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The reverse-interference effect: A reexamination of the interference theory of forgetting

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The Reverse-Interference Effect:
A Reexamination of the Interference Theory of Forgetting.

by
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Submitted in partial fulfillment of the requirements
for the Degree of Doctor of Philosophy

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GRADUATE STUDIES

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Abstract
by
ANJALI THAPAR

Burns (1989) first observed the reverse-interference effect when investigating the effects of transfer specific (A-B, A-C) paired associate learning on long term retention. He demonstrated that free recall of the critical-list response terms was better in the interference condition than in the control condition. This reversal of the traditional interference effect is referred to as the reverse-interference effect. Burns proposed a processing tradeoff explanation to account for both the traditional interference effect and the reverse-interference effect. The series of experiments presented here examine two proposed accounts of the reverse-interference effect, the processing tradeoff account and the list-length account proposed by Hirshman, Burns, and Kuo (1993). In addition, three other explanations for the reverse-interference effect were also investigated. The results of the seven experiments reported here demonstrate that the reverse-interference effect is a robust phenomenon that cannot be explained by current accounts.
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Table of Contents

Title Page ................................................................. i
Abstract ................................................................. ii
Acknowledgements .................................................... iii
Table of Contents ..................................................... iv
Introduction ............................................................. 1
Experiment 1 ............................................................. 18
    Method ............................................................. 18
    Result and Discussion ......................................... 20
Experiment 2 ............................................................. 21
    Method ............................................................. 23
    Result and Discussion ......................................... 24
Experiment 3 ............................................................. 26
    Method ............................................................. 29
    Result and Discussion ......................................... 30
Experiment 4 ............................................................. 31
    Method ............................................................. 32
    Result and Discussion ......................................... 34
Experiment 5 ............................................................. 37
    Method ............................................................. 38
    Result and Discussion ......................................... 39
Experiment 6 ............................................................. 40
    Method ............................................................. 41
    Result and Discussion ......................................... 42
Experiment 7 ................................................................................................................. 44
  Method ......................................................................................................................... 45
  Result and Discussion ................................................................................................. 46
General Discussion ........................................................................................................ 47
References ....................................................................................................................... 56
Appendix A: Lists used for the Control and Interference Conditions .............................. 58
Appendix B: Sample Answer Sheet ................................................................................ 60
Appendix C: Sample of a Single Item Repeated and Nonrepeated List .......................... 62
Appendix D: List D-F used in Experiment 4 .................................................................... 64
Appendix E: Prior and Critical Lists used for the Within-Subjects List Design ............ 66

For decades, the interference theory of forgetting dominated discussion and research concerning forgetting. According to the interference theory, forgetting is the result of retrieval failure, that occurs because some unwanted memories are retrieved instead of the information to be remembered (Crowder, 1976). The basic idea that distinguishes this theory from other forgetting theories (e.g., the decay or contextual-change theories of forgetting), is that forgetting is not due to the loss in retention or availability of information but is the result of unsuccessful retrieval caused by competing information. Retroactive and proactive interference are the two ways in that memories are believed to interfere with the accurate recall of information. Information that is learned can be forgotten either by learning that occurred prior to the critical learning (proactive interference) or by learning that occurred after the learning of the critical list but before the test (retroactive interference). A good example of retroactive and proactive interference that occurs quite commonly is when you get a new phone number. Proactive interference is the failure to remember your new phone number due to interference from the old phone number. Failure to remember your old phone number due to interference with the new number is an
example of retroactive interference.

The paired-associate learning methodology was designed to study retroactive and proactive interference. In a paired association task, subjects are shown a list of paired items (e.g., train-cabin). The item on the left hand side (train) is referred to as the stimulus term, and the item on the right hand side (cabin) is the response term. After learning the list of paired items, subjects are given another list of stimulus-response pairs to learn. In the most common design, subjects are split into two groups, one referred to as the experimental group and the second as the control group. Subjects in the experimental group are given the same stimulus terms in both lists, paired with different response terms (referred to as A-B, A-C). Subjects in the control group are given different stimulus and response pairs on the two lists (a D-B, A-C list-design for proactive interference and a A-B, D-C list-design for retroactive interference). Both proactive and retroactive interference are defined by the difference in retention between the experimental (A-B, A-C) and the control (e.g., D-B, A-C or A-B, D-C) group. Proactive interference is demonstrated by asking subjects to remember the response terms on the second list (the C terms) when cued with the stimulus terms. Typically, one finds that subjects in the experimental group remember fewer responses from the second list as compared to subjects in the control group. To demonstrate retroactive interference,
subjects are asked to remember the response terms for the first list (the B terms), and again the experimental group is impaired relative to the performance of the control group. The results from both retroactive and proactive interference demonstrate that subjects in the experimental group perform significantly worse on a paired-associate task as compared to the control group.

One mechanism believed to be responsible for both retroactive and proactive interference is response competition (McGeoch, 1942). In the paired-associate task described above, the impaired performance of the experimental group when compared to the control group is due to the fact that subjects in the experimental group learn two different response terms (B and C) in association to one stimulus term (A). Retroactive interference occurs when subjects are given the stimulus term “A” from the prior list and are asked to remember “B”. Because subjects in the experimental group learned associations for both the A-B and A-C word pairs, the “B” and “C” response terms compete at time of test, and subjects incorrectly recall some “C” terms as having occurred on the first list. Subjects in the control group don't face this dilemma because they associated only the “B” response terms with the “A” stimulus terms. Proactive interference occurs when subjects are given the stimulus term “A” from the second list and are asked to remember “C”. Because subjects in the experimental group
learned both A-B and A-C associations, the “B” and “C” response terms compete at time of test, and subjects incorrectly recall some “B” terms as having occurred on the second list. Again, as in retroactive interference, subjects in the control group don’t face this dilemma because they associated only the “C” response terms with the “A” stimulus terms. The underlying idea of response competition is that subjects retain both the original association and the newly formed one. At test, when subjects are required to make a response, both responses are remembered, but since only one response is allowed, a handful of times subjects will pick the incorrect response.

Recently, Burns (1989) has suggested another possible mechanism for proactive interference. Burns suggests that proactive interference is the result of subjects switching the encoding processing strategies they use to learn the paired-associate items on the two lists. He believes that subjects switch from relational processing on the original list to individual-item processing on the second list. He cites the reverse-interference effect as support for this hypothesis. The reverse-interference effect is a phenomenon Burns found while investigating the effects of transfer specific (A-B, A-C) paired-associate learning on long-term retention. He found that free recall of the critical list (C) responses was better under conditions of interference (A-B, A-C) learning than under control (D-B, A-C) learning conditions, whereas cued recall of
the critical list response terms was better under the control learning conditions. Burns refers to this as the reverse-interference effect because one usually finds less retention in the interference condition. Understanding the mechanisms of the reverse-interference effect is of great theoretical importance as most accounts of interference do not predict any situations where the interference condition would be at an advantage (Gardiner, Craik, & Birtwistle, 1972; Greeno, James, & Dapolito, 1971; Postman & Underwood, 1973).

