it is also possible that both study-strategies attenuated a cross-category inhibition effect. Although this is less likely, assuming that participants who demonstrated cross-category inhibition in Experiments 1 and 2 also used either of the current study-strategies. Theoretically, cross-category inhibition should have been observed in at least the individual-study condition since a significant effect of RIF was found. According to RIF theory, memories themselves become impaired; thus, unpracticed related-exemplars regardless of category membership should have been inhibited, but we found (although marginally) exemplar membership in an unpracticed category to protect against memory impairment. Other researchers have also observed an RIF effect without the observation of cross-category-inhibition (Perfect et al., 2004; Williams & Zacks, 2001). Therefore, we cannot confidently conclude that memories are directly inhibited nor can we be certain of the influence individual-study and similar-study strategies have on cross-category inhibition.

Summary

The primary hypotheses for the current experiment were that individually studying the word-pairs would facilitate the RIF and cross-category inhibition effect, whereas studying similar word-pairs together would attenuate RIF, but not cross-category inhibition. The results of recall and recognition are consistent with the attenuation of RIF in the similar-study condition, as well as the lack of a difference in cross-category inhibition between the two conditions. However, an actual cross-category inhibition effect was not observed in either condition. Cross-category inhibition was observed in Experiments 1 and 2 however, whereas RIF was not. The interplay between strategy-use and attenuation of impairment effects warrants further investigation, although a more precise method of analysis may be needed due to the discrepant results obtained between subjective and behavioral measures of the type of strategy used.

General Discussion

In Experiments 1 and 2, it was expected that retrieval practice would cause impairment for unpracticed exemplars within the practiced category and for unpracticed related-exemplars across categories (effects of RIF and cross-category inhibition, respectively). However, results from both experiments failed to detect an effect of RIF, but did display cross-category inhibition. This set of findings is inconsistent with the theory of RIF, since the impairment associated with both effects is thought to operate by the same inhibitory mechanism. Therefore, according to theory, both effects should have been detected when testing for impairment with the RPP with IPT.

Nevertheless, although not predicted by the theory, RIF without cross-category inhibition has previously been observed (Camp, 2006; Perfect et al., 2004; Williams & Zacks, 2001). However, cross-category inhibition without RIF—as found in Experiments 1 and 2—has not been found in previous work. Furthermore, in Experiment 2 the dissociation between impairment effects was extended to recognition. Thus, not only did the recall results from Experiment 2 show replication for those found in Experiment 1, but identical results were observed for recognition. Recall and recognition memory processes are believed to operate by different retrieval mechanisms (Dobbins, Kroll, Yonelinas, & Liu, 1998; Yonelinas, 2002), thus strengthening the conclusion that the RIF and cross-category inhibition dissociation was not an anomalous result of recall. Therefore, although this dissociation has currently only been reported from our lab, replication across experiments was observed, as well as across method of test.

We hypothesized that a possible reason for the observed dissociation may have been due to the majority of participants using a similar encoding strategy for the category-exemplar pairs. According to the feature-based model of inhibition (Anderson & Spellman, 1995), studying exemplars from the same category as a group eliminates the RIF effect because the unified overlapping features between exemplars undergo facilitation during retrieval practice (see Figure 6; Anderson & McCulloch, 1999). We wondered what effect this might have for the unpracticed related-exemplars that were studied together under a different category. Specifically, we hypothesized that if all exemplars in a RP category receive facilitation, then impairment should have occurred for related exemplars in an NRP category (see Figure 4). That is, an effect of RIF should not have been observed since all exemplars within the RP category were studied together and thus facilitated; moreover, we expected to find an effect of cross-category since competition would still exist between the related exemplars in the RP and NRP categories.

The results of Experiment 3 do confirm that encoding exemplars based on similarity has a different influence on the RIF effect than studying category-exemplar pairs individually, for both recall and recognition. As expected, the similarity condition did not show an effect of RIF, whereas RIF was observed in the individual-study condition. Furthermore, as predicted, no difference was observed for cross-category inhibition between the two types of encoding strategies. However, neither group demonstrated a significant effect of inhibition between independent categories. Therefore, the results of Experiment 3 only partially support our original hypotheses, since a main effect of cross-category inhibition was not observed. Furthermore, these results do not explain the RIF and cross-category inhibition dissociation observed in Experiments 1 and 2. However, although RIF was demonstrated in Experiment 3 whereas cross-category inhibition was not, these results are not necessarily at odds with those of Experiments 1 and 2, since Experiment 3 called for the use of explicit encoding strategies defined by the researcher. That is, the difference in results between experiments may still be a result of strategy-use, but the strategy used by the majority of participants in Experiment 1 and 2 may not have been the same type of strategy as defined by the researcher in Experiment 3.

One potential problem with this set of studies is that only approximately half of the collected data set was analyzed after excluding participants who did not successfully complete retrieval-practice. Fifty category-exemplar pairs were initially presented for a period of three seconds each, for total study-phase duration of two and a half minutes where participants were instructed to look at a computer screen and memorize the presented exemplars. Inattention, fatigue, or boredom may have led participants to fail to learn the critical exemplars, which would naturally lead to their inability to retrieve, recall, or recognize the critical exemplars. The moderately large number of exemplars required to study may have also caused the rise in attrition. However, it is then surprising that attrition was the same for the individual-study condition where participants studied exemplars individually, compared with the similar-study condition where participants were instructed to memorize exemplars in chunks since *chunking* improves memory when using large item sets (Gobert et al., 2001). Thus, the similar-study condition would have been expected to show a lower level of attrition. Furthermore, the counterbalancing design of the stimuli and control analyses should rule out general stimulus effects. We are unsure of an exact reason why the attrition rate was so great.

