von Restorff Revisited: Isolation, Generation, and Memory for Order

Matthew R. Kelley and James S. Nairne
Purdue University

The effects of isolation and generation on memory for order were investigated in 4 experiments. Experiments 1 and 2 examined the effect of isolation on order retention. Previous investigations in this area have yielded equivocal results. Experiments 1 and 2 revealed that isolation enhances memory for order: Isolated items were repositioned more accurately than comparable items in control lists. Experiments 3 and 4 investigated the effect of generation on order retention. These experiments revealed that generation can enhance, disrupt, or have no effect on memory for order, depending on the relative number of generated items appearing within a list. Implications of these results for general theoretical accounts of isolation effects in memory are discussed. A simplified version of the feature model (J. S. Nairne, 1990) is shown to provide a general account of isolation effects.

In her classic 1933 study, Hedwig von Restorff demonstrated the powerful effect that "difference" can have on memory. In the study, von Restorff presented a series of three lists to participants over a span of 3 days. On the first day, everyone saw a list of 10 unrelated items (e.g., a symbol, a number, a word, a photograph, etc.). On Days 2 and 3, participants received separate lists in which 1 item was different (isolated) from the remaining list items. These isolated lists consisted of either 9 numbers and 1 nonsense syllable or 9 nonsense syllables and 1 number. The isolated item occurred in either the second or third serial position. Delayed recall results revealed better memory for the isolated items compared to the average recall of the remaining list items. This effect has since been termed the "von Restorff effect" (or isolation effect) and can be defined simply as the enhancement of memory for events that differ, or deviate, from their context. In the years since von Restorff's initial article, a considerable amount of research has been devoted to the investigation of this phenomenon and the effect has proven robust, having been replicated with a wide variety of designs and materials (for reviews, see Cimballo, 1978; Hunt, 1995; Schmidt, 1991; Wallace, 1965).

Historically, investigators have achieved isolation by physically changing, or augmenting, the stimulus in some manner. Cimballo (1978) identified a number of such isolation techniques, including size, shape, color, intensity, and voice. However, other techniques have been used to isolate items as well, such as meaningfulness, underlining, spacing, background color, and electric shock (Cimballo, 1978). Investigators have typically placed the isolated item, or items, near the middle of the list, but significant effects of isolation also have been found for items placed at the beginning and at the end of the list (Bellezza & Cheney, 1973; Pillsbury & Raush, 1943; Experiments 1–4). Traditionally, researchers have assessed retention with tests of free recall, comparing recall performance for the isolated item either against the average recall of the remaining list items or against the recall of a comparable item in a nonisolated list. When the middle items of the list are isolated, the first method of comparison has the problem of understimating the size of the isolation effect because primacy and recency items are included in the average recall of the nonisolated items. The second method does not have this problem and is the preferred technique. Other retention measures used in the isolation effect literature include recognition and serial recall.

A number of factors influence the magnitude of the isolation effect. For example, the nature of the isolate plays an important role in determining the size of the effect. Cimballo, Capria, Neider, and Wilkins (1977) reported that size, color, and spacing are the most effective isolation techniques. Gumenik and Levitt (1968) showed that the degree to which an item differs from the rest of the list is also important. In their study, the isolated item was displayed in one of four sizes, each being 7½ of the next largest size. They found that the size of the isolation effect increased as the difference between the isolate and the background items increased. This held true both when the context stimuli were small and the size of the isolate increased and when the context stimuli were large and the size of the isolate decreased. Another important factor is the relative number of isolated items in the list—the size of the isolation effect increases as the number of isolated items within the list decreases (Newman & Jennette, 1975; von Restorff, 1933).

The Effect of Isolation on Memory for Order

Memory researchers commonly draw a distinction between item information (what items occurred on a list) and order information (the ordinal location or serial position of an item in the list. Bjork & Healy, 1974; Healy, 1974; Murdock, 1976; Murdock & von...
The memory tests that investigators use to assess retention differ in the types of information that they require. For example, item but not order information is important in a recognition test, whereas both item and order are potentially important in a free recall test. Although serial recall is generally regarded as a measure of order, both order and item information are needed in this task: people must remember both the items that were on the list and the order in which those items occurred. Studies in the isolation effect literature have used free recall, serial recall, and recognition to assess memory retention almost exclusively. Consequently, little is known about the effect of isolation solely on memory for order.

It is possible that isolation affects item and order information differently. Nairne, Riegler, and Serra (1991) showed that generation of complete words from word fragments produces opposite effects on item and order retention. In their experiment, generation helped the participants' abilities to remember the individual list items but hurt their abilities to remember the order in which those items were presented (see also Burns, 1992; Greene, Thapar, & Westerman, 1998; Serra & Nairne, 1993). To explain this dissociation, Nairne et al. (1991) suggested that generation induces extra item-specific processing that enhances item retention but disrupts order retention. They argued that participants focused more on the generated item and less on the ordered relationships among the list items (see also DeLosh & McDaniel, 1996). This suggestion bears some similarity to Hunt and Mitchell's (1982) explanation of the isolation effect. Hunt and Mitchell asserted that isolation encourages extra individual-item processing of the isolated item. On the sole basis of the similarity of these two explanations, it seems reasonable to propose that isolation will have a disruptive effect on memory for order, just as generation does.

Isolation, however, may enhance order retention. Bruce and Gaines (1976) proposed an explanation of the isolation effect based on organizational processes that are active during encoding (see also, Fabiani & Donchin, 1995; Schmidt, 1985, 1991). They argued that when a list contains an isolated item, the members of that list are organized into separate mnemonic categories: The isolated item is placed into one category and the nonisolated items are placed into a different category (or categories). The probability of retrieving an item from one of these categories is inversely proportional to the size of the category (similar to Watkins & Watkins's, 1975, cue overload hypothesis). For this reason, an isolated item is more likely to be retrieved than the nonisolated items because it is the only member of its category. If one assumes that order information is preserved during the organization process and becomes available during retrieval of an item, then isolation may well help order retention.

Cimbal, Nowak, and Soderstrom (1981) provided some evidence that isolation enhances memory for order. In their study, school-aged children were shown lists of seven cards. Each card contained a line-drawn picture of a different animal. On some of the lists, one of the line-drawn animals appeared colored in pink (isolated item). The isolate always occurred in the fourth serial position. After each list was presented, the children were given a cued-position test, where they were given an animal name and were asked to identify which card (position) had the animal's picture on it. Cimbal et al. (1981) found that children were better at remembering the position of the isolated item compared to the same item in a nonisolated list. Lippman (1978) obtained a similar result using a reconstruction of order test, with letter trigrams as stimuli, but, once again, the isolated item always appeared in the same serial position across trials.

