Short-term recall of order information: Influence of encoding and generation processes on distinctiveness, isolation, and background effects

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We examined the influence of encoding and generation processes on distinctiveness, isolation, and background effects in short-term recall of order information. Adults recalled the order of letters in one of two segments following a distractor task, knowing in advance the identity of the letters. A distinctive letter was one that was either in red or absent and replaced with a red dash, thereby requiring generation. On trials with a distinctive letter, the letter was primed in advance. A negative generation effect was found; in addition, there was a positive distinctiveness effect but a negative background effect on trials in which generation was required. These effects can be explained in terms of the extra processing given to distinctive items when they need to be generated.

That there is superior long-term memory for a distinctive or isolated item in a list has been supported by much research (von Restorff, 1933; see Schmidt, 1991, for a review). However, the effects of distinctiveness or isolation on short-term memory and on memory for order information are more controversial (see, e.g., Kelley & Nairne, 2001). Some confusion about the effects of distinctiveness may arise because there are different ways to examine such effects. To understand these differences, let us consider trials in which a *distinctive* item is embedded within a list of *nondistinctive* items. Such *experimental* trials can be contrasted with *control* trials containing no distinctive items. A common way to assess the effects of distinctiveness is to compare a distinctive item on an experimental trial with a comparable item on a control trial. We refer to this measure as an assessment of the *isolation* effect. Alternatively, as in recent studies by Cunningham, Marmie, and Healy (1998) and Healy, Cunningham, and Parker (2002), as well as in the classic study by von Restorff, distinctiveness can be assessed by comparing a distinctive item on an experimental trial

with the nondistinctive items on the same trial. We refer to this measure as an assessment of the *distinctiveness* effect. In a related assessment, which we refer to as an evaluation of the *background* effect, the nondistinctive items on an experimental trial would be compared with the comparable items on a control trial. In the present study, we separately evaluate all three of these effects under two related conditions: a *generate* condition, in which the distinctive item is not presented and must be produced by the participant, and a *read* condition, in which the distinctive item is presented and must only be read by the participant. Kelley and Nairne specifically noted the need to disentangle the effects of generation and isolation, which in previous studies have been confounded.

This study follows two recent studies in which recall of distinctive items was examined (Cunningham et al., 1998; Healy et al., 2002), in which distinctiveness was defined as changing the characteristics of an item to make it qualitatively different from other items in a list. In these studies, a manipulation of distinctiveness stronger than the usual ones (e.g., those in which the distinctive item is a different color from the other items) was used, because an item was made distinctive by deleting it from a known list of items and replacing it with a red dash. The overall methodology in these studies consisted of (1) a distractor paradigm (in which the to-be-recalled items were letters, and the distractor task required reading digits aloud), (2) a partial-report procedure (in which a list of eight letters presented on a trial was divided into two four-letter segments, with only one segment cued for recall), and (3) a reconstruction procedure (in which the letters used were held constant across trials and, thus, were known by the participants, so that their task was

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solely to reproduce the order of those letters). Specifically, the participants received two segments of letters and recalled the order of one segment after a digit-filled retention interval.

Both Cunningham et al. (1998) and Healy et al. (2002) found that replacing a letter with a red dash led to a negative distinctiveness effect, whereby recall of the position of the absent letter was lower than that for the other letters in the segment, even when the participants were instructed that it was most important to recall the missing letter. These findings of a negative distinctiveness effect contrast with the findings of Kelley and Nairne (2001), who used a different paradigm and observed both a positive generation effect and a positive isolation effect for order reconstruction in short-term recall. One reason for the negative effects of distinctiveness in the studies by Cunningham et al. (1998) and Healy et al. is that the distinctive letter was missing, so it was difficult or impossible to encode the letter at the time at which the letter segments were presented on a trial. To overcome this problem, in the present study, the distinctive letter was always primed immediately prior to the presentation of the letter segments on an experimental trial, so that the distinctive letter (and its position) could be encoded later during letter segment presentation. This priming procedure also enabled us to examine the generation effect by comparing two groups of participants, one in a *generate* condition, in which the distinctive letter was missing and the participants had to generate it when they saw a red dash in the letter segment, and the other in a *read* condition, in which the distinctive letter was not missing but was shown in red to the participants, who read it aloud.

