

Is Perceptual Salience Needed in Explanations of the Isolation Effect?

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The isolation effect is a well-known phenomenon that has a well-accepted explanation: An item that is isolated on a list becomes perceptually salient, which leads to extra rehearsal that enhances memory for the isolate. To evaluate this hypothesis, the authors isolated an item near the beginning of a list. Immediately after each item was presented for study, participants judged the likelihood of recalling the item. Although the isolation effect occurred, participants did not judge the isolate as being more memorable than the preceding item, suggesting that the isolate was not salient. In a second experiment, participants rehearsed items aloud. Isolation at the beginning of the list did not produce extra rehearsal. By contrast, isolation in the middle of the list produced extra rehearsal; however, even when the isolate did not receive extra rehearsal, an isolation effect was evident. Thus, salience and extra rehearsal are not necessary for producing an isolation effect.

The isolation effect in memory is a robust and well-known phenomenon. If all of the items on a list are categorically similar save one, then the isolated item is remembered better than the same item embedded in a control list. The effect and its dominant explanation are intuitively obvious. The distinctiveness of the isolated item draws more attention than other items due to the violation of the context established by surrounding items. The enhanced attention allows more processing and subsequently better memory.

The intuitive explanation of the isolation effect, in particular, and distinctiveness effects, in general, is that the perceptual salience of the distinctive event attracts additional processing. This intuition is most readily realized through the mechanism of selective attention. Jenkins and Postman (1948) were first to propose that differential attention could be a necessary condition for the isolation effect, and subsequently, most prominent theories have followed suit. Green (1956) argued that the isolation effect resulted from surprise induced by the change from preceding items. "Surprise increases the attention paid to the item and hence the likelihood of recall" (Green, 1956, p. 340). Surprise, the emotional response to perceptual salience, explicitly elicits attention to the item in Green's theory. But why should attention enhance memory? Rundus (1971) suggested that the function of attention was to engage rehearsal such that an isolated item is better remembered because it receives more rehearsal than other items.

Given the plausibility of this account, it is surprising that the differential attention hypothesis has been under attack for some time (e.g., Bruce & Gaines, 1976) and appears now

to be out of favor (e.g., Waddill & McDaniel, 1998). The principal argument against the differential attention hypothesis is the empirical finding that isolated items do not, or at least do not always, disrupt performance on surrounding background items (e.g., Bruce & Gaines, 1976; Fabiani & Donchin, 1995; Schmidt, 1985). If the beneficial effects of isolation were due to increased attention to the isolate, then the reasoning is that it would come at the expense of attention to surrounding items. Although detrimental effects of isolation on recall of surrounding items sometimes are found (e.g., Hunt & Mitchell, 1982), the inconsistency of this effect suggests that differential attention is not necessary for isolation effects. Nonetheless, recall of background items is an indirect index of differential attention to the isolated item and does not address the question of whether perceived salience is a necessary condition for enhanced memory of the isolate. Salience is not only the most intuitive component of the isolation paradigm but serves as the trigger mechanism for differential processing of the isolate.

Ironically, von Restorff's (1933) classic research directly argued against the necessity of perceptual salience for isolation effects. Unlike the standard practice of isolating an item in the middle of a list, von Restorff placed the isolated item in the second serial position of a list explicitly to avoid rendering the isolate perceptually salient. Given that no context has been established at this point in the list, the item is unlikely to be perceived as salient and should not attract extraordinary attention. Yet, an isolation effect obviously was obtained given that isolation effects are commonly called the von Restorff effect (see Hunt, 1995, for a replication and further discussion of von Restorff's research). Subsequently, Pillsbury and Raush (1943) reported an isolation effect when the isolated item appeared as the first item in the list.

One might object to the use of these data as evidence against the perceptual salience hypothesis of isolation effects on the grounds that there is no independent index of salience. Although von Restorff's argument seems reasonable, it is possible that early isolation does not eliminate the

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salience of the item. In the first experiment, we report indices of salience by collecting judgments of learning, which are a person's predictions about the likelihood of correctly recalling a recently studied item on the future test of memory. Current theories about how judgments of learning are made indicate that perceived salience of a stimulus dimension critically influences judgments of learning (cf. Koriat, 1997; Sommer, Heinz, Leuthold, Matt, & Schweinberger, 1995). Our contention is not that judgments of learning measure the distinctiveness of items in memory, which would be inconsistent with empirical evidence indicating that people's metacognitive judgments do not reflect direct access to the underlying representation of items in memory (for reviews, see Koriat, 1993, 1997; Schwartz, Benjamin, & Bjork, 1997). Instead, judgments of learning presumably reflect the phenomenology of study and hence are expected to be influenced by isolation given that isolation itself produces explicit, perceptual salience of the isolate. To evaluate this possibility in Experiment 1, we isolated an item early in the list or in the middle of the list, and we then compared both recall and judgments of learning for the items as a function of the serial position of isolation. If perceptual salience is necessary for isolation effects, then judgments of learning will be greater for the isolated item than for the immediately preceding item.