Cunningham, Marmie, and Healy (1998) found mixed results in their investigation into the effect of isolation on order retention. Cunningham et al. (1998) used a partial report–reconstruction of order procedure to assess retention. In this procedure, participants received two consecutive segments of four letters. Each segment consisted of the same four letters (BHKF and LRMQ, respectively) throughout the experiment; the order of the letters within each segment varied across trials. Isolation was achieved by presenting one of the items in red (control items were in black). Over trials, the isolated item occurred equally often across serial positions for both segments. The participants were given a cue both before and after presentation of the segments, signaling which segment to recall. Cunningham et al. (1998) found small, nonsignificant advantages for all of the isolated items in the second segment and for the first isolated item in the first segment.

These studies suggest that isolation facilitates specific order retention of the isolated item. However, only limited conclusions can be drawn from these experiments. Both Cimbal et al. (1981) and Lippman (1978) found significant isolation effects when testing order, but the isolated item occurred in only one serial position across trials. Thus, participants could have deduced that the isolated item always occurred in the same position and given it special processing. Cunningham et al. (1998) isolated items in every serial position across trials, but their data were essentially inconclusive. Consequently, the literature, at present, provides an equivocal accounting of the effect of isolation on memory for order.

The current set of experiments was designed to provide a more definitive answer to this empirical question: What is the effect of isolation on the retention of order information? Our experiments differ from previous research in two important ways. First, the isolated item occurred equally often in each serial position across trials. With the exception of Cunningham et al. (1998), most studies have isolated items in only one serial position, usually near the middle of the list. It is important to assure that the isolated item occurs in all serial positions in order to rule out explanations of the isolation effect based simply on "surprise" or perceptual salience (e.g., Hunt, 1995). Second, reconstruction was used to assess order retention. Although it is not a pure test of order memory (Nairne & Kelley, 1999; Neath, 1997), reconstruction is generally regarded as a better measure of order retention than other tasks, such as serial recall. In a reconstruction task, the items that occurred on the just-presented list are provided at the point of test. The participant's task is simply to place the items back into their original order of presentation. Thus, in the present experiments, we alleviate a problem shared by the majority of previous investigations (i.e., confounding item and order information) by using reconstruction to assess order retention.

In summary, previous investigations into the effect of isolation on memory for order have produced equivocal results or have suffered from design flaws. To preview the present results, our
experiments establish that isolation has a clear and reliable effect on order retention. Moreover, through various analyses, we are able to test, and rule out, certain existing theoretical interpretations of the isolation effect. In Experiments 3 and 4, we show that the act of generation, which has been shown previously to enhance item but impair order retention, can itself serve as an isolation manipulation. Whether generation helps or hinders order memory turns out to depend critically on the number of generated items within the list. Overall, these results provide benchmark data that should aid in the development and assessment of theories of the von Restorff effect, the generation effect, and, more generally, theories of order retention and immediate memory.

Experiment 1

In Experiment 1, participants viewed 54 lists of six unique items. The items were displayed visually on a computer screen and participants were required to read each item aloud as it was presented. Thirty-six of the lists contained an isolated item and eighteen did not. An item was isolated from the rest of the list by displaying it in a larger size. Following presentation of the last item, the six list items were re-presented, in a new random order, and participants were instructed to place the words back into their original order. Of primary interest was the participants' ability to remember the positions of the isolated items compared to the nonisolated items.

Method

Participants and apparatus. Sixty Purdue University undergraduates participated for course credit in an introductory psychology course. Everyone was tested individually in sessions lasting approximately 1 hr. Stimuli were presented and controlled by IBM-compatible computers.

Materials and design. The stimulus set consisted of 324 medium-to-high frequency nouns drawn from Paivio, Yuille, and Madigan (1968). The stimulus items were matched on a number of attributes, namely imageability ($M = 6.02$; range = 4.07–6.90), concreteness ($M = 6.17$; range = 4.97–7.00), meaningfulness ($M = 6.59$; range = 3.88–9.22), and word length ($M = 5.41$; range = 4.00–7.00). The stimuli were randomly assigned to 54 lists, each containing 6 items. The word lists were presented in exactly the same order to all participants.

An experimental session consisted of 36 isolated trials, in which each list contained one isolated item, and 18 control trials, in which none of the items was isolated. The isolated item occurred equally often at each of the six serial positions across the session. To ensure generality, three separate versions of the 54 experimental trials were constructed so that, across every 3 participants, each list served as a control list once and an isolated list twice. The position of the isolated item within a list varied for each of these conditions. At the onset of each trial, participants had no way of knowing which, if any, of the list items would be isolated.

The stimuli were displayed successively in the center of the screen. The nonisolated words were presented in sans serif font formed by 5-mm × 10-mm letters (word length: 20 mm–35 mm). The isolated words were twice as large, formed by 10-mm × 20-mm letters, and were also presented in sans serif font (word length: 40 mm–70 mm). During the reconstruction test, all of the list items appeared in the same size font, sans serif font formed by 3-mm × 5-mm letters, regardless of initial presentation size.

Procedure. Each trial began with the word READY accompanied by a tone, followed by the presentation of a six-item list. Each list item was presented for 750 ms, with a 250-ms interval separating the offset of one item from the onset of the next. Participants were instructed to say each item aloud as it appeared on the screen. Immediately after the last item, the participant received a reconstruction test. The six list items were represented on the screen, in a new random order. A series of six empty boxes, representing all possible list positions, was shown below the reordered list. The task was to reconstruct the original order of presentation by placing the items into their appropriate serial positions (boxes). Items were reordered by a two-step process. Step 1 required participants to select one of the words from the reordered list. This was accomplished by moving the cursor (using the arrow keys) to a word and pressing the space bar to make the selection. In Step 2, participants placed the word into its proper position by moving the cursor to one of the six boxes and pressing the space bar, thereby depositing the word. Participants were allowed to fill in the boxes in any order they wished and were instructed not to repeat or omit any items. Everyone was given as much time as they needed to complete the reconstruction task; the enter key initiated the next trial.

Results

The data from the reconstruction test are displayed in Figure 1 as a function of item type (isolate vs. control) and serial position (Positions 1–6). The isolate serial position function shows how well participants were able to reposition isolated items; it was formed by plotting mean proportion correct reconstruction performance for only the isolated items (collapsed across trials). The control serial position function shows how well participants were able to reposition all of the items that appeared in control lists and was formed by plotting the mean proportion correct for each control item.

