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When Does Generation Enhance Memory for Location?

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Generation is thought to enhance both item-specific and relational processing of generated targets as compared with read words (M. A. McDaniel & P. J. Waddill, 1990). Generation facilitates encoding of the cue–target relation and sometimes boosts encoding of relations across list items. Of interest is whether generation can also increase the encoding of target-location associations. Because the literature on this point is mixed, 3 procedural differences between 2 studies (E. J. Marsh, G. Edelman, & G. H. Bower, 2001; N. W. Mulligan, 2004) were identified and manipulated. A positive generation effect was found for location memory, but this effect was reduced when subjects wrote down the study words and when the filler task involved generation. Generation can enhance location memory in addition to item memory but only if the experimental parameters do not interfere with the processing benefits of generation.

Keywords: generation effect, context memory, item memory, location memory

The *generation effect* is the finding that people are better able to remember items that were produced in response to cues than items that were simply read (Slamecka & Graf, 1978; see also Jacoby, 1978). For example, a subject who generated *truck* in response to *a vehicle: tr—* would later show better memory for *truck* than if he or she had read *a vehicle: truck*. The generation effect has been found with many different kinds of stimuli, including pictures (Kinjo & Snodgrass, 2000), arithmetic problems (Smith & Healy, 1998), and general knowledge questions (DeWinstanley, 1995). The effect is not limited to a particular type of memory test; it can be observed in free recall, in cued recall, and on recognition tests (for a review, see Mulligan & Lozito, 2004).

Numerous accounts of the generation effect have made reference to item-specific processing by hypothesizing that generation enhances encoding of the target and its individual properties. For example, explanations have included that generated items are more memorable because they benefit from additional rehearsals (Slamecka & Katsaiti, 1987) or because they become distinctive as they are processed in mixed lists of read and generated items (e.g., Begg, Snider, Foley, & Goddard, 1989). However, theories that solely rely on item-specific processing have trouble explaining all of the data points on the generation effect (Hirshman & Bjork, 1988; McDaniel, Waddill, & Einstein, 1988). More successful are theories that posit that generation enhances both item-specific and relational processing. For example, the multifactor theory of the generation effect asserts that in addition to increasing attention to and processing of each generated word (item-specific processing), generation also increases encoding of relations between the target and other aspects of the study session (relational processing). The most obvious relation is between the target word and its cue for generation, which is consistent with the idea that relational processing supports the generation effect; memory for the cue (e.g., *a vehicle*) is better for words that were generated (*a vehicle: tr—*) than for those that were read (*a vehicle: truck*; Greenwald & Johnson, 1989; McDaniel & Waddill, 1990).

However, processing the cue–target relationship is just one possible type of relational processing in the read–generate paradigm. McDaniel and colleagues (McDaniel, Riegler, & Waddill, 1990) argued that subjects can also relate target items to one another, across the study list. For example, a subject who generated *a vehicle: tr—* could relate the target *truck* to the target generated from *a vehicle: ai—*. When exemplars from multiple categories were intermixed during study, only generation led to above-chance clustering in later free recall, supporting the role of relational processing in the generate but not in the read condition (McDaniel & Waddill, 1990).

The argument is that generation leads to more relational processing than does reading because subjects are looking beyond the to-be-completed fragment for clues to the solution, leading to associations between the target, the cue word, and the other list items. If generation is treated as a problem-solving activity (Jacoby, 1978), then the to-be-generated target might be ostensibly associated to anything that could help subjects solve the problem (McDaniel et al., 1988). Greenwald and Johnson (1989) have specifically suggested other types of information the generated target may become associated to, including "all general cues of the experimental situation, such as the laboratory room, the experimenter, and the task instructions, as well as cues self-generated by the subject" (p. 680). Intriguing as this extension of the multifactor theory may be, the evidence for this hypothesis is mixed.