In the second experiment, we directly examined the mechanism of differential rehearsal as a necessary condition for the isolation effect. Rundus (1971) reported that isolated items receive more rehearsal than background items in the isolation list. Furthermore, Rundus noted that an item may appear in the rehearsal protocol, disappear with the presentation of subsequent items, but then reappear at a later point in the list. Perhaps items isolated early in the list are not perceived as salient, but as more items are presented, the difference between those items and the isolate emerge. That is, the rehearsal of an item may be distributed throughout the list (cf. Modigliani & Hedges, 1987). The difference is noted in effect as memorial salience and the isolate then receives differential attention. One form this differential attention could take is increased numbers of rehearsals in which case one would expect the pattern of rehearsal described by Rundus. Although the rehearsal mechanism has been discounted along with the differential attention hypothesis (Fabiani & Donchin, 1995; Schmidt, 1985; Waddill & McDaniel, 1998), only two investigations have included a direct examination of rehearsal. Also, as discussed in detail below, these investigations yielded disparate conclusions—an apparent conflict that we also sought to resolve in the present research.

Experiment 1

Method

Design and Participants

A full-factorial design with two factors was used. The two between-subjects factors were the kind of list (isolation list or control list) and the position of the critical item (either near the beginning of the list or in the middle of the list).

Eighty-four students from the University of North Carolina at Greensboro (UNCG) participated to receive class credit for an introductory psychology course. Twenty-one students were randomly assigned to each group by order of appearance.

Materials

The two lists were constructed from a pool of 24 items, which consisted of nonsense syllables, digits, and assorted items such as icons and shapes (from Hunt, 1995). The isolation lists consisted of 11 nonsense syllables and 1 digit, the isolated item. The control lists consisted of 12 heterogeneous items, which included the digit in the serial position of the corresponding isolation list and the 11 assorted items. For isolation near the beginning of the list, the critical item was placed in the second serial position. For isolation in the middle of the list, the critical item was in the seventh position. Macintosh computers presented instructions and items (timing of presentation was accurate to 1/60 s) and collected all responses.

Procedure

The experiment consisted of a single study-test trial. During the study trial, items were presented individually for 3 s per item. Immediately after the offset of the presentation of an item for study, a judgment of learning was made for that item. Each judgment of learning was participant paced and was cued by the item and the query, "How confident are you that in about 10 minutes from now you will be able to recall the item?" (0 = *definitely will not recall*; 10 = *10% sure*; 20 = *20% sure*; 30 = *30% sure*; 40 = *40% sure*; 100 = *definitely will recall*).

After each item had been studied and judged, the participants attempted to solve a puzzle for 10 min. Finally, participants were given as much time as they wanted to recall as many items as possible.

Results and Discussion

To evaluate the influence of isolation on recall, we computed the proportion of recall for the critical item separately for all four groups of participants. When the critical item was placed near the beginning of the list, recall was greater for the item in the isolation list (.86) than in the control list (.67). When the critical item was placed in the middle of the list, recall was also greater for the item in the isolation list (.71) than in the control list (.48).¹ Consistent with these observations, a 2 (position of the isolate: beginning vs. middle) \times 2 (list: isolation vs. control) analysis of variance (ANOVA) revealed a main effect for list, $F(1, 80) = 4.60$, $MSE = .210$. The main effect of position and the List \times Position interaction were not reliable, $F_s < 2.8$, $MSEs = .210$. Thus, the isolation effect

¹ Making judgments of learning has had a minimal influence on recall performance (Nelson & Dunlosky, 1992; Kelemen & Weaver, 1997). However, even if judgments of learning disrupt rehearsal of individual items, according to the salience hypothesis, such an influence would diminish the effects of isolation. That is, if judgments of learning disrupted rehearsal, the present outcomes would likely underestimate the magnitude of the isolation effect, if rehearsal were producing it.

was evident regardless of where the critical item was presented in the list.

More important, however, is whether isolating an item near the beginning of the list influences people's judgments of learning, which was evaluated by comparing judgments for the isolated item versus for the item immediately preceding the isolated item. Although comparing judgments of learning for the critical item in the isolated list versus the control list may at first seem most appropriate, the present comparison between the isolate and the immediately preceding item of the same list was preferred for two reasons. First, comparisons between lists may reduce the likelihood of detecting effects of isolation on the judgments because of a criterion shift that may occur in between-subjects designs (Carroll & Nelson, 1993). Second, and most important, perceptual salience presumably does not result from psychological comparisons between items that are presented on different lists but results from the relations among the isolated item and items that occur on the same list. Given that the isolate is perceived as salient against the background of previously presented items, judgments of learning were expected to be greater for the isolate than for the item immediately preceding it.

Before we reveal the influence of isolation on the judgments, first consider recall performance of this comparison item. Regardless of the position of the critical item, recall was substantially less for the comparison item (.29 and .19 for early and late positions, respectively) than for the corresponding isolated item, $t(20)s > 3.50$. Will judgments of learning track this difference in recall performance? Mean judgments of learning across participants within each of the two critical groups—in which the critical item was isolated in a background of homogeneous items—are presented in Figure 1.

A 2 (position of the isolated item: beginning vs. middle) \times 2 (item: critical or comparison item) ANOVA was conducted. The main effect for position of the isolated item was not reliable, $F(1, 40) = .08$, $MSE = 946.2$, whereas a main effect occurred for the kind of item, $F(1, 40) = 12.18$, $MSE = 451.9$. However, this main effect for kind of item was qualified by a reliable interaction, $F(1, 40) = 20.4$, $MSE = 451.9$. Specifically, when the critical item was isolated near the beginning of the list, the magnitude of the judgments was not reliably different for the critical item than for the comparison item, $t(20) = 0.68$. By contrast, when the critical item was isolated in the middle of the list, the magnitude of the judgments of learning was reliably greater for the critical item than for the comparison item, $t(20) = 6.13$.

