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Processing Instructions and the Generation Effect: A Test of the Multifactor Transfer-appropriate Processing Theory

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We report two experiments designed to test further the multifactor transfer-appropriate processing explanation of generation effects (deWinstanley, Bjork, & Bjork, 1996). The present research focuses on the following assumptions: (a) that processing resources are limited and, thus, the processing of one type of information can be, and often is, incompatible with the processing of other types of information; and (b) that reading and generating differ in terms of the flexibility they permit for the distribution of the subject's processing resources across the available information in an experimental context. These assumptions were tested by examining the consequences of processing instructions on the occurrence of generation effects, and the lack thereof, in free recall and cued recall. Across both experiments, identical processing instructions had strikingly different consequences on the later free-recall and cued-recall performance of subjects who encoded targets by generating them versus reading them, a pattern consistent with the foregoing assumptions.

INTRODUCTION

The generation effect refers to the finding that subject-produced information is better remembered than experimenter-supplied information (Jacoby, 1978; Slamecka & Graf, 1978). For nearly two decades, the generation effect has proved remarkably robust. It has been obtained for a variety of materials and types of tests and, more recently, has even withstood what initially appeared to

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be a devastating challenge to its importance as a memory phenomenon—namely, the finding of little or no generation advantage on free-recall tests when the read-versus-generate manipulation was implemented on a between-list basis (e.g. Begg & Snider, 1987; Slamecka & Katsaiti, 1987). Individual theories of the generation effect, however, have proved less robust to challenges. Indeed, McDaniel, Waddill, and Einstein (1988, p.522) have asserted that ''it is only a mild exaggeration to note that the number of accounts for the generation effect is slightly less than the number of reports of the effect itself''. On the other hand, while perhaps no individual theory has survived intact, few have died entirely. Rather, aspects of older theories have tended to reappear, often with slight modification, in newer theories. For example, in proposing their multifactor theory of generation effects, McDaniel, Waddill, and Einstein built on the two-factor theory of Hirshman and Bjork (1988) and, more recently, deWinstanley, Bjork, and Bjork (1996) built on the previous accounts of these researchers as well as those of others (e.g. Rabinowitz & Craik, 1986) in proposing a multifactor transfer-appropriate processing account of generation effects.

In the multifactor transfer-appropriate processing account, the primary subject of the present research, the following assumptions are made: (a) that the requirement to generate presents subjects with a problem to be solved, and subjects are thus led to process whatever information is helpful in solving the problem—the types of information that subjects might find useful include target-specific information (information about the target item itself, e.g. how it looks; Hirshman & Bjork, 1988), cue–target relational information (information about the relationship the target has to the cue, e.g. an antonym; Hirshman & Bjork, 1988), and whole-list or target–target relational information (e.g. categorical relationships among targets in the list; McDaniel et al., 1988); (b) that the requirement to generate enhances the processing of whatever type of information is used as the basis for generation in comparison to the processing that would typically be given to such information by subjects reading intact stimuli; (c) that the processing of one type of information can be, and often is, incompatible with the processing of other types of information—for example, the processing of cue–target relational information can be incompatible with the processing of whole-list relational information (e.g. Hirshman & Bjork, 1988); and (d) that a generation advantage will be observed to the extent that a later criterion test (e.g. recognition or cued recall) is sensitive to the type of information enhanced by the generation task (e.g. Hirshman & Bjork, 1988; Jacoby, 1983; Rabinowitz & Craik, 1986).

In deWinstanley et al. (1996), research was reported testing the last assumption, which essentially applies the notion of transfer-appropriate processing (Morris, Bransford, & Franks, 1977) to the multifactor framework for explaining generation effects. The materials used in this research were cue–target pairs in which each target, while belonging to one of four categories, also had a unique cue—that is, a cue to which it was related but which bore little or no relation to other targets in the same category (e.g. island–pineapple; fuzzy–peach). At the same time, however, each target was only weakly related to its specific cue and, thus, difficult to generate on the basis of that information alone. In their first experiment, pairs were presented blocked by category membership, leading generate subjects to rely primarily on this highly salient target–target relational information—as opposed to the weak cue–target relational information—in order to generate targets. As predicted by the framework's transfer-appropriate processing assumption, the resulting enhanced processing of target–target relational information led to a generation advantage on a later free-recall test, presumed to be primarily sensitive to such information (Einstein & Hunt, 1980; Hunt & Einstein, 1981); whereas the lessened processing of cue–target relational information as a basis for generation led to the lack of a generation advantage on a later cued-recall test, presumed to be primarily sensitive to cue–target relational information (Begg 1978; Hirshman & Bjork, 1988).

In deWinstanley et al.'s second experiment, the same pairs were presented, but were no longer blocked by category membership, forcing generate subjects to rely on cue–target relational information in order to generate targets. Again, in keeping with the framework's transfer-appropriate processing assumption, the resulting enhanced processing of cue–target relational information led to a generation advantage on a later cued-recall test, while the lessened processing of target–target relational information eliminated the generation advantage on a later free-recall test. Thus, across these two experiments, completely opposite patterns of results were obtained as a function of the nature of a later criterion test (free recall vs. cued-recall) and the type of information (target–target relational vs. cue–target relational) processed by subjects as a basis for generating identical targets.

In the present paper, we report research primarily focusing on the third assumption described earlier—that the processing of one type of information can be incompatible with the processing of other types of information—and the consequences of this assumption, which is essentially an assumption of limited processing resources, for producing (or failing to produce) generation effects as a function of the nature of a later criterion test. We also propose and test some possible processing differences between generating and reading as ways of encoding information—differences that, combined with the other assumptions of the multifactor transfer-appropriate processing framework, allow predictions of circumstances under which we should or should not expect to observe generate advantages as well as read advantages.