An overall analysis of variance (ANOVA) revealed reliable main effects of serial position, $F(5, 290) = 42.19$, $MSE = 0.04$, $p < .001$, and item type, $F(1, 58) = 15.58$, $MSE = 0.02$, $p < .001$. The serial position functions showed the typical bow-shaped form, with marked primacy and recency effects. In addition, it is important that the data revealed a highly significant isolation effect. Participants reconstructed the positions of the isolated items better than the same items in a control list. Collapsed across serial position, average reconstruction performance was 0.77 for the isolated items and 0.72 for the control items. Of the 60 participants, 49 showed an isolation advantage, 8 showed the opposite

![Figure 1. Serial position curves for isolated and control items in Experiment 1.](image-url)

[Diagram showing serial position curves for isolated and control items in Experiment 1.]
pattern, and there were 3 ties. There is some indication in Figure 1 that the isolation effect disappeared at the second serial position, but the Item Type × Serial Position interaction did not approach significance, $F < 1$.

Although there was no obvious way to predict when an item would be isolated (isolates appeared randomly across all serial positions), participants might have changed their mnemonic strategy after seeing an isolated item. They might have learned that only one item could be isolated per list. When the participants saw this item, they could have devoted extra resources to that item at the expense of the other list items. If such a strategy were employed, one might expect the size of the isolation effect to increase over the course of the experiment. To illustrate this point, imagine that it takes a few trials to learn the “one-isolate-per-list rule.” The size of the isolation effect on these trials might be small (or nonexistent) because the participants are not yet selectively attending to the isolated item. However, once the participants learn the rule and become proficient using it, they can devote more attention to the isolate, which will enhance retention of that item. At the same time, this strategy might disrupt retention of background items (nonisolated items in an isolated list) because participants focus more on the isolated item than on other list items. For this reason, one might expect reconstruction performance to be lower for background items than for comparable control-list items.

To check on these possibilities, we conducted two analyses. First, we compared reconstruction performance on the first several trials (i.e., the first four isolated and the first four control trials) with performance on the last several trials (i.e., the final four isolated and final four control trials). An ANOVA revealed that the size of the isolation effect did not change over the course of the experiment, $F < 1$. This null effect suggests that participants did not alter their mnemonic strategy during the experiment, at least not in the form proposed above. Second, we compared reconstruction performance for background items (nonisolated items from an isolated list) with performance for comparable items in a control list. Table 1 shows that background items and their counterparts in control lists were reconstructed equally well. This finding is important because it establishes that the positive effect of isolation on order retention does not arise at the expense of the other list items. Additionally, it suggests that the positive effect of isolation does not extend to the background items; the isolated item is the only beneficiary.

**Discussion**

By demonstrating a von Restorff effect in order retention, our results are consistent with those reported by Cimbal et al. (1981), Lippman (1978), and certain conditions of Cunningham et al. (1998). Additionally, this basic finding seems to mesh with a theory of the isolation effect that is based on organizational processes. According to Bruce and Gaines (1976), an isolated item is organized into a separate category than nonisolated items. The probability of retrieving an item from a category is inversely proportional to the number of items in that category. Because the isolated item is alone in its category, both the item and its order information are retrieved well, relative to the nonisolated items. Clearly, this prediction is consistent with basic findings reported in Experiment 1.

However, the theory appears to have difficulty predicting the proper pattern of results regarding retention of background items. The theory predicts better retention of background items (nonisolated items in an isolated list) than of comparable items in a control list. To illustrate, imagine that a participant is given a six-item list and organizes the items into two categories: “nonisolated” and “isolated.” For a control list, all six items are placed into the nonisolated category. For an isolated list, only five items are placed into the nonisolated category and one item is placed into the isolated category. Because there is one fewer item in the nonisolated category for an isolated list, these items will support a higher level of retrieval than items in the nonisolated category for a control list (cue-overload principle). This prediction is not supported by the background-item analysis of Experiment 1, which showed equivalent retention of background items and their counterparts in control lists. Thus, despite the fact that it can account for the basic, positive effect of isolation on memory for order, the organization hypothesis has trouble accounting for the full range of data reported in Experiment 1.

Our findings also fail to confirm the prediction derived from Nairne et al.’s (1991) generation experiment. We suggested that isolation might have a disruptive effect on order retention, just as generation does. Yet, the results showed that isolation clearly enhances order retention. It is curious that these two seemingly similar manipulations produce such contrasting results. Both generation and isolation presumably promote attention to the item, but very different mnemonic effects on order are produced. However, in Nairne et al.’s (1991) experiment all of the items on a “generate” list were generated, whereas, in this study, only one of the items on an “isolate” list was isolated. Because it has been shown that the size of the isolation effect depends on the number of isolates in the list (e.g., Newman & Jenette, 1975; von Restorff, 1933), it is possible that this difference in list composition may have been sufficient to produce these opposing results. We examine this issue in more detail in Experiments 3 and 4.

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Mean Proportion of Correct Responses, Collapsed Across Serial Position, for Background Items (Nonisolated Items From an Isolated List) and for Comparable Items in a Control List</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experiment and condition</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Experiment 1</td>
</tr>
<tr>
<td>Experiment 2—large</td>
</tr>
<tr>
<td>Experiment 2—small</td>
</tr>
<tr>
<td>Experiment 3</td>
</tr>
<tr>
<td>Experiment 4—half</td>
</tr>
<tr>
<td>Experiment 4—one</td>
</tr>
</tbody>
</table>
What accounts for the enhancing effect of isolation? Cunningham et al. (1998) proposed that when a list contains an isolated item, the isolate tends to be the first item recalled (or reordered). As a result, it is subject to less output interference (Broadbent, 1958) leading to better recall or reordering performance. Cunningham et al. (1998) further suggested that Este's perturbation model (Este, 1972, 1997; Lee & Este, 1981) could account for the isolation effect because more recent versions of the model contain a mechanism for output interference (Este, 1997). The model predicts better memory performance for the isolated items, as long as the isolate is the first item recalled or reordered. Cunningham et al.'s (1998) hypothesis draws support from studies showing that isolated items are typically the first items in a list to be recalled (Bruce & Gaines, 1976; Fabiani & Donchin, 1995; Schmidt, 1985) and from their own study showing that participants were less likely to respond in left-to-right order when a list contained an isolated item. Experiment 2 was designed, in part, to test Cunningham et al.'s hypothesis.

