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Process dissociation using a guided procedure

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A method for achieving process dissociation is described that places less emphasis on participants' understanding and remembering interpretations of test cues than does the standard procedure. The proposed method, called the *guided procedure*, tests memory with a sequence of two prompts, one requesting word-stem recognition, followed by another for word-stem completion. Inclusion and exclusion conditions are produced by requesting completion of recognized stems to form previously presented or new words, respectively. Estimates of automatic and conscious memory produced by the standard and the guided procedures are compared in studies modeled after Toth, Reingold, and Jacoby (1994). Although not significantly different in many aspects, the outcomes differ in ways that may reflect less reliance on a generate–recognize strategy of participants tested with the guided procedure. Additional measures of memory available only with the guided procedure are presented.

The process dissociation procedure (PDP; Jacoby, 1991, 1998) offers a means for attributing performance on a memory task to independent conscious and unconscious processes. Conscious processes are those that make use of limited capacity attentional resources and require effort, whereas automatic processes make minimal demands on attentional capacity and cannot be intentionally inhibited (Hasher & Zacks, 1979). The procedure was developed, in part, out of a concern that direct (e.g., recognition) and indirect (e.g., word-stem completion) tasks do not reflect purely conscious and unconscious processes, respectively (Toth, Reingold, & Jacoby, 1994). Rather, it appeared that automatic processes can contribute to performance of direct tasks (Johnston, Dark, & Jacoby, 1985) and conscious processes can affect performance of indirect tasks (Challis & Brodbeck, 1992).

The PDP tests memory by using inclusion and exclusion instructions. If participants have processed a single list of words, using two or more encoding tasks (e.g., Bodner, Masson, & Caldwell, 2000; Curran & Hintzman, 1995; Jacoby, 1998; Toth et al., 1994), inclusion test instructions for a word-stem task may request completing stems of old and new words to form a previously processed word or, if none can be remembered, any other word that comes to mind. Exclusion test instructions request that a stem be completed to form a word not previously presented. The purpose of the exclusion instructions is to put conscious and automatic memory processes into opposition. That is, in the exclusion condition, the probability of producing an old word is the probability that the word is not consciously remembered $(1 - C)$ but comes to mind automatically (A). If these processes are independent,

$$P_{\text{old|exclusion}} = (1 - C)A. \tag{1}$$

On the other hand, in the inclusion condition, both conscious and automatic memory processes act together to produce a previously processed word. Thus, the probability of producing an old word equals the probability that the word is consciously remembered (C) plus the probability that it is not consciously remembered $(1 - C)$ but comes to mind automatically (A):

$$P_{\text{old|inclusion}} = C + (1 - C)A. \tag{2}$$

Solving the two equations for C gives

$$C = P_{\text{old|inclusion}} - P_{\text{old|exclusion}}. \tag{3}$$

Solving for A gives

$$A = P_{\text{old|exclusion}} / (1 - C). \tag{4}$$

Although the PDP has been used to examine a number of memory-related phenomena (e.g., Hertel & Milan, 1994; LeCompte, 1995; Payne, 2001), interpretation of its results may not be straightforward. For the paradigm to produce valid estimates of C and A, a number of assumptions must be met. One important assumption is that the processes underlying C and A are independent. Curran and Hintzman (1995) have shown that correlations between C and A can produce theoretically inappropriate patterns of A estimates; in several of their experiments, longer study durations were found to produce lowered estimates of A. Jacoby (1998) has proposed that a dependence between C and A that underlies outcomes such as those reported by Curran and Hintzman can result from participants' adopting a generate–recognize strategy in the testing process, whereby stems that are completed automatically to form an old word are subsequently recognized and withheld, thereby lowering the probability of providing old words in the exclusion condition and, thus, decreasing the estimate of A.

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Two other assumptions underlying the PDP have been termed by Graf and Komatsu (1994) the *invariance of familiarity* (i.e., $A_{\text{inclusion}} = A_{\text{exclusion}}$) and the *invariance of recollection* (i.e., $C_{\text{inclusion}} = C_{\text{exclusion}}$) assumptions. Although Jacoby (1991) has provided evidence to support the invariance of familiarity assumption, Graf and Komatsu considered that evidence "sparse" (p. 120), and Komatsu, Graf, and Uttl (1995) provided evidence that they interpret as being at odds with both the invariance of familiarity (Experiment 1) and the recollection (Experiment 2) assumptions.

A problem with the PDP that Graf and Komatsu (1994) term practical, rather than theoretical, is the complexity of the test instructions that typically are provided to participants. Graf and Komatsu comment that

> such complicated instructions are difficult to understand and remember by anyone...but especially by young children, older adults and amnesic patients....To the extent that the instructions are not clearly and equally understood or remembered, the PDP does not yield interpretable data. (p. 120)

In support of this possibility, Curran and Hintzman (1995), using college students as participants, found that 15% (Experiment 4) did not properly follow test instructions. Curran and Hintzman found it advantageous to administer the PDP to participants individually (Experiment 5) so that clarification of the test instructions could be provided by the experimenter when requested.