More specifically, we assume that because subjects who generate have a task to perform—the generation of targets—and usually have only a limited time in which to generate each target, their processing efforts will be more restricted in terms of the types of information they process as compared to subjects reading intact information. That is, subjects who generate will be led to focus their processing efforts on that information most useful to solving the generation task.

Consequently, while the processing of that information may be enhanced, the processing of other information is likely to be impaired. If, for example, cue–target relational information was critical for target generation, the processing of that information would be enhanced, but at the expense of whole-list or target–target relational processing—because, in the present framework, the processing of cue–target information is assumed typically to be incompatible with the processing of whole-list information. In contrast, subjects who read—and, thus, do not have their processing efforts guided by the generation task—are more free to engage in whatever types of processing they may deem to be memory-enhancing. More specifically, we assume that subjects reading intact information for the purpose of remembering will typically distribute their processing efforts more or less evenly across the different types of available information. It is important to point out, however, that we view this as a default assumption—that is, we assume it to hold when subjects who are reading intact information for the purpose of remembering are performing under no special instructional or situational constraints. If given explicit (or implicit) instructions to carry out particular mnemonic strategies (as was done, for example, by Begg, Vinski, Frankovich, & Holgate, 1991), the processing activities of read subjects should be altered.[1]

In the present research, we test these proposed assumptions concerning processing differences that occur when subjects encode information by generating it versus reading it, in the context of the other assumptions of the multifactor transfer-appropriate processing framework. According to this framework, generation advantages occur when the requirements to generate opportunely focus processing resources—that is, lead to enhanced processing by generate subjects, as compared to read subjects, of information to which a later memory test is sensitive. Consequently, if read subjects were also to be led to focus their processing resources in an opportune manner, generation advantages should be reduced or eliminated.

Suppose, for example, that—as in Experiment 1 of deWinstanley et al. (1996)—materials were constructed such that generate subjects would be forced to focus on the processing of target–target relational information in order to

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[1] With respect to the present framework, the studies of Begg et al. (1991) would not be considered as demonstrating differences between the mnemonic effectiveness of generation versus reading *per se*. Rather, we see their research as comparing the memorial consequences of generating to those of reading when both are combined with additional types of encoding strategies, such as imagery or silent pronunciation. Furthermore, there are complications with interpreting the read versus generate results they obtained because—given a constant presentation time for both intact and to-be-generated targets—read subjects would always have had more time than generate subjects to engage in whatever additional type of processing they had been instructed to do. Thus, for example, how to interpret the lack of a generation advantage in the condition in which subjects were instructed to engage in imagery processing is unclear as, essentially, one is comparing the mnemonic consequence of generation plus a small amount of imagery processing to that of reading plus a greater amount of imagery processing. It is thus unclear whether generation would have resulted in an advantage in memory given the same amounts of additional imagery processing in the two conditions.

generate targets and, furthermore, that a later free-recall test, sensitive to such information, were given. In the absence of providing read subjects with any particular processing instructions (i.e. the typical experimental situation), we would expect the free-recall performance of the generate subjects to be superior to that of the read subjects—that is, to obtain a generation advantage—which was, indeed, what happened. On the other hand, suppose that, rather than being left alone to spread their processing efforts across all the types of information present in the list, read subjects were explicitly directed in this situation to focus their processing efforts on target–target relational information. According to the present assumptions, the generation advantage should be greatly lessened or eliminated. In contrast, because generate subjects must focus their processing efforts on the type of information most useful for target generation, explicit instructions to attend to other types of information should have less influence on their processing efforts and, consequently, on their later criterion test performance. That is, the performance of generate subjects should be determined almost entirely by the relationship between the type of information they must process in order to generate targets and the nature of a later criterion test—specifically, whether the information guiding the generation act is, or is not, the type of information to which a later criterion test is sensitive.

As an empirical test of these notions, we first constructed a list of cue–target pairs that we believed would force generate subjects to focus on the processing of target–target relational information in order to generate targets. Giving such materials, we then investigated what the consequences of different types of processing instructions would be, as a function of whether a later criterion test was, or was not, sensitive to the type of information subjects were explicitly instructed to process. Basically, if our assumptions about processing differences between reading and generating are correct, then the performance of generate subjects should be largely unaffected by the type of explicit processing instructions they are given, because their processing efforts will be largely restricted by the requirements of the generation task. In contrast, because the processing strategies of read subjects are not so restricted and, thus, potentially modifiable on the basis of instructions, their performance should vary as a function of the type of processing instructions they are given and whether such instructions are, or are not, appropriate for a later criterion test.

EXPERIMENT 1

In Experiment 1, the criterion test employed was a free-recall test because of its assume primary sensitivity to whole-list relational processing (see e.g. Einstein & Hunt, 1980; Hunt & Einstein, 1981; Hunt & Seta, 1984; Swartz, 1973; Tulving, 1962), and all subjects were given one of three types of processing instructions: target–target, cue–target, and nonspecific. The target–target processing instructions advised subjects to focus their processing efforts on the relations among the target items in expectation of a free-recall test. The cue–

target processing instructions advised subjects to focus their processing efforts on the relationship between each cue and target in expectation of a later cued-recall test. The nonspecific instructions replicated the modal type of instruction given in intentional learning conditions in previous studies of the generation effect: namely, they advised subjects to expect a later memory test, the nature of which was unspecified.