Experiment 2

Although Experiment 1 revealed a highly significant effect of isolation on order retention, the overall difference in reconstruction performance between the control and isolated items was relatively small (5%) compared to the size of the isolation effects reported in free and serial recall (15–30%) (e.g., Fabiani & Donchin, 1995; Hunt & Mitchell, 1982). During the test phase of the experiment, the six list items displayed during presentation were re-presented on the computer screen in the same size regardless of whether a given item was an isolate or a control. By displaying all of the words in the same size test, the isolated items may have been at a disadvantage because the conditions at retrieval (isolate same size as controls) did not match the conditions at encoding (isolate larger than controls).

foot;010112;10;2PICKFOOT;Fn2There is strong evidence that the correspondence between encoding and retrieval is an important factor contributing to the isolation effect. Fabiani and Donchin (1995) showed that, in recognition, the isolation effect depends on whether there is a match between encoding and retrieval conditions. In their study, Fabiani and Donchin (1995) obtained an isolation effect only when the original encoding context for the isolated items was reinstated at the time of the recognition test. A recognition advantage occurred for the isolated items when the isolate matched its original encoded form (e.g., larger size) but not otherwise. Thus, it is possible that the lack of an encoding-retrieval match for the isolated items in Experiment 1 may have had an adverse effect on reconstruction performance for those items.

In Experiment 2, measures were taken to ensure that the relative sizes of the items shown during list presentation were preserved during the reconstruction task. The retrieval conditions for both the control and isolated items always matched their respective encoding conditions. When an item was displayed in the large size during presentation, it appeared in a larger size, relative to the remaining list items, during reconstruction. When an item appeared in the small size during presentation, it was displayed in a smaller size than the remaining list items during reconstruction. Because of computer screen restraints, however, the absolute sizes of the items at presentation could not be preserved at test — only the relative sizes of the items remained intact.

Two additional changes were incorporated into Experiment 2. The first change was the inclusion of a "small isolate" condition. Experiment 1 could be characterized as a "large isolate" condition because isolation was achieved by doubling the size of one list item. In Experiment 2, half of the participants viewed isolated items that were twice as large as the control items (large isolate condition), whereas the other half viewed isolated items that were half as large as the control items (small isolate condition). The small isolate condition was included to extend the generality of the isolation effect in reconstruction. The second change in Experiment 2 was to record the output order data. As each list was reconstructed, the computer recorded the order in which the participant repositioned the list items. The output data were gathered in an attempt to examine the output interference hypothesis proposed by Cunningham et al. (1998).

Method

Participants and apparatus. Seventy-eight Purdue University undergraduates participated for credit in an introductory psychology course. The stimuli were presented and controlled by IBM-compatible computers, and the experiment lasted approximately 1 hr.

Materials and design. The stimulus materials and design of Experiment 2 were identical to those used in Experiment 1, with two exceptions. First, a new isolation condition was added. In Experiment 1, the isolated items appeared twice as large (10 mm × 20 mm) as the nonisolated items (5 mm × 10 mm). In Experiment 2, half of the participants received isolated items that were twice as large as the nonisolated items, whereas the other half received isolated items that were half as large (5 mm × 10 mm) as the nonisolated items (10 mm × 20 mm).

Second, the relative sizes of the isolated and nonisolated items were preserved during the reconstruction task, improving the encoding-retrieval match. An item appearing in the large (10 mm × 20 mm) size during presentation was displayed in large (uppercase) letters at test and an item appearing in the small (5 mm × 10 mm) size during presentation was displayed in small (lowercase) letters at test.

Procedure. The procedure of Experiment 2 matched that of Experiment 1 in all details, with one addition. In Experiment 2, the computer recorded the order in which the participants reconstructed the memory list items.

Results

Figure 2 shows the data from the reconstruction test, broken down by isolation condition (large vs. small), item type (isolated vs. control), and serial position (1–6). The serial position functions were formed by the method described in the first experiment and are displayed as mean proportion correct reconstruction performance. As in Experiment 1, an overall ANOVA revealed reliable main effects of serial position, \(F(5, 380) = 59.99, MSE = 0.03, p < .001\), and item type, \(F(1, 76) = 30.36, MSE = 0.04, p < .001\). The serial position curves exhibited a bow-shaped form, with pronounced primacy and recency effects, and reconstruction performance was better for the isolated items than for the control items.

The analysis of variance revealed no main effect of isolation condition (large vs. small), \(F(1, 76) = 1.78, MSE = 0.17, p > .18\), and no interaction effects, all \(F_s < 1\). Planned comparisons showed highly significant isolation effects both in the large isolate condition, \(F(1, 76) = 20.86, MSE = 0.034, p < .001\), and in the small isolate condition, \(F(1, 76) = 10.40, MSE = 0.04, p < .001\). In the large isolate condition, 34 of the 39 participants showed an isolation effect, 4 showed the reverse pattern, and 1 showed a tie. Thirty-one of the 39 participants in the small isolate condition showed an isolation effect, 6 showed the opposite pattern, and there were 2 ties. The size of the isolation effect in the large isolate condition (8%) did not differ from that of the small isolate condition (6%).

As in Experiment 1, we compared reconstruction performance on the first several trials with performance on the last several trials.
in an attempt to determine whether the size of the isolation effect changed over the course of the experiment. The analyses revealed no change in the magnitude of the isolation effect in either the large isolate condition, \( F(1, 38) = 1.98, MSE = 0.03, p > .16 \), or in the small isolate condition, \( F < 1 \). Again, this suggests that participants did not alter their mnemonic strategy during the experiment. With regard to the background-item analysis, Table 1 confirms the pattern of results reported in Experiment 1. The table shows that both the background items and their counterparts in control lists were reconstructed equally well for both the large isolate and small isolate conditions. It appears that the background items were unaffected by the presence of an isolated item.

Output order analysis. The data from the output order analysis are shown in Figure 3 as a function of isolation condition (large vs. small), item type (isolated vs. control), and output position (first 2 vs. middle 2 vs. last 2). The results are plotted as mean proportion correct and are collapsed across serial position. An item was classified as having an output position of "first 2" when it was either the first or second item in the list to be reordered. The third and fourth items to be reordered were classified in the "middle 2" category, whereas the fifth and sixth items to be reordered were designated to the "last 2" category. The advantage of organizing the data in this manner is that reconstruction performance for the isolated and control items can be compared with respect to response order.

An ANOVA revealed reliable main effects of item type, \( F(1, 76) = 25.14, MSE = 0.02, p < .001 \), and output position, \( F(1, 152) = 141.46, MSE = 0.02, p < .001 \), and a reliable interaction between item type and output position, \( F(2, 152) = 4.86, MSE = 0.01, p < .01 \). The output position data showed that reconstruction performance was better for the items repositioned either first or second than for the items repositioned thereafter. Overall, there was a significant isolation effect, although the size of the effect varied with output position. The isolation advantage was larger in the middle 2 group than in the other two output position groups. The remaining main effect and interactions did not approach significance, all \( F < 1 \).