One explanation for these outcomes, suggested by a reviewer (S. Schmidt), is that the isolate is salient regardless of whether it occurs at the beginning of the list or in the middle of the list. When presented in the middle of the list, people are aware that the item is perceptually salient. By contrast, when the item is initially presented near the beginning of the list, the increased attention that is caused by salience is automatic, occurring outside of awareness. Thus, assuming judgments of learning are less sensitive to dimensions of stimuli that do not induce awareness, these judg-

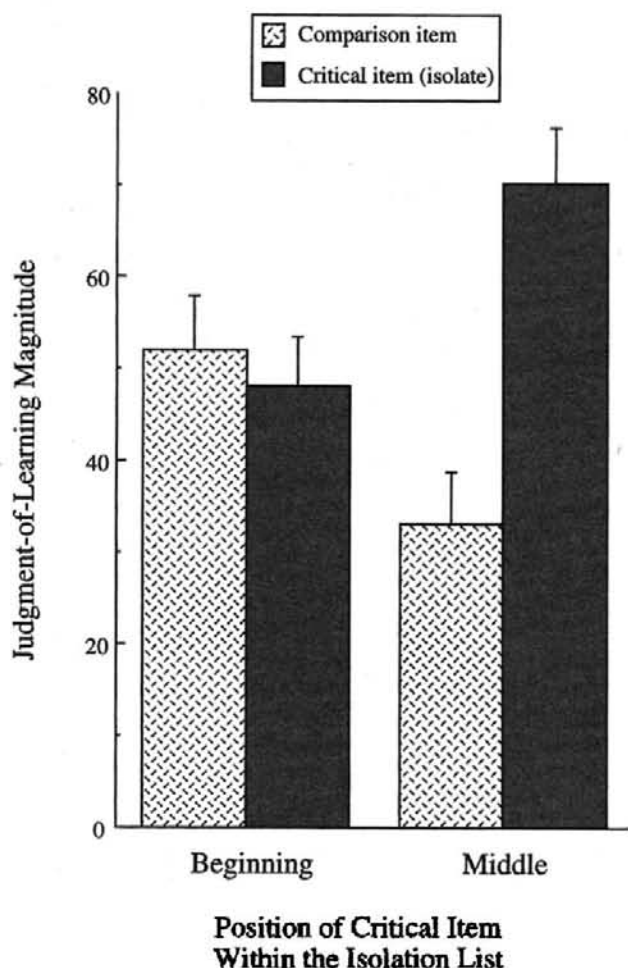


Figure 1. Mean of the judgments of learning across individuals' judgments are shown as (a) a function of the serial position of the critical item on the list (either in the second serial position—beginning—or in the seventh serial position—middle) and (b) for the comparison item (which immediately preceded the isolated item) and for the isolated item.

ments will be less sensitive to salience at the beginning of the list than near the middle of the list. Most important, even if subthreshold salience can trigger increased attention, the present data are still inconsistent with the current hypothesis in which salience *explicitly* elicits attention (cf. Green, 1956).

In conclusion, the phenomenology that presumably underlies the isolation effect differs qualitatively depending on where the critical item is isolated in the list: The isolate is not explicitly salient when appearing near the beginning of the list, but when embedded in the middle of the list, it is explicitly salient. Importantly, in contrast to previous research, these results are the first to establish that isolating an item leads to subjective salience, which is a critical component of salience accounts of the isolation effect. Nevertheless, the outcomes involving isolation near the beginning of the list suggest that salience is not necessary for producing an isolation effect.

Experiment 2

Evidence from the first experiment indicates that an item isolated early in a list is not perceptually salient, demonstrating that perceptual salience is not necessary for the isolation effect. Even so, a salience-based process may still account for this *primacy isolation effect*, so called because the isolate resides in a primacy position of the list. The idea is that when the isolate appears in the beginning of the list, it is not initially salient but becomes salient sometime after its presentation. For instance, after studying several other items on the list, the individual may attend to the isolate (e.g., through retrieval), which then induces a surprise response via conceptual salience. We call this conceptual salience because salience here does not rely on the direct perception of the isolate but instead is triggered by conceptual processes, such as retrieving the isolate and comparing it to previously presented items from the list. As with the original salience hypothesis, conceptual salience presumably will lead to extra processing of the isolate, which in turn produces the primacy isolation effect.

Our primary goal in Experiment 2 was to evaluate this hypothesis, particularly with regard to the assumption that an isolate receives extra rehearsal. Although the differential rehearsal hypothesis has fallen out of favor (Fabiani & Donchin, 1995; Schmidt, 1985; Waddill & McDaniel, 1998), the evidence against the hypothesis is indirect. Direct tests of this hypothesis have been presented in the literature (Einstein, Pellegrino, Mondani, & Battig, 1974; Rundus, 1971), and consequently, we used their methods of recording overt rehearsals during the presentation of items for study. Neither investigation examined rehearsal of an item isolated at the beginning of the list, and perhaps surprisingly, these investigations also yielded inconsistent results concerning the role of rehearsal of the isolate when it was embedded in the middle of a list: Whereas Rundus (1971) reported that isolates received extra overt rehearsal, Einstein et al. (1974) reported that an isolate did not receive extra overt rehearsal (although a nonsignificant trend of greater rehearsal of the isolate was evident). Closer scrutiny of both investigations, however, suggests that neither outcome is definitive with respect to whether isolation elicits extra rehearsal. Rundus told participants "that [isolated] words might appear, and if so, to be sure to remember them" (p. 70), which may have itself boosted rehearsal of the isolate. Einstein et al. compared rehearsal of the isolate with mean rehearsal of all other items on the list (cf. Rundus, 1971), which included items in primacy positions that typically receive more rehearsal than others and hence may obscure the effects of isolation on rehearsal. A more appropriate control involves comparing rehearsal of the critical item when it is isolated versus when it is placed in the same position of a control list composed of heterogeneous items.