Given our assumption that read subjects should be able to modify their processing activities in accordance with the instructions provided, the performance of read subjects was predicted to be best when the processing instructions matched the later criterion test. Thus, given a free-recall criterion test, target–target processing instructions should produce better performance for read subjects than either cue–target or nonspecific processing instructions. In contrast, the performance of generate subjects should be largely unaffected by the processing instructions they are given, owing to the restrictions placed on their processing efforts by the demands of the generation task. Furthermore, in the condition in which read subjects are given explicit target–target processing instructions, little or no generation advantage would be expected, because the processing of such information by generate subjects, as compared to read subjects, should no longer be enhanced.

A secondary set of predictions can be made regarding the occurrence of output clustering. Because generate subjects should be forced by the demands of the generation task to focus on the processing of target–target information rather than other types of information available in the list, their recall performance should reflect a tendency to cluster with respect to category membership regardless of the type of processing instructions they are given. The amount of clustering in the recall of read subjects, on the other hand, should vary as a function of processing instructions if, in fact, they are able to modify their processing efforts as assumed. Specifically, then, we would expect more clustering in the free recall of read subjects given target–target processing instructions than in that of read subjects given either cue–target or nonspecific processing instructions.

Method

Subjects. The subjects were 114 Oberlin College undergraduates whose participation in the experiment partially fulfilled an introductory psychology course requirement. They were randomly assigned to each of the six between-subjects conditions, with the total in each condition being as follows: 19 in each of the three generate × processing-instruction conditions; 20 in both the read × cue–target and the read × target–target processing conditions; and 17 in the read × nonspecific processing condition.

Design. The design was a 2 × 3 factorial, with encoding task (read vs. generate) and type of processing instructions (target–target, cue–target, and nonspecific) manipulated between subjects. Read subjects read the cue and the target, and then wrote both the cue and the target on a page in their response booklet. Generate subjects read the cue, solved the fragment, and then wrote both the cue and the target on a page in their response booklet. Subjects given target–target processing instructions read the following: ‘‘You will be receiving a free-recall test in which you will be asked to recall all of the second members of the word pairs. To do well on your memory test, it is particularly important that you pay close attention to the relations among all of the second items of the word pairs.’’ Subjects given cue–target processing instructions read the following: ‘‘You will be receiving a cued-recall test in which you will be given the first word and you must indicate which word was paired with that word during the slide presentation. To do well on your memory test, it is particularly important that you pay close attention to the relations between the two words.’’ Subjects given nonspecific processing instructions read that they would be given a memory test, but the nature of the test was unspecified. All subjects actually received a free-recall test.

Materials and Apparatus. The stimuli were 24 cue–target pairs selected from Marshall and Cofer’s (1970) word-association norms. Six targets came from each of the following categories: birds, fruit, alcoholic beverages, and insects. Within each category, cues were selected such that a pre-experimental association existed between each cue and all six targets. For example, the word ‘‘sweet’’ (paired with the target ‘‘pineapple’’ in the study list) has a pre-experimental association with all of the other target items in the fruit category as well. The study list was constructed in this manner—that is, with pre-experimental associations existing between all cues and targets within a given category—to ensure the saliency of the target–target relational information.

Cue–target pairs were presented one at a time using a Kodak Ektagraphic projector. In the read conditions, each slide contained a cue paired with an intact target (e.g. juice–orange). In the generate conditions, each slide contained a cue paired with a fragmented target (e.g. juice–or-n- -). The presentation order of the pairs was determined using a block randomisation procedure with items blocked by category membership and, once determined, was held constant for all subjects.

Response and test booklets were prepared for each subject. Response booklets contained 24 pages so that each cue–target pair could be written on a separate page. The first page of each test booklet presented instructions regarding the test on the following page, and the actual free-recall test page contained 24 blank lines on which subjects wrote the target items.

Procedure. Subjects were tested in groups of 1–10 individuals. They were informed of the type of items they would be seeing and shown an example. Each subject was given a response booklet and instructed to write both the cue and the target member of each pair, as it was presented, on a separate page of the booklet, turning to the next blank page in preparation for writing down the next cue–target pair as the projector advanced to the next slide. Subjects then received target–target, cue–target, or nonspecific processing instructions as appropriate. (Requiring subjects to write both the cue and the target ensured that they could not simply ignore the cue—a potential problem, particularly for subjects given the target–target processing instructions.)

Next, the stimuli were presented at a rate of seven seconds per slide, with the projector taking about one second to advance between successive slides. After the last slide was shown, the response booklets were collected, and the subjects engaged in a verbal distractor task for two minutes. Test booklets were then handed out, and subjects were allowed two minutes to complete the free-recall test.

Results and Discussion

For the present experiment, and the experiment to follow, all means reported are percentages and all mean-squared errors reported are squared-percentages.

Generation Rate. The mean generation failure—that is, the mean percentage of targets that subjects failed to generate at study—was 7.8%. The analyses conditionalised on correctly generating the target at study did not differ from the analyses that were unconditional with respect to correct generation; thus, only the unconditional analyses are presented here.

Free-recall. Figure 1 presents the mean percentages of targets that were correctly recalled by the generate versus the read subjects as a function of the three types of processing instructions. The line extending beyond the top of each bar shows the corresponding standard error for that condition. The data were analysed using a two-way between-subjects analysis of variance and planned-comparisons.