The output data also indicated that isolated items were not repositioned first more often than comparable control items. Table 2 shows the proportion of times that an item at a given serial position was repositioned first or second (first 2), third or fourth (middle 2), and fifth or sixth (last 2), as a function of item type (control vs. isolated) and isolation condition (large vs. small). Of primary interest in Table 2 is the proportion of times that the control and the isolated items were repositioned first or second at each serial position. The table shows that the isolated items were not repositioned first or second more often than the control items—the proportions were essentially equal at each serial position. This finding fails to provide any support for the output interference hypothesis, which has at its core the assumption that isolated items are remembered better because they are recalled first more often.

Discussion

As mentioned previously, one of the primary goals of Experiment 2 was to establish and further extend the generality of the isolation effect in order retention. To this end, the experiment was successful in two important ways. First, Experiment 2 provided a replication of the findings reported in Experiment 1. This was important because earlier studies yielded inconclusive results regarding the effect of isolation on

---

2 Figure 3 was constructed in three stages. In the first stage, each participant's data were organized such that one could compare isolated and control performance at each input serial position (1–6) for all of the three combined output positions (first two, middle two, last two). In the second stage, the results for each individual were collapsed across input serial position (1–6). In short, the data were combined so that each participant had six summary values reflecting his or her performance (i.e., control–first 2; control–middle 2; control–last 2; isolate–first 2; isolate–middle 2; isolate–last 2). In the final stage, these six summary values were collapsed across participants. Figure 3 represents the mean proportion correct reconstruction performance for the control and isolated items at each "output position" for the two isolation conditions.
match might have lowered reconstruction performance for the isolated items, which, in turn, might have reduced the size of the isolation effect. A cross-experiment ANOVA was conducted on the data from Experiment 1 and the data from the large isolate condition of Experiment 2. Although numerically larger, the ANOVA revealed that the size of the isolation effect in Experiment 2 (8%) did not differ significantly from that of Experiment 1 (5%), $F(1, 96) = 2.51, MSE = 0.03, p > .116$.

Finally, Experiment 2 was designed to evaluate Cunningham et al.’s (1998) “output interference” hypothesis. Cunningham et al. suggested that isolated items are recalled (and reordered) better than control items because isolated items tend to be the first items recalled (or reordered) and, thus, are subject to less output interference. The results of the present experiment provide no support for this view. We found no indications in our data that isolated items are reconstructed earlier than control items during output. Moreover, according to the output interference hypothesis, one would not expect an isolation effect when response order is equated between the control and isolate conditions. Again, a significant isolation effect was found when output order was equated, although the size of the effect varied with output position.

Experiment 3

Prior to Experiments 1 and 2, we suggested that isolation might produce effects on item and order retention similar to those produced by generation—enhanced item retention and disrupted order retention (e.g., Nairne et al., 1991). This suggestion seemed reasonable because generation and isolation shared a similar explanation; both were presumed to promote attention to the item (e.g., Hunt & Mitchell, 1982; Nairne et al., 1991; Serra & Nairne, 1993).

Table 2

<table>
<thead>
<tr>
<th>Output position</th>
<th>Serial position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item type</td>
<td>1</td>
</tr>
<tr>
<td>Large isolate condition</td>
<td></td>
</tr>
<tr>
<td>First 2</td>
<td>.30</td>
</tr>
<tr>
<td>Control</td>
<td>.25</td>
</tr>
<tr>
<td>Isolate</td>
<td>.14</td>
</tr>
<tr>
<td>Middle 2</td>
<td>.16</td>
</tr>
<tr>
<td>Control</td>
<td>.06</td>
</tr>
<tr>
<td>Isolate</td>
<td>.07</td>
</tr>
<tr>
<td>Last 2</td>
<td>.30</td>
</tr>
<tr>
<td>Control</td>
<td>.26</td>
</tr>
<tr>
<td>Isolate</td>
<td>.13</td>
</tr>
<tr>
<td>Small isolate condition</td>
<td></td>
</tr>
<tr>
<td>First 2</td>
<td>.14</td>
</tr>
<tr>
<td>Control</td>
<td>.07</td>
</tr>
<tr>
<td>Isolate</td>
<td>.08</td>
</tr>
</tbody>
</table>
However, the data from Experiments 1 and 2 revealed that isolation did not disrupt order retention, but actually enhanced order retention of the isolated items.

This result is somewhat puzzling. Intuitively, it seems that generation and isolation should have similar effects on order retention. In fact, one could even argue that generation is just one of many ways to isolate an item from the rest of the list. Why, then, would these two manipulations produce opposing effects on memory for order? A likely possibility is that in Naire et al.'s (1991) study, all of the items on a "generate" list were generated, whereas in Experiments 1 and 2, only one of the items on an "isolate" list was isolated. Considering that the size of the isolation effect depends on the number of isolated items in the list (e.g., Newman & Jennette, 1975; von Restorff, 1933), it is plausible that this difference in design might have been sufficient to produce these different results. Generation might have an entirely different effect on order retention if only one item in a list was generated. Experiment 3 was designed to examine this possibility.

In Experiment 3, participants again viewed 54 lists of six unique items. Thirty-six of the lists contained one isolated item and 18 did not. The isolated item in a list was displayed in fragment form (e.g., ph_ne) and appeared in the same font size as nonisolated items. The list items were presented visually, and participants were required to read each item and complete (generate) each fragment aloud as it appeared. A reconstruction of order test followed the final item of each list. The participants' abilities to remember the positions of the generated items compared with the nongenerated items was of central interest. If the contrasting effects of generation and isolation are due merely to a difference in design (all generated vs. one generated), one might expect generation to enhance order retention, just as isolation does.

Method

Participants and apparatus. Participants were 54 Purdue University undergraduates who participated for course credit in an introductory psychology course. Everyone was tested individually in sessions lasting approximately 1 hour. Stimuli were presented and controlled by IBM-compatible computers.

Materials and design. The same stimuli used in Experiments 1 and 2 were used again in Experiment 3. The primary difference between this experiment and the previous two was the nature of the isolation manipulation. In the previous experiments, an item was isolated from the rest of the list by either increasing or decreasing its size. In Experiment 3, the isolated items appeared in the same font size as the nongenerated items. The item was isolated from the rest of the list by presenting it in fragment form, requiring participants to generate the item. When an item appeared in fragment form, one letter was deleted and was replaced by the "underline" character. The deleted letter was selected according to the criteria outlined by Naire et al. (1991); the fragment had only one solution and that solution was relatively obvious.

As in Experiment 2, measures were taken to ensure a relative match between conditions at encoding and at retrieval. An item appearing in fragment form during presentation was displayed in fragment form at test and an item appearing in nonfragment form during presentation was displayed in nonfragment form at test.