We critically extended this research (a) by investigating differential rehearsal of an item isolated in the middle of the list without providing instructions that may orient participants toward differentially rehearsing the isolate; (b) by including a more appropriate control condition as described above; and most important, (c) by investigating whether an

item isolated at the beginning of the list receives extra rehearsal, an outcome that is critical for evaluating the general role of rehearsal in producing isolation effects and that has not yet been reported in the literature. Concerning the latter, if an isolate near the beginning of the list later becomes salient, this item is expected to receive extra rehearsals. That is, the critical item will be rehearsed more when presented in the isolation list than when presented in the control list. An alternative is that an isolate near the beginning of this list does not become salient and will not receive extra rehearsal. To evaluate this prediction, we examined several measures of rehearsal. As described in detail later, each measure provides a different perspective on how often (or in what manner) participants rehearsed the isolate.

According to the salience hypothesis, isolation produces salience, which in turn leads to extra rehearsal of the isolate. Even if the isolate receives extra rehearsal, however, this rehearsal may not enhance recall. That is, extra rehearsal may not be necessary for producing an isolation effect. Because rehearsal causes the isolation effect according to the salience hypothesis, we also empirically evaluated whether extra rehearsal of the isolate was necessary for isolation effects. The contribution of rehearsal to the isolation effect was estimated using the rehearsal protocols: If extra rehearsal is not necessary, an isolation effect will be evident even when isolates do not receive extra rehearsal.

Method

Design and Participants

The design was a 2×2 factorial, consisting of the two between-subjects manipulations used in Experiment 1: the position of the critical item (beginning vs. middle of the list) and the kind of list (either the isolation or control list).

One hundred and forty-eight students from UNCG participated in the experiment as part of a course requirement. Participants were randomly assigned to each group by order of appearance. Because of a transcription error, the number of participants was not equal across groups. For isolation near the beginning of the list, 39 participants received the isolation list, and 36 received the control list. For isolation in the middle of the list, 35 participants received the isolation list, and 38 received the control list.

Materials

The 12-item lists consisted of the same items that were used in Experiment 1. Each item was presented on a 3×5 card by the experimenter, who was concealed from each participant by a divider. A tape recorder was used to record rehearsal protocols.

Procedure

The experiment consisted of a single study-test trial. During the study trial, participants were instructed to rehearse the items of the list aloud (Rundus, 1971). If the participant could not repeat the instructions back to the experimenter, the instructions were restated. Any questions the participants had about the procedure were answered prior to the study-test trial. Items were presented individually for 3 s each. Rehearsal was recorded during this time.

After the study trial, participants attempted to solve a puzzle for 10 min. Next, they were to recall (in any order) as many items as they could. The recall trial was self-paced.

Results and Discussion

Recall Performance

To evaluate the influence of isolation on recall, we computed the proportion of recall for the critical item for all four groups of participants. When the critical item was placed near the beginning of the list, recall was greater for the item in the isolation list (.87) than in the control list (.56). When the critical item was placed in the middle of the list, recall was also greater for the item in the isolation list (.63) than in the control list (.26). As expected, a 2 (position of the critical item: beginning vs. middle of the list) \times 2 (list: isolated vs. control) ANOVA revealed a main effect for list, $F(1, 144) = 21.46$, $MSE = 0.20$. Recall was also reliably greater when the items were presented near the beginning of the list than in the middle (i.e., a reliable primacy effect), $F(1, 144) = 13.25$, $MSE = 0.20$. Most important, the main effect of the list was not compromised by a Position \times List interaction, $F(1, 144) = 0.11$, $MSE = 0.20$. Thus, the isolation effect was evident regardless of whether the critical item was presented near the beginning of the list or embedded in the middle of the list.

Rehearsal

Can these isolation effects be explained by increased rehearsal to the isolate, which may have been triggered either by conceptual salience (for isolation near the beginning of the list) or by perceptual salience (for isolation at the middle of the list)? To answer this question, we considered both (a) whether isolating an item in a list increased rehearsal to the isolate and (b) whether rehearsal was necessary to obtain an isolation effect.