The apparent interaction between encoding task and processing instructions indicated in Fig. 1 was revealed to be significant, $F\ (2,108) = 3.07$, $MS_e = 256.81$, $P < .05$. As predicted, the performance of generate subjects was unaffected by processing instructions, $F\ (2,108) = 0.82$, $MS_e = 256.81$, $P > .10$; whereas the performance of read subjects varied as a function of processing instructions, $F\ (2,108) = 8.85$, $MS_e = 256.81$, $P < .001$. Furthermore, for the read conditions, target–target processing instructions led to significantly more items recalled than cue–target and nonspecific processing instructions, $F\ (1,108) = 11.02$, $MS_e = 256.81$, $P < .01$, $F\ (1,108) = 15.19$, $MS_e = 256.81$, $P < .001$, respectively. The lack of a processing-instruction effect in the generate conditions supports our hypothesis that the requirement to perform the generation task, given the nature of the present materials, would essentially restrict generate subjects to the

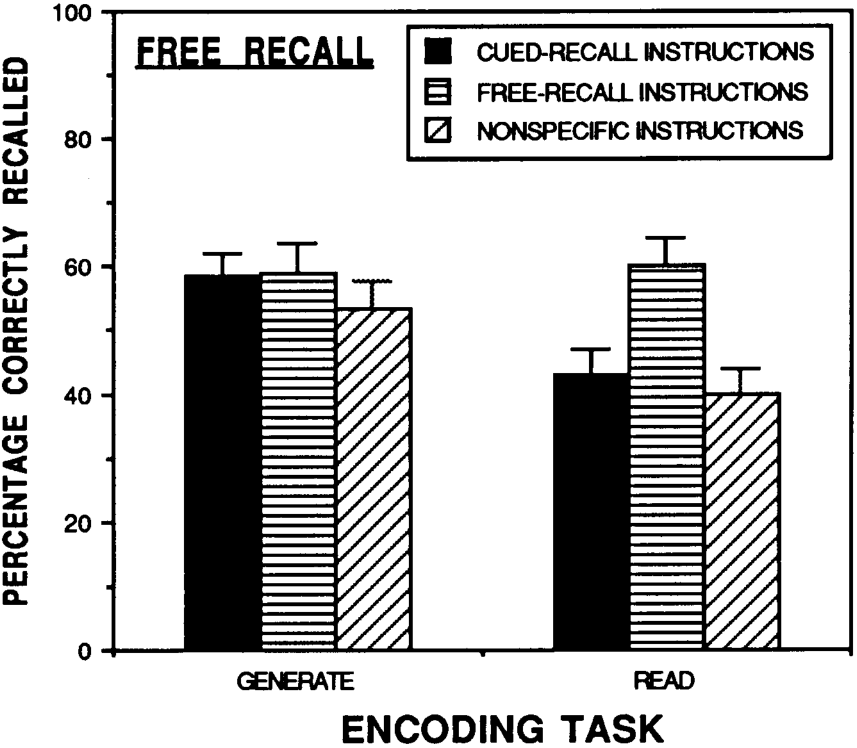

FIG. 1. Mean percentage of correctly recalled targets on a free-recall test for the generate and read conditions as a function of processing instructions in Experiment 1. The lines extending beyond the bars represent standard errors.

processing of target–target relational information and, by and large, render them unable to modify their processing efforts in response to instructions. Read subjects, on the other hand, not being restricted in their processing efforts by the need to generate targets, were able to modify their processing activities in a manner consistent with the processing instructions, as indicated by their superior free-recall performance when directed to process the type of information to which free-recall tests are presumed to be most sensitive—namely, target–target relational information.

Additionally, our argument that the occurrence of a generation advantage should depend on the type of processing instructions given to read subjects—in particular, that little or no generation advantage should occur when read subjects were directed to process target–target relational information—was supported by the results. The difference between the free-recall performance of read and generate subjects given target–target processing instructions did not differ significantly, $F\ (1,108) = 0.04$, $MS_e = 256.81$, $P > .50$; whereas the performance of generate subjects was significantly better than that of the corresponding read subjects given cue–target or nonspecific processing instructions, $F\ (1{,}108) = 8.73$, $MS_e = 256.81$, $P < .01$; $F\ (1{,}108) = 6.67$, $MS_e = 256.81$, $P < .05$, respectively. Thus, when read subjects were not explicitly instructed how to allocate their processing efforts effectively during study, their later performance on a free-recall test suffered in comparison to that of generate subjects who, in order to perform the generation task, were presumably always processing target–target relational information regardless of processing instructions. On the other hand, when read subjects were directed to allocate their processing efforts in a manner presumably similar to the generate subjects—that is, to engage in target–target relational processing—the generation advantage was removed.

Interpreting this pattern of results in terms of the present framework, the benefit of generating was to focus processing efforts on the type of information most useful to the later free-recall test, namely whole-list or target–target relational information. Indeed, even when generate subjects were instructed to focus on the processing of cue–target relational information, they were apparently unable to do so, resulting in similar levels of performance for all three types of instructions and a generate advantage in the cue–target and nonspecific processing conditions.

Given that our interpretation of the present pattern of results rests on the assumption that the generation task primarily resulted in whole-list or target–target relational processing, additional support for this assumption was desirable. To this end, we examined the degree to which items from the same category were grouped together during recall, by calculating category clustering scores for each condition, with the idea that subjects primarily engaging in whole-list or target–target relational processing should produce more category groupings in their recall than subjects engaging in other types of processing.

Clustering. Clustering was measured using the adjusted ratio of clustering (ARC) score (Roenker, Thompson, & Brown, 1971), and the pattern of clustering results obtained was identical to that for free recall. For the generate conditions, clustering did not vary with type of processing instructions, $F\ (2{,}108) = 1.68$, $MS_e = 0.105$, $P > .10$ ($M = 0.65$, 0.47, & 0.63, for target–target, cue–target, and nonspecific instructions, respectively); whereas, for the read conditions, type of processing instruction *did* have a significant effect on clustering, $F\ (2{,}108) = 9.53$, $MS_e = 0.105$, $P < .001$ ($M = 0.59$, 0.16, & 0.26, for target–target, cue–target, and nonspecific instructions, respectively). Overall, significantly more clustering occurred when subjects were given target–target processing instructions than when given cue–target or nonspecific processing instructions, $F\ (1{,}108) = 17.35$, $MS_e = 0.105$; $P < .001$; $F\ (1{,}108) = 10.32$, $MS_e = 0.105$, $P < .01$, respectively. Finally, and most importantly with respect to the present set of predictions, although generating resulted in significantly more overall clustering than did reading, $F\ (1{,}108) = 16.97$, $MS_e = 0.105$,

$P < .001$, there was no difference in the amount of clustering by generate versus read subjects given target–target processing instructions, $F(1,108) = 0.314$, $MS_e = 0.105$, $P > .50$.