As a specific example of the reverse-interference effect, I will discuss an experiment by Hirshman, Burns, and Kuo (1993) that replicated Burns' (1989) findings in paired-associate learning and free recall. Hirshman et al. told subjects that they were to learn a paired-associate list after which they would be given a cued-recall memory test with the stimulus terms and were to remember the response terms. Half of the subjects were randomly assigned to the interference condition (A-B, A-C) and half to the control condition (D-B, A-C). Subjects were presented with a list of stimulus-response pairs to learn. After the last stimulus-response pair was presented, subjects were given a written cued-recall test. Subjects were given the appropriate stimulus terms (either "A" or "D") and had to recall the correct response term ("B"). Upon completion of the first cued-recall test, subjects were shown the entire list over and completed another cued-recall test. All of the subjects
completed three such study-test trials of the prior list and then were given the critical list. The procedures for acquisition of the critical list were identical to the procedures used for the prior learning list with the exception that subjects were only presented with one study-test cycle of the critical list. After the cued-recall test for the critical list was completed, subjects were asked to write down the names of states for 5 min. After this distractor task was completed, subjects were given a free-recall test on the response terms for the critical list. The results demonstrated both the traditional proactive interference and the reverse-interference effects. Subjects in the control condition had significantly higher cued recall for the responses on the critical list than subjects in the interference condition, replicating the traditional proactive interference effect. Subjects in the interference condition demonstrated significantly higher free recall for the response terms than subjects in the control condition, replicating Burns’ reverse-interference effect.

In addition to demonstrating the reverse-interference effect, Burns’ (1989) investigated the relationship between retention for the response and the stimulus terms. Burns’ intention was to determine whether the difference in response recall could be attributed to differential accessibility of the critical list’s stimulus terms by subjects in the control and interference conditions. Burns found no evidence for the
hypothesis that the reverse-interference effect is due to
differential accessibility of the critical list's stimuli by the two
groups. In fact, his results suggest that having greater
accessibility to the critical list stimuli is not enough to
guarantee higher performance on a subsequent free-recall test
(Experiment 3). Burns also investigated the effect of time
interval on the reverse-interference effect. The rationale for
this study was based on the fact that the advantage the control
group has over the interference group in proactive interference
Burns wanted to investigate whether the reverse-interference
effect was also sensitive to time manipulations. The results
showed that the reverse-interference effect can be found at
very short intervals (5 min) as well as longer intervals (24
hrs).

The processing tradeoff theory proposed by Burns (1989)
uses the distinction between relational and item-specific
processing (Hunt & Einstein, 1981). Relational processing
refers to encoding the similarities among a class of events (e.g.,
encoding associations between "train-cabin"), and individual-
item processing refers to encoding item-specific information
(e.g., encoding information for "cabin"). Burns believes that
proactive interference arises in a paired-associate learning task
because subjects employ different encoding strategies in the
control and interference conditions while learning the second
list. Subjects in the control condition use a relational processing strategy for learning the associations on both the prior and the critical list. Subjects in the experimental condition use relational processing information to acquire the first list but switch to an item-specific processing strategy to acquire the second list. Proactive interference and the reverse-interference effect are the result of switching processing strategies between the prior and the critical list.

This theory is based on six assumptions. First, Burns assumes that subjects can distinguish between item-specific and relational-specific information when presented with a list of word pairs to learn. His second assumption is that an item-specific information processing strategy is best for free recall tasks. He also assumes that a relational processing strategy is best for cued-recall tasks. The fourth assumption is that subjects in the control and interference conditions use relational information to help remember the word pairs on the prior lists. He assumes that when the critical list is presented, subjects in the control condition continue to use relational information to process the word pairs. His last assumption is that subjects in the interference condition switch from a relational processing strategy to a item-specific processing strategy to learn the critical list.

The results of his experiments are in agreement with the individual-item/relational processing theory of transfer
specific interference and suggest that the interference
condition causes subjects to switch from processing primarily
relational (stimulus-response) information to processing
primarily individual-item information. However, since subjects
in the control group have minimal interference between the
stimulus-response associations in the prior list and the critical
lists, they are able to learn associations between the stimulus
and response terms in the critical list and continue to use
relational processing when they are given the critical list as
opposed to switching to individual-item information processing.
The result of switching processing for the critical list is
detrimental in a cued-recall task where relational information
is vital but is an advantage in free recall in which individual
item information is more important.

To summarize, Burns claims that proactive interference in
paired-associative learning occurs because subjects employ
different encoding strategies in the control (D-B) and
interference (A-B) conditions during second-list (A-C) learning.
Burns characterizes these encoding strategies using the
distinction between relational and item-specific processing.
Burns claims that subjects in the interference condition focus
on response-specific information, at the expense of relational
information, during the encoding of the second-list pairs. This
deficit in relational processing is assumed to cause proactive
interference in paired-associate learning of the second list. One
motivation for this processing tradeoff may be that subjects in
the interference condition realize that stimulus-response
mediators have been "used up" during prior-list learning.
Burns' position predicts that interference effects should reverse
on memory tests that are sensitive primarily to the item-
specific characteristics of response terms. Consistent with this
prediction, Burns' demonstrated that free recall of second-list
responses was better in the interference condition than in the
control condition and refers to this as the reverse-interference
effect.

Hirshman et al.'s (1993) Experiment 4 was designed to
test Burns' processing tradeoff account of the reverse-
interference effect. In Experiment 4, Hirshman et al.
manipulated the pre-experimental strength of the prior-list
pairs (strong or unrelated) and the prior learning condition
(control or interference). Half of the subjects received strongly
associated prior-list pairs (table-chair) while the remaining
subjects received unrelated pairs (table-cabin). Hirshman et al.
were hoping to determine whether the occurrence of the
traditional interference effect correlated with the reverse
interference effect. The authors predicted that, if strongly
associated prior-list pairs enhance the traditional interference
effect (Hirshman et al.'s Experiments 1-3), then Burns'
processing tradeoff hypothesis would predict that one should
also find a greater reverse-interference effect. In Experiment
4. strength of prior list associations (strong or unrelated) was orthogonally manipulated with prior learning (control or interference). Subjects were presented with a single study-test cycle of both the prior list and the critical list. Free recall of the critical list responses revealed a significant interaction between prior-list associative strength (strong or unrelated) and prior-learning condition (interference or control). The reverse-interference effect was found with unrelated prior-list pairs but wasn’t found for the strongly-associated pairs used in the prior list. Hirshman et al. argued that this finding is inconsistent with Burns’ processing-tradeoff account. This conclusion seems unnecessarily strong. Burns never specifically dealt with the issue of associative strength or how this might affect subjects’ tendencies to switch processing strategies between lists. It seems fairer to treat the finding that the reverse-interference effect is greater when unrelated prior-list pairs are used than when strongly-related pairs are used as a finding that is not predicted by Burns’ account but is not necessarily inconsistent with it.

As a result of their findings from Experiment 4, Hirshman et al. (1993) proposed the list-length hypothesis as an alternative to the processing tradeoff account as a viable explanation of the reverse-interference findings. The list-length effect (Roberts, 1972) refers to the finding that the probability of recalling items from a list decreases as the
number of items on the list increase. Hirshman et al. noted that subjects in the control condition see more stimuli than subjects in the experimental condition, where the "A" terms are repeated; they attribute the advantage for the experimental condition in free recall to this difference in the number of different stimuli seen. Hirshman et al. based the explanation on two assumptions. First, following Underwood and Ekstrand (1967), they assumed that the representations of the prior and critical lists are intermingled in memory. For example, individual items from the prior list (either the A, B, or D items) can be associated with the critical list's memory representation. Second, following Shiffrin, Ratcliff, and Clark (1990), the authors assumed that an item that is encoded repeatedly as a list item can be represented as a single list item in memory. In other words, multiple encodings of an item accrue strength to a single, common memory representation (Hirshman et al., p. 8).

Hirshman et al. (1993) used these two assumptions to derive the list-length account of the reverse-interference effect. The first assumption implies that some of the prior-list items are encoded as critical-list items and the second assumption implies that list differentiation failures are more detrimental to the control group than the experimental group. The justification for this hypothesis is that, in the interference condition, an "A" term from the prior list will be encoded with an "A" term on the critical list as a single critical-list item.
However, because the control condition doesn't share any terms in the prior and critical list, the result is a longer list from which subjects must recall items. Hence, performance on a free-recall test is lower in the control group as compared to the interference group.