Alternative methods for implementing process dissociation have been suggested (e.g., Curran & Hintzman, 1995; Yonelinas, 1994). Curran and Hintzman (Experiment 2) tested participants with a list of stems of old and new words for which the participants were to provide, in column 1 of the response sheet, a word that was definitely on the study list and, in column 2, a word that had not been presented. The C component was measured directly from the proportion of old word stems that were completed correctly to form an old word in column 1; the A component was based on stems completed to form old words in column 2, using the standard Equation 4. As Curran and Hintzman pointed out, however, a drawback of their method is that it "violates the spirit" (p. 539) underlying the PDP, in that responses listed in column 1 are assumed to reflect only the C, and not the A, memory component.

One purpose of the research reported here was to describe an alternate means of implementing process dissociation that is not as dependent on understanding and following a set of test instructions as is the standard procedure. Motivating development of the alternate procedure was an interest in testing the memory of patients diagnosed with dissociative identity disorder for information encountered in mutually amnesic personality states. It is important, under these circumstances, to have each personality properly understand and follow test instructions. The test procedure that will be described and evaluated here is termed the *guided PDP*, because on each test trial the participant is guided to respond, using a sequence of two questions. The first question presents a word stem and asks whether the stem is reminiscent of a word encountered in a previous study list. The second question depends both on the test condition (inclusion or exclusion) and on the participant's response to the first question. In the inclusion test condition, participants who indicate that they recognize the stem are asked to provide the completed word; participants who indicate that they do not recognize the stem are asked to provide the first word that the stem brings to mind. In the exclusion test condition, participants who signal that they recognize the stem are asked to provide another word; participants who do not recognize the stem are asked to provide the first word that the stem brings to mind. Figure 1 illustrates these different sequences of questions. From the proportions of old words provided, the C and A components are calculated, using Equations 3 and 4.

One advantage of the guided procedure is that, unlike the standard procedure, it does not require understanding and remembering how to use the NEW and OLD cues that accompany each test stem. As a result, the guided procedure may be more suitable for memory-impaired participants or for unimpaired participants who do not properly attend to test instructions. A second advantage of the guided procedure is that it minimizes the influence of a generate–recognize strategy (Jacoby, 1998; Jacoby, Toth, & Yonelinas, 1993; Reingold & Toth, 1996), by which a test stem can be used to automatically generate a word that is then subjected to a recognition check. Because a word that is initially completed automatically to form a studied word can simultaneously or subsequently elicit awareness of its prior occurrence, a process Richardson-Klavehn, Gardiner, and Java (1994, 1996) call *involuntary conscious memory*, use of the generate–recognize strategy can undermine the independence of the C and A processes assumed in the PDP. The guided procedure minimizes the influence of the generate–recognize strategy first by utilizing instructions for stem recognition that emphasize a direct retrieval strategy—that is, participants are told that before attempting to complete a stem they must decide whether the stem reminds them of a previously rated word—and second by delaying the inclusion/exclusion test prompt and word generation process until after a recognition decision has been made, so that automatically generated words that are subsequently recognized will not be withheld in the exclusion condition (see Figure 1).

A third advantage of the guided procedure is that, by delaying the prompts that introduce a distinction between the inclusion and the exclusion test conditions, it helps to meet the invariance of retrieval and familiarity assumptions during word-stem recognition. Finally, the guided procedure allows calculation of additional measures of memory performance that the standard procedure does not. As will be illustrated in the experiments reported here, these include conventional measures of word-stem recognition and proportion of stem completions in the in-