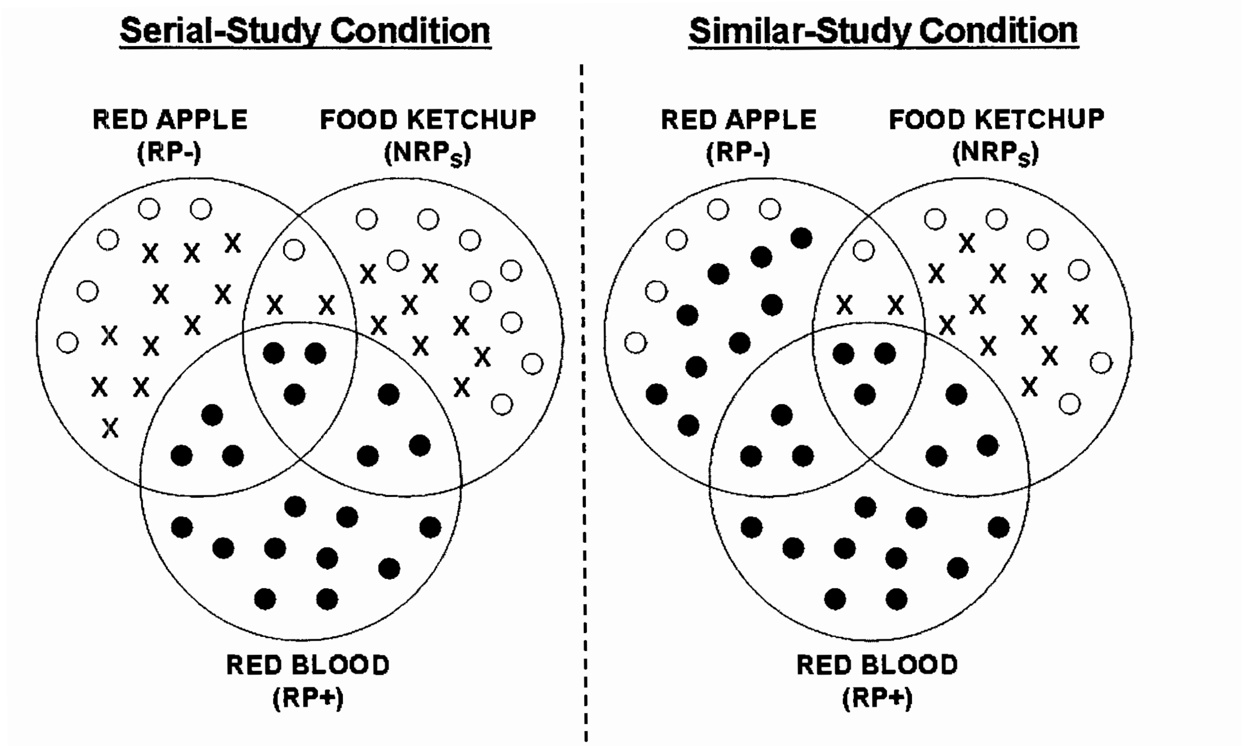


Figure 6. Features refer to semantic characteristics used to describe an item. For example, BLOOD and KETCHUP have the features *red* and *liquid*. Across exemplars, darkened dots represent facilitated features, *X*s represent inhibited features, and empty dots represent features that were neither facilitated nor inhibited. In the individual-study condition, retrieval-practice of BLOOD leads to the facilitation of some features of APPLE and KETCHUP, whereas interference caused by retrieval-practice inhibits some features of APPLE and KETHCUP. In the similar-study condition, the retrieval-practice of BLOOD leads to facilitation of some features of APPLE, but still impairs some features of KETCHUP. Facilitation or inhibition of the features depends on whether or not interference exists with the desired target-memory.

A future follow-up study might be to have participants think-out-loud while performing the experiment. This would produce a better idea of how participants are actually studying and retrieving items, as well as the type of strategies they are using during recall and recognition. Our questionnaire tried to address this topic, but formality of the questions, latency between the actual process and administered question, and question matter might not have been the best way to assess strategy. For example, using post-experimental questionnaires, Anderson, Green, and McCulloch (1999) found that participants would often create self-cues for category-exemplar pairs to facilitate their memory for the exemplars, and Anderson and Bell (2001) found that participants would perform "extra" retrievals during the time allotted in the retrieval-practice phase. Additionally, the argument has been made that independent-cueing with the IPT may not occur if participants recall an exemplar first and then scan their memory to find the studied category to which it was studied under (Camp, 2006; Camp, Pecher, & Schmidt, 2005; Perfect et al., 2004). Thus, there are numerous possible strategies that participants can use during any phase of the experimental paradigm that can have different possible influences for effects of RIF and cross-category inhibition. Individual variability in strategy-use is naturally expected. However, in general and in this study, the transient nature of a RIF and cross-category inhibition effect may be due to participants' strategy use across samples and the operational wording of the instructions which they are provided.

It is also possible that forgetting can result from mechanisms other than direct memory-inhibition (e.g., association weighting theories). The RPP with the IPT appears to demonstrate that memories become directly inhibited and the associations between memories and cue remain unaffected. However, a connection mechanism is implicated by the feature-based model of inhibition that can cause unified facilitation or inhibition of overlapping features between semantically related exemplars. According to the model, studied items are encoded as semantic features, which subsequently form associations and structure the composition of learned items. Retrieval practice performed by participants then causes the facilitation and inhibition of the associative network of features related to the item. That is, the sum of activation across associations of the features of an exemplar determines whether it will be recalled (Anderson & McCulloch, 1999). Fundamentally, the feature-based model of inhibition is a distributed network theory that builds upon the foundation of older association-weighting theories. Therefore, associations still play a pivotal role in determining whether an item will be remembered except that the operation of associative mechanisms has been extracted to a lower level.

When coupled with strategy-use that emphasizes similarities within categories, it seems probable that RIF would be attenuated since the sets of features for each item have greater overlap and greater activation between them. Conversely, related items across categories that are not studied together do not have the same amount of feature-overlap nor activation as items within categories, but they do share similar features that compete between within-category studied item sets. For this reason, we expected an effect of cross-category inhibition to still occur regardless of instruction condition.