The logic used to examine whether generation facilitates binding of the target to its physical location is similar to that used to show that generation yields better memory for the cue–target association. Specifically, at test, the targets are again presented, and the subjects are tested on their memory for prior location of

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those targets (akin to how the Greenwald & Johnson [1989] and the McDaniel et al. [1988] subjects were tested on their memories for the cue words). The strongest evidence comes from two studies in which words were read and generated in different rooms, and subjects were later asked to remember in which room targets had been studied. Koriat, Ben-Zur, and Druch's (1991, Experiment 1) subjects read and generated in a laboratory room and in an office; the authors found that room memory was better for generated items. Similarly, E. J. Marsh, Edelman, and Bower's (2001, Experiment 1) subjects read and generated category exemplars in a laboratory room and in a large student lounge with picture windows; again, these authors found that room memory was better for generated items.

The data are more confusing when one examines the relationship between generation and other instantiations of experimental context, such as audience or source (e.g., Geghman & Multhaup, 2004; Jurica & Shimamura, 1999). Even other types of spatial information yield mixed results about the relationship between generated targets and their associations to location. For example, it is simpler to manipulate location via the placement of items on a computer screen rather than to move subjects back and forth between two rooms. E. J. Marsh et al. (2001, Experiment 2A) found a positive generation effect in location memory when subjects were remembering whether targets had appeared on the left or on the right of two adjacent computer monitors. However, the opposite effect was found when imagined versus seen pictures were projected on two adjacent screens, with left–right memory being better for the depicted pictures (Johnson, Raye, Foley, & Kim, 1982). More puzzling is that Mulligan (2004, Experiment 11) used the exact same materials as did E. J. Marsh et al. (2001) and found no relationship between generation and left–right memory. These inconsistencies raise important questions about the nature of the generation effect. Can generation enhance memory for a wide range of contextual details as suggested by Greenwald and Johnson (1989)? Such a finding would support theories that emphasize the importance of relational processing and treat generation as a problem-solving activity.

Seemingly contradictory results involving the generation effect have been previously resolved through careful examination of procedural differences across studies. For example, whether subjects were aware of the upcoming memory test turned out to be important and helped to resolve seeming discrepancies in the literature on the generation effect (e.g., Begg & Snider, 1987; McDaniel et al., 1988). The present observation examines the relationship between generation and location memory, with *location memory* defined as the spatial background of a to-be-remembered item. The focus is on location memory because this is the aspect of the larger experimental context that has been most researched, thus it allows comparisons of methods that have yielded the presence versus the absence of the generation effect. In the present research, the most effective way to identify potentially key procedural differences is to carefully compare the procedures of E. J. Marsh et al. (2001, Experiment 2A) and Mulligan (2004, Experiment 11) as these studies used the exact same stimuli, and yet only the former yielded a generation effect in left–right memory.

A close examination of the procedures of E. J. Marsh et al. (2001) and Mulligan (2004) yields numerous methodological differences, three of which were manipulated in the current study. First, modality of generation was manipulated, as subjects in E. J. Marsh et al. generated covertly, whereas those in Mulligan wrote both read and generated responses on a piece of paper. Writing both read and generated words effectively reduces the differences between the two sources. It also associates the to-be-remembered words to a third location: the piece of paper in front of the computer (a central location). Writing down all targets might be particularly problematic for generated items, as they will have been seen only in their complete form in the central location. Second, the filler task was manipulated as the subjects in the E. J. Marsh et al. experiments did unrelated visuospatial puzzles that contained few words, whereas subjects in the Mulligan experiment generated city names. Because of similarity in processing, generation during delay might interfere more with memory for generated items than for read ones. Third, the test format was manipulated, as subjects in the E. J. Marsh et al. experiments responded in paper-and-pencil format, whereas Mulligan's subjects responded on a computer. More important, E. J. Marsh et al.'s subjects first made an old–new decision followed by a left–right decision, whereas Mulligan's subjects made a single left–right–new decision. Test formats can affect ability to monitor source (R. L. Marsh & Hicks, 1998), so this is potentially an important variable.

In short, the method used in the current study was as close as possible to that of Mulligan (2004, Experiment 11), except that three key variables were manipulated. Showing a generation effect in location memory would be strong support for the multifactor theory of the generation effect and would help characterize the kind of relational processing afforded by generation.

Method

Subjects

Subjects were 138 Duke University students who were recruited through the preexisting psychology subject pool and via fliers; they received either course credit or monetary compensation for their participation in the study. Ten subjects were excluded from the analyses because they scored below chance when identifying studied words. Thus, the data from 128 subjects are presented here.