In Experiment 5, Hirshman et al. (1993) contrasted the list-length and the processing tradeoff accounts of the reverse-interference effect. The authors designed a task for which the list-length and the processing tradeoff accounts make contrasting predictions. The authors investigated whether the reverse-interference effect can be found for prior-list responses. The list-length account predicts that the reverse-interference effect should occur for prior-list responses because failure for list differentiation can occur on prior lists as well as on critical lists. That is, critical list items can be encoded as prior-list items and will increase the functional list length of the prior list more in the control condition than in the experimental condition. The processing tradeoff account predicts that one should not find the reverse-interference effect on prior-list responses as the change in encoding processing strategies occurs during the encoding of the critical list. To summarize, the list-length account would predict better recall for the interference group than in the control group, whereas the processing tradeoff account predicts no differences or minimal differences between the control and the
interference groups for the free recall of the prior list response terms.

The results from Hirshman et al.'s Experiment 5 demonstrated a reverse-interference effect for prior-list responses. Free recall of the prior-list responses was better in the interference condition than the control group. These results suggest that the processing tradeoff is no longer a sufficient explanation for the reverse-interference effect. On the other hand, Hirshman et al. contend that the list-length account is still a viable explanation for the reverse-interference effect.

The purpose of the present study is to investigate the fundamental assumptions of both the processing-tradeoff account and the list-length account of the reverse-interference effect. In addition, two other explanations, one based on task difficulty and one based on distinctiveness will also be tested. The processing-tradeoff account is based on the assumption that subjects in the control and interference conditions use relational information to help encode the word pairs on the prior lists. The account also assumes that when the critical list is presented, subjects in the control condition continue to use relational information to process the word pairs but that subjects in the interference condition switch from a relational processing strategy to an item-specific processing strategy to learn the critical list. Burns' processing-tradeoff account
hypothesizes that the reverse-interference effect is due to superior free recall by subjects in the interference condition because the subjects switched to an item-specific processing strategy and an item specific strategy leads to better free recall than a relational processing strategy. However, Burns has no evidence that subjects in the interference condition switch processing strategies when presented with the critical list and that subjects in the control condition use the same processing strategy for the prior and critical list. These assumptions need to be tested before Burns' processing-tradeoff account of the reverse-interference effect can be accepted.

The list-length account is also based on several assumptions that need to be empirically tested. The crucial assumption presumes that having repeated items on a list decreases the functional length of the list and results in better free recall. This assumption needs to be tested before the list-length account of the reverse-interference effect can be accepted.

The task difficulty account is based on the observation that the cued-recall test for the critical list in Burns (1989) and Hirshman et al. (1993) is a more difficult task for subjects assigned to the experimental condition as compared to the control condition. This refers to the fact that when subjects in the interference and control groups are given a cued-recall test for the critical list, performance by the experimental group is
lower than the control group, demonstrating proactive interference. An indirect effect of this could be that since subjects in the experimental condition had to work harder to remember the correct response items during the cued-recall test because of interference from the response items on the previous list, their subsequent free recall for these response items will be better than subjects in the control condition. The task difficulty account of the reverse-interference effect can be investigated by not giving subjects a cued-recall test for the critical list. The task difficulty account would predict that the reverse-interference effect is not found in the absence of the cued-recall test.

The distinctiveness account of the reverse-interference effect was derived from Burns' processing-tradeoff account. However, whereas Burns' processing-tradeoff account is based on six assumptions, this account is based on only two assumptions. The distinctiveness account assumes that subjects in the interference condition switch encoding strategies when presented with the critical list, and that the process of switching strategies helps subjects to discriminate whether a response term is from the prior list or the critical list during the free-recall test. Because there are no repeated stimulus terms between the prior and the critical lists, subjects in the control condition use the same encoding strategy for learning the prior and critical list. Since subjects in the control condition
don't need to switch strategies, they are at a disadvantage when it comes to discriminating whether a stimulus-response pair is from the prior list or the critical list. This account will be investigated by asking subjects to report on the free-recall test as many of the response terms that they can remember regardless of list membership. If the reverse-interference effect is the result of differences in distinctiveness, than asking subjects to recall both the prior list and the critical list's response terms should wipe out any advantage the interference condition has over the control condition.

In the present study, Experiment 1 will be a replication of the reverse-interference effect. Experiment 2 will attempt to replicate Hirshman et al.'s Experiment 5 (1993) where the reverse-interference effect was found using a free-recall test of the prior list's response terms (the "B" terms). Experiments 3 and 4 examine the effect of repetition and list length on the subsequent free recall of the non-repeated items on a list and directly test the assumptions that form the basis of the list-length account of the reverse-interference effect. Experiment 5 explores the task-difficulty hypothesis by removing the cued-recall task to determine whether this influences the magnitude of the reverse-interference effect. Experiment 6 examines the distinctiveness hypothesis by requiring subjects to recall the response terms regardless of list membership. Experiment 7 examines the effect of design manipulation on the reverse-
interference effect.

Experiment 1

As previously stated, the purpose of Experiment 1 was to demonstrate the reverse-interference effect reported by Burns (1989) and Hirshman et al. (1993).

Method

Subjects. Thirty-four students enrolled in introductory psychology classes at Case Western Reserve University participated to fulfill a course requirement and were tested individually on a Macintosh Plus computer. Seventeen subjects were randomly assigned to the control condition and 17 to the interference condition.

Design and Materials. Experiment 1 used a single-factor between-subject design with three dependent measures. Group membership (control vs. interference) was manipulated between subjects. The three dependent measures were (1) final-trial cued recall of the prior list, (2) cued recall of the critical list, and (3) free recall of the critical list response terms. The items used in the present study were the same as those used by Burns (1989) and were reported in Tulving and Thompson (1973). Twenty-four word pairs were randomly assigned to three lists (list A-B, list A-C, and list D-B). The lists are reported in Appendix A. The lists were presented on a
computer screen. Word-pairs were presented in upper case letters. For the cued-recall test, a randomly generated answer sheet was prepared and used for all four trials in the interference condition and another one was designed for the prior list's cued recall in the control condition. Subjects in the control and interference conditions received the same answer sheet for the cued recall of the critical list. Subjects were given the answer sheet with the stimulus terms shown and were asked to write down the appropriate response terms. A sample answer sheet is presented in Appendix B. Subjects were given sheets of blank paper to complete the distractor task and the free-recall task.

**Procedure.** At the beginning of the experiment, subjects were informed that they would be presented with a list of word pairs and that their memory for the pairs would be tested. Subjects were told that the memory test would be a cued-recall test where they would be given the stimulus term and were to write down the appropriate response term that it had been paired with on the list. Following these instructions, subjects were presented with the prior list. Subjects in the control condition were presented List D-B for the prior list, and subjects in the interference condition were given List A-B for the prior list. The 24 word-pairs were presented one at a time on the computer screen for 4 s. Upon presentation of the last word pair, subjects were given the cued-recall test. Subjects
were given a sheet of paper with the stimulus terms in random order and were asked to write down the corresponding response terms. Upon completion of the cued-recall test, subjects were shown the entire list over on the computer and completed another cued-recall test. All of the subjects completed three such study-test trials of the prior list and then were presented with the critical list (List A-C). The procedures for acquisition of the critical list were identical to the procedures used for the prior learning list with the exception that subjects were only presented with one study-test cycle of the critical list. The stimulus terms for the prior lists' and the critical list's cued-recall test for both the interference and the control condition were shown in the same order to all of the subjects. After the cued-recall test for the critical list was completed, subjects were asked to write down the names of states for 5 min. After this distractor task was completed, subjects were given a free-recall test for the response terms on the critical list.