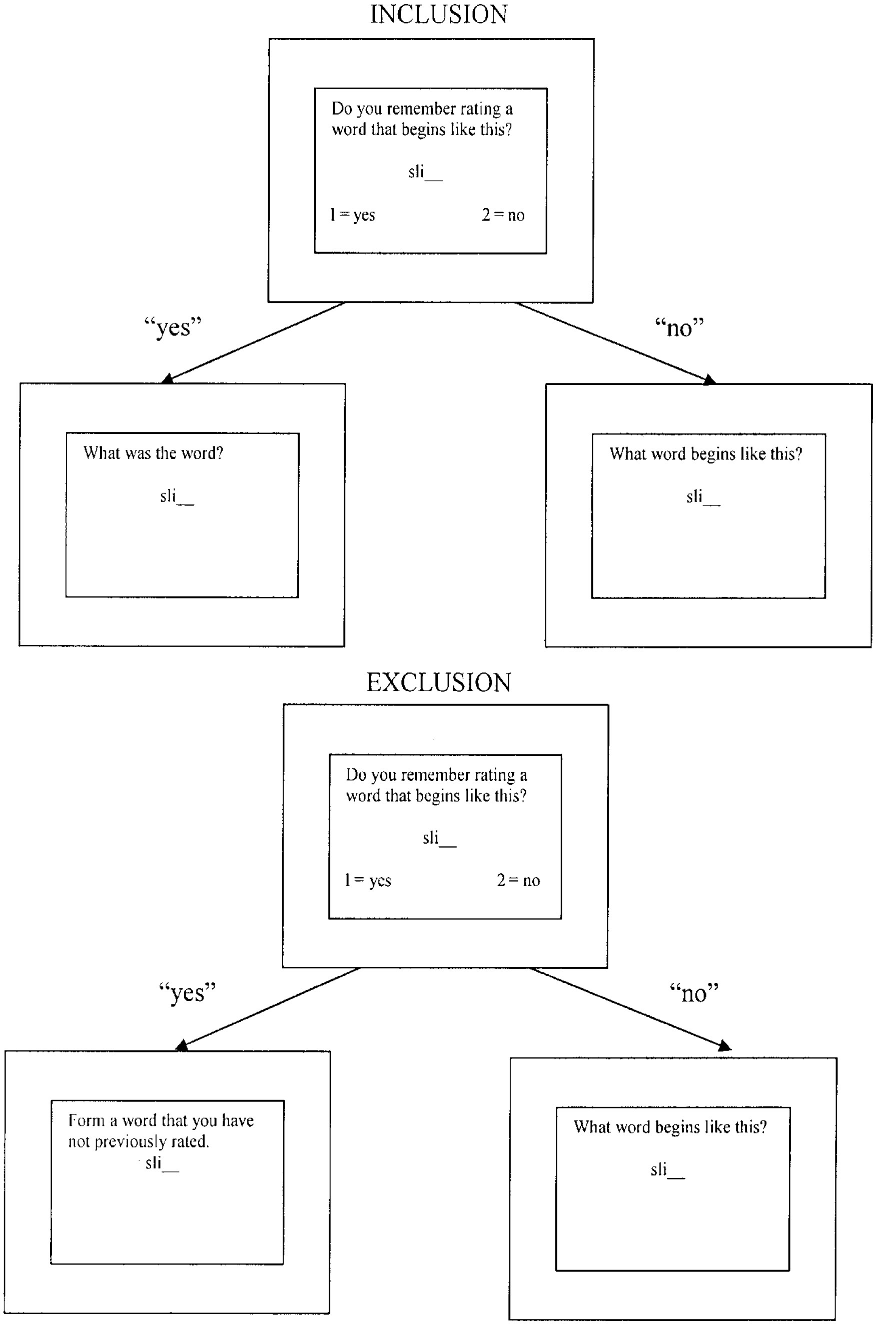

Figure 1. Sequence of prompts used in the guided procedure to implement inclusion (top) and exclusion (bottom) test conditions.

clusion and the exclusion conditions contingent on stem recognition response (see Experiments 1B and 2).

The research reported here compares the outcome of the guided PDP with that of the standard PDP, using experiments modeled after those of Toth et al. (1994). In their Experiment 1, Toth et al. had participants process words semantically or nonsemantically and then perform a word-stem completion task under standard inclusion and exclusion instructions. They found a levels-of-processing effect for the *C* component, but not for the *A* component (see the bottom panel of Table 1). In our Experiments 1A and 1B, the guided procedure was expected to reveal a similar pattern of estimates of *C* and *A*. However, to the extent that the guided procedure reduces use of a generate–recognize strategy, proportion of completions that form old words in the exclusion condition should exceed that

Table 1
Experiments 1A and 1B: Mean Proportions of Stems Completed to Form Critical Words, *C* Component, and *A* Component as a Function of Instruction Condition, Test Condition, and Study List Processing

Experiment	Instruction Condition	Test Condition/ Component	Study List Processing		
			Semantic	Nonsemantic	New
1A	standard (*n* = 60)	inclusion	.60	.48	.26
		exclusion	.33	.48	.31
		C	.27	.00	
		A	.44	.48	
	guided (*n* = 60)	inclusion	.64	.52	.31
		exclusion	.41	.45	.29
		C	.23	.06	
		A	.50	.47	
1B	standard (*n* = 27)	inclusion	.59	.43	.27
		exclusion	.30	.47	.32
		C	.29	−.04	
		A	.34 (.44)	.45 (.43)	
	guided (*n* = 26)	inclusion	.64	.48	.33
		exclusion	.41	.45	.31
		C	.23	.04	
		A	.51 (.58)	.46 (.48)	
Toth, Reingold, & Jacoby (1994)	standard	inclusion	.60	.47	.29
		exclusion	.33	.43	.26
		C	.27	.03	
		A	.42	.45	

Note—Numbers in parentheses were calculated after removing participants with exclusion scores of zero.

produced with standard instructions. It is worth noting that because Richardson-Klavehn, Gardiner, and Ramponi (2002) had difficulty replicating Toth et al.'s results (exclusion performance for deeply processed words was generally found to be below baseline, and level of processing affected *A*), our data are relevant not just to the merits of the guided procedure, but also to the replicability of Toth et al.'s findings as well.