Thus, the clustering pattern provides converging evidence for the picture presented by the recall results. Overall, clustering scores were greater for generate subjects than for read subjects and, in addition, the clustering scores of the generate subjects did not vary in relation to processing instructions. This pattern supports the contention that, as a consequence of the generation task, generate subjects were led to focus their processing efforts on target–target relational information and, furthermore, were unable to shift this focus to the processing of other types of information even when instructed to do so as a way to optimise their later memory performance. In contrast, the clustering scores for read subjects did vary with the type of processing instruction, supporting the contention that read subjects would be able to distribute their processing efforts in accordance with the processing instructions they received. Finally, the fact that the clustering score for read subjects given target–target processing instructions did not differ from that of the generate subjects supports the conclusion that it was the read subjects' focusing of their processing efforts on target–target relational information that led to the lack of a free-recall generation advantage in this condition.

EXPERIMENT 2

In Experiment 1, when read subjects were given either cue–target or nonspecific processing instructions, a generate advantage was observed on a later free-recall criterion test; when read subjects were given target–target processing instructions, however, which presumably led them to process the stimulus material in the same manner as the generate subjects, no generate advantage was observed. In Experiment 2, we investigated whether a different pattern of generate advantages and non-advantages would be obtained were a memory test less sensitive to target–target relational processing to be given as the later criterion test—specifically, a cued-recall test.

If, as was argued in Experiment 1, the requirement to perform the generation task combined with the nature of the stimulus materials would lead generate subjects to focus their processing efforts on target–target relational information, and, if, as was argued in the introduction, cued-recall tests are primarily sensitive to cue–target relational information and relatively insensitive to target–target relational information, then—unlike the results of Experiment 1—little or no generate advantage should be obtained on a later cued-recall test when subjects are given target–target or nonspecific processing instructions. Moreover, when subjects are given cue–target processing instructions, a read advantage might well be expected. That is, according to our assumptions and the results of Experiment 1, read subjects should be able to modify their processing efforts in response to the instructions given, whereas generate subjects would continue to focus on the processing of target–target relational information because of their need to perform the generation task. Thus, in the cue–target relational processing conditions, read subjects should be led to focus on the type of information to which the later criterion test is primarily sensitive, whereas generate subjects will be forced to continue focusing their processing efforts on a type of information to which the later criterion test is relatively insensitive. On the other hand, although generate subjects are primarily dependent on the processing of target–target relational information to generate targets with the present stimulus materials, they may also engage in some minimal amount of cue–target relational processing if they feel required to check whether each generate target also fits with the particular cue with which it was paired. It is unclear, however, whether such ''post-generation'' checking would be sufficient to offset the advantage read subjects would have in being able to focus their processing efforts on cue–target relational information.

To summarise, given the same stimulus materials as used in Experiment 1, which were constructed to force generate subjects to focus on the processing of target–target relational information in order to perform the generation task, and the use of a cued-recall test, assumed to be sensitive to cue–target relational information and largely insensitive to target–target relational information, the present framework would lead us to expect the following pattern of results in Experiment 2: little or no generation advantage when subjects are given target–target relational or nonspecific processing instructions, and a possible read advantage when subjects are given cue–target relational processing instructions. Additionally, as with Experiment 1, the performance of generate subjects should not vary as a function of processing instructions, whereas the performance of read subjects should, resulting in best performance for read subjects when the processing instructions they receive match the type of information to which the later criterion test is most sensitive. In Experiment 2, then, best performance for read subjects should occur when cue–target processing instructions are given.

Method

Subjects. The subjects were 116 Oberlin College undergraduates whose participation partially fulfilled an introductory psychology course requirement. They were randomly assigned to each of the six between-subjects conditions, with the total in each condition being as follows: 20 in both the generate × target–target and the generate × nonspecific processing conditions; 19 in the generate × cue–target processing condition; 20 in both the read × cue–target and read × target–target processing conditions; and 17 in the read × nonspecific processing condition.

Materials and Apparatus. The study phase materials and the apparatus were the same as those used in Experiment 1, but the test booklets contained a cued-recall rather than a free-recall test. The first page of the test booklet informed subjects about the test on the next page. The cued-recall test page itself contained the 24 cues presented in a randomly determined order that was held constant for all subjects. A new ordering of the cues at test ensured that subjects could not take advantage of order information to do well on the test. Next to each cue was a blank line on which subjects wrote the target item that they remembered as being paired with that cue on the study list.

Design and Procedure. The basic design and procedure were the same as those used in Experiment 1. The dependent variable in Experiment 2, however, was performance on a later cued-recall test, rather than a later free-recall test.

Results and Discussion

Generation Rate. The mean generation failure rate was 6.4%. The analyses conditionalised on correct target generation at study did not differ from the analyses that were unconditional with respect to correct generation; thus, only the unconditional analyses are presented here.