**Results and Discussion.**

All effects reported as significant used a .05 significance criterion. The proportion of prior list items reported on the cued-recall test after the last study trial and the proportion of critical words reported in cued recall and free recall by subjects in the control condition were .96, .54, and .20
respectively. The proportion of prior list items reported on the cued-recall test after the last study trial and the proportion of critical words reported in cued recall and free recall by subjects in the interference condition were .92, .45, and .31 respectively. An analysis of variance (ANOVA) revealed no significant difference between the performance of subjects in the control and interference condition on the cued-recall test for the prior list \([E(1,32)= 2.66, \text{MSE} = 3.59]\). Thus, acquisition of the prior list was approximately equal across the two conditions. In addition, even though the interference condition reported fewer critical list response terms on the cued-recall test as compared to the control condition, the difference failed to reach significance \([E(1,32)= 2.05, \text{MSE} = 27.77]\). However, a significant difference was found for the free recall of the critical list's response terms between the control and interference groups \([E(1,32)=3.99, \text{MSE} = 13.64]\). The pattern of results demonstrated here replicate the significantly higher free recall performance by the interference group over the control group reported by Burns (1989) and Hirshman et al. (1993). Experiment 1 also replicated Burns and Hirshman et al.'s failure to demonstrate the traditional interference effect while finding the reverse interference effect.

Experiment 2

Experiment 2 was an attempt to replicate Hirshman et
al.'s Experiment 5 (1993). In Experiment 5, Hirshman et al. found the reverse-interference effect using free recall of the prior list's response terms. Burns' processing-tradeoff account is based on the assumption that the presentation of the second list leads subjects in the interference condition to switch from a relational to an item-specific processing strategy. Item-specific processing strategy is believed to be best for a free-recall test and results in the increased recall of response terms in the interference condition as compared to the control condition. The account also assumes that subjects use a relational processing strategy for learning the word pairs on the prior list. Relational processing strategy is believed to be detrimental for free recall. Therefore, the processing tradeoff account does not predict a reverse-interference effect for recall of the prior list's response terms. However, the list-length account proposed by Hirshman et al. (1993) does predict a reverse-interference effect for recall of prior list response terms. This account assumes that the proportion of items correctly free recalled is determined by the number of different stimuli seen by a subject during the experiment. Following Shiffrin et al. (1990), Hirshman and his colleagues assumed that an item encoded repeatedly as a list item can be represented by a single trace in memory. Hirshman et al. also cite the work done by Roberts (1972), who demonstrated that the probability of recalling items decreases as the number of items increases. Based on
the Shiffrin et al. and Roberts findings, Hirshman et al. assume that having repeated items on a list decreases the functional length of the list as compared to a list with only once-presented items. The result of the decreased functional list-length in the repeated condition results in better free recall as compared to the nonrepeated condition. To explain the reverse-interference effect, Hirshman et al. assume that the stimulus-response terms of each word pair are encoded separately as individual items and that having repeated stimulus terms decreases the functional length of the interference list as compared to the control list. Therefore, the list-length account proposed by Hirshman et al. predicts that a reverse-interference effect will be found for both the prior list and the last list's response terms. Hirshman et al.'s findings of a reverse-interference effect on free recall of prior-list responses therefore represents the only evidence inconsistent with Burns' processing-tradeoff account. If Hirshman et al.'s results can be replicated, it places serious constraints on the processing-tradeoff explanation of the reverse-interference effect.

Method

Subjects. Twenty-two introductory psychology students participated and were tested individually on a Macintosh Plus computer. Eleven subjects were randomly assigned to the
control condition and eleven to the experimental condition.

**Design and Materials.** The design and materials used in Experiment 2 were identical to those described in Experiment 1 with one exception. In Experiment 1, the order in which the stimulus terms appeared on the answer sheets for the cued-recall test were identical for each of the study-trial sessions. It is possible that subjects were acquiring associations between the order of the stimulus terms on the answer sheet and using these associations to complete the cued-recall test. It is also possible that since subjects in the interference condition were getting the same answer sheet after learning the critical list that they were able to use the associations between the stimulus terms as cues during the free-recall test. To make it more difficult for subjects to use such associations for completing the cued-recall and free-recall tests, different random orders of the stimulus terms were used on each of the answer sheet for a subject.

**Procedure.** The instructions and procedure for the acquisition and the cued-recall test of both the prior list and the critical list were identical to those described in Experiment 1 with one exception. After completing the 5 min. distractor task, all of the subjects were asked to report the prior list's response terms on the free-recall test.

**Results and Discussion**
The proportion of prior list items reported on a cued-recall test after the last study trial and the proportion of critical words reported on the cued-recall test by subjects in the control condition were .91 and .47 respectively. The proportion of prior list items reported on the cued-recall test after the last study trial and the proportion of critical words reported on the cued-recall test by subjects in the interference condition were .96 and .44 respectively. Subjects in the control condition reported .44 of the prior list's response terms on the free-recall test as compared to the .59 reported by subjects in the interference condition. Analysis of variance revealed no significant difference between the performance of subjects in the control and interference condition on the cued-recall test for the prior list \(F(1,20) = 1.64, \text{MSE} = 6.26\), or the critical list \(F(1,20) = 0.23, \text{MSE} = 20.06\). A significant difference was found in the number of prior list's response terms reported in a free-recall test by subjects in the control condition as compared to the interference condition \(F(1,20) = 7.35, \text{MSE} = 9.41\).

The results from Experiment 2 replicated Hirshman et al. (1993) finding of a reverse-interference effect for the free recall of the prior list's response terms. As previously mentioned, these findings are not predicted by Burns' processing-tradeoff account of the reverse-interference effect and are difficult to reconcile with the fundamental assumptions of the processing-tradeoff account. The list-length account
proposed by Hirshman et al. does predict the pattern of findings from both Experiments 1 and 2 and therefore is still a viable account of the reverse-interference effect.

Experiment 3

Experiment 2 replicated Hirshman et al.'s (1993) findings of a reverse-interference effect for free recall of the prior-list items. These findings are difficult to reconcile with Burns' processing tradeoff account but can be accounted for by Hirshman et al.'s list-length account of the reverse-interference effect. This experiment is designed to test the fundamental assumption of the list-length account of the reverse-interference effect. Basically, Hirshman et al., assume that free recall is determined by the number of different stimuli seen by a subject during the experiment. This account assumes that an item encoded repeatedly as a list item can be represented by a single trace in memory. In addition, the account also assumes that the probability of recalling items decreases as the number of items increases and that having repeated items on a list decreases the functional length of the list as compared to a list with only once-presented items. The decreased functional list-length in the repeated condition results in better free recall as compared to the nonrepeated condition. To account for Burns' findings in a paired associate task, Hirshman et al. assume that the stimulus-response terms of each word pair are encoded
separately as individual items and having repeated stimulus
terms decreases the functional length of the interference list as
compared to the control list.