Materials

The stimuli were the same as those used in both E. J. Marsh et al. (2001) and Mulligan (2004): 90 exemplars from 15 categories in the Battig and Montague (1969) norms.

Two exemplars from each category were designated as lures; across subjects, the other four exemplars were either read (e.g., *musical instrument: flute*) or generated (e.g., *musical instrument: fl—*) and were presented on the left or the right side of the computer screen. Four different study lists were created to counterbalance item type (read or generated) with location (left or right). The 60 study trials were randomized by using Medialab (Jarvis, 2004b) and DirectRT (Jarvis, 2004a) software. Within read and generated sets, half were presented on the lower right side of the screen, and half were presented on the upper left. Items were written in white print on a black background. The screen had a white line down the middle dividing the right and the left sides. The manipulation of modality of study response means that half the of subjects read and generated silently, whereas the other half wrote down all read and generated words on a numbered worksheet. The filler task materials consisted of either visuospatial brainteasers for half the subjects or city-name generation for the remaining subjects. This constituted the manipulation of filler task.

Test items consisted of the entire set of 90 words (60 studied words plus 30 nonstudied words). The manipulation of test format means that half of the subjects took a computerized test and half responded by using paper and pencil. In the computer test condition, Medialab and DirectRT software was used to randomly present each test item on the screen for a left–right–new judgment via keypress. In the paper-and-pencil test condition, subjects made an old–new judgment for each item followed by a location judgment (left or right) for items judged old. There were three different random orders of the paper test, with the constraint that no words from the same category (e.g., *cello* and *drum*) were presented consecutively, and no more than three old (studied words) or new (nonstudied words) were presented consecutively.

Design

The study had a 2 (item type: read or generated) × 2 (modality of study response: thought or written) × 2 (filler task: city generation or visuospatial puzzles) × 2 (test format: computer single decision vs. paper two-part question), which was fully counterbalanced. All variables except for item type were manipulated between subjects. Dependent measures were recognition and location memory.

Procedure

After providing informed consent, each subject read instructions presented visually via computer. In Phase I, subjects were told that they would read and generate category cue exemplars and that they should expect an (unspecified) memory test at the end of the experiment. Half of the students generated and read silently (the thought condition), as in the E. J. Marsh et al. (2001) article. In contrast, students in the writing condition wrote down all words on a numbered sheet, regardless of whether they were read or generated (as in Mulligan, 2004). Following a single practice trial, the 60 study trials began at a pace of 6 s per item. Across the entire session, half of the items appeared in the upper left of the screen and half of them appeared in the lower right; similarly, half of the items were read and half of them were generated.

Phase II consisted of a filled delay. In the visuospatial puzzle condition, subjects spent 2 min solving visuospatial brainteasers that contained few words. In the city generation condition, subjects generated completions for city names for 3 min. Both task and timing (2 min vs. 3 min) differed, as was the case for E. J. Marsh et al. (2001) and Mulligan (2004), respectively.

In Phase III, all subjects were tested on their memories for the studied words, which were intermixed with related lures. Each word was tested alone, without its category cue. Subjects in the computer test condition made their responses via pressing one of three labeled keys: *N* (new), *L* (left), or *R* (right). The definitions of these keys were explained in detail. The remaining subjects took a paper-and-pencil test and received the same instructions, except they were told to first circle either *old* or *new* and then to circle *left* or *right* if they had studied the word. In both conditions, the experimenter made sure the subject understood that generated words were considered to be old words. Following the 90 test trials, subjects were debriefed and thanked for their participation.

Results

All results are significant at the $p < .05$ level, unless otherwise noted.

Recognition

In the computer test condition, old judgments were inferred from *left* and *right* keypresses.

False alarms were low (M = .06) and a 2 (modality of study response: thought or written) × 2 (filler task: city generation or visuospatial puzzles) × 2 (test format: computer single decision or paper two-part question) between-subjects analysis of variance (ANOVA) revealed no significant main effects or interactions. Because there were no differences in the false-alarm rates across conditions, the remaining analyses of recognition memory focus on hits. An analysis of hits was desirable so that the key manipulation of read versus generated could be included in the analyses (new items could not be classified as read or generated because they were never presented in the study phase).