Since cross-category inhibition was not found in Experiment 3, a double dissociation was observed between the typical RIF effect and cross-category inhibition within the current study. This lends strong evidence to the hypothesis that a mechanism other than memory inhibition may have been operating during the retrieval process. As previously mentioned, this may be the result of impairment taking place at a location other than to the memory itself (e.g., the association between cue and memory), or that inhibition alone may not be a single mechanism that causes forgetting. Even if the use of study-strategy can explain this double dissociation, it does not negate the hypothesis that a mechanism other than memory impairment also leads to forgetting since there is now evidence of a double dissociation. However, it does mean that the IPT might not be valid for demonstrating the independence of memory inhibition from some other type of forgetting mechanism that produces the within-category RIF effect. Therefore, further exploration of study-strategy use and the mechanisms affected by study-strategy must still be investigated.

In summary, Experiment 1 was an attempt to replicate the normal effects of the RPP with IPT. However, we unexpectedly found a dissociation of cross-category inhibition without an effect of RIF. This dissociation was then replicated in Experiment 2 for both recall and recognition. Based on the responses to our mnemonic-use questions on the post-experiment questionnaires, we believed the dissociation might have been the result of the use of a within-category-similarities encoding-strategy. Therefore in Experiment 3, we hypothesized that instructing participants to study items within categories together based on similarity would attenuate RIF but not cross-category inhibition. On the other hand, we expected participants who were instructed to study items individually to demonstrate both RIF and cross-category inhibition. Recall and recognition results show that as predicted, the similarity-study condition did not display an effect of RIF, but the individual-study condition did. However, contrary to our predictions there was no effect of cross-category-inhibition across groups. Therefore, across all three experiments we witnessed a double dissociation between the effect of RIF and cross-category inhibition. As a result, we cannot confidently conclude that memories are directly inhibited due to a lack of cross-category inhibition in Experiment 3, nor can we be certain about the influence of individual-study and similar-study strategies on cross-category inhibition (due to lack of power). However, we can conclude that studying items together within-categories attenuates the RIF effect. Future work exploring the effects of precise study-strategy protocols with relation to the feature-based model of inhibition still needs to be performed to disentangle the primary components contributing to RIF.

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Appendix A

Study Stimuli

Table A1

Experimental Category-Exemplar Pairings

	Experimental categories					
Item type	Red	Food	Fly	Animal	Loud	Tool
Dissimilar	BLOOD	BREAD	FRISBEE	GIRAFFE	THUNDER	FILE
	SUNBURN	CRACKERS	GLIDER	HAMSTER	TRAFFIC	PLIERS
	FIRE	PEAS	KITE	SHEEP	YELL	SCREWDRIVER
Similar	APPLE		BAT		CHAINSAW	
	CHERRY		PIGEON		DRILL	
	TOMATO		WASP		JACKHAMMER	
	KETCHUP		BUTTERFLY		COMPRESSOR	
	RADISH		EAGLE		LAWNMOWER	
	STRAWBERRY		LADYBUG		SANDBLASTER	

Note. Items between categories form a related condition. Cross-category membership occurs between learning sets. Reproduced from Anderson & Spellman, 1995.

Table A2

Filler Category-Exemplars Pairings

Filler categories			
Metals	Cities	Countries	Trees
Silver	Denver	Canada	Birch
Brass	Chicago	Germany	Hickory
Gold	Orlando	Russia	Spruce
Pewter	Paris	Ireland	Cedar
Chrome	London	Sweden	Willow
Nickel	Madrid	Japan	Palm

Table A3

Semantically Categorized Lures

Experimental categories					
Red	Food	Fly	Animal	Loud	Tool
Stopsign	Noodle	Balloon	Snake	Party	Wrench
Rose	Bagel	Airplane	Lion	Cymbals	Hammer
Clay	Cupcake	Rocket	Donkey	Cry	Crowbar
Wine	Beef	Mosquito	Swan	Horn	Forklift
Lobster	Yams	Hummingbird	Duck	Vacuum	Generator
Beets	Salami	Beetle	Owl	Mixer	Snowblower

Appendix B

Material Set Examples with Counterbalancing

Table B1

Exemplar-Exchanged Learning Sets with Balanced Retrieval-Practice

Category relation		Learning list 1 (cross-category context 1)		Learning list 2 (cross-category context 2)	
		Practice set 1	Practice set 2	Practice set 1	Practice set 2
	Similar	**RED BLOOD**	RED BLOOD	**RED BLOOD**	RED BLOOD
		RED FIRE	RED FIRE	**RED FIRE**	RED FIRE
		RED SUNBURN	RED SUNBURN	**RED SUNBURN**	RED SUNBURN
		RED APPLE	*RED APPLE*	*RED KETCHUP*	*RED KETCHUP*
		RED CHERRY	*RED CHERRY*	*RED RADISH*	*RED RADISH*
		RED TOMATO	*RED TOMATO*	*RED STRAWBERRY*	*RED STRAWBERRY*
		FOOD BREAD	**FOOD BREAD**	FOOD BREAD	**FOOD BREAD**
		FOOD CRACKERS	**FOOD CRACKERS**	FOOD CRACKERS	**FOOD CRACKERS**
		FOOD PEAS	**FOOD PEAS**	FOOD PEAS	**FOOD PEAS**
		FOOD KETCHUP	*FOOD KETCHUP*	*FOOD APPLE*	*FOOD APPLE*
		FOOD RADISH	*FOOD RADISH*	*FOOD CHERRY*	*FOOD CHERRY*
		FOOD STRAWBERRY	*FOOD STRAWBERRY*	*FOOD TOMATO*	*FOOD TOMATO*
	Dissimilar	**FLY KITE**	FLY KITE	**FLY KITE**	FLY KITE
		FLY GLIDER	FLY GLIDER	**FLY GLIDER**	FLY GLIDER
		FLY FRISBEE	FLY FRISBEE	**FLY FRISBEE**	FLY FRISBEE
		FLY BUTTERFLY	FLY BUTTERFLY	FLY BUTTERFLY	FLY BUTTERFLY
		FLY EAGLE	FLY EAGLE	FLY EAGLE	FLY EAGLE
		FLY LADYBUG	FLY LADYBUG	FLY LADYBUG	FLY LADYBUG
		LOUD THUNDER	**LOUD THUNDER**	LOUD THUNDER	**LOUD THUNDER**
		LOUD YELL	**LOUD YELL**	LOUD YELL	**LOUD YELL**
		LOUD TRAFFIC	**LOUD TRAFFIC**	LOUD TRAFFIC	**LOUD TRAFFIC**
		LOUD LAWNMOWER	LOUD LAWNMOWER	LOUD LAWNMOWER	LOUD LAWNMOWER
		LOUD SANDBLASTER	LOUD SANDBLASTER	LOUD SANDBLASTER	LOUD SANDBLASTER
		LOUD COMPRESSOR	LOUD COMPRESSOR	LOUD COMPRESSOR	LOUD COMPRESSOR

Note. Four learning sets comprised of identical category labels. Items in bold undergo subsequent retrieval practice. Item Context 1 & 2 demonstrate similar-exemplar exchange between categories. Practice Set 1, 2, 3, &, 4 demonstrate counterbalanced retrieval practice of items across similar-exemplar exchange.