As far as I know, the effect of repeated stimulus terms on
the free recall of response terms has not been directly tested.
A handful of experiments have explored a similar issue, the
extent to which recall of once-presented items on a list is
dependent on the presentation frequency of other items on the
list (Hastie, 1975; Tulving & Hastie, 1972; Waugh, 1963). The
results from Waugh's study revealed that recall of once-
presented words was not affected by the proportion of twice-
presented words appearing in the same list. Tulving and Hastie
found that recall of once-presented words from lists containing
both once- and twice-presented words was lower than recall of
words from comparable lists containing only once-presented
words. In short, Tulving and Hastie's results revealed that
recall of once-presented words was inhibited when they were
presented with repeated items on a list. Hastie (1975)
explored the possibility that the discrepancy in the results
were due to different encoding instructions. Waugh's subjects
were told that they would have to write out all of the recalled
items once, regardless of presentation frequency. Tulving and
Hastie's subjects were instructed to write out twice-presented
words twice. Hastie compared the effect of both types of
encoding instructions along with a control condition where
subjects were not given any encoding instructions. His results showed that the discrepancy between Waugh’s results and Tulving and Hastie’s results was due to different encoding instructions. Recall of once-presented items was inhibited when subjects were previously instructed that they would be required to know frequency attribute information during free recall (as was found by Tulving & Hastie). However, when subjects were told that they would not be tested on the frequency attribute information, there was little inhibition of the once-presented items (as was found by Waugh). In Hastie’s Experiment 1, recall of once-presented items was compared between a control list with no repeated items and an experimental list with both once-presented and repeated items. Subjects in the experimental condition were instructed to write down all of the items they could recall once, regardless of the actual frequency of presentation. The proportion of once-presented words recalled was .50 on lists containing repeated items and .48 on lists containing only once presented items; in his Experiment 2, these proportions were .38 and .39, respectively.

The results from Hastie’s (1975) studies suggest that the effect of repeated items on a list either inhibit the recall of once-presented items (i.e., when subjects are told that they need to know frequency information) or have little effect on the recall of once-presented items (i.e., when they are told to
disregard frequency information). Even though Hastie’s experiment was not designed to test Hirshman et al.’s (1993) list-length theory, the results appear inconsistent with the list-length account. Experiment 3 directly examines the effect of repeated items on the free recall of the nonrepeated items on a list. The list-length theory would predict higher recall of the nonrepeated items on a list with repeated items as compared to the recall of these items on a list with only once-presented items.

**Method**

**Subjects.** Twenty students enrolled in introductory psychology classes at Case Western Reserve University participated to fulfill a course requirement and were tested individually on a Macintosh Plus computer.

**Design and Materials.** Test items for Experiment 3 were from the set reported in Tulving and Thompson (1973). Six lists were constructed. Three lists were randomly assigned to the control condition and the remaining three to the repeated condition. The control lists were constructed of 15 once-presented items. The repeated lists were constructed of five once-presented items and five twice-presented items, totaling 15 test items. The lists were counterbalanced across subjects so that each list was presented as a control and as a repeated list equally often. In addition, the order of list presentation...
was also counterbalanced across subjects so that an equal number of subjects were given the lists in the control-interference order and the interference-control order. The lists and their critical items are reported in Appendix C. The lists were presented on a computer screen in upper case letters. Subjects were given a blank sheet of paper to complete the free-recall task.

Procedure. At the beginning on the experiment, subjects were informed that they would be presented with a list of words and that their memory for the words would be tested. Following these instructions, subjects were presented with the first list. Half of the subjects were given the three control lists prior to the three repeated lists. The remaining subjects were given the lists in the opposite order. Items were presented one at a time on the computer screen for 4 s. After the last item in each list was presented, subjects were given a free-recall test. Upon completion of the free-recall test, subjects were presented with the next study list. All of the subjects completed six such study-test trials.

Results and Discussion.

The proportion of once-presented critical items reported on the free-recall test was .42 for the control list with only once-presented items, and .43 for the experimental list with both once-presented and repeated items. This difference was
not significant. In addition, ANOVAs were also computed to determine whether the order of lists (once-presented followed by repeated vs. repeated followed by once-presented), influenced performance on the free-recall test. The effect of order of lists on free recall was not significant.

The results from this experiment suggest that having repeated items on a list does not affect the recall of the nonrepeated items on the list. In this experiment, subjects recalled approximately the same number of critical items from a list composed of only once presented items as compared to a list with both once presented and repeated items. These findings are consistent with earlier studies (Hastie, 1975; Tulving & Hastie, 1972; Waugh, 1963) but are troubling for the list-length account because the basic assumption of the account is that having repeated items on a list decreases the functional length of the list and increases the amount free recalled. However, it is possible that one can not equate acquisition of lists comprised of single items with lists of paired-associate items. A more stringent and comparable test of the list-length account was attempted in Experiment 4.

Experiment 4

In Experiment 3, the basic assumption of the list-length account was tested, and the results demonstrated that having repeated items on a list did not affect the amount of once-
presented items recalled as compared to the amount recalled from a list with only once-presented items. One can argue that there are fundamental procedural differences between the acquisition of lists of single items and lists composed of paired-associate items. Therefore, Experiment 4 will use the paired-associate methodology to test the assumptions of the list-length account. In Experiment 4, a new paired-associate list was added to the beginning of the testing session for the interference condition in an attempt to increase the functional list length in the interference condition as compared to the control condition.

In addition, this experiment attempted to investigate how the presentation of an earlier list (either the interference and the control lists) influenced the cued and free recall of a single list. Subjects were presented with a single study session of the critical list (List A-C) and then were given a cued-recall and free-recall test for the list. The primary reason for this condition was to determine whether subjects in both the control and interference condition are differentially impaired as compared to the free recall performance of subjects in the single-trial condition, or whether only the control condition is impaired by the earlier lists.

Method

Subjects. Sixty students enrolled in introductory
psychology classes at Case Western Reserve University participated to fulfill a course requirement and were tested individually on a Macintosh Plus computer. Twenty subjects were randomly assigned to the control condition, twenty to the experimental condition, and twenty to the single-trial condition.

**Design and Materials.** The design and materials were similar to those described in the earlier experiments with the exception that a new paired-associate list (List D-F) was created from the remaining set of items reported by Tulving and Thompson (1973). The new list is reported in Appendix D.

**Procedure.** The instructions and procedure followed in this experiment for the control and interference conditions is identical to that described in the procedure section in Experiment 1 with the exception that subjects in the interference condition were given a single presentation of List D-F at the beginning of the testing session. After the list was completed, subjects were given an answer sheet for the cued-recall test of List D-F. Upon completing the cued-recall test, subjects in the interference condition were presented with the three prior list (List A-B) study-test sessions as described in the previous experiments. Subjects assigned to the single-trial condition were given a single presentation of the critical list (List A-C). After the last stimulus-response pair was shown, subjects were given a cued-recall test for the critical list. Upon
completion of the cued-recall test, subjects were given the 5 min distractor task and then were asked to write down as many of the response terms from the critical list that they could remember.

**Result and Discussion.**

The proportion of prior list items reported on the cued-recall test after the last study trial and the proportion of critical words reported in cued recall and free recall by subjects in the control condition were .90, .51, and .20 respectively. The mean proportion of prior list items reported in a cued-recall test after the last study trial and the proportion of critical words reported in cued recall and free recall by subjects in the interference condition were .90, .46, and .28 respectively. The mean proportion of critical words reported in cued recall and free recall by subjects in the single-trial condition were .50 and .29 respectively. Analysis of variance revealed no significant difference between the performance of subjects in the control and interference condition on the acquisition of the prior list \[F(1,38)= 0.07, \text{MSE}= 24.80\]. In addition, even though subjects in the interference condition reported fewer critical list responses on the cued-recall test, as compared to the control condition, the difference failed to reach significance \[F(1,38)= 0.42, \text{MSE}= 24.1\]. The interference condition did report a significantly
higher number of critical list response terms as compared to
the control condition on the free-recall test. \( \text{F}(1,38)= 5.71,\)
\( \text{MSe}= 7.01\). Analyses of variance revealed no significant effect
of group between subjects' performance on the cued-recall test
in the control, interference, and single-trial conditions.
However, a significant effect of group was found between
subjects' performance on the free-recall test in the control,
interference, and single-trial condition. \( \text{F}(2,57)= 4.25, \text{MSe}= 6.99\). Paired comparisons between the groups revealed a
significant difference between the number of items reported on
the free-recall test by subjects in the single-trial condition as
compared to the control condition and a significant difference
between the number of items reported on a free-recall test by
subjects in the interference condition and the control condition.
The difference between subjects' performance on the free-
recall test in the interference and the single-trial condition was
not significant.