Cued-recall. Figure 2 presents the mean percentages of targets that were correctly recalled by the generate versus the read subjects as a function of the three types of processing instructions. As in Fig. 1, the line extending beyond the top of each bar shows the corresponding standard error for that condition. The data were analysed using a two-way between-subjects analysis of variance and planned-comparisons to test the hypotheses.

The apparent interaction between encoding task and type of processing instruction indicated in Fig. 2 was revealed to be significant, $F\ (2,110) = 3.10$, $MS_e = 310.19$, $P < .05$. As predicted the performance of generate subjects was unaffected by processing instructions, $F\ (2,110) = 1.32$, $MS_e = 310.19$, $P > .20$; whereas the performance of read subjects was significantly influenced by processing instructions, $F\ (2,110) = 7.41$, $MS_e = 310.19$. $P < .002$. Also, as predicted, read subjects given instructions to focus on the processing of cue–target relational information performed significantly better on the cued-recall test than did read subjects given target–target and nonspecific processing instructions, $F\ (1,110) = 8.46$, $MS_e = 310.19$, $P < .005$; $F\ (1,110) = 13.00$, $MS_e = 310.19$, $P < .001$, respectively.

With respect to the prediction of a possible read advantage when both read and generate subjects were given cue–target processing instructions, read subjects did perform marginally better than the corresponding generate subjects, consistent with the prediction that read subjects would be more able to modify their processing efforts in response to instructions than would generate subjects owing to the constraints imposed on their processing efforts by the generation task, $F\ (1,110) = 3.24$, $MS_e = 310.19$, $P < .08$. When given either target–target or

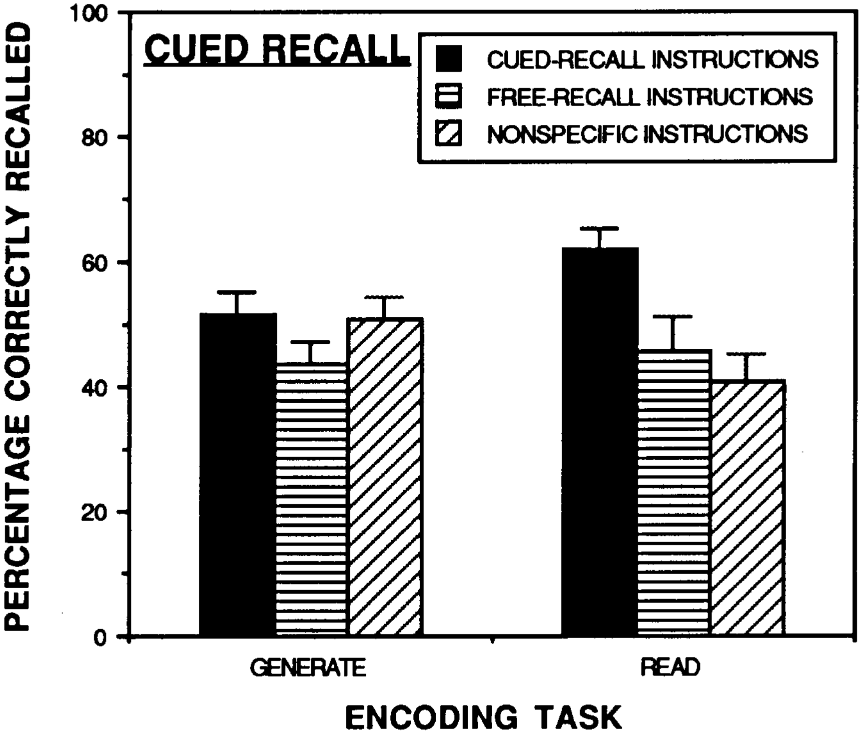

FIG. 2. Mean percentage of correctly recalled targets on a cued-recall test for the generate and read conditions as a function of processing instructions in Experiment 2. The lines extending beyond the bars represent standard errors.

nonspecific processing instructions, however, the cued-recall performance of the read and generate subjects did not differ, $F(1,110) = 0.16$, $MS_e = 310.19$, $P > .05$; $F(1,110) = 2.90$, $MS_e = 310.19$, $P > .05$, respectively.

Thus, the pattern of results obtained in Experiment 2 are also consistent with the contention that read subjects would be better able than generate subjects to modify their allocation of processing resources in accordance with processing instructions. First, when given instructions that directed them to process the type of information to which the later cued-recall test would be sensitive, the performance of read subjects was marginally better than that of the corresponding generate subjects and significantly better than that of read subjects given either target–target or nonspecific processing instructions. Second, the performance of the generate subjects did not vary as a function of the type of processing instructions given, supporting the assumption that the requirement to generate largely prescribes the allocation of processing resources. That is, while generate subjects were largely forced to continue processing target–target information at the expense of cue–target information in order to perform the generation task, read subjects—not being constrained by any generation requirements—were free to direct their processing efforts to whatever information they had been told would be most helpful to them on a later test, resulting in a marginally significant read advantage when instructed to process cue–target relational information. As contemplated earlier, the failure of the observed read advantage to reach statistical significance in this condition could be due to generate subjects always engaging in some degree of cue–target relational processing owing to the implicit task demand to see if a target—although primarily generated on the basis of target–target relational information—nonetheless fitted with its cue.

As an additional check on our prediction that read subjects would be more able than generate subjects to take advantage of the processing instructions they received, an analysis of cue–target mispairings was performed. Specifically, we assumed that if read subjects were able to modify their processing efforts in response to processing instructions, then they should commit fewer cue–target mispairings when given cue–target processing instructions than when given other types of processing instructions; whereas the number of cue–target mispairings made by generate subjects would be largely unaffected by the type of processing instructions they received. Additionally, if read subjects were able to engage in more cue–target processing than generate subjects when both were given instructions to process cue–target information in order to optimise their performance on a later cued-recall test, then one might expect the read subjects to commit fewer cue–target mispairings on the later cued-recall test than would the generate subjects.