A 2 (item type: read or generated) × 2 (modality of study response: thought or written) × 2 (filler task: visuospatial puzzles or city generation) × 2 (test format: computer single decision or paper two-part question) mixed ANOVA was computed on mean proportion of items correctly recognized as old. The only significant effect was a main effect of item type: Subjects were much better at correctly recognizing generated words (M = 0.91, SEM = 0.007) than read words (M = 0.73, SEM = 0.012), $F(1, 120) = 186.20$, MSE = 0.011. Subjects were equally good at recognizing old items regardless of whether they thought or wrote the study words, spent the delay solving visuospatial puzzles or generating city names, or took the paper-and-pencil or the computer test (all Fs < 1). There were no significant interactions (all Fs < 1); the generation effect was equally strong in all conditions.

Location Memory

As in both E. J. Marsh et al. (2001) and Mulligan (2004), location memory scores were computed by dividing the number of correct left–right attributions by the total number of items correctly recognized as old. A 2 (item type: read or generated) × 2 (modality of study response: thought or written) × 2 (filler task: city generation or visuospatial puzzles) × 2 (test format: computer single decision or paper two-part question) mixed ANOVA was computed on location memory scores.

Location memory was better when subjects had thought their responses during study (M = 0.74) than it was when they had written them down (M = 0.60), $F(1, 120) = 58.48$, MSE = 0.022. There was also a significant interaction between study response modality and filler task, $F(1, 120) = 7.63$, MSE = 0.022. When study responses had been thought, performance on location memory was better for subjects who had done the city generation task (M = 0.78) than for those who had completed the visuospatial puzzles (M = 0.71) during the filler. In contrast, for subjects who had written down study items, the city generation filler task led to worse location memory (M = 0.58) than did the visuospatial puzzles (M = 0.62).

More important for the purposes of this article, all remaining significant effects involved the item-type variable. First, the positive generation effect was still obtained in location memory, $F(1, 120) = 33.35$, MSE = 0.01. Overall, subjects were better at making left–right decisions for generated (M = 0.71) than for read words (M = 0.64).

However, unlike recognition memory, two significant interactions were observed. Item type interacted with filler task, $F(1, 120) = 4.64$, MSE = 0.01. When subjects solved visuospatial puzzles during the delay, they were much more likely to remember the spatial locations of previously generated items (M = 0.71) than the locations of read ones ($M = 0.62$), $t(63) = 5.33$, $SE = 0.02$. The generation effect was smaller when subjects had generated cities during the delay (generated words: $M = 0.70$; read words: $M = 0.66$), although it still reached significance, $t(63) = 2.55$, $SE = 0.02$.

Item type also interacted with mode of study response, $F(1, 120) = 5.01$, $MSE = 0.01$. Subjects who thought their responses during study were much better at remembering the locations of generated words ($M = 0.79$) than the locations of read ones ($M = 0.70$), $t(63) = 5.55$, $SE = 0.02$. Again, a significant generation effect was obtained in the writing condition, $t(63) = 2.42$, $SE = 0.02$, but the difference in location memory for generated ($M = 0.62$) and read items ($M = 0.58$) was smaller than in the thought condition. Table 1 shows the complete pattern of data.

Because one goal is to explain the difference in results between E. J. Marsh et al. (2001) and Mulligan (2004), I have included here the analyses of the generation effect in the cells that most closely mirror those of the two prior studies. In the cell that most closely replicates the design of Mulligan (2004), the generation effect was not significant. That is, when subjects had written down the study words, generated city names during the delay, and taken a three-alternative forced-choice test on the computer, the advantage for generated items ($M = 0.60$) over read items ($M = 0.56$) did not reach significance, $t(15) = 1.26$, $SE = 0.03$, $p > .20$. In the cell most closely replicating the design of E. J. Marsh et al. (2001), a positive generation effect was obtained. That is, when subjects thought the study words, solved visuospatial puzzles during the delay, and completed a paper test with old–new and left–right decisions, the advantage for generated items ($M = 0.76$) over read items ($M = 0.61$) was significant, $t(15) = 4.15$, $SE = 0.04$.