There are two important results from this experiment
that need to be stressed. First of all, this experiment was a test
of the basic assumptions of Hirshman et al.'s (1993) list-length
account of the reverse-interference effect. The account
assumes that the free-recall advantage found in the
interference condition is the result of a shorter functional list
length due to the repeated stimulus terms in the prior and
critical lists. To test this assumption, an extra list (List D-F)
was added to the test session for the interference condition that resulted in a functional list length of 120 items in the interference condition as compared to the 96 items in the control condition. The predictions of the list length account are straightforward; no advantage should be found for the free recall of the critical items in the interference condition. In fact, the list length account would predict that subjects in the control condition will recall more items as their functional list length is shorter. The results from this experiment contradict these predictions. Subjects in the interference condition reported significantly more critical items as compared to the control condition on the free-recall test. The findings from this experiment along with the results from Experiment 3 suggest that the list-length account is not a viable explanation of the reverse-interference effect.

The second noteworthy finding from this experiment is the results from the single-trial condition. Subjects in the single-trial condition were presented with a single study session of the critical list to determine what effect the earlier lists (both the interference and the control lists) had on the cued and free recall of the critical list. The results reveal that the single-trial condition is more similar in free recall to the interference condition as compared to the control condition (single-trial = .29, interference = .28, and control = .20). These results suggest that some aspect of the acquisition of an earlier
list negatively affects free recall of the critical list in the control condition.

Experiment 5

Experiment 5 investigates another explanation for the reverse-interference effect, the task difficulty account. This account is based on the theory that proactive interference in the experimental condition creates a more difficult cued-recall test for subjects assigned to the interference condition as opposed to the control condition. This could indirectly affect the performance of subjects in the interference condition. Since subjects in the interference condition have to work harder to remember the correct response terms for the cued-recall task, their subsequent free recall for these response items will be better than subjects in the control condition. The task-difficulty account would not necessarily predict the results of Hirshman et al.'s (1993) Experiment 5 or our Experiment 2, where the reverse-interference effect was found when free recall for the prior list was tested. However, this account may be extended to explain these findings by assuming that during the cued-recall test for the critical list when subjects are presented with the stimulus terms, subjects in the interference condition think of both the critical list’s response terms and the prior list’s response terms. This would act as an extra study session for the prior list’s response terms in the
interference condition and would give these subjects an advantage for free recall of the prior list’s response terms as compared to the subjects in the control condition. Experiment 5 will explore the task-difficulty hypothesis by not testing subjects on cued recall of the critical list. The task difficulty account would predict that the reverse-interference effect would not be found in the absence of the cued-recall test.

**Method**

**Subjects.** Eighteen introductory psychology students participated and were tested individually on a Macintosh Plus computer. Nine subjects were randomly assigned to the interference condition and nine to the control condition.

**Design and Procedure.** The design and procedures used in Experiment 5 are identical to those described in the previous experiments with two exceptions. First, subjects’ cued recall of the critical list was not tested. Second, at the end of the experiment, subjects were asked to complete a questionnaire attempting to determine what strategies the subjects used for learning the study lists. The questionnaire consisted of two questions. The first question asked subjects, "What did you do to help yourself remember the word pairs on the first list?". The second question asked was, "What did you do to help yourself remember the word pairs on the last list?".
Results and Discussion

The proportion of prior-list items reported on the cued-recall test after the last study trial and the proportion of critical words reported on the free-recall test by subjects in the control condition were .93 and .10 respectively. The proportion of prior list items reported on the cued-recall test after the last study trial and the proportion of critical words reported on the free-recall test by subjects in the interference condition were .91 and .25 respectively. Analysis of variance revealed no significant difference between the performance of subjects in the control and interference condition on the cued-recall test for the prior list \[F(1,32)= 2.01, \text{MSe} = 29.70\]. Thus, acquisition of the prior list is equal across the 2 experimental conditions. However, a significant difference was found for the free recall of the critical list's response terms between the control and interference groups \[F(1,32)=3.99, \text{MSe} = 13.64\], demonstrating the reverse-interference effect.

The results from Experiment 5 can't be reconciled with the task difficulty account of the reverse-interference effect, and therefore the task difficulty account is no longer a viable explanation of the reverse-interference effect. The results from the questionnaire given to the subjects at the end of the experiment reveal that subjects in both the control and the interference condition used visual and semantic associations between the word pairs to learn the items on the study lists.
In addition, all of the subjects in the control and interference condition responded that they used the same strategy for learning word pairs on both the prior list and the critical list. Unless one assumes that subjects aren't consciously aware of switching encoding strategies, the result of our questionnaire contradicts the basic assumptions of Burns' processing-tradeoff account.

Experiment 6

Experiment 6 examined a distinctiveness account of the reverse-interference effect. This distinctiveness account was derived from Burns' processing-tradeoff account (1989). The distinctiveness account assumes that subjects in the interference condition switch encoding strategies when presented with the critical list, and the process of switching strategies helps subjects to discriminate whether a response was from the prior list or the critical list during the free-recall test. Because there are no repeated stimulus terms between the prior and the critical lists, subjects in the control condition use the same encoding strategy for learning the prior and critical list. Since subjects in the control condition don't need to switch strategies, they are at a disadvantage when it comes to discriminating whether a stimulus-response pair is from the prior list or the critical list. The results from our questionnaire in Experiment 5 suggest, that if subjects are switching encoding
strategies between the acquisition of the prior and the critical list, they aren't consciously aware of it. If the reverse-interference effect is the result of differences in distinctiveness, than asking subjects to recall both the prior list and the critical list's response terms should wipe out any advantage the interference condition has over the control condition. To explore this, subjects were asked to report on the free-recall test as many of the response terms as they could remember from the previous lists, regardless of list membership. After subjects had written down all of the responses that they could remember, they were asked to go back and indicate list membership by placing the number "1" next to the items from the earlier list and the number "2" next to the items from the last list.

Method

Subjects. Forty four introductory psychology students participated and were tested individually on a Macintosh Plus computer. Twenty two subjects were randomly assigned to the interference condition and 22 to the control condition.

Design and Procedure. The design, materials, and procedures used in Experiment 6 are identical to those described in the previous experiments with one exception. Upon completion of the distractor task, subjects were instructed to report on the free-recall test in any order as
many of the response terms as they could remember from the previously presented lists. After the subjects had written down all of the response terms that they could remember, they were instructed to go back and place the number "1" next to the terms that were from the first list and the number '2' next to the terms that were from the very last list.

Results and Discussion

The proportion of prior list items reported on the cued-recall test after the last study trial, the proportion of critical words reported on the cued-recall test, and the proportion of response terms reported on the free-recall test by subjects in the control condition were .97, .63, and .40 respectively. The proportion of prior list items reported on the cued-recall test after the last study trial, the proportion of critical words reported on the cued-recall test, and the proportion of response terms reported on the free-recall test by subjects in the interference condition were .95, .50, and .49 respectively. Subjects in the control condition reported .53 of the prior-list responses and .25 of the critical-list responses on the free-recall test. Subjects in the interference condition reported .63 of the prior-list responses and .34 of the critical-list responses on the free-recall test.