EXPERIMENT 1A

Method

Participants. One hundred twenty-two volunteer undergraduate students at Eastern Washington University participated in the experiment for extra credit in a class. The participants were assigned randomly and in equal numbers to a standard or a guided instruction condition. The data of 2 participants, 1 from each instruction condition, were discarded, one due to experimenter error in recording data and one for failure of the participant to properly follow instructions.

Design. Instruction condition was a between-subjects variable that had two levels: a standard instruction condition in which the prompts OLD and NEW signaled how test stems were to be completed in the inclusion and the exclusion conditions, respectively, and a guided instruction condition that utilized the test procedure outlined in Figure 1. Test condition (inclusion or exclusion) was a within-subjects variable, as was study list processing (semantic, nonsemantic, or new).

Materials. From a master list of 80 five-letter words taken from Jacoby (1998), eight 10-word lists were prepared by random assignment. Each list was assigned to one of eight conditions formed by factorially combining the variables just described. The lists were rotated in the experiment to serve equally often in each of these eight conditions. Sixteen additional five-letter words served as buffer items in study lists.

Study lists consisted of four 10-word sets, each preceded and followed by 2 buffer words. The test list consisted of word stems formed by removing the last two letters from each of the 80 words in the master list. The stems of all 80 words were unique.

Procedure. As in Toth et al.'s study (1994, Experiment 1), there was a study and a test phase. During study, four lists of 14 words (10 critical and 4 buffer words) were displayed for participants to process either semantically or nonsemantically. Type of processing was kept constant for all words in a study list but alternated over the four lists (e.g., Lists 1 and 3 were processed semantically; Lists 2 and 4 were processed nonsemantically), and the alternating order was counterbalanced over participants. The stimuli and instructions were presented on a PC monitor, using MEL software (Schneider, 1990).

Prior to seeing the study lists, the participants viewed instructions that informed them that four lists of words would be displayed and either that all words in a list should be rated for pleasantness on a scale of 1–5 (where 1 = *extremely pleasant* and 5 = *extremely unpleasant*) or that the number of ascending or descending letters should be counted. The encoding task was specified by a prompt displayed several lines above each study word. The study words were displayed one at a time in lowercase letters centered on the screen until the participants pressed a response key to signal a judgment. Within each list, presentation order of critical words was random. For the ascending/descending letter-counting task, the computer beeped whenever the participant's response was incorrect. The feedback on letter-counting trials was intended to motivate the participants to carefully scan all the letters in each word; pilot testing had revealed to the experimenters that, without the feedback, participants exhibited undue confidence in their letter-counting performance and responding was noticeably faster than on pleasantness judgment trials. The participants used the number keys on a keyboard to signal each response. Pressing a key triggered presentation of the next study stimulus.

After the study phase, the participants in both instruction conditions read test instructions on the PC monitor. Because the intent of the study was to compare the outcomes of the standard and the guided instructions, it was important that standard instructions were no less understandable than guided instructions. Pilot testing was used to prepare comprehensible instructions for the standard instruction condition (see the Appendix). These instructions informed the participants that they should use the computer keyboard to type two letters to complete each test stem to form a previously presented word when the test cue was OLD and a word not previously presented when the cue was NEW. In the guided instruction condition, the participants were told that, for each test stem, they would first be prompted to decide whether they remembered having previously evaluated a word that began with the three letters shown on the screen and to signal their decision by pressing a 1 or a 2 key on the keyboard. Next, if the stem did not remind them of a previously presented word, they would be asked to type two letters to form the first word that came to mind; if the stem was recognized, they could be asked to type in letters either to form the word they recognized or to form a different word. The participants in both instruction conditions were informed that each stem completion had to be made within 10 sec. The participants in the guided instruction condition were informed that an additional 10 sec was allowed for their prior recognition decision to each stem. A recognition response not made within that time was treated as a decision that the stem had not been recognized.