Discussion

A positive generation effect for location memory was observed in almost all of the conditions reported here. In particular, two out of the three manipulations had consequences for effects of generation on location memory. Most interesting was the interaction between modality of study response and item type; the generation effect in location memory was larger when subjects thought their responses during study than when they wrote them down. As predicted, generated responses were disproportionately affected by being associated to a third location (the paper), likely because that was the only location in which generated items were seen intact (after they had been written down). Item type also interacted with the filler task; the generation effect in location memory was larger when the filler task did not involve any sort of word generation (the city generation task) and instead involved unrelated visuospatial tasks. Together, these data suggest that generation may increase the binding of a target to its location and that the benefit is susceptible to various forms of interference.

As with other findings linking generation to relational processing, the finding of a generation effect in location memory cannot be accommodated by theories that attribute only an item-specific processing advantage to generation. Rather, the results are consistent with the multifactor theory outlined in the introductory paragraphs. The novel finding is that generation can facilitate an additional type of relational processing: the association of targets to their study locations. The data also provide some information about what types of procedural manipulations may interfere with the ability to observe the consequences of that relational processing, and, as such, they help to explain the contradictory results reported in the literature.

If the idea of generation as a problem-solving activity (Jacoby, 1978) is correct, and associations between the target and location are made as the subject strives to solve the generation puzzle, it raises the issue of how location aids in discovering the to-be-generated target. Most plausible is that the environment somehow provides cues to the solution, in the same way that the environment provides retrieval cues in context-dependent memory effects (Smith & Vela, 2001). This argument is more applicable when the locations are rich in cues, such as actual physical rooms (as opposed to the left or the right side of a computer screen). However, even simply looking to the left or to the right of a computer screen during study requires eye movements, potentially binding locations to targets.

I have discussed these results in the theoretical context of item-specific versus relational processing, but there are other ways of thinking about the effects of generation. For example, an item trade-off account has been hypothesized to accommodate positive and negative generation effects (Jurica & Shimamura, 1999). This account proposes that generation focuses attention on the to-be-generated target (yielding positive benefits) at the expense of other information (yielding negative generation effects for information such as audience). However, it seems most likely that the item trade-off account would predict a negative generation effect, with item being encoded at the expense of location—the opposite of what was found in the current study.

More relevant is Mulligan's (2004) processing account of the generation effect, whereby the effects of generation depend on whether generating aids, hinders, or has no effect on the processing required to encode other types of information such as location and perceptual details. The point of the present work is not to argue with a processing account of the generation effect, which follows quite naturally from principles of transfer-appropriate processing (Morris, Bransford, & Franks, 1977). Rather, the question is about what effect generation has on processing location in particular and whether it aids the binding of targets to locations. The processing

Table 1
Location Memory (Means) as a Function of Item Type (Read vs. Generated), Modality of Study Response (Written vs. Thought), Filler Task (Visuospatial Puzzles vs. City Name Generation), and Test Format (Computer Single Decision vs. Paper-and-Pencil Two-Part Question)

Response modality and task	Paper and pencil		Computer	
	Read	Generated	Read	Generated
Written				
Visuospatial puzzles	.60	.65	.57	.66
City name generation	.59	.59	.56	.60
Thought				
Visuospatial puzzles	.61	.76	.69	.79
City name generation	.79	.81	.69	.81

Note. Location memory is the proportion of hits correctly identified as having appeared on the left versus on the right side of the computer screen during study. The standard error of the mean was .032 for read items and .029 for generated items.

account of generation would predict a generation effect in location memory if one accepted that generation led to stronger target-location associations. My point is simply that generation can aid the association of the target to its location, although that benefit can be easily obscured by certain experimental parameters.

One additional comment on the work of Mulligan (2004) should be made here. The present work uses a comparison of the methods of E. J. Marsh et al. (2001) and Mulligan (2004) as a tool to better understand when location is, versus when it is not, more associated to generated targets. Conclusions from the present data are limited to location memory and might not necessarily generalize to color memory (which was also investigated in Mulligan, 2004, with different results from location memory). What the patterns of generation effects in context memory reported here do clarify are the inconsistencies between the reports of E. J. Marsh et al. and Mulligan in location memory, with the larger goal of constraining theories of generation more generally.

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