Analysis of variance revealed no significant difference between the performance of subjects in the control and
interference condition on the cued-recall test for the prior list \( F(1,42) = 2.70, MSe = 1.90 \). A significant difference was found between the performance of subjects in the control and interference condition on the cued-recall test for the critical list, \( F(1,42) = 4.53, MSe = 22.55 \), demonstrating the traditional proactive interference effect. Subjects in the interference condition recalled significantly more response terms on the free-recall test than the control condition, \( F(1,42) = 6.91, MSe = 30.32 \). In addition, a 2 x 2 ANOVA revealed a significant main effect of group (control vs. interference), \( F(1,42) = 7.31, MSe = 14.63 \), and a significant main effect of list (prior vs. critical), \( F(1,42) = 221.8, MSe = 4.34 \). The interaction between group and list was not significant. Subjects in the interference condition significantly recalled more prior list' response terms and more critical list' response terms on the free-recall test as compared to the control condition.

Analyses were also performed on the number of errors produced by subjects in the interference and control condition when assigning list membership to the response terms that were recalled. The mean proportion of errors produced was .36 words for the control condition and .00 words for the interference condition. This difference was significant, \( F(1,42) = 5.51, MSe = .264 \).

The distinctiveness account presented here assumes that subjects in the control condition are at a disadvantage when it
comes to discriminating whether a stimulus-response pair is from the prior list or the critical list as compared to the subjects in the interference condition, resulting in the reverse-interference effect for both prior and critical list response terms. This experiment investigated this hypothesis by asking subjects to write down as many of response terms that they could remember, regardless of list membership. Some evidence for the distinctiveness account was obtained. Subjects in the interference condition were far more accurate in remembering the list membership of response terms than the control condition. However, Experiment 6 also showed some evidence against the distinctiveness account. Even when subjects were asked to write down as many response terms as possible in free recall and therefore did not have to distinguish between lists, subjects in the control condition recalled fewer response terms than the interference condition. The results suggest that the reverse-interference effect is not the result of subjects in the control condition being unable to discriminate list membership of the response terms.

Experiment 7

All of the previous studies examining the reverse-interference effect, including Experiments 1-6 reported here, have used a between-subjects design. Some possible explanations, such as the list-length account, predict that this
effect would not be found when condition is varied within subjects. Experiment 7 examines whether the reverse-interference effect is obtained when a within-subject design is used.

Method

Subjects. Eighteen introductory psychology students participated and were tested individually on a Macintosh Plus computer.

Design and Materials. This experiment used a within-subject design to examine the reverse-interference effect. Two new list were constructed by randomly choosing 12 word pairs from List A-B and 12 word pairs from List D-B, and can be found in Appendix E. Each subject was given one of the new 24 word-pair lists as the prior list. Lists were counterbalanced across subjects. Corresponding answer sheets were designed for the cued-recall test of the two newly constructed prior lists. The critical list in this experiment is identical to the one used in previous experiments.

Procedure. The instructions and procedures followed in this experiment are similar to the those described in earlier experiments. Subjects were presented with the new prior list for three study and cued-recall test trials, after which they were presented with the critical list (List A-C). Upon completion of the cued-recall test for the critical list, subjects
were given a 5 min. distractor task. After the 5 mins. were up, subjects were asked to report on the free-recall test as many of the items from the critical list.

**Results and Discussion**

The proportion of prior list items reported on the cued-recall test after the last study trial was .94. For the critical list, subjects correctly reported .52 of the response terms paired with the interfering stimuli and .61 of the response terms paired with the control stimuli on the cued-recall test. For the free-recall test, subjects correctly recalled .38 of the response terms paired with the interfering stimuli and .21 of the response terms paired with the control stimuli. Repeated-measures analysis of variance revealed that the difference between the proportion of items correctly reported on the cued-recall test by subjects in the interference and control conditions failed to reach significance, $F(1,16) = 2.67$, $MSe = 4.60$. A significant difference was found between the proportion of items correctly reported on the free-recall test by subjects in the interference and control conditions, $F(1,16) = 11.06$, $MSe = 3.08$. The results from this experiment demonstrate that the reverse-interference effect can be found with a within-subject design manipulation.
General Discussion

The seven experiments reported here investigated the reverse-interference effect and tested alternative theoretical accounts to explain the findings. The reverse-interference effect is a phenomenon Burns (1989) found while investigating the effects of transfer specific (A-B, A-C) paired-associate learning on long-term retention. He found that free recall of the critical list’s (C) responses were better under conditions of interference (A-B, A-C) learning than under control (D-B, A-B) learning conditions, whereas cued recall of the critical list response terms was better under the control learning conditions. Burns refers to this as the reverse-interference effect because one usually finds less retention in the interference condition than in the control condition. As previously mentioned, understanding the mechanisms responsible for the reverse-interference effect is of great theoretical importance as most accounts of interference do not predict any situations where the interference condition would be at an advantage.

The experiments reported here presented and tested four possible accounts of the reverse-interference effect; (1) Burns’ (1989) processing-tradeoff account, (2) Hirshman et al.’s (1993) list-length account, (3) the task difficulty account, and (4) the distinctiveness account of the reverse-interference effect. In addition, the hypothesis that the reverse-interference effect is
dependent on the use of between-subjects design was also tested. In the following section, the results of each of the hypotheses tested will be presented separately.

**The Processing-Tradeoff Account**

The processing-tradeoff account of the reverse-interference effect is based on the assumption that subjects employ different encoding strategies in the control (D-B) and interference (A-B) conditions during second-list (A-C) learning. The account makes a distinction between individual-item and relational processing strategies. The theory states that interference between the stimulus terms in the prior list and the critical list cause subjects in the interference condition to switch from processing primarily relational (stimulus-response) information to processing primarily individual-item information. However, since subjects in the control group have minimal interference between the stimulus-response associations in the prior list and the critical lists, they are able to learn associations between the stimulus and response terms in the critical list and continue to use relational processing for encoding the critical list as opposed to switching to individual-item processing. The result of switching processing strategies for encoding the critical list causes the reverse-interference effect.

The processing-tradeoff account was investigated in
Experiments 2 and 5. Experiment 2 attempted to replicate Hirshman et al.'s (1993) finding of a reverse-interference effect for the free recall of the prior list's response terms. The processing tradeoff account predicts that one would not find the reverse-interference effect on a free-recall test for the prior-list response terms, as the change in encoding strategies occurs during the encoding of the critical list. Therefore, the account predicts no difference between the control and the interference groups for the free recall of the prior list's response terms. However, the findings from Hirshman et al.'s Experiment 5 and our replication of their findings of a reverse-interference effect on the free recall of the prior-list responses are inconsistent with the processing-tradeoff account.

In addition, Burns (1989) provides no evidence for his assumption that subjects in the interference condition switch processing strategies when presented with the critical list and that subjects in the control condition use the same processing strategy for the prior and critical list. These assumptions were tested in Experiment 5 where subjects were asked to fill out a questionnaire upon completion of the free-recall test. The results from the questionnaire given to the subjects failed to reveal any differences between the encoding strategies used by subjects in the control and interference condition. Subjects in both the control and the interference condition reported using visual and semantic associations between the word-pairs to
help learn the items on the study lists. In addition, all of the
subjects responded that they used the same strategy for
learning word pairs on both the prior list and the critical list.
The results from Experiments 2 and 5 place serious constraints
on the processing-tradeoff explanation of the reverse-
interference effect.