Procedure. The procedure of Experiment 3 matched the procedure of Experiment 1, with two exceptions. First, the stimuli were presented for a longer interval. In Experiment 1, each list item was presented for 750 ms, with a 250 ms inter-item interval separating the offset of one item from the onset of the next, whereas, in Experiment 3, each list item was presented for 1000 ms, with a 250 ms inter-stimulus interval. Second, the experimenter re-corded any incorrect fragment completions (generation failures) and reading errors during list presentation.

Results

Participants correctly completed 92% of the word fragments and correctly read all of the nonfragmented words. The overall data patterns did not depend on whether the word fragments were generated successfully or not. Therefore, only the unconditional data are reported below.

The results from the reconstruction test are plotted in Figure 4 as a function of item type (generated vs. control) and serial position (1–6). The serial position functions were formed by the method described in Experiment 1 and are displayed as mean proportion correct reconstruction performance. An overall ANOVA revealed reliable main effects of item type, \( F(1, 53) = 9.84, \text{MSE} = 0.02, p < .01 \), and serial position, \( F(5, 265) = 36.72, \text{MSE} = 0.03, p < .001 \). The individual serial position curves were bow-shaped and showed clear primacy and recency effects. More important, the data revealed a highly significant reconstruction advantage for the generated items. Participants remembered the positions of the generated items better than comparable items in a control list. The average reconstruction performance, collapsed across serial position, was (.79) for generated items and (.75) for control items. Of the 54 participants, 33 showed a generation advantage, 13 showed the opposite pattern, and there were 8 ties. The Item Type \times Serial Position interaction was reliable, \( F(5, 265) = 2.47, \text{MSE} = 0.02, p < .04 \), and reflects the fact that the generation advantage occurred only when the generated items appeared on the second half of the list. At this point, it is unclear why the generation advantage was restricted to the final three list items. However, we return to this issue in Experiment 4.

As in the first two experiments, we compared reconstruction performance on the first several trials with performance on the last several trials in an attempt to determine whether the size of the
generation advantage changed across the duration of the experiment. The analysis revealed that the magnitude of the generation advantage did not change over the course of the experiment, \( F(1, 53) = 1.28, MSE = 0.03, p > .26 \); apparently, participants did not modify their mnemonic strategy during the experiment. The background-item analysis in Table 1 also shows no difference in reconstruction performance for the background items and their counterparts in control lists.

It is worth noting that the background-item data reported here are at odds with findings reported earlier by Schmidt (1992). In this study, participants were asked to free recall lists of 24 items. Lists contained either 24 read items or 20 read and 4 generated items. Schmidt (1992) found that generation had an adverse effect on retention of the background items (nongenerated items in a generated list). Recall was poorer for background items than for comparable items in a control list. His results provide support for a general trade-off view in which extra encoding resources are allocated to generated items at the expense of the other list items. At this point, the origin of these disparate results is unclear, although the answer may lie in the nature of the retention tests employed. The present data indicate that isolation or generation can have enhancing effects on memory for order that are clearly not at the expense of background items.

Discusison

The results of Experiment 3 indicate that generation, at least for the items appearing in the second half of the list, can enhance memory for order. When only one item in a list was generated, participants remembered the positions of the generated items better than the same items in a nongenerated list. In retrospect, this result may not be too surprising given that the presentation of a fragment for generation is itself a kind of isolation manipulation. In fact, because of the nature of the generation procedure (presentation of a fragment), it is difficult to disentangle the true cause of the memory advantage at this point—is it the act of generation or the presence of the visually distinctive word fragment?

As noted earlier, the effect of generation appears to depend on the number of generated items within the list. Nairne et al. (1991) demonstrated that generation disrupts order retention when every item in a list is generated. Experiment 3 showed that generation enhanced order retention when only one item in a list is generated. Similarly, studies in the isolation effect literature have shown that the size of the isolation effect decreases as the number of isolated items within a list increases (e.g., Newman & Jennette, 1975; von Restorff, 1933). It seems likely that the positive effect of generation on order retention will decrease as the number of generated items in the list increases and, at a certain point, generation will no longer enhance order retention but will disrupt it. Experiment 4 was designed to examine this possibility.

Experiment 4

In Experiment 4, participants were assigned to one of three generation conditions: all, half, or one. In the “all” generation condition, all six of the items in a generated list required generation. In the “half” condition, three of the six items required generation. In the “one” condition, one of the six items required generation. Participants were required to read and generate each list item aloud and were given a reconstruction of order test following each list. The participants’ abilities to reposition the generated items compared with the control items in each of the three generation conditions was of primary interest.

Method

Participants and apparatus. The participants were 90 Purdue University undergraduates, who participated for credit in an introductory psychology course. The stimuli were presented and controlled by IBM-compatible computers and the experiment lasted approximately ½ hr.

Materials and design. The stimulus set consisted of 204 medium to high frequency nouns taken from Paivio, Yiuile, and Madigan (1968). The stimulus items were matched on a number of attributes, namely: imagability (\( M = 5.99 \); range = 3.73–6.90), concreteness (\( M = 6.07 \); range = 2.18–7.70), meaningfulness (\( M = 6.63 \); range = 4.58–9.22), and word length (\( M = 5.60 \); range = 4.00–7.00). The stimuli were randomly assigned to 34 lists, each containing six items. The word lists were presented in exactly the same order to all participants in a given condition.

Participants were assigned to one of three generation conditions: all, half, or one. In the “all” condition, each participant received 30 experimental trials (20 generated and 10 control). All six of the items on a “generated” trial appeared as word fragments. The word fragments were formed by the method described in Experiment 3. To ensure generality, three separate versions of the 30 experimental trials were constructed so that, across every 3 participants, each list served as a control list once and a generated list twice. At the onset of each trial, participants had no way of knowing whether the upcoming list contained generated or control items.

In the “half” condition, each participant received 30 experimental trials (20 generated and 10 control). Three of the six items on a generated trial appeared as word fragments. The positions of the three generated items in the list were different on each generated trial, as all possible three-item combinations (20 in all) were used. As in the “all” condition, three separate versions of the 30 experimental trials were constructed so that, across every 3 participants, each list served as a control list once and a generated list twice. At the onset of each trial, participants had no way of knowing which, if any, of the list items would be word fragments on a given trial.

In the “one” condition, each participant received 34 experimental trials (24 generated and 10 control). One of the six items on a generated trial appeared as a word fragment. To ensure that each generated item appeared equally often at each of the six serial positions, 4 experimental trials were added to this condition (24 total trials). As in the previous two conditions, three separate versions of the 30 experimental trials were constructed so that, across every three participants, each list served as a control list once and a generated list twice. The four extra generated trials were always the last four trials of the session. At the onset of each trial, participants had no way of knowing which, if any, of the list items would be word fragments on a given trial.