In this section, we examine the former by describing how isolation influenced overt rehearsal. We used Modigliani and Hedges' (1987) analyses of rehearsal protocols to evaluate whether isolation influences rehearsal. *Rehearsal* refers to whether the item was spoken aloud in two or more rehearsal sets. A *rehearsal set* includes the items spoken aloud during the presentation of one item and is the unit of analysis for rehearsal and for distributed rehearsal. For instance, each item was presented for 3 s; during this time, participants rehearsed items aloud. After one item was presented, then another item was presented for 3 s, and so on. If BOQ was the first item, the participant may have said, "BOQ, BOQ, BOQ" until the next item (e.g., 198) was presented. At this time, the participant may have said, "198, BOQ, 198, BOQ." Once the presentation of 198 was finished and the next item (e.g., POY) was presented, the rehearsal protocol may have included, "POY, 198, BOQ, POY." In this example, BOQ and 198 would be considered rehearsed because the participant said each of them while another item was being presented. *Distributed rehearsal* is analogous to distributed presentations of an item: An item is scored as having distributed rehearsal when it appears in two (or

more) rehearsal sets that are separated by at least one other rehearsal set in which the item was not rehearsed. None of the items in the example above received a distributed rehearsal. Distributed rehearsal of the isolate may be most prominent, assuming that the isolate becomes conceptually salient after several other items are presented for study. That is, distributed rehearsal may underlie the primacy isolation effect. Finally, we briefly report the total number of overt rehearsals (BOQ received six total rehearsals in the example above). Although total rehearsal does not distinguish between the kinds of rehearsal that presumably have a differential influence on recall performance (Modigliani & Hedges, 1987), it provides the most straightforward measure of how often each item was rehearsed during study.

For each participant, we analyzed whether isolating the critical item influenced (a) whether the critical item was rehearsed; (b) whether the critical item received distributed rehearsal; (c) the number of rehearsal sets in which the critical item appeared (excluding the rehearsal set composed of presenting the critical item); and (d) the total number of rehearsals, a measure of rehearsal that is not based on rehearsal set. We first present descriptive and inferential statistics for these measures and then discuss the outcomes. Means across each of the first three dependent measures are reported in Figure 2, with total rehearsals reported subsequently in the text.

Rehearsal. The left-most panel of the figure includes the proportion of individuals who rehearsed the critical item when it had been presented in either the isolated list or in the control list. Note that "rehearsal" here is not the number of times the isolate was rehearsed (which is better captured by the descriptions in *Rehearsal sets* and *Total rehearsals*), but instead indicates *whether* an item was rehearsed after it was no longer being presented to the participant. As evident from inspection of these values, rehearsal was moderated by where the critical item appeared on the list.² A 2 (position: beginning vs. middle of the list) \times 2 (list: isolation vs. control)

² An alternative analysis involves computing the measures of rehearsals normalized on the number of rehearsal sets that are available for rehearsing the critical item. In this case, each value would be divided by 10 for isolation near the beginning of the list and by 5 for isolation in the middle of the list. This conversion would diminish rehearsal differences between isolation at the beginning versus middle of the list. However, we prefer the nonnormalized values presented for two reasons. First, the values presented in Figure 2 reflect actual differences in rehearsal between the critical item at the beginning versus middle of the list, and hence these values would better reflect the amount of processing for a given item, regardless of why differential rehearsal occurred. (Of course, differences in rehearsal of the critical item when it appears near the beginning vs. middle of the list may be due to the amount of time available for rehearsal and not serial position per se.) Second, and more important, the critical analyses for our purposes involve comparing rehearsal measures between the isolation versus control list. Given that such analyses involve comparing rehearsal for the critical item within a given serial position (i.e., either the beginning or middle of the list), normalizing values will not influence these effect sizes or the meaningful interactions that occur across the positions of the list.