The test stems were displayed in lowercase letters centered horizontally on the PC monitor, with response prompts centered three lines above the stem. For the guided instruction condition, the first prompt in the test sequence was, “Do you remember rating a word that begins like this?” and six lines below the stem was the reminder about the meaning of the response keys, “1 = yes 2 = no.” The second prompt for the guided instruction condition was one of the following: “What was the word?” “Form a word that you have NOT previously rated,” or “What word begins like this?” For the standard instruction condition, the prompts were the words OLD or NEW centered horizontally three lines above the word stem. For both instruction conditions, letters typed using the keyboard replaced dashes added to the word stem, and the backspace key erased letters shown on the screen. Pressing the Enter key ended the trial. Test items were presented in a different random order for each participant.

Prior to beginning the test, each participant was asked to rate the understandability of the test instructions on a 1–7 scale, where 1 = *very easy* and 7 = *very difficult*. The experimenter then questioned the participants to ascertain that the instructions were understood. In addition, the participants were asked to verbally summarize the instructions, and the experimenter corrected any misunderstandings. After completing the test, the participants were asked to estimate the percentage of test trials on which instructions were properly followed.

Results and Discussion

The participants’ mean assessment of the ease of understanding of the test instructions in the guided (2.25) and standard (1.92) instruction conditions did not differ significantly, despite revealing a slight advantage for the standard instructions [$t(118) = 1.69, p < .10$]. Mean estimates of the percentage of test trials on which instructions were properly followed in the guided (84.33) and the standard (83.67) instruction conditions were not significantly different ($t < 1$). These findings help to ensure that differences between the outcomes of the two test instruction conditions were not due to differential comprehension of and compliance with the test instructions.

Mean proportion of word stems completed to form critical words as a function of test instruction condition (standard or guided), test condition (inclusion or exclusion), and study list processing condition (semantic, nonsemantic, or new) are shown in Table 1. The data in this table are based on participant means, as in Toth et al. (1994). To facilitate comparison with Toth et al.’s study, data produced in their Experiment 1 are shown in the bottom panel of the table. Inspection of the data from our standard instruction condition reveals results that appear to correspond closely with those of Toth et al. As in their study, mean proportion of stems completed to form old words was significantly higher in the semantic than in the nonsemantic processing condition of the inclusion test [$F(1,59) = 14.86, MS_e = 0.03, p < .01$], was significantly lower in the semantic than in the nonsemantic processing condition of the exclusion test [$F(1,59) = 17.45, MS_e = 0.04, p < .01$], and approached but did not differ significantly for new items tested in the inclusion and exclusion conditions [$F(1,59) = 3.69, MS_e = 0.02, p < .10$]. Estimates of C and A calculated from formulas described earlier revealed a levels-of-processing effect on the C component [$F(1,59) = 27.38, MS_e = 0.08, p < .01$], but not on the A component [$F(1,59) = 2.48, MS_e = 0.03, p > .10$]. Thus, unlike the results reported by Richardson-Klavehn et al. (2002), our data replicated those of Experiment 1 in Toth et al.

Corresponding analyses performed on data produced by the participants receiving guided test instructions revealed a significantly higher proportion of stems completed to form old words in the semantic than in the nonsemantic processing condition of the inclusion test condition [$F(1,59) = 15.53, MS_e = 0.03, p < .01$], but no significant difference in these proportions for the exclusion test condition ($F < 2$). The proportion of stems completed to form critical words for new items in the inclusion and the exclusion test conditions did not differ significantly ($F < 1$). As in the standard instruction condition, there was a levels-of-processing effect for the C component [$F(1,59) = 11.96, MS_e = 0.07, p < .01$], but not for the A component ($F < 1$).

To better compare performance across the two test instruction conditions, mean proportion of stems completed to form old words was analyzed as a function of study list processing (semantic or nonsemantic) and test instruction (standard or guided) separately for inclusion and exclusion test conditions. For the inclusion test condition, an analysis of variance (ANOVA) revealed a significant main effect of study list processing [$F(1,118) = 30.37, MS_e = 0.03, p < .01$] but no significant main effect of instruction condition or interaction of instruction condition and study list processing (both Fs < 2). Thus, in the inclusion test condition, both instructions produced more old words for semantically than for nonsemantically processed words. In the exclusion test condition, however, there was a significant interaction of instruction condition and study list processing [$F(1,118) = 4.63, MS_e = 0.04, p < .05$], a significant main effect of study list processing [$F(1,118) = 14.12, MS_e = 0.04, p < .01$], and no main effect of instruction condition ($F < 1$). The main effect of study list processing corresponds to a general tendency in both instruction conditions to produce fewer old words for semantically than for nonsemantically processed words, and the interaction derives from this tendency being more pronounced in the standard than in the guided instruction condition.

ANOVAs similar to those just described were carried out on the C and A components. For the C component, there was a significant main effect of study list processing [$F(1,118) =$

38.18, $MS_e = 0.08, p < .01$], no significant main effect of instruction condition, and no interaction of instruction condition and study list processing (both Fs < 1). For the A component, there were no significant main effects (both Fs < 2) and no interaction between the variables [$F(1,118) = 2.62, MS_e = 0.10, p > .10$]. These results indicate that the guided procedure produced estimates of the C and A components that did not differ significantly from those of the standard procedure.