As in previous experiments in which a negative distinctiveness effect was found, in both the read and the generate encoding conditions of the present experiment, the participants were told that it was most important to recall the distinctive letter. At the start of experimental and control trials in both conditions, the participants saw either a red letter or a black exclamation point prime, which informed them whether or not a distinctive item would occur in a letter segment (see Table 1 for sample trials). If a red letter prime occurred, a distinctive red item (a letter or dash) would occur in the segment cued for recall, whereas the remaining items would be black letters. If a black exclamation point prime occurred, all of the items were black letters. In the read condition, the distinctive item was the red letter that had been primed, whereas in the generate condition, it was a red dash. The participants read aloud all letters they saw, said "mark" for an exclamation point, and said aloud the name of the primed letter in the generate condition whenever a red dash was displayed. Thus, both control trials (black exclamation point prime with all black letters) and experimental trials (red letter prime with one red letter or red dash) occurred in the read and the generate conditions. Also, the articulation demands were identical in the two conditions. Only the visual characteristics of the distinc-

Table 1
Sample Trials

Generate Condition	
Sample control trial	-- ! : B H K F ! L R M Q 8 5 7 8 :
Sample experimental trial	-- M : B H K F ! L R ■ Q 8 5 7 8 :
Read Condition	
Sample control trial	-- ! : B H K F ! L R M Q 8 5 7 8 :
Sample experimental trial	-- M : B H K F ! L R M Q 8 5 7 8 :

Note—Bold font indicates that the character was presented in red.

tive item on an experimental trial (red letter or red dash) and the requirement for generation differed across the read and the generate conditions.

In the present study, we seek to determine whether there are distinctiveness, isolation, and background effects in the present paradigm, in which the distinctive letter is primed in advance of the trial and, thus, can be encoded at the time the segment is presented. We also examine how these three related effects interact with the generation effect observed by comparing the generate and the read conditions.

METHOD

Design

We manipulated a single between-subjects variable: encoding condition (generate or read). Three within-subjects variables were manipulated: trial type (experimental or control), retention interval (0, 4, or 10 digits), and position of recalled segment (first or second). For experimental trials, in order to examine the distinctiveness effect, there was also the within-subjects variable of letter type (distinctive or nondistinctive), with recall of the single red item (letter or dash) compared with that of the three black letters on an experimental trial. In order to examine the isolation effect, the distinctive item (letter or dash) on an experimental trial was also compared with the comparable letter on a control trial. Likewise, in order to examine the background effect, nondistinctive letters on experimental trials were compared with comparable letters on control trials.

Participants

Thirty-two University of Colorado undergraduates participated, 16 in each of the two encoding conditions.

Apparatus and Stimulus Materials

The characters were presented successively in the center of a computer monitor for 1 sec each. Every character was displayed in black on a white screen, except that on experimental trials, two characters (i.e., two letters or one letter and a dash) were presented in red.

A trial included two successive four-letter segments and a digit-filled retention interval consisting of digits pseudorandomly selected from 1 to 9. Three retention intervals were used: 0, 4, and 10 digits. At the start of the trial, two black dashes were presented, followed by either a red letter or a black exclamation point prime. The presence of a red letter prime indicated that a red character would be shown in one of the letter segments, always the segment cued for recall. Recall cues, one dot (.) or two dots (:), were presented next,

as well as at the end of the character sequence, with one dot indicating recall of the first segment and two dots the second. An exclamation point marked the boundary between the first and the second four-letter segments. There was a 16-sec recall interval, including a beep after every 8 sec. Table 1 illustrates the sequence of stimuli shown on sample control and experimental trials in each encoding condition.