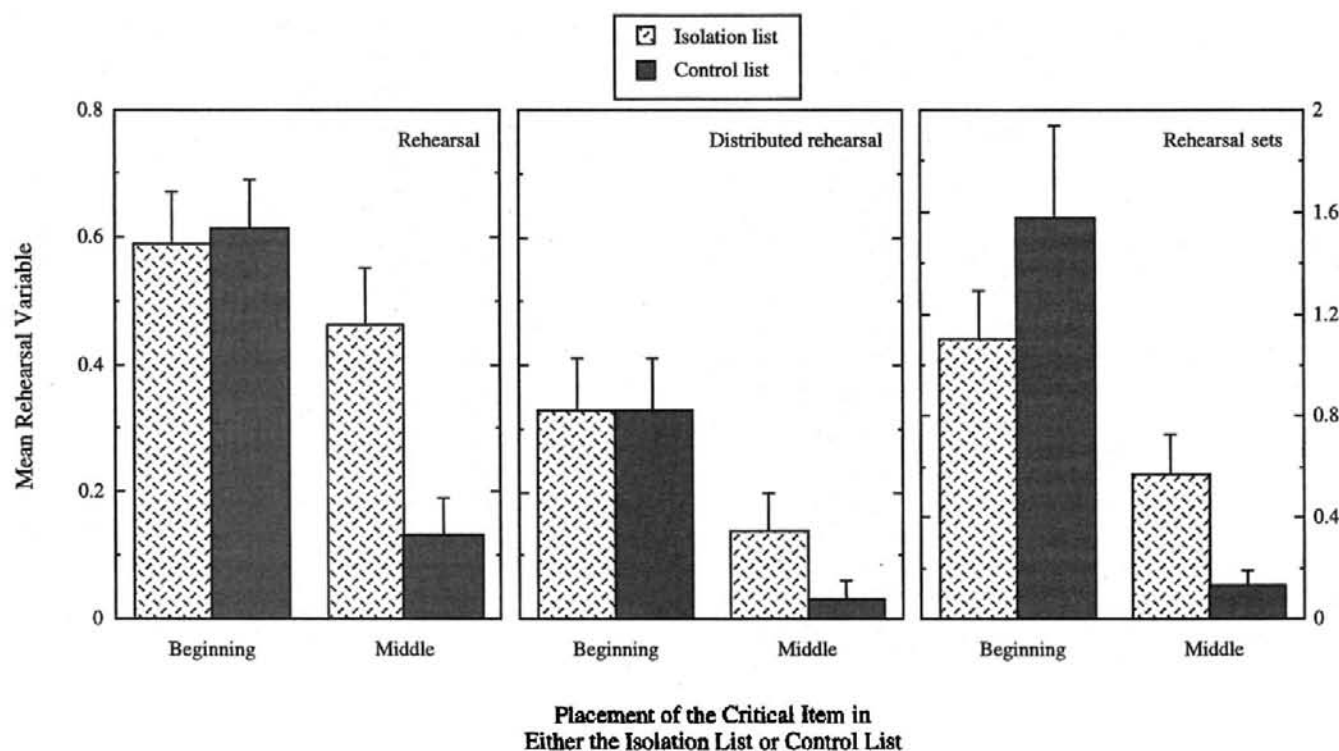


Figure 2. Mean values for three measures of rehearsal are shown as a function of (a) the serial position of the critical item on the list (either in the second serial position—beginning—or in the seventh serial position—middle) and (b) whether the critical item was isolated in a list of homogeneous background items (isolated list) or in a list of heterogeneous items (control list). Rehearsal (left panel) refers to the proportion of individuals who rehearsed the critical item after it had been presented for study; distributed rehearsal (middle panel, with left-most scale) refers to the proportion of individuals who distributed the rehearsal of the critical item across the list; and rehearsal sets (right panel) refers to the mean (across individuals) of the number of rehearsal sets that the critical item appeared in after it had been presented for study. See text for details concerning these measures of rehearsal and for data relevant to total number of overt rehearsals.

ANOVA revealed a main effect for list, $F(1, 144) = 3.97$, $MSE = 0.22$, and for position of the critical item, $F(1, 144) = 16.06$, $MSE = 0.22$. The latter effect indicates that items were rehearsed more often when they appeared in the beginning of the list than in the middle of the list, which replicates outcomes from Modigliani and Hedges (1987). More important, the List \times Position interaction was reliable, $F(1, 144) = 5.16$, $MSE = 0.22$, and qualified the main effects. Namely, when presented in the beginning of the list, the critical item did not receive more rehearsal in the isolation list than in the control list, $t(73) = 0.19$. But when presented in the middle of the list, the critical item received reliably more rehearsal in the isolation list than in the control list, $t(71) = 3.24$.

Distributed rehearsal. As shown in the middle panel of Figure 2, the same pattern of effects for rehearsal is evident for distributed rehearsal, with distributed rehearsal being greater for the isolate than for the control item when presented in the middle of the list but not in the beginning of the list. These outcomes, however, were not completely substantiated by the 2×2 ANOVA. Whereas the main effect of position was reliable, $F(1, 143) = 14.77$, $MSE = 0.15$, the

main effect of list and the interaction were not reliable, $F_s < 1.0$, $MSEs = 0.15$. In contrast to a conceptually based version of the salience hypothesis, distributed rehearsal of the isolate does not contribute to the primacy isolation effect.

Rehearsal sets. The number of rehearsal sets that the critical item received is shown in the right-most panel of Figure 2. Note that these values do not include the rehearsal set in which the critical item was presented, which would merely add a constant of 1 to each mean shown in this panel. Whereas the measure of rehearsal discussed above weights all rehearsed items equally regardless of how many times they were rehearsed, rehearsal sets indicates how often an item was rehearsed while different items were being presented for study. As with rehearsal and distributed rehearsal, analysis of rehearsal sets indicated that the isolate received more rehearsal when it was presented in the middle of the list. A 2×2 ANOVA revealed a reliable main effect for position, $F(1, 144) = 20.8$, $MSE = 1.76$, but not for list, $F(1, 144) = .01$, $MSE = 1.76$. The Position \times List interaction was also reliable, $F(1, 144) = 4.49$, $MSE = 1.76$: Whereas the isolated item (vs. the control item) was in more rehearsal sets when isolation occurred in the middle of the list, $t(71) =$

2.68, this effect was not evident when isolation occurred near the beginning of the list, $t(73) = 1.21$.

Total rehearsals. Total rehearsal is the number of times an item was rehearsed aloud during presentation. Whereas rehearsal sets provides a more informative measure of the temporal spacing of rehearsals across the presentation of the list, total rehearsal provides the sheer quantity of overt production of a given item. For isolation near the beginning of the list, the mean number of rehearsals of the critical item was 3.97 (standard error of the mean, or $SEM = .52$) and 3.59 ($SEM = .50$) when it was presented in the isolation versus control list, respectively. By contrast, for isolation in the middle of the list, the mean number of rehearsals of the critical item was 1.74 ($SEM = .21$) and 1.26 ($SEM = .08$) when it was presented in the isolation versus control list, respectively. The main effect of position was reliable, $F(1, 144) = 37.4$, $MSE = 5.13$, whereas the main effect of list was not reliable, $F(1, 144) = 0.02$, $MSE = 5.13$. Although the Position \times List interaction was evident in the mean values, it was not statistically reliable, $F(1, 144) = 1.34$, $MSE = 5.13$.