As was noted earlier, one difference between the outcomes of the two procedures occurred in the exclusion test condition, where the guided procedure did not lead to as sizeable a reverse levels-of-processing effect as did the standard procedure. This outcome conforms to the hypothesis that participants incorporate a generate–recognize strategy in performing the stem completion task and that participants given guided test instructions use this strategy less often than do those given standard test instructions. The reason may be that, in the guided procedure, stems that are not recognized in the exclusion test condition are not prompted to be completed exclusively with a new word, thus curtailing any further possible use of a generate–recognize process.

As was previously mentioned, an advantage of the guided procedure is that it yields more conventional measures of recognition performance. Table 2 shows the proportions of word stems recognized as a function of study list processing and test condition. Because word stems in the inclusion and the exclusion test conditions were treated alike until after the participant had made a recognition response, no significant differences were expected in recognition decisions as a function of test condition, but only as a function of study list processing. An ANOVA confirmed these expectations. There was a significant effect of study list processing on proportion of stems recognized [$F(2,118) = 294.01, MS_e = 0.03, p < .01$], no significant effect of test condition, and no interaction of test condition and study list processing (both Fs < 1). Planned comparisons revealed that, in accord with a typical levels-of-processing effect, proportion of recognition differed significantly between old words processed semantically and old words processed nonsemantically [$F(1,59) = 237.80, MS_e = 0.04, p < .01$] and between old words processed nonsemantically and new words [$F(1,59) = 56.90, MS_e = 0.01, p < .01$].

Overall, the results of Experiment 1A showed that the guided procedure produced a pattern of C and A estimates similar to that produced by the standard PDP. One difference between the procedures, however, is that the guided method appears to have reduced the participants' use of a generate–recognize strategy, as evidenced by a reduced tendency in the exclusion test condition to withhold old responses to stems of semantically versus nonsemantically processed words. Experiment 1B was run to replicate these results and, in addition, to collect data from the participants in the guided instruction condition that would allow analysis of stem completion responses contingent on stem recognition response. (Due to a programming error, these data were not saved for all the participants in Experiment 1A.) Stem completion data from unrecognized stems should be informative about participants' involuntary conscious memory (Richardson-Klavehn et al., 1996), resulting from completions produced after participants signal that they do not remember previously having encountered the test stem.

EXPERIMENT 1B

Method

Fifty-four undergraduate students at Eastern Washington University served as participants and received extra credit in a class as compensation. The data of 1 participant were removed for failure to follow instructions, leaving 27 participants in the standard instruction condition and 26 in the guided instruction condition. The participants were tested individually, as in the previous experiment. The materials and procedures were identical to those in the previous experiment.

Results and Discussion

The participants' mean ratings of the ease of understanding the instructions in the standard (2.19) and the guided (2.35) instruction conditions did not differ significantly, nor did their mean rating of the percentage of test trials on which instructions were properly followed (85.19% and 83.46% in the standard and the guided instruction conditions, respectively; both ts < 1).

Table 1 includes mean proportions of word stems completed to form critical words as a function of test instruction, test condition, and study list processing in Experiment 1B. As in Experiment 1A, mean proportion of stems completed to form old words was analyzed as a function of study list processing (semantic or nonsemantic) and test instruction (standard or guided) separately for inclusion and exclusion test conditions. In the inclusion test condition, an ANOVA revealed a significant main effect of

Table 2
Experiments 1A and 1B: Proportions of Stems Judged Old as a Function of Test Condition and Study List Processing

		Study List Processing					
		Semantic		Nonsemantic		New	
Experiment	Test Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*
1A	inclusion	.62	.24	.20	.18	.10	.11
	exclusion	.64	.16	.21	.17	.10	.11
1B	inclusion	.65	.20	.28	.28	.19	.20
	exclusion	.63	.18	.26	.25	.21	.23

study list processing [$F(1,51) = 23.33$, $MS_e = 0.03$, $p < .01$] no main effect of test instruction ($F < 2$), and no interaction of study list processing and test instruction ($F < 1$). Thus, as in Experiment 1A, the participants' stem completion performance in the inclusion test did not differ significantly over instruction conditions. In the exclusion test condition, however, the interaction of instruction condition and study list processing approached significance [$F(1,51) = 3.26$, $MS_e = 0.12$, $p < .10$], the main effect of study list processing was significant [$F(1,51) = 7.44$, $MS_e = 0.28$, $p < .01$], and there was no main effect of instruction condition ($F < 1$). The main effect of study list processing corresponds to a general tendency in both instruction conditions to produce fewer old words for semantically than for nonsemantically processed words, and the marginally significant interaction derives from this tendency being more pronounced in the standard than in the guided instruction condition. Further testing of these means separately for each instruction condition revealed that the participants in the standard instruction condition completed significantly fewer stems corresponding to previously studied words in the semantic versus nonsemantic condition [$F(1,26) = 8.43$, $MS_e = 0.03$, $p < .01$] but that those in the guided condition did not ($F < 1$). As was suggested earlier, the absence of an effect of processing in the exclusion condition for the participants receiving guided test instructions may reflect reduced use of a generate–recognize strategy, due to the testing sequence utilized in the guided procedure.