Table B2

Balance Practice Status of the Category Red

	Related condition		Unrelated condition	
Category	RP+	RP-	Nrp_D	Nrp_S
Red	***Blood***	*Blood*	***Blood***	*Blood*
	Fire	Fire	**Fire**	Fire
	Sunburn	Sunburn	**Sunburn**	Sunburn
	Apple	Apple	Apple	Apple
	Cherry	Cherry	Cherry	Cherry
	Tomato	Tomato	Tomato	Tomato
Food	Bread	**Bread**		
	Crackers	**Crackers**		
	Peas	**Peas**		
	Ketchup	Ketchup		
	Radish	Radish		
	Strawberry	Strawberry		
Fly	**Kite**	**Kite**	**Kite**	Kite
	Glider	**Glider**	**Glider**	Glider
	Frisbee	**Frisbee**	**Frisbee**	Frisbee
	Butterfly	Butterfly	Butterfly	Butterfly
	Eagle	Eagle	Eagle	Eagle
	Ladybug	Ladybug	Ladybug	Ladybug
Animal			Sheep	**Sheep**
			Giraffe	**Giraffe**
			Hamster	**Hamster**
			Wasp	Wasp
			Bat	Bat
			Pigeon	Pigeon
Loud	Thunder	Thunder		
	Yell	Yell		
	Traffic	Traffic		
	Lawnmower	Lawnmower		
	Sandblaster	Sandblaster		
	Compressor	Compressor		
Tool			File	**File**
			Pliers	**Pliers**
			Screwdriver	**Screwdriver**
			Jackhammer	Jackhammer
			Drill	Drill
			Chainsaw	Chainsaw

Note. Related pairs of categories are vertically adjacent. Each column represents one learning list. Practiced items appear in boldface. Within each category, the first three items are dissimilar items; the last three are similar items.

Appendix C

Post-Experiment Questionnaire Exp. 1 & 2

Please note that you can choose not to respond to any of the following items. If you do choose to respond, please respond as accurately and honestly as possible.

1. What is your current age?

   ➢

2. How many hours of sleep did you get last night?

   ➢

3. How many consecutive hours have you been awake for today?

   ➢

4. What is your cumulative GPA?

   ➢

5. On a 7-point scale (1 being very little, 4 being average, and 7 being very much), how much effort did you put into memorizing and recalling the category examples?

   ➢

6. While memorizing the category-example pairs, did you try to integrate the items that you were trying to remember in any way? For example, linking the example *rum* to your favorite drink, a rum-and-coke. Or linking examples together such as *vodka, rum,* and *gin* as all being ingredients in a Long-Island Ice Tea?

   ➢

7. Did you perform any other sort of mnemonic technique in trying to remember the items? If so, please be as detailed as possible.

   ➢

8. During any part of the experiment, did you feel the time allotted to you for completion of that portion was either too short or overly long? Again, if yes, please be as detailed in your response as is warranted.

   ➢

9. If you have any further comments associated with this study that you would like to make, please list them here:

➢

Appendix D

Post-Experiment Questionnaire Exp. 3

Please note that you can choose not to respond to any of the following items. If you do choose to respond, please respond as accurately and honestly as possible.

1. What is your current age?

➢

2. How many hours of sleep did you get last night?

➢

3. How many consecutive hours have you been awake for today?

➢

4. What is your cumulative GPA?

➢

5. Did you memorize items <u>individually for each category</u>? For example, memorizing APPLE as a healthy fruit belonging to the category FOOD. If you did something similar, please explain.

➢ Yes ______ No ______ Explain ____

6. Did you memorize items by <u>grouping the examples from each category together</u>? For example, memorizing APPLE and KETCHUP as belonging to the category FOOD. If you did something similar, please explain.

➢ Yes ______ No ______ Explain ____

7. Did you memorize items by <u>grouping the examples together into new categories</u>? For example, memorizing APPLE and KETCHUP as belonging to the category RED FOOD. If you did something similar, please explain.

➢ Yes ______ No ______ Explain ____

8. Did you perform <u>any other sort of mnemonic technique</u> in trying to remember the items? If so, please be as detailed as possible.

➢ Yes ______ No ______ Explain ____

9. On a 7-point scale (1 being very little, 4 being average, and 7 being very much), how much effort did you put into memorizing category examples?

➢

10. On a 7-point scale (1 being very little, 4 being average, and 7 being very much), how much effort did you put into completing the stems of the category examples?

➢

11. On a 7-point scale (1 being very little, 4 being average, and 7 being very much), how much effort did you put into recalling the category examples?

➢

12. On a 7-point scale (1 being very little, 4 being average, and 7 being very much), how much effort did you put into trying to recognize the category examples?

➢

13. During any part of the experiment, did you feel the time allotted to you for completion of that portion was either too short or overly long? Please respond by placing an **X** in the appropriate cells of the table.

	Too short	Okay	Too long
Word study			
Stem completion			
Distractor			
Recall test			
Recognition test			

14. If you have any further comments associated with this study that you would like to make, please list them here:

➢

Appendix E

Full Data-Set Analyses

Experiment 1

On average, participants (N = 41) correctly completed 66.7% (*SD* = 18.0%) of the word stems with exemplars they had initially studied. During the recall phase, the rate of intrusion of words not presented at study was 10.5% (*SD* = 15.6%) and the rate of intrusion of words studied for other categories was 6.2% (*SD* =14.0%). Planned comparisons were performed to identify the effects of retrieval-induced facilitation, RIF, and cross-category inhibition. Criterion for significance for all analyses was set at $\alpha = .05$ unless otherwise noted.