In summary, the amount (and kind) of rehearsal that the isolate received depended on whether it was presented in the beginning or middle of the list. When presented in the beginning of the list, the critical item received no extra rehearsal. Thus, rehearsal per se is not necessary for producing the primacy isolation effect. By contrast, when placed in the middle of the list, the isolate did receive extra rehearsal, which is consistent with the prediction from the salience hypothesis. This outcome, however, does not establish the degree to which rehearsal contributes to the isolation effect. Similar to the primacy isolation effect, rehearsal may not be necessary for producing an isolation effect even when an item is isolated in the middle of the list. Our argument is not that extra rehearsal cannot improve recall, but merely that extra rehearsal of the isolate may contribute minimally to the isolation effect. This possibility is explored next.

Relation Between Rehearsal and Recall Performance

To further investigate the role of rehearsal in producing the isolation effect, we examined the relation between rehearsal and recall performance. The proportion of recall was calculated for critical items that were rehearsed and for critical items that were not rehearsed (as operationalized above). These values are reported in Table 1.

A 2 (position) \times 2 (list) \times 2 (rehearsal: rehearsed vs. not rehearsed) ANOVA revealed reliable main effects for position, $F(1, 140) = 5.87$, list, $F(1, 140) = 17.92$, and rehearsal, $F(1, 140) = 12.86$, $MSE = .18$ for all main effects. No interactions were reliable, $F_s < 1.75$, $MSE = .18$ for all interaction effects. These outcomes substantiate two main conclusions. First, rehearsal is related to higher levels of recall. Thus, the extra rehearsal of the isolate placed in the middle of the list may contribute to the isolation effect. Second, the isolation effect is evident regardless of whether the isolate was rehearsed, suggesting that extra rehearsal of the isolate per se is not necessary for producing an isolation effect.

Table 1

Proportion of Participants Who Recalled the Isolated Item as a Function of Whether the Isolate Had or Had Not Been Rehearsed

Condition	Isolation list	Control list
Beginning of the list		
Rehearsed	.96 (23)	.77 (22)
Not rehearsed	.75 (16)	.21 (14)
Middle of the list		
Rehearsed	.75 (16)	.40 (5)
Not rehearsed	.53 (19)	.24 (33)

Note. Entries are the proportion of participants who recalled the critical item. "Rehearsed" are values from participants who rehearsed the isolate, and "not rehearsed" are values from participants who did not rehearse the isolate. Number of participants contributing to each value are in parentheses.

Finally, as in previous research (e.g., Einstein et al., 1974), we examined the relation between rehearsal and recall performance across all items of the list. For each group, we correlated the number of items rehearsed (as measured by "rehearsal" above) with overall recall for all items excluding those in the last three serial positions, which correspond with the recency positions in the list. Because the position of the critical item (beginning vs. middle of the list) had little influence on these outcomes, we computed correlations collapsed across these groups to increase statistical power. For participants who studied the control list, the Pearson r correlation coefficient was .35, $p < .01$, indicating that individuals who rehearsed more also had higher recall performance. The correlation coefficient for participants who studied the isolation list was substantially attenuated, $r = .03$, which was somewhat expected given that even when the isolate was not rehearsed the likelihood of recall was still substantial. Along with outcomes reported above, our analyses suggest that rehearsal can influence recall performance, but more important, that rehearsal per se is not necessary for producing an isolation effect.

General Discussion

The isolation effect on memory is a well-studied phenomenon, with published reports on the effect extending back over 100 years (e.g., Calkins, 1894). Prior interpretations (Green, 1956; Jenkins & Postman, 1948) of the effect agreed on two necessary conditions. First, the isolate, by virtue of its incongruity with the prevailing context, is perceived as salient, and second, the salience attracts additional processing that is responsible for enhanced memory. This mechanism accords well with our intuitions about memory for isolated items, but yet our data are inconsistent with the necessity of both assumptions.

Ironically, the seeds of skepticism about the necessity of perceptual salience for isolation effects were sown in the most widely cited of all articles on isolation effects. Von Restorff's (1933) argument was that isolation in early serial positions would not induce perceptual salience because no context had been established, and yet she consistently reported isolation effects with this preparation. Both of our

experiments replicated von Restorff's results. One would not expect early isolation to arouse perceptual salience, and consequently, the comparability of the early and late effects raises further suspicion about the necessity of perceptual salience for the isolation effect.

Importantly, our first experiment included an independent index, called judgments of learning, that allowed us to evaluate the perceived salience of the isolated item (cf. Koriat, 1997; Sommer et al., 1995). Because judgments of learning also are presumably based on an individual's belief about how a stimulus dimension—e.g., isolation—will influence subsequent memory performance (Koriat, 1997), perceived salience of the isolate may not be necessary nor sufficient to influence judgments of learning. Most important, judgments of learning were influenced when the isolate was presented in the middle of the list (see Figure 1), suggesting that people believe isolation influences recall and perceive the isolate as perceptually salient. By contrast, an item isolated early in the list received judgments of learning that did not differ from a control item. Nonetheless, early and late isolation produced the isolation effect, and hence these data are consistent with the proposal that perceptual salience is not necessary for the isolation effect.