An ANOVA carried out on the combined estimates of the *C* components of the participants in the two instruction conditions revealed that there was only a significant main effect of study list processing [semantic or nonsemantic; $F(1,51) = 29.80$, $MS_e = 1.80$, $p < .01$] and no significant main effect of instruction condition or interaction of instruction condition and study list processing (both *F*s < 1). A similar analysis of *A* estimates revealed that the main effect of study list processing was not significant ($F < 1$). However, the interaction of study list processing and instruction condition was significant [$F(1,51) = 4.71$, $MS_e = 0.17$, $p < .05$], as was the main effect of instruction condition [$F(1,51) = 4.05$, $MS_e = 0.20$, $p < .05$]. An unusually low value of *A* for semantically processed words produced by the participants given standard test instructions may have helped produce both of these effects. This, in turn, may have resulted from the fact that more participants in the standard instruction condition ($n = 6$) than in the guided instruction condition ($n = 3$) had exclusion scores of zero. The *A* estimates obtained by omitting the data of these participants are shown in parentheses in Table 1. An ANOVA based on these data yielded a nonsignificant interaction between study list processing and instruction condition ($F < 2$) but there was still a significant main effect of instruction condition [$F(1,42) = 5.84$, $MS_e = 0.18$, $p < .05$]. Overall, the data from the standard instruction condition replicated those of Toth et al. (1994), and the data from the guided instruction condition, although generally conforming to this same pattern, also were consistent with participants' reduced reliance on a generate–recognize strategy.

Mean proportions of word stems recognized as a function of study list processing and test condition are included in Table 2. It is unclear why the participants' false alarm rates were higher than those in Experiment 1A. Some participants may have been involved in a study conducted in another laboratory that utilized similar words. Nevertheless, as in Experiment 1A, there was a significant effect of study list processing on proportion of stems recognized [$F(2,50) = 86.60$, $MS_e = 0.03$, $p < .01$] and no significant effect of test condition or interaction of test condition and study list processing (both *F*s < 1). Planned comparisons revealed that in accord with a typical levels-of-processing effect, mean proportion of recognition differed significantly between old words processed semantically and nonsemantically [$F(1,25) = 81.42$, $MS_e = 0.04$, $p < .01$] and between old words processed nonsemantically and new words [$F(1,25) = 7.43$, $MS_e = 0.01$, $p < .025$].

Mean proportions of stems completed to form critical words as a function of study list processing and test condition, conditional on whether the stem was or was not recognized, are shown in Table 3. The data are shown in terms of both mean number of items and means of participant

Table 3
Experiment 1B: Mean Proportions of Stems Completed to Form Critical Words as a Function of Study List Processing Condition, Test Condition, and Recognition Decision

Processing Condition	Test Condition	Recognized?	No. Old No. Yes/No	Mean Participant Proportion
Semantic	inclusion	yes	5.54/6.54	.85
		no	0.88/3.46	.24
	exclusion	yes	3.31/6.27	.54
		no	0.81/3.73	.19
Nonsemantic	inclusion	yes	1.81/2.77	.69
		no	3.04/7.23	.43
	exclusion	yes	1.12/2.58	.46
		no	3.35/7.42	.41
New	inclusion	yes	1.65/3.88	.35
		no	4.88/16.12	.31
	exclusion	yes	0.85/4.31	.20
		no	5.28/15.69	.33

proportions. Of most interest were the proportions of stems that were not recognized but were completed to form critical words. An ANOVA on proportion of unrecognized stems completed to form critical words resulted in a significant main effect of study list processing [$F(2,46) = 10.12$, $MS_e = 0.52$, $p < .01$] but no significant main effect of test condition or interaction of study list processing and test condition (both Fs< 1). Because unrecognized stems in both the inclusion and the exclusion test conditions were treated alike by the participants (as is shown in Figure 1, all unrecognized stems were prompted to be completed with the first word that came to mind), additional analyses were conducted on means formed from combining inclusion and exclusion performance within each processing condition. Unexpectedly, the combined inclusion and exclusion test performance of semantically processed words ($M = .22$) was significantly lower than that of new items [$M = .33$; $F(1,24) = 4.55$, $MS_e = 0.29$, $p < .05$], forming what will be termed here a *negative priming effect*; the combined inclusion and exclusion test performance of nonsemantically processed words ($M = .43$) was significantly higher than that of new items [$F(1,24) = 7.43$, $MS_e = 0.26$, $p < .025$]. Thus, deeply processed words whose stems were not recognized were less likely to be completed to form critical items than were unstudied words; for shallowly processed words, the opposite was true. Possible reasons for the negative priming effect will be pursued in the General Discussion section.