In each condition, the stimuli appeared successively in the center of the computer screen. All of the words were presented in sans serif font and were formed by 5-mm × 10-mm letters (word length: 20 mm–35 mm). During the reconstruction test, all of the items were displayed in 14-pt sans serif font. As in Experiments 2 and 3, the relative conditions at encoding were preserved at retrieval. An item appearing in fragment form during presentation was displayed in fragment form at test and an item appearing in nonfragment form during presentation was displayed in nonfragment form at test.

Procedure. The procedure of Experiment 4 matched that of Experiment 3 in all details.

Results

Participants correctly completed 93.2%, 92.6%, and 91.9% of the word fragments and correctly read 99.5%, 99.4%, and 99.6%
of the nonfragmented words for the all, half, and one conditions, respectively. The overall data patterns did not depend on whether the word fragments were generated correctly or not and only the unconditioned data are reported below.

Figure 5 shows the results from the reconstruction test, broken down by generation condition (all vs. half vs. one), item type (generated vs. control), and serial position (1–6). The serial position functions were formed by the method described in Experiment 1 and are displayed as mean proportion correct. A $2 \times 3 \times 6$ mixed design ANOVA revealed reliable main effects of generation condition, $F(2, 87) = 7.26, MSE = 0.18$, $p < .01$, and serial position, $F(5, 435) = 120.05, MSE = 0.03$, $p < .001$. The main effect of item type was not significant, $F < 1$. The serial position functions were bow-shaped, with pronounced primacy and recency effects, for both generated and control lists at each of the three generation conditions. Overall, performance decreased systematically across the generation conditions (.78, .70, and .67) for the “one,” “three,” and “six” conditions, respectively.

The ANOVA revealed a reliable Generation Condition × Item Type interaction, $F(2, 87) = 10.88, MSE = 0.03$, $p < .001$. This interaction reflects three important findings. First, generation enhanced the participants’ abilities to reorder the generated items in the “one” condition. Across the 30 participants, 22 showed a generation advantage, 7 showed a read advantage, and there was 1 tie. This result is consistent with the findings of Experiment 3, although the generation advantage was no longer restricted to the second half of the list. Second, generation disrupted the participants’ order retention in the “all” condition. Of the 30 participants, 22 showed a read advantage and 8 showed a generation advantage. This finding is consistent with the results reported in Nairn et al. (1991). Finally, generation had no significant effect on performance in the “half” condition. Generation neither hurt nor helped order retention. Fourteen of the 30 participants showed a generation advantage, 14 showed the opposite pattern, and 2 tied. Clearly, the effect of generation on order retention changes as a function of the number of generated items in the list. The positive effect of generation on order retention appeared to decrease as the number of generated items in the list increased until generation no longer enhanced order retention, but began to disrupt it.

The ANOVA also revealed a significant Generation Condition × Serial Position interaction, $F(10, 435) = 3.80, MSE = 0.03$, $p < .001$. The serial position function for the “all” condition appears to be slightly more bow-shaped than the function for the “half” condition which, in turn, is significantly more bow-shaped than the “one” serial position function. The serial position function for the generated items in the “one” condition also appears to be flattened relative to the control condition, but neither the Item Type × Serial Position interaction, $F < 1$, nor the three-way Generation Condition × Item Type × Serial Position interaction, $F(10, 435) = 1.40, MSE = 0.02$, $p < .17$, reached statistical significance. Unlike in Experiment 3, the generation advantage in the “one” condition appeared throughout the list and was not restricted to the final three list items. Although the isolation advantages in positions one and six were small, the data suggest that generation enhanced order retention throughout the list.

As in Experiments 1–3, we compared reconstruction performance on the first several trials with performance on the last several trials in an attempt to determine whether the size of the generated versus read difference changed over the duration of the

Figure 5. Serial position curves for the generated and control items in (A) “all” generation condition, (B) the “half” generation condition, and (C) the “one” generation condition of Experiment 4.
experiment. In the "one" condition, the magnitude of the generation advantage did not change over the course of the experiment, $F < 1$. There was no change in the size of the read advantage in the "all" condition, $F < 1$, and, in the "half" condition, generation and read performance remained equivalent throughout, $F < 1$. The background-item analysis in Table 1 revealed no difference in reconstruction performance between the background items and their counterparts in control lists. This held true for both the "one" and the "half" conditions. The "all" condition was not included in this analysis because the generated lists in this condition did not contain background items. These findings suggest that the background items were unaffected by the presence of one or more word fragments.

Discussion

The results of Experiment 4 show that generation can enhance, disrupt, or have no effect on order retention. It appears that the relative number of generated items within a list determines which of these three effects will occur. When only one of the six list items required generation, participants remembered the positions of the generated items better than the same items in control lists. When a random half of the six list items were generated, participants remembered the positions of generated and control items equally well. Finally, when all of the six list items required generation, participants remembered the positions of the control items better than the same items in a generated list.

General Discussion

The effects of isolation and generation on memory for order were examined in four experiments. Experiments 1 and 2 investigated the effect of isolation on order retention. Previous explorations into this topic have yielded equivocal results. Cimbalø et al. (1981) reported a reliable isolation effect when using a cue-position task; however, in their experiment the isolated items were always presented in the same serial position (see also Lippman, 1978). Cunningham et al. (1998) isolated items in every serial position across trials but failed to find a reliable effect of isolation in serial recall. In the current set of experiments, isolated items occurred equally often in each serial position across trials and reconstruction was used to assess order retention. The results clearly established that isolation can enhance order retention across the board. Thus, one can safely assume that the classic von Restorff effect generalizes to both item and order retention.

The current experiments also explored the effect of generation on order retention. At the outset, we hypothesized that generation and isolation might produce similar disruptive effects on order memory. Nairne et al. (1991) reported that generation hurts order retention, presumably because attention is directed toward generating the individual item and away from the encoding of order or position (see also DeLosh & McDaniell, 1996). Similarly, it was reasoned, isolation may well direct attention selectively to the unique item information at the expense of order encoding. However, the results of Experiments 3 and 4 revealed that isolated fragments, requiring generation, actually enhanced order retention relative to control lists, mimicking the von Restorff effect. Generation disrupts order retention, at least empirically, only when all (or most) of the items in the list require generation.

What accounts for the presence or absence of isolation effects? First, it is clear that the isolation advantages seen in these experiments cannot be explained simply by appealing to surprise or to some other kind of perceptual salience. Significant isolation effects were found when the isolated item occurred in the very first serial position. At this point, the item's unique characteristics (large or small; generated) could not be especially surprising or salient because the other items were not presented (see Hunt, 1995; von Restorff, 1933). Moreover, as Experiment 2 demonstrates, it is not the "largeness" or "smallness" of the stimulus that matters—what matters is the relationship between the isolated item's characteristics and those of the remaining items in the list. The features of the critical item need to be different from, or distinctive relative to, the other items in the list.