Retrieval-Induced Facilitation

It was predicted that retrieval practice of exemplars would facilitate later recall of the practiced items. As expected, a dependent samples t-test comparing RP+ and NRPd items revealed that the mean recall for RP+ items was significantly greater than NRPd items (see Table 7 for recall rates), $t(40) = 6.55$, $MSE = .039$, $p < .001$, $d = 1.20$. Therefore, exemplars that underwent retrieval practice were more likely to be remembered at recall.

Table 7

Experiment 1 Full Data-Set Proportion of Exemplars Correctly Recalled

	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.54 (.32)	.27 (.27)	.29 (.26)	.30 (.27)
Related	.53 (.27)	.23 (.24)	.26 (.23)	.16 (.26)

Note. Numbers in parentheses represent standard deviations.

Retrieval-Induced Forgetting

Retrieval practice of half of the exemplars from a category should impair recall for the unpracticed half, thus, unrelated RP- and unrelated NRPs items were compared using a dependent samples t-test. The analysis for RIF was performed within the unrelated condition only, due to possible confounding of cross-category inhibition within the related condition (i.e., cross-category inhibition predicts reduced recall for related NRPs items). Although the mean unrelated RP- score was less than the unrelated NRPS score; we failed to see a significant difference (see Table 7), $t(40) = .59$, $MSE = .056$, $p = .56$, $d = .12$, $1 - \beta = .15$. Therefore, the expected RIF effect was not observed.

Cross-Category Inhibition

Cross-Category Inhibition was predicted to occur, demonstrated by reduced recall for related NRPs items compared to unrelated NRPs items. Even though RIF was not observed, a dependent samples t-test comparing the mean recall rates of related and unrelated NRPs items revealed cross-category inhibition, $t(40) = 2.21$, $MSE = .063$, $p = .033$, $d = .53$. Therefore, retrieval practice of half of the exemplars in one related category impaired the recall of unpracticed exemplars in a second related category.

Control Comparisons

To ensure that exemplars in the related and unrelated conditions were equally retrieved during retrieval practice, a paired-samples t-test was performed on RP+ items between the two relation conditions. The analysis failed to show a significant difference in retrieval rate between the sets of items. (related: 66.9%, $SD = 24.0\%$; unrelated: 66.1%, $SD = 28.2\%$), $t(40) = .14$, $MSE = .059$, $p = .89$, $d = .03$, $1 - \beta = .07$.

Further control analyses assessed the effects of the stimulus materials on RIF and cross-category inhibition. Because of the number of comparisons required by the control analyses (7), significance levels were adjusted using the Bonferroni correction: pair-wise comparisons were assessed at an alpha of 0.007. To assess the effect of learning list, a 6 x 2 (learning list: A, B, C, D, E, F x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVA was performed for RIF, and a similar 6 x 2 (learning list: A, B, C, D, E, F x item status: related NRPs, unrelated NRPs) repeated measures ANOVA was performed for cross-category inhibition. No effects of learning list were observed (Fs < 1.55, $p > .20$ for RIF; Fs < 2.03, $p > .098$ for cross-category inhibition). To assess the effect of retrieval practice list, 2 x 2 (retrieval-practice list: A, B x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVAs were performed for RIF, and similar 2 x 2 (retrieval-practice list: A, B x item status: related NRPs, unrelated NRPs) repeated measures ANOVAs were performed for cross-category inhibition for each of the individual learning lists. These multiple analyses were required due to the nesting of different retrieval-practice lists within each learning list. No effects of retrieval-practice lists were observed (Fs < 9.04, $ps > .016$ for RIF; Fs < 9.14, $ps > .015$ for cross-category inhibition).

Post-Experiment Questionnaire

All participants completed the open-ended post-experimental questionnaire. Two independent judges coded the responses with an interscorer reliability of greater than 70%. Disagreements in response categorization were re-evaluated and fit into one of the categories. Response tallies show that most participants (80.5%) explicitly used a memory encoding strategy during the experiment, with studying exemplars within categories together as the most common method (42.4%). Participants also reported using a combination of rehearsal, personalization (i.e., making exemplars self-relevant), and integration (i.e., grouping exemplars between categories together based on similarities).

Experiment 2

Participants (N = 50) correctly completed 71.7% (*SD* = 20.1%) of the word stems with exemplars they had initially studied. Planned comparisons were performed to identify the effects of retrieval-induced facilitation, RIF, and cross-category inhibition for both recall and recognition. Criterion for significance for all analyses was set at $\alpha = .05$ unless otherwise noted.

Recall

The rate of intrusion of words not presented at study was 15.4% (*SD* = 25.2%) and the rate of intrusion of words studied for other categories was 3.8% (*SD* = 8.3%).

Retrieval-Induced Facilitation. It was predicted that retrieval practice of items would facilitate later recall of the practiced exemplars. As expected, a dependent samples t-test comparing RP+ and NRPd items revealed that the mean recall for RP+ items was significantly greater than NRPd items (see Table 8 for recall rates), $t(49) = 7.00$, $MSE = .031$, $p < .001$, $d = .97$. Therefore, exemplars that underwent retrieval practice were more likely to be remembered at recall.

Table 8

Experiment 2 Full Data-Set Proportion of Exemplars Correctly Recalled

	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.55 (.31)	.27 (.27)	.35 (.27)	.31 (.30)
Related	.56 (.30)	.20 (.21)	.33 (.26)	.21 (.21)

Note. Numbers in parentheses represent standard deviations.

Retrieval-Induced Forgetting. Retrieval practice of half of the exemplars from a category should impair recall for the unpracticed half, thus, unrelated RP- and unrelated NRPs items were compared using a dependent samples t-test. The analysis for RIF was performed within the unrelated condition only, due to possible confounding of cross-category inhibition within the related condition (i.e., cross-category inhibition predicts reduced recall for related NRPs items). Contrary to our hypothesis however, mean recall of the unrelated RP- items did not show significant impairment compared to mean recall of the unrelated NRPs items (see Table 8), $t(49) = .95$, $MSE = .042$, $p = .35$, $d = .14$, $1 - \beta = .17$. Therefore, the expected RIF effect was not observed.