Extant theories of isolation effects, with the exception of von Restorff's explanation, are based on data from late isolation. Our evidence is consistent with these theories in that isolation of an item late in the list is accompanied by perceptual salience. Theoretically, the role of salience is recruitment of additional processing of the salient item. Our second experiment examined this assumption using the only dependent measure of additional processing that has been operationalized in the isolation literature, rehearsal. Results from the second experiment again suggest that salience is not necessary for the primacy isolation effect in that an early list isolate attracted no more rehearsal than a control item. More important, an isolate in the middle of the list received more rehearsal than a control item, consistent with the notion that perceptual salience functions to recruit additional processing. However, the data also suggest that rehearsal is not necessary for subsequent recall of this late isolate; and even though the late isolate was rehearsed more than its control item, the amount of rehearsal devoted to the late isolate was unimpressive. For example, more rehearsal was devoted to an early list control item than to an item isolated in the middle of the list. More telling were analyses indicating that the amount of rehearsal devoted to this late list isolate was unrelated to recall. Thus, our conclusions here are consistent with previous investigations that yielded apparently inconsistent outcomes concerning isolation and rehearsal. Namely, even though isolation later in the list attracted more processing in the form of rehearsal (Rundus, 1971), this mechanism does not appear to be solely responsible for the isolation effect in memory (Einstein et al., 1974).

In summary, the data from our experiments unequivocally indicate that perceptual salience and accompanying enhanced processing, at least in the form of rehearsal, are not necessary for the isolation effect. In so doing, the data are consistent with the conclusion drawn by others (e.g., Bruce

& Gaines, 1976; Fabiani & Donchin, 1995; Schmidt, 1985), but our research strengthens this conclusion by providing a direct measure of salience and by directly measuring rehearsal following Rundus (1971).

Several ideas have been offered as alternatives to the differential attention-rehearsal hypothesis of distinctiveness effects in general and isolation effects in particular. Prominent among them is Schmidt's (1991) incongruity hypothesis. "According to this definition, distinctive events are those that are inconsistent with active conceptual frameworks, or that contain salient features not present in active memory. These events lead to increased attention in direct proportion to the degree of incongruity." (Schmidt, 1991, p. 537) On the face of it, Schmidt's hypothesis appears to continue the emphasis on differential attention resulting from salience at presentation of the item, but two assumptions of his theory bring the idea into congruence with the deemphasis of differential attention and rehearsal. First, the type of differential processing engaged by additional attention could be "elaboration, relational processing, and rehearsal" (p. 537). Thus, Schmidt's hypothesis reasonably suggests that processes other than mere rehearsal may be responsible for the memory enhancement. Second, Schmidt explicitly states that differential attention is not sufficient for enhanced memory because the retrieval context must be taken into account. Nonetheless, it would seem from the quote that distinctive events "lead to increased attention in direct proportion to the degree of incongruity" that attention is a necessary condition and further that it is engaged by incongruity, which might be reasonably interpreted as salience. A final assumption, however, allows the incongruity hypothesis to encompass our data; that is, "increased attentiveness to distinctive stimuli . . . is automatic" (p. 537). On this view of the relationship between attention and automaticity, the incongruity hypothesis can maintain that incongruity detection is below the level of awareness and, hence, not susceptible to conscious indices such as judgments of learning and that the additional processing attracted by incongruity does not occupy capacity that otherwise would be consumed by processing background items.

How the incongruity hypothesis explains the early isolation effect is less obvious. According to the incongruity hypothesis, "Increased attentiveness to distinctive stimuli occurs during the first second or so of processing" (Schmidt, 1991, p. 537). Von Restorff's (1933) logic for using early isolation was to avoid just this kind of immediate differential attention, and our judgment-of-learning data suggest that the manipulation is successful in doing so. One possibility is that the incongruity of the early isolate is noted at some later point in list presentation. Our data on rehearsal do not support this idea, but perhaps the form of processing engaged by incongruity is not rehearsal. By contrast, late isolation was perceived as incongruent as indexed by judgments of learning, and late isolates did receive additional rehearsal. This pattern of results may be used to argue that the mechanisms of late isolation are those of the incongruity hypothesis, but that early isolation operates through different mechanisms. The burden of proof

for such an argument then falls to the incongruity hypothesis.

Waddill and McDaniel (1998) have offered an alternative account of distinctiveness effects that also could encompass our results. They suggest that distinctiveness effects are due to discriminative properties of the memory trace at retrieval. According to this view, distinctiveness is not a property of encoding. Consequently, factors such as salience and differential processing of isolates at encoding are moot. The effects of distinctiveness are manifest entirely in the retrieval context where, if whatever encoding was established emerges as distinctive in the set of retrieved items, memory will benefit.

An interesting challenge to this idea about distinctiveness effects, as well as to the incongruity hypothesis, comes from a simple version of the isolation paradigm. Why should one obtain an isolation effect when the control comparison is an unrelated list? In an unrelated list, the difference between items is just as great as the difference between the isolate and surrounding items in an isolation list (von Restorff, 1933). Consequently, the incongruity (Schmidt, 1991) of each item in an unrelated list would be equivalent to the incongruity of the isolate in an isolation list. By the same token, the discriminative properties of the traces (Waddill & McDaniel, 1998) of unrelated items should be equivalent to the discriminative properties of the isolate. Nonetheless, an isolated item will be better remembered than its corresponding control in the unrelated list.

Thus, although we can agree that perceptual salience and ensuing differential attention are not necessary for the isolation effect, we are still short of a complete explanation of this robust and simple phenomenon.

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