The experiment proper consisted of a sequence of 96 trials (48 experimental and 48 control) that included four 24-trial blocks. Four tasks were defined by the combination of trial type (experimental or control) and segment position cued for recall (first or second). Each of the four tasks occurred six times per block of 24 trials, twice with each of the three retention intervals.

The letters used in each segment were fixed. The first four-letter segment consisted of B, F, H, and K, whereas the second segment consisted of L, M, Q, and R. The 24 permutations of the four letters in the first segment were randomly paired with the 24 permutations of the four letters in the second segment. Each pair of permutations occurred four times at the same retention interval, once with each of the four tasks. Each experimental trial was equivalent to a matching control trial in terms of the letters shown, the segment position cued for recall, and the retention interval. This matching allowed for a comparison of the distinctive letter in experimental trials with the corresponding letter in control trials, as well as a comparison of the nondistinctive letters in experimental trials with the corresponding letters in control trials. The order of the trials was pseudorandom within each block. Across all trials, each letter in both segments was distinctive twice with each retention interval, and for both segments, each serial position contained a distinctive letter twice with each retention interval.

Procedure

Each participant was instructed to read aloud the name of each letter and digit as it appeared, to say "mark" at the appearance of an exclamation point, "first" at the appearance of one dot, and "last" at the appearance of two dots. A prime character at the start of a trial indicated by both its type and its color whether or not this would be an experimental trial. The black exclamation point that occurred at the start of a control trial indicated that all the letters would be presented and would appear in black. The red letter that occurred at the start of an experimental trial indicated the identity of the distinctive letter on that trial. When a red dash appeared during a letter segment, in the generate condition, the participants articulated the letter that had been primed. At the beginning and end of a sequence of letters and digits, the recall cue indicated which one of the two four-letter segments was to be recalled.

The participants in the generate condition were told that, on some trials, one of the letters would be missing, and a single red dash would appear in its place. They were instructed that the red dash—hence, the missing letter—would always occur in the to-be-recalled segment. As in previous studies (e.g., Cunningham et al., 1998; Healy et al., 2002), the instructions emphasized that on trials containing a missing letter, it was most important to try to recall that letter. The participants were told that on those trials, the initial prime would be red, the subsequent character (one- or two-dot recall cue) would indicate in which letter segment (first or second) there would be a missing letter, and the same recall cue would occur at the start and the end of a trial. They were also told that the red letter appearing at the beginning of a trial would always be the missing letter represented by the red dash. The participants in the read condition were given comparable instructions; they were told that the red letter prime would always occur in the to-be-recalled segment and that it was most important to try to recall that letter.

The participants entered their responses on sheets of paper, one for each trial. Each sheet included a horizontal array of four squares, with one square for each letter. The participants were told not to leave a square blank and to guess if necessary. They were told to recall the letters of the cued segment in their order of appearance on

that trial, placing the letter that appeared first in the leftmost square. However, the participants were not given any instructions concerning the order in which to enter their responses. Thus, their task was a free (unconstrained) reconstruction of order.

Prior to initiating the 96 trials of the experiment proper, the participants received 12 practice trials in which the first four-letter segment consisted of A, B, C, and D, and the second of E, F, G, and H. At the beginning of both the practice trials and the 96 trials of the experiment proper, the participants were told the four letters that constituted each letter segment. In addition, a card displaying this information was in the participants' view throughout the trials.

RESULTS

Each of the four letters recalled on a given trial was scored separately. A correct response was scored only when the letter recalled at a particular position matched the letter presented at that position or (in the case of the absent letter) matched the letter missing from that position. The four effects of interest were assessed in different analyses. The generation effect was evaluated by comparing read and generate conditions on experimental trials, with control trials serving as a baseline. The distinctiveness effect was evaluated by comparing distinctive and nondistinctive letters on experimental trials. The isolation effect was evaluated by comparing distinctive letters on experimental trials with comparable letters on control trials. Finally, the background effect was evaluated by comparing nondistinctive letters on experimental trials with comparable letters on control trials.