Cross-Category Inhibition. Cross-Category Inhibition was predicted to occur; as demonstrated by reduced recall for related NRPs items compared to unrelated NRPs items. Even though RIF was not observed, a dependent samples t-test comparing the mean recall rates of related and unrelated NRPs items revealed cross-category inhibition, $t(49) = 2.04$, $MSE = .046$, $p = .047$, $d = .35$. Therefore, retrieval practice of half of the exemplars in one related category impaired the recall of unpracticed exemplars in a second related category.

Control Comparisons. To ensure that exemplars in the related and unrelated conditions were equally retrieved during retrieval practice, a paired-samples t-test was performed on RP+ items between the two relation conditions. The analysis failed to show a significant difference in retrieval rate between the sets of items. (related: 69.6%, $SD = 26.7\%$; unrelated: 73.8%, $SD = 25.7\%$), $t(49) = .89$, $MSE = .048$, $p = .38$, $d = .16$, $1 - \beta = .20$.

Further control analyses assessed the effects of the stimulus materials on RIF and cross-category inhibition. Because of the number of comparisons required by the control analyses (7), significance levels were adjusted using the Bonferroni correction: pair-wise comparisons were assessed at an alpha of 0.007. To assess the effect of learning list, a 6 x 2 (learning list: A, B, C, D, E, F x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVA was performed for RIF. There was no main effect of learning list for RIF, $F(5, 44) = 1.84$, $MSE = .200$, $p = .125$, $\eta_p^2 = .17$, $1 - \beta = .57$, nor an interaction with RIF, $F(5, 44) = 1.94$, $MSE = .079$, $p = .106$, $\eta_p^2 = .18$, $1 - \beta = .60$. A similar 6 x 2 (learning list: A, B, C, D, E, F x item status: related NRPs, unrelated NRPs) repeated measures ANOVA was performed for cross-category inhibition. No main effect was observed for learning list for cross-category inhibition, $F(5, 44) = 1.39$ $MSE = .110$, $p = .246$, $\eta_p^2 = .14$, $1 - \beta = .44$, but there was a significant interaction between learning list and cross-category inhibition, $F(5, 44) = 4.22$, $MSE = .166$, $p < .003$, $\eta_p^2 = .32$. A post-hoc analysis revealed that learning list *B* tended to produce a greater amount of cross-category inhibition than the other lists, but the difference between individual lists was not significant following Bonferroni correction ($\alpha = .002$).

To assess the effect of retrieval practice list, 2 x 2 (retrieval-practice list: A, B x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVAs were performed for RIF, and similar 2 x 2 (retrieval-practice list: A, B x item status: related NRPs, unrelated NRPs) repeated measures ANOVAs were performed for cross-category inhibition, for each of the individual learning lists. These multiple analyses were required due to the nesting of different retrieval-practice lists between each learning list. No effects of retrieval-practice lists were observed (*F*s < 1.81, *p*s > .227 for RIF; *F*s < 2.01, *p*s > .200 for cross-category inhibition).

Recognition

Participants demonstrated an overall mean hit rate of 82.0% (*SD* = 8.8%), recognizing 78.5% (*SD* = 13.9%) of the critical exemplars and 85.6% (*SD* = 9.3%) of the filler exemplars.

Retrieval-Induced Facilitation. It was predicted that retrieval practice of items would facilitate later recognition for the practiced exemplars. As expected, a dependent samples t-test comparing RP+ and NRPd items revealed that RP+ items were recognized significantly more often than NRPd items (see Table 9 for hit rates), $t(49) = 4.80$, $MSE = .033$, $p < .001$, $d = .79$. Therefore, exemplars that underwent retrieval practice were more likely to be recognized when the stimuli were presented alone.

Table 9

Experiment 2 Full Data-Set Proportion of Exemplars Correctly Recognized

	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.92 (.16)	.77 (.29)	.80 (.28)	.84 (.27)
Related	.89 (.18)	.65 (.35)	.69 (.32)	.72 (.26)

Note. Numbers in parentheses represent standard deviations.

Retrieval-Induced Forgetting. Retrieval practice of half of the exemplars from a category should impair recognition for the unpracticed half, thus, unrelated RP- and unrelated NRPs items were compared using a dependent samples t-test. The analysis for RIF was performed within the unrelated condition only, due to possible confounding of cross-category inhibition within the related condition (i.e., cross-category inhibition predicts reduced memory for related NRPs items). Contrary to our hypothesis however, the unrelated RP- items did not show significant recognition impairment compared to the unrelated NRPs items (see Table 9), $t(49) = 1.50$, $MSE = .049$, $p = .140$, $d = .26$, $1 - \beta = .37$. Therefore, the expected RIF effect was not observed.

Cross-Category Inhibition. We hypothesized an effect of cross-category inhibition would be established through the reduced recognition for related NRPs items compared to unrelated NRPs items. A dependent samples t-test comparing hit rates of related and unrelated NRPs items confirmed our prediction, $t(49) = 2.17$, $MSE = .055$, $p = .035$, $d = .45$. Therefore, retrieval practice of half of the exemplars in one related category did impair recognition for the unpracticed exemplars in a second related category.

Control Comparisons. Control analyses assessed possible effects of the stimulus materials on RIF and cross-category inhibition. Because of the number of comparisons required by the control analyses (7), significance levels were adjusted using the Bonferroni correction: pair-wise comparisons were assessed at an alpha of 0.007. To assess the effect of learning list, a 6 x 2 (learning list: A, B, C, D, E, F x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVA was performed for RIF, and a similar 6 x 2 (learning list: A, B, C, D, E, F x item status: related NRPs, unrelated NRPs) repeated measures ANOVA was performed for cross-category inhibition. No effects of learning list were observed (Fs < 2.61, p > .037 for RIF; Fs < 2.02, p > .093 for cross-category inhibition). To assess the effect of retrieval practice list, 2 x 2 (retrieval-practice list: A, B x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVAs were performed for RIF, and similar 2 x 2 (retrieval-practice list: A, B x item status: related NRPs, unrelated NRPs) repeated measures ANOVAs were performed for cross-category inhibition, for each of the individual learning lists. These multiple analyses were required due to the nesting of different retrieval-practice lists within each learning list. No effects of retrieval-practice lists were observed (Fs < 4.21, ps > .085 for RIF, Fs < 3.01, ps > .133 for cross-category inhibition).