Cue–Target Mispairings. The number of times that a target was given in response to a cue other than the cue with which it had been paired at study was scored, and these data were analysed using a two-way between-subjects analysis of variance and planned-comparisons to test the hypotheses. A significant interaction between encoding task and type of instruction was obtained, $F\ (2,110) = 3.06$, $MS_e = 3.54$, $P < .05$. Read subjects made significantly fewer target mispairings when given cue–target processing instructions (M = 0.80) than when given target–target (M = 2.25) or nonspecific processing instructions (M = 2.82), $F\ (1,110) = 5.94$, $MS_e = 3.54$, $P < .02$; $F\ (1,110) = 10.62$, $MS_e = 3.54$, $P < .002$, respectively. In contrast, processing instructions failed to produce a significant difference in the number of cue–target mispairings made by generate subjects. In the cue–target, target–target, and nonspecific processing conditions, the mean number of mispairings were 2.11, 2.70, and 2.82, respectively, $F\ (2,110) = 0.80$, $MS_e = 3.54$, $P > .40$. Moreover, consistent with our earlier speculations, when we look only at the performance of subjects given cue–target processing instructions, the read subjects made significantly fewer cue–target mispairings than the subjects required to generate, $F\ (1,110)$, $MS_e = 3.54$, $P < .05$.

The pattern of cue–target mispairings is thus consistent with the picture painted by the cued-recall results. Read subjects, being unconstrained by the need to generate targets, were apparently able to modify their processing efforts in accordance with the instructions given, as evidenced by the significantly fewer cue–target mispairings they made when given cue–target versus target–target or nonspecific processing instructions. In contrast, even when explicitly instructed to process cue–target relational information, generate subjects made as many cue–target mispairings as when given target–target or nonspecific processing instructions, and significantly more cue–target mispairings than read subjects given cue–target processing instructions, consistent with our assumption that the need to perform the generation task renders generate subjects inflexible with regard to the type of processing in which they can engage during study. That is, subjects required to generate targets must focus on the type of information needed to generate targets, which, in the present experiments, was target–target or whole-list relational information.

GENERAL DISCUSSION

Present Results

The present research provides new as well as corroborative evidence for the multifactor transfer-appropriate processing framework, as originally proposed in deWinstanley et al. (1996) and as further elaborated in the present paper. First, consistent with the assumption of this framework that a generation effect should only be expected when a later retention test is sensitive to the information enhanced by the generation task, a generation advantage was only observed in the present studies when the primary type of information used as the basis for solving the generation task—namely, target–target relational information—was the type of information to which the later retention test was sensitive—namely, the free-recall test of Experiment 1. Second, the pattern of results obtained across the present two experiments is consistent with what we have called the limited processing resource assumption of this framework—namely, the contention that the processing of one type of information can be, and often is, incompatible with the processing of other types of information. Accordingly, while the requirement to generate may lead to enhanced processing of the type of information used as the basis for generation, the processing of other types of information is likely to be impaired as a consequence, resulting in either costs or benefits depending on the nature of a later retention test. Consistent with this notion, when a cued-recall test was administered in Experiment 2—a test assumed to be primarily sensitive to cue–target relational information and not sensitive to target–target relational information—no generation advantage was observed.

Additional, the present results support the currently proposed difference between generating and reading as ways of encoding information. According to this view, the requirement to generate results in subjects focusing their processing efforts on whatever type of information is most helpful in guiding the solution of the generation task; whereas, when reading intact information for the purpose of remembering, subjects are more free to distribute their processing efforts across the different types of available information. Consistent with this proposed distinction, the performance of subjects required to generate did not vary as a function of the processing instructions they received, whether measured in terms of free-recall performance and category clustering as in Experiment 1 or in terms of cued-recall performance and cue–target mispairings as in Experiment 2. In contrast, the performance of subjects reading intact information did vary in relation to the processing instructions given, with better performance being obtained when the retention test was consistent with processing instructions. Furthermore, when, in Experiment 1, both read and generate subjects were led to focus their processing efforts on the type of information to which the later retention test was primarily sensitive—the read subjects by instruction and the generate subjects by the nature of the generation task—the generation advantage observed in the other two instruction conditions was eliminated. Similarly, when, in Experiment 2, read subjects were led to focus their processing efforts on the type of information to which the later retention test was sensitive, but generate subjects were constrained by the nature of the generation task to continue focusing on the processing of target–target relational information, a marginally significant read advantage was observed.

Previously Reported Results

In addition to the present results and those reported by deWinstanley et al. (1996), results supporting the proposed multifactor transfer-appropriate processing framework can also be found in a variety of other studies reported in the literature. Not surprisingly, all findings previously interpreted as supportive of two-factor, three-factor, or multifactor theories of generation effects (e.g. Burns 1990; Hirshman & Bjork, 1988; McDaniel, Riegler, & Waddill, 1990; McDaniel et al., 1988) can also be interpreted as supportive of the present framework, given that it was built on those previous accounts. More specifically, however, support can also be found in earlier findings for what we have called the limited processing resource assumption of the present framework—that is, the contention that the focusing of processing efforts on one type of information—while enhancing the processing of that information—can be, and often is, incompatible with the processing of other types of information leading to costs or benefits, depending on the nature of a later retention test.