The List-Length Account

The list-length account of the reverse-interference effect
assumes that the proportion of items correctly free recalled is
determined by the number of different stimuli seen by a
subject during the experiment. The account assumes that an
item encoded repeatedly as a list item is represented by a
single trace in memory. Therefore, having repeated items on a
list decreases the functional length of the list as compared to a
list with only once-presented items. The result of the
decreased functional list-length in the repeated condition
results in better free recall as compared to the nonrepeated
condition. To account for the reverse-interference effect, the
list-length account assumes that the stimulus-response terms
of each word pair are encoded separately as individual items
and that having repeated stimulus terms decreases the
functional length of the interference list as compared to the
control list.

The basic assumptions of the list-length account were
tested in Experiments 3 and 4. Experiment 3 directly tested the effect of repeated items on the free recall of the nonrepeated items on a list. The results demonstrated that having repeated items on a list did not affect the number of once-presented items recalled as compared to the number recalled from a list with only once-presented items. However, one can argue that there are fundamental procedural differences between the acquisition of lists of single items and lists composed of paired-associate items. Therefore, Experiment 4 used the paired-associate methodology to test the assumptions of the list-length account. In Experiment 4, a new paired-associate list was added to the beginning of the testing session for the interference condition in an attempt to increase the functional list length in the interference condition as compared to the control condition. The results demonstrated that even when an extra list is added to the interference condition, one still finds the reverse-interference effect.

The findings from Experiments 3 and 4 are consistent with the result of earlier studies that explored a similar issue: the recall of once-presented items on a list is not greatly affected by the presentation frequency of other items on the list (Hastie, 1975; Tulving & Hastie, 1972; Waugh, 1963). The results from the experiments reported here are troubling for the list-length account because they contradict the fundamental assumptions of the account.
The Task Difficulty Account

The task difficulty account of the reverse-interference effect assumes that proactive interference in the experimental condition creates a more difficult cued-recall test for subjects assigned to the interference condition as opposed to the control condition. This refers to the fact that when subjects in the interference and control groups are given a cued-recall test for the critical list, performance by the experimental group is generally lower than the control group, demonstrating proactive interference. An indirect effect of this would be that since subjects in the experimental condition had to work harder to remember the correct response items during the cued-recall test because of interference from the response items on the previous list, their subsequent free recall for these response items will be better than subjects in the control condition.

Experiment 5 investigated the task-difficulty account by not giving subjects a cued-recall test for the critical list. The task difficulty account predicts that the reverse-interference effect would not be found in the absence of the cued-recall test. The results from Experiment 5 revealed that the reverse-interference effect can be found in the absence of a cued-recall test for the critical list. These findings cannot be reconciled with the predictions of the task-difficulty account. Therefore, the account is no longer seen as a viable explanation of the
reverse-interference effect.

The Distinctiveness Account

The distinctiveness account of the reverse-interference effect was derived from Burns' (1989) processing-tradeoff account. The account assumes that subjects in the interference condition switch encoding strategies when presented with the critical list, and that the process of switching strategies helps subjects to discriminate whether a response term is from the prior list or the critical list during the free-recall test. Because there are no repeated stimulus terms between the prior and the critical lists, subjects in the control condition use the same encoding strategy for learning the prior and critical list. Since subjects in the control condition don't need to switch strategies, they are at a disadvantage when it comes to discriminating whether a stimulus-response pair is from the prior list or the critical list.

Experiment 6 examined the distinctiveness account of the reverse-interference effect by asking subjects to report on the free-recall test as many of the response terms as they could remember, regardless of list membership. After subjects had written down all of the responses that they could remember, they were asked to go back and indicate list membership by placing the number "1" next to the items from the earlier list and the number "2" next to the items from the last list. The
results from Experiment 6 revealed that the reverse-interference effect is not solely the result of subjects in the control condition being unable to discriminate list membership of the response terms. Specifically, the results demonstrated that subjects in the control condition remember fewer response terms overall, in addition to making more errors concerning list membership than subjects in the interference condition, which results in the reverse-interference effect.

The findings from the seven experiments reported here can be summarized in three statements. First of all, the reverse-interference effect can be found for both the prior-list’s and the critical-list’s response terms. Second, the reverse-interference effect is not an artifact of design. The results from Experiment 7 demonstrate that the effect can be found when using a within-subjects list design, as well as when using a between-subjects list-design. Finally, our findings from Experiments 4 and 6 suggest that some aspect of the acquisition of earlier lists negatively affects free recall of both the prior list and the critical list in the control condition relative to the interference condition, resulting in the reverse-interference effect. The findings from Experiments 4 and 6 are noteworthy because they suggest that for any account of the reverse-interference effect to be satisfactory, it must explain why the presentation of an earlier list negatively affects performance in the control condition as compared to the single-
trial condition, but doesn’t affect performance in the
interference condition as compared to the single-trial condition.

The effects of interference on memory have been among
the most heavily studied phenomena in experimental
psychology. The reverse-interference effect demonstrates that
surprises still lurk even in areas generally believed to be
adequately understood.
References


Appendix A

Lists used for the Control and Interference Conditions
### Lists used for the Control and Interference Conditions

<table>
<thead>
<tr>
<th>List A-B</th>
<th>List D-B</th>
<th>List A-C</th>
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<tr>
<td>CHEESE-WATER</td>
<td>MOTH-WATER</td>
<td>CHEESE-LIGHT</td>
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<td>DRINK-LOVE</td>
<td>COTTAGE-LOVE</td>
<td>DRINK-BABY</td>
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<td>TRAIN-BLACK</td>
<td>GRASP-SWEET</td>
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<tr>
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<td>PREETY-DAY</td>
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<td>BLADE-CUT</td>
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<td>SPIDER-COAT</td>
<td>NOISE-CHAIR</td>
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<td>LADY-GO</td>
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<td>TOOL-HAND</td>
<td>CAVE-WET</td>
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<td>EXIST-GIRL</td>
<td>CLOTH-PAIN</td>
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<td>GROUND-COLD</td>
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<td>DEEP-CAKE</td>
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<td>ART-FOOD</td>
<td>BATH-GREEN</td>
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Appendix B

Sample Answer Sheet
Sample Answer Sheet

BLADE
CHEESE
GRASP
NOISE
HEAD
GROUND
CAVE
PRETTY
DRINK
FRUIT
CLOTH
BEAT
PLANT
BUTTER
STOMACH
SWIFT
WISH
COMMAND
HOME
SUN
WHISTLE
LADY
BATH
GLUE
Appendix C

Sample of a Single Item Repeated and Nonrepeated Lists
**Sample of a Single Item Repeated and Nonrepeated Lists**

<table>
<thead>
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<th>Nonrepeated List</th>
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<td>BRAVE</td>
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<td>HEAD*</td>
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<td>WIND</td>
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<td>MOUNTAIN*</td>
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* Critical Items looked for during Free Recall.
Appendix D

List D-F used in Experiment 4
LIST D-F used in Experiment 4

ROLL-HATE
CRUST-INSECT
MOTH-SMALL
COTTAGE-FINGER
STEM-HOT
BARN-SCISSORS
TRAIN-LAKE
EXIST-LABOR
MEMORY-INFANT
HOPE-CARPET
CABBAGE-NIGHT
COVERING-LAMB
ADULT-EAGLE
BRAVE-LEAF
WHISKEY-GRASS
TOOL-BITTER
DEEP-COLOR
COUNTRY-BLOOM
GLASS-TENNIS
THINK-BAKE
ART-CLEAN
SPIDER-SOAP
MOUNTAIN-SQUARE
DOOR-BED
Appendix E

Prior and Critical Lists used for the Within-Subject List Design
### Prior and Critical Lists used for the Within-Subject List Design

<table>
<thead>
<tr>
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<th>Critical List</th>
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<tr>
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</table>

* Interference Stimulus Terms.