Post-Experiment Questionnaire

All participants completed the open-ended post-experimental questionnaire. Two independent judges coded the responses with an interscorer reliability of greater than 75%. Disagreements in response categorization were re-evaluated and fit into one of the categories. Response tallies show that most participants (84.0%) explicitly used a memory encoding strategy during the experiment, with studying exemplars together within categories as the most common method (38.1%). Participants also reported using a combination of rehearsal, personalization (i.e., making exemplars self-relevant), and integration (i.e., grouping exemplars between categories together based on similarities).

Experiment 3

Individual-study participants (N = 27) successfully completed 58.9% (*SD* = 27.4%) of the word stems, and similar-study participants (N = 28) correctly completed 65.3% (*SD* = 16.7%). Criterion for significance for all analyses was set at $\alpha = .05$ unless otherwise noted.

Recall

In the individual-study condition, the rate of intrusion for words not presented at study was 22.7% (SD = 29.0%) and the rate of intrusion for words studied for other categories was 6.1% (*SD* = 11.9%). For the similarity condition, the rate of intrusion of words not present at study was 19.6% (SD = 21.5%) and the rate of intrusion of words studied for other categories was 8.4% (*SD* = 10.9%). Mean recall rates for the critical items for both instruction conditions can be found in Table 10.

Retrieval-Induced Facilitation. A 2 x 2 (instructions: similar, individual x item status: RP+, NRPd) mixed repeated-measures ANOVA was performed in order to assess whether manipulating study instructions would have a differential effect on item facilitation (RP+ - NRPd). There was no main effect of study instructions, $F(1, 53) = .37$, $MSE = .029$, $p = .54$, $\eta_p^2 < .01$, $1 - \beta = .09$, but there was a predicted main effect of item status, $F(1, 53) = 36.44$, $MSE = 1.23$, $p < .001$, $\eta_p^2 = .41$. Follow-up dependent-sample t-tests confirmed facilitated recall of previously practiced exemplars in both the individual-study, $t(26) = 4.11$, $MSE = .044$,

Table 10.

Experiment 3 Full Data-Set Proportion of Exemplars Correctly Recalled

Individual Strategy				
	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.52 (.35)	.19 (.21)	.32 (.28)	.26 (.27)
Related	.51 (.33)	.20 (.25)	.35 (.27)	.25 (.24)

Similarity Strategy				
	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.60 (.29)	.31 (.27)	.29 (.22)	.29 (.30)
Related	.56 (.34)	.21 (.28)	.38 (.28)	.21 (.24)

Note. Numbers in parentheses represent standard deviations.

$p < .001$, $d = .68$, and similar-study, $t(28) = 4.47$, $MSE = .055$, $p < .001$, $d = 1.08$, conditions. As was further expected, there was no significant interaction between facilitation and instruction set,

$F(1, 53) = .86$, $MSE = .029$, $p = .36$, $\eta_p^2 = .02$, $1 - \beta = .15$.

Retrieval-Induced Forgetting. A 2 x 2 (instructions: similar, individual x item status: unrelated RP-, unrelated NRPs) mixed repeated-measures ANOVA was performed to assess if RIF would be found under both study-instruction conditions. There were no main effects (instructions: $F(1, 53) = 1.51$, $MSE = .156$, $p = .23$, $\eta_p^2 = .03$, $1 - \beta = .23$; item status: $F(1, 53) = .48$, $MSE = .017$, $p = .49$, $\eta_p^2 < .01$, $1 - \beta = .10$), and there was no instruction by item-status interaction, $F(1, 53) = 1.82$, $MSE = .066$, $p = .18$, $\eta_p^2 = .03$, $1 - \beta = .26$. Thus, there was no effect of RIF observed across study conditions regardless of study instructions.

Cross-Category Inhibition. A 2 x 2 (instructions: similar, individual x item status: related NRPs-, unrelated NRPs) mixed repeated-measures ANOVA was performed to assess possible differences for cross-category inhibition between instruction sets. There was no main effect for either instruction set, $F(1, 53) < .01$, $MSE < .001$, $p = .96$, $\eta_p^2 < .01$, $1 - \beta = .05$, or item status, ($F(1, 53) = .89$, $MSE = .048$, $p = .35$, $\eta_p^2 = .02$, $1 - \beta = .15$, nor an interaction, $F(1, 53) = .44$, $MSE = .024$, $p = .51$, $\eta_p^2 < .01$, $1 - \beta = .10$. Thus, there was no effect of cross-category inhibition observed across study conditions regardless of study instructions.

Recognition

Participants in the individual-study condition demonstrated an overall mean hit rate of 80.9% (SD = 11.2%), with a 76.9% (SD = 11.2%) hit rate for critical exemplars and a 84.9% (SD = 21.8%) hit rate for filler exemplars. Those in the similar-study group had an overall mean hit rate of 80.6% (SD = 7.1%), with a 69.5% (SD = 13.8%) hit rate for critical exemplars and a 91.7% (SD = 8.9%) hit rate for filler exemplars. Hit rates based on critical-exemplar status between instruction conditions can be found in Table 11.