Analysis of Both Experimental and Control Trials: Generation Effect

For the initial analysis, we examined the proportion of items correctly recalled in position across all four letters in a segment for the experimental and the control trials. The variables of retention interval and segment position had their usual effects on retention. Specifically, there was a decline in proportion correct as retention interval increased from 0 digits (.87), to 4 digits (.81), to 10 digits [.80; $F(2,60) = 17.82$, $MS_e = 0.049$, $p < .01$]. Also, a segment recency advantage was obtained because recall was greater for the second segment (.88) than for the first [.78; $F(1,30) = 56.96$, $MS_e = 0.067$, $p < .01$].

As in earlier studies on distinctiveness (Cunningham et al., 1998; Healy et al., 2002), trial type (the comparison of experimental and control trials) had a significant main effect [$F(1,30) = 22.03$, $MS_e = 0.030$, $p < .01$]. Recall accuracy was greater for control trials (.85) than for experimental trials (.81). In addition, there was an interaction between trial type and segment position [$F(1,30) = 7.98$, $MS_e = 0.018$, $p < .01$], because the disadvantage for experimental trials was larger for Segment 1 (experimental, .75; control, .81) than for Segment 2 (experimental, .87; control, .89).

Although encoding condition did not have an overall effect, it did significantly interact with trial type [$F(1,30) = 8.18$, $MS_e = 0.030$, $p < .01$], because the disadvantage for experimental trials was much larger for the generate condition, in which the distinctive letter was absent, than

for the read condition, in which the distinctive letter was present (see Table 2). Thus, the disadvantage for the experimental trials was not due to the presence of a distinctive item. Instead, the disadvantage was due largely to the generation required in the generate condition. Indeed, this interaction reflects the fact that there was a negative generation effect on experimental trials but little effect of encoding condition on control trials. Also note that the participants were not aided in the read condition by being primed with the distinctive letter in advance (which occurred on experimental trials, but not on control trials), which might have reduced the memory load in that case.

Analysis of Experimental Trials Only: Distinctiveness Effect

For the analysis of experimental trials, we will consider here only the effects involving letter type (i.e., comparing distinctive and nondistinctive letters). The studies by Cunningham et al. (1998) and Healy et al. (2002) showed that the proportion of correct responses was *lower* on the absent letter than on the present letters within a missing-letter trial, despite the fact that the participants were instructed that it was most important to recall that letter. This negative distinctiveness effect was eliminated in the present experiment. In fact, there was a trend toward a positive distinctiveness effect [$F(1,30) = 3.80$, $MS_e = 0.049$, $p = .06$], because recall was numerically higher for the distinctive (i.e., red or missing) letter (.82) than for the nondistinctive (i.e., black) letters (.80). In separate planned analyses of each encoding condition, there was a significant positive distinctiveness effect for the generate condition [$F(1,15) = 4.37$, $MS_e = 0.044$, $p = .05$], but not for the read condition (see Table 2).

Table 2
Proportion Correct Recall as a Function of
Encoding Condition, Trial Type, and Letter Type

	Encoding Condition	
	Read	Generate
Trial type (all letters)		
Experimental	.84	.77
Control	.86	.84
Letter type (experimental trials only; distinctiveness effect)		
Distinctive	.85	.80
Nondistinctive	.84	.76
Trial type (distinctive and corresponding letters only; isolation effect)		
Experimental	.85	.80
Control	.87	.84
Trial type (background and corresponding letters only; background effect)		
Experimental	.84	.76
Control	.86	.84

Analyses of Distinctive and Nondistinctive Letters: Isolation and Background Effects