Consider, for example, the findings that Hirshman and Bjork (1988) originally regarded as a puzzling outcome of their research. (See also Hirshman, 1988; and Hirshman, Whelley, & Palij, 1989, for a discussion of these findings.) Across four experiments, Hirshman and Bjork found a dissociation between free-recall and cued-recall tests for cue–target pairs in which the targets were first associates versus third associates of their cues: cued recall of first-associate targets exceeded cued recall of third-associate targets, whereas the reverse was true for free recall. Although interpreting this interaction as indicating that the effect of generation on response activation (target-specific information in the present framework) was greater for third associates than first associates, whereas the effect of generation on stimulus–response association (cue–target relational information) was equal for the two types of associates, they arrived at this interpretation in a post hoc manner— having initially assumed that the effect of generation would be to strengthen both types of information more for third associates than for first associates.

In contrast, the present framework would predict such an outcome as follows: for the purpose of generating the appropriate target, the cue–target relationship would not be as sufficient for third associates as for first. For first-associate targets, the cue–target relationship would be likely to produce the response with only minor processing of the actual fragment. For third-associate targets, however, the less strong relationship between cue and target would force subjects to focus more attention on the processing of information provided by the fragment in order to generate the appropriate target, resulting in relatively greater target-specific processing for third associates. In a later cued-recall test— assumed to be primarily sensitive to cue–target relational information and less sensitive to target-specific information— first associates would profit both from their greater pre-experimental association strength and from the subjects' greater reliance on cue–target relational information in order to perform the generation task. In a later free-recall test— assumed to be sensitive to target-specific information as well as to target–target relational information— third associates would profit from the subjects' greater reliance on target-specific information in order to perform the generation task.

Similarly, although specifically designed to test the assumption that generation enhances cue–target relational processing as well as item-specific processing, the overall pattern of results obtained by Burns (1990) can also be interpreted in terms of this aspect of the present framework. In his study, phonemically related cue–target pairs were presented for twice the typical duration to allow ample time for post-generating and post-reading processing. Then, by manipulating the amount of categorical structure in the lists, both read and generate subjects were induced to allocate their processing resources during this extra time to the same type of information.

When minimal categorical structure was provided, both read and generate subjects were induced to spend this extra time engaged in the processing of cue–target relational information— the most salient type of information present in the list. Thus, in terms of the present framework, although the benefits of enhanced target-specific processing should remain for the generate subjects, the induced additional processing of cue–target information by the read subjects could eliminate the advantage of enhanced cue–target relational processing for the generate subjects, resulting in a generation advantage in recognition and possibly free recall, but not in cued recall—the pattern that Burns (1990), in fact, obtained. When, however, maximal categorical structure was provided, so that both read and generate subjects were induced to spend this extra time engaged in target-specific and target–target relational processing, the reverse pattern of results would be expected. Although the benefits of enhanced cue–target processing should remain for the generate subjects, the induced additional processing of target-specific and target–target processing by the read subjects could eliminate the advantage of enhanced target-specific and target–target processing for the generate subjects, resulting in a generation advantage in cued recall but possibly eliminating the generation advantage in recognition and free recall—again, the pattern that Burns, in fact, obtained.

The results obtained in the research of Nairne, Riegler, and Serra (1991) and Serra and Nairne (1993) can also be interpreted as providing support for the pattern of facilitation and impairment predicted by the present framework. Across a number of experiments, these researchers have shown dissociative effects of generation on memory for item (target-specific) and order information. For example, Nairne et al. (1991, Experiment 1) found a generation advantage in a between-list design for item information as measured by a recognition test, but a negative generation effect for order information as measured by an order-reconstruction test. Again, these types of dissociative effects of generation are consistent with the limited processing resource assumption of the present framework. According to this assumption, when processing efforts are focused on target-specific information in order to generate targets, the processing of other types of information available in the list, such as order information, can be impaired. Were it possible in the type of paradigm used by Nairne and his associates to make processing of order information congruent with or useful to the generation task, then a generation advantage for order as well as item information might well occur.

Concluding Comments

In conclusion, the present research has provided new as well as corroborative support for the multifactor transfer-appropriate processing explanation of generation effects. According to this framework, how subjects allocate their processing resources to the various types of information available in an experimental context will depend not only on whether they are required to read or to generate stimulus information, but also on variations in procedures, instructions, and materials. Subjects required to generate will be led to focus their processing efforts on the type of information most helpful in solving the generation task. In contrast, subjects reading intact information will not have their processing efforts guided by the necessity to perform a generation task and will therefore typically spread their processing efforts more or less evenly across the different types of available information. Additionally, the need to perform the generation task and, thus, to focus processing efforts on the type of information most useful for generation, renders generate subjects, as compared to read subjects, less able to modify their processing efforts in response to other factors, such as explicitly provided processing instructions.

In the present framework, then, a generation advantage should occur in those situations where the requirement to generate opportunely focuses processing resources—that is, leads to the enhanced processing by generate subjects, as compared to read subjects, of the type of information to which a later retention test is sensitive, as was observed in the pattern of results obtained in Experiment 1 for read and generate subjects given either cue–target or nonspecific processing instructions. On the other hand, generation advantages are unlikely to occur when the generation task does not focus processing efforts on the type of information to which a later test is primarily sensitive, as was observed in the results of Experiment 2. Furthermore, even when the generation task leads to focused processing of the type of information to which a later test is sensitive, a generation advantage will not necessarily be observed if read subjects have somehow also been led to focus their processing efforts on that same type of information, as was observed in the lack of a generation advantage when read subjects were explicitly given target–target processing instructions in Experiment 1. Thus, the multifactor transfer-appropriate processing framework, as previously proposed in deWinstanley et al. (1996) and further elaborated in the present paper, provides a compelling theoretical framework in which the sometimes apparently conflicting outcomes regarding the generation effect can be explained, and in which the effects of a variety of variables—in terms of producing, or failing to produce, a generation advantage—can be predicted.

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