One way to explain these data is to assume that the participant encodes and then uses item characteristics as cues for reconstructing item position at test. In the present experiments, the isolation manipulation was always associated with unique physical properties at presentation (size or fragments). If those properties are encoded and used as cues at test, then they could help to identify the record of the isolated item in memory. For example, assume the word carrot has been uniquely presented in a fragment form and a lasting record of the encoding is stored in secondary, or long-term, memory. At test, if carrot is presented in fragment form as a cue, or if a lingering representation of the earlier encoding remains in primary memory, the participant should be able to use its presentation format—the fact that it was presented as a fragment—to help identify the correct secondary memory trace. The physical aspects of presentation in this case uniquely specify one of the list items—the item that was presented as a word fragment.

Nairne's feature model of primary memory (Nairne, 1988, 1990, in press) can be used to provide a concrete example of how this process might work. In the feature model, residual traces in primary memory are used as cues to sample recall candidates from secondary memory. Traces are represented as vectors of features—hence, the name the "feature" model—and some of the features are assumed to be "modality dependent," which means they faithfully represent the presentation conditions (e.g., modality, language, etc.). At test, traces are interpreted, or deblurred, by comparing them with possible recall candidates in a secondary memory search set (Nairne, 1990). If a particular primary memory trace's features are unique—that is, they uniquely specify, or predict, one of the recallable items—then performance for the item improves. It is important that these features be unique. If they are shared by other members of the recall set, then there will be no special performance advantage (see Nairne, in press, for an extended discussion of this point).

In a more formal manner, the probability of sampling a particular recall candidate is stated as such:

$$P(SM(j)|PM(i)) = \frac{s(i,j)}{\sum s(i,k)},$$

where $s(i,j)$ stands for the computed similarity between primary memory trace $PM(i)$ and secondary memory trace $SM(j)$. In accordance with Shepard and others (Nosofsky, 1986; Shepard, 1987), similarity is defined by the distance between two trace vectors in some psychological space. Distance ($d$) is calculated by adding the number of mismatched features across the primary and
secondary memory vectors and dividing by the number of features. That is,

$$d(i, j) = \frac{\sum M(k)}{N},$$  \hspace{1cm} (2)

where the index of mismatches, $M(k)$, is incremented by one if feature position $x(i, k)$ does not match feature position $x(j, k)$. The distance measure is then related to similarity in the manner described by Shepard (1987):

$$s(i, j) = e^{-d(i, j)}.$$  \hspace{1cm} (3)

Table 3 shows some hypothetical list vectors that are meant to correspond roughly with the manipulations of the present experiments. The first vector in each row is the “cue,” and the remaining three vectors (labeled “Traces”) comprise the items in the search set. In this case, for simplicity, we have assumed that the memory list contains only three items and each item is represented faithfully in the search set. The numbers in each vector are hypothetical features; the last feature, “V,” records the fact that an item was presented in a normal visual presentation mode. The first line in the table shows the probability of correctly sampling the second item from the search set in a normal control condition given that a residual trace of the second item is used as a cue. This probability is determined by first adding up the mismatches between the cue and the second item (there are no mismatches), dividing by the number of features (4), and calculating similarity through Equation 3. This value then serves as the numerator in Equation 1. The denominator, in turn, is the sum of the similarity values between the cue and each of the three search set members. Note that the probability of correctly sampling the second item in this case is 0.42. (The sampling probabilities for the first and third items on the list, which would be classified as errors if recalled, are shown as well.)

The second line in Table 3 shows what happens when the second item is presented in fragment form. Here, the last feature in the trace is set to “F,” representing the fragment presentation, for both the second item in the search set as well as for the second item cue. Note that the resulting sampling probability increases for this item, relative to the control condition, because there is now less overlap between the cue and the first and third members of the search set. This advantage models the von Restorff effect. The locus of the effect, from the perspective of the model, is occurring primarily at retrieval. When items are presented in an unusual way, distinctive features are encoded that help to reconstruct the appropriate item at test (for a somewhat similar account of the bizarre-imagery effect, see McDaniel, DeLosh, & Merritt, 2000).

However, it is important to note that it is not the encoded physical features per se that lead to the advantage—those features will be helpful only to the extent that they are not associated with other possible recall candidates (Nairne, in press). Thus, if many items are presented in a fragment form, as in the “all” condition of Experiment 4, the physical aspects of presentation lose their uniqueness and become poor predictors of secondary memory records. The third and fourth lines in Table 3 show how sampling probabilities in the feature model change as the number of fragmented items increases in the list. Note that when all the items are presented in fragment form (Iso = 3) the sampling probability is exactly the same as in the control condition. Furthermore, it is important to note that because participants are assumed simply to encode the physical aspects of presentation, it should not matter where in the list the isolated item occurs; it is the presence of distinctive features at retrieval that determines the boost in retention.

The feature model provides a general accounting of von Restorff effects, but it is almost certainly the case that other variables factor into final memory performance. For example, as noted throughout, when all the items in a list are generated, order memory is disrupted relative to control lists. The distinctive-features account described above predicts equivalent performance between generated and control lists when all items in a list are generated. Thus, as the participant engages in solving a word fragment, less time may be available for noticing relationships among the items to be remembered. Final performance will then reflect a trade-off between reduced order knowledge and the presence of potentially distinctive trace features. Whether final memory performance will be enhanced or depressed will depend on the type of retention test and the presence or absence of the particular mnemonic byproducts that are needed to perform well.

Consequently, with respect to the generation effect literature, the current data indicate once again that simple statements about the effects of generation on item and order memory are likely to be misleading. No simple statements about the enhancing or depressing effects of generation on order retention are viable because the mnemonic effects depend on the circumstances. The act of gener-

---

3 This is a "bare bones" version of the feature model for demonstration purposes only. The full model contains assumptions about trace degradation through overwriting, a recovery stage that translates sampling probabilities into recall and various parameters (e.g., attention) that control overall performance levels.
ation can serve itself as a kind of isolation manipulation, producing facilitation in order memory, but only to the extent that the act is distinctive relative to the other list items. Similar conclusions are, of course, relevant to the traditional von Restorff manipulations. Physically changing, or augmenting, the stimulus in some manner (increasing its size or changing its color) leads to an advantage in performance only to the extent that those changes are unique in the list context.

References


Received June 24, 1999
Revision received June 8, 2000
Accepted June 19, 2000