Two additional analyses were conducted. The first assessed the possibility of an isolation effect and was restricted to a comparison of distinctive letters on experimental trials and their corresponding letters on control trials. The second assessed the possibility of a background effect and was restricted to a comparison of nondistinctive letters on experimental trials and their corresponding letters on control trials. We consider here only effects involving trial type (see Table 2). For the distinctive letters, there was only a marginally significant main effect of trial type [$F(1,30) = 3.46$, $MS_e = 0.091$, $p = .07$], reflecting a trend for worse performance on experimental trials (i.e., distinctive letters; .82) than on control trials (i.e., matched corresponding letters; .85). Thus, there was a trend toward a negative isolation effect, despite the fact that the participants' instructions emphasized recall of a distinctive letter. For the nondistinctive letters, there was both a main effect of trial type [$F(1,30) = 33.03$, $MS_e = 0.025$, $p < .01$] and an interaction of encoding condition and trial type [$F(1,30) = 13.59$, $MS_e = 0.025$, $p < .01$]. This interaction reflects a large disadvantage in the generate condition for experimental trials, relative to control trials, and a smaller disadvantage in the read condition for experimental trials, relative to control trials. Thus, there was a significant negative background effect, which was especially large in the generate condition.

GENERAL DISCUSSION

The procedures introduced in the present study, unlike those used in earlier studies (e.g., Kelley & Nairne, 2001), were able to separate the effects of generation from those of distinctiveness, isolation, and background. We eliminated the previously observed *negative* distinctiveness effect for a distinctive letter on an experimental trial (Cunningham et al., 1998; Healy et al., 2002) by providing overt opportunities for participants to encode the distinctive letter both before and during the presentation of the letter sequence. We found, instead, a significant *positive* distinctiveness effect in the generate condition, and we found little difference between the distinctive and the nondistinctive letters in the read condition. Furthermore, we found a negative background effect, because the nondistinctive letters on an experimental trial were recalled less accurately than the comparable items on a control trial, especially in the generate condition. These findings imply that encoding and generation processes are responsible for the distinctiveness effect.

Observations of our participants suggest that they found the generate condition taxing because of time constraints and the extra processing requirements of recalling the absent letter and vocalizing it. As witnessed by the negative background effect (and by the trend toward

a negative isolation effect), this extra processing took away from and disrupted the encoding of the other (present) letters and their positions in the test segment (see Schmidt, 1992, for a similar observation). Indeed, in the generate condition, memory was better for the absent (distinctive) letter than for the present (nondistinctive) letters. This extra processing explanation is reminiscent of the retrieval-induced forgetting effect (e.g., Anderson, Bjork, & Bjork, 1994), in which practice retrieving items from a category leads to enhanced recall of those items but depressed recall of other items from the same category. Retrieval-induced forgetting can explain not only the positive distinctiveness effect when the absent letter was compared with the present letters on experimental trials in the generate condition, but also the negative background effect when nondistinctive letters on experimental trials were compared with comparable letters on control trials. Also, because there were three present letters but only one absent letter, retrieval-induced forgetting can explain the negative generation effect when overall recall of order information on experimental trials in the generate condition was compared with that in the read condition.

In summary, we separated the effects of generation from those of distinctiveness. We found negative effects of generation and background, as well as a trend toward a negative effect of isolation, but we also found a positive effect of distinctiveness in the same list, showing that these effects are distinguishable, even though they may be caused by similar processes, such as retrieval-induced forgetting. The extra processing explanation seems compatible with some of the theorizing of Kelley and Nairne (2001), who explained their findings in terms of Nairne's (1990) feature model. Although their pattern of results did not coincide with ours (e.g., they found a

positive generation effect when only a single item in a list was generated and no background effect), they also refer to a special encoding of distinctive and generated items. In any event, it is clear from the present results that both encoding and generation processes strongly influence distinctiveness, isolation, and background effects in the short-term recall of order information.

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