Retrieval-Induced Facilitation. A 2 x 2 (instructions: similar, individual x item status: RP+, NRPd) mixed repeated-measures ANOVA was performed in order to assess whether or not manipulating study instructions would have a differential effect on facilitating exemplar recognition. There was no main effect of study instructions, $F(1, 53) = 2.90$, $MSE = .136$, $p = .095$, $\eta_p^2 = .05$, $1 - \beta = .39$, but there was a predicted main effect of item status, $F(1, 53) = 36.61$, $MSE = 1.30$, $p < .001$, $\eta_p^2 = .41$. Follow-up dependent-sample t-tests using the Bonferroni correction (alpha set at 0.025) confirmed facilitated recognition for previously practiced exemplars in both the individual-study, $t(26) = 5.93$, $MSE = .031$, $p < .001$, $d = 1.13$, and similar-study, $t(27) = 3.92$, $MSE = .064$, $p = .001$, $d = .96$,conditions. As was further

Table 11

Experiment 3 Full Data-Set Proportion of Exemplars Correctly Recognized

Individual Strategy				
	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.88 (.18)	.68 (.28)	.67 (.31)	.83 (.21)
Related	.90 (.18)	.69 (.29)	.75 (.24)	.74 (.30)

Similarity Strategy				
	Retrieval-Practice Item-Status			
	Practiced Category		Unpracticed Category	
Category-Relation	RP+	RP-	NRP_D	NRP_S
Unrelated	.85 (.21)	.74 (.25)	.56 (.35)	.62 (.27)
Related	.87 (.19)	.65 (.31)	.65 (.36)	.62 (.31)

Note. Numbers in parentheses represent standard deviations.

expected, there was no significant interaction between facilitation and instruction set, $F(1, 53) = .81$, $MSE = .029$, $p = .37$, $\eta_p^2 = .02$, $1 - \beta = .14$.

Retrieval-Induced Forgetting. A 2 x 2 (instructions: similar, individual x item status: unrelated RP-, unrelated NRPs) mixed repeated-measures ANOVA was performed to assess if RIF would be found under both study instruction conditions. There were no main effects (instructions: $F(1, 53) = 2.12$, $MSE = .153$, $p = .15$, $\eta_p^2 < .04$, $1 - \beta = .30$; item status: $F(1, 53) = .10$, $MSE = .006$, $p = .75$, $\eta_p^2 < .01$, $1 - \beta = .06$), but there was an instruction by item-status interaction, $F(1, 53) = 8.50$, $MSE = .491$, $p = .005$, $\eta_p^2 = .14$, $1 - \beta = .82$. Follow-up dependent-sample t-tests revealed a significant effect of RIF in the individual-study condition, $t(26) = 2.06$, $MSE = .072$, $p = .050$, $d = .58$, whereas in the similarity condition a significant facilitation of RP- items was observed—an effect opposite of normal RIF for RP- items, $t(27) = 2.07$, $MSE = .057$, $p = .048$, $d = .46$.

Cross-Category Inhibition. A 2 x 2 (instructions: similar, individual x item status: related NRPs-, unrelated NRPs) mixed repeated-measures ANOVA was performed to assess possible differences in cross-category inhibition between study instruction sets. There was a main effect for instruction set, $F(1, 53) = 8.36$, $MSE = .748$, $p = .006$, $\eta_p^2 = .14$, where participants in the similar-study condition demonstrated identical recognition rates for related NRPs and unrelated NRPs items, and participants in the individual-study condition demonstrated the expected reduced recognition for related NRPs items (see Table 11). However, there was no main effect of item status, ($F(1, 53) = .83$, $MSE = .051$, $p = .37$, $\eta_p^2 = .02$, $1 - \beta = .15$, nor an interaction, $F(1, 53) = .83$, $MSE = .051$, $p < .37$, $\eta_p^2 = .02$, $1 - \beta = .15$. Thus, there was no effect of cross-category inhibition observed across study conditions regardless of study instructions.

Control Comparisons

Dependent sample t-tests showed no difference in retrieval practice rates between related and unrelated items in either the individual-study condition, $t(26) = .59$, $MSE = .056$, $p = .56$, $d = .11$, $1 - \beta = .13$, or the similarity condition, $t(27) = .23$, $MSE = .069$, $p = .82$, $d = .06$, $1 - \beta = .09$. A one-way ANOVA also revealed no significant difference in the proportion of items correctly retrieved between the two study-instruction conditions, $F(1, 53) = 1.11$, $MSE = .057$, $p = .30$, $\eta_p^2 = .02$, $1 - \beta = .18$.

Further control analyses assessed possible stimulus effects for RIF and cross-category inhibition within each of the instruction conditions for both recall and recognition tests. Because of the number of comparisons required by the control analyses for each instruction condition within both tests (Total: 14; learning list analysis (1) with nested retrieval-practice list analyses (6) performed for each instruction condition (2)), significance levels were adjusted using the Bonferroni correction; pair-wise comparisons were assessed at an alpha of 0.003. Analyses were performed separately for each instruction condition.

To assess the effect of learning list, a 6 x 2 (learning list: A, B, C, D, E, F x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVA was performed for RIF, and a similar 6 x 2 (learning list: A, B, C, D, E, F x item status: related NRPs, unrelated NRPs) repeated measures ANOVA was performed for cross-category inhibition; the analyses were first performed for the recall test than for the recognition test. To assess the effect of retrieval practice list, 2 x 2 (retrieval-practice list: A, B x item status: unrelated RP-, unrelated NRPs) repeated measures ANOVAs were performed for RIF, and similar 2 x 2 (retrieval-practice list: A, B x item status: related NRPs, unrelated NRPs) repeated measures ANOVAs were performed for cross-category inhibition, for each of the individual learning lists. These multiple analyses were required due to the nesting of different retrieval-practice lists between each learning list. No effects of learning list (Fs < 3.583, ps > 0.015) or retrieval-practice lists (Fs < 12.001, ps > 0.012) were observed for either effect for either test within either instruction condition.

Manipulation Check. 27 of the 28 participants in the similar-study condition, and 23 of the 27 participants in the individual-study condition completed the post-experimental questionnaire. The questions were partially close-ended that required yes-no answers, but in addition asked participants to elaborate on their answers. Response tallies of the yes-no responses show that most participants (92.0%) explicitly used an encoding strategy as instructed during study. In the individual-study condition 52.2% of participants reported using a similarity-based strategy, whereas only 47.8% also reported studying exemplars in an individual-study fashion. In the similar-study condition, 63.0% of participants reported studying exemplars together based on similarity and 33.3% of the same participants reported studying the exemplars individually. Thus, not only did subjective reports of study strategies differed from the objective reports based on the difference in RIF between groups, but participants indicated using multiple types of strategies. Perhaps initially performing individual-study and then switching to similar-study as a greater number of items were introduced.