EXPERIMENT 2

The effect of a generation versus reading task on the C and A memory components of a word-stem completion task was examined in Experiment 2. Toth et al. (1994, Experiment 2) found that generation produced a higher C component than did reading but that reading produced a higher A component than did generation. Their results correspond well with a transfer-appropriate processing view (Roediger, Weldon, & Challis, 1989) that accounts for the effects of study processing on testing in terms of degree of processing overlap. That is, because generation is primarily conceptually driven, it affects performance on explicit tests, such as free recall, and is manifested in the C component obtained from the PDP; however, reading a word is a more data-driven activity that affects implicit tasks such as word identification and word-stem completion and is manifested in the A component of the PDP.

Experiment 2 utilized a procedure modeled after Experiment 2 of Toth et al. (1994). During Phase 1, the participants read or generated words from a list of stimuli consisting of single intact words or sentences with a missing word whose first letter was shown. Testing in Phase 2 utilized either the standard PDP or the guided procedure. Study processing was expected to produce a similar pattern of effects on C and A memory components when testing used standard or guided instructions (i.e., $C_{\text{generate}} > C_{\text{read}}$, and $A_{\text{generate}} < A_{\text{read}}$). However, on the basis of the outcomes of Experiments 1A and 1B, if the guided procedure reduces use of a generate–recognize strategy, performance in the exclusion condition of the guided instruction condition should be less affected by study processing than that in the standard instruction condition. In addition, analysis of stem completions for unrecognized stems, available only in the guided instruction condition, were analyzed for the presence of a negative priming effect of words generated in Phase 1 and a positive priming effect of words read in Phase 1.

Method

Participants. Sixty-four undergraduate students at Eastern Washington University participated in the study and received extra credit in a class as compensation. The data of 4 participants were removed, 1 due to machine error, 1 for not properly following instructions, and 2 because they were not fluent in English. The participants were tested individually in sessions that lasted less than 30 min.

Design. The participants were randomly assigned to a standard or a guided instruction condition. Test condition (inclusion or exclusion) and study list processing (generate, read, or new) were within-subjects variables.

Materials. The same master list of 80 five-letter words as that used in Experiments 1A and 1B again served as critical stimuli. For each of these words, a sentence frame was constructed that was intended to function as a cue. In these sentence frames, the critical word, usually located at the end of each sentence, was represented by its first letter, followed by four underline characters. Examples are "The ducks began to q_ _ _ _" and "The drill sergeant ordered the troops to m_ _ _ _." Sentence frames ranged in length from 4 to 18 words. Four additional words served as buffer items in the study list, 2 at the beginning and 2 at the end. Two sentence frames were prepared for 2 of the buffer words, one of which was included in the first two and one in the last two items of the study list. As in the previous experiment, critical words were rotated so that they served equally often in each study list processing and test condition. Word stems for the test list again consisted of the first three letters of each critical word.

Procedure. As in the previous experiments, all study and test stimuli were presented on a computer monitor using MEL software. During the first phase of the study, the participants saw a series of 44 items, either single words or single sentence frames. Instructions that preceded the display of these stimuli notified the participants that a list of individual words or sentences containing a missing word would appear on the monitor and that, if the stimulus was a single word, they should read it aloud so the experimenter could record it and, if the stimulus was a sentence, only the missing word that was suitable for the sentence should be said aloud. The participants were told that they had up to 15 sec to provide a response and that, if they could not do so, the experimenter would provide a suitable response for them. The participants were told to press the space bar on a keyboard after completing each study trial, to initiate presentation of the next item in the list. The stimuli were presented in the same random order to all the participants, with the restriction that no more than two stimuli from the read or the generate condition were shown in succession. Single words were displayed centered horizontally on the monitor; sentence frames were shown left justified. The experimenter recorded each vocal response made by the participant and, if no response was made within approximately 10 sec, spoke the missing word aloud. The testing procedure was identical to that in the previous experiments.

Results and Discussion

The mean number of generation errors made during Phase 1 in the standard instruction condition (4.03) did not differ significantly from that in the guided instruction

Table 4
Experiment 2: Mean Proportions of Stems Completed to Form Critical Words, *C* Component, and *A* Component as a Function of Instruction Condition, Test Condition, and Study List Processing

Instruction Condition	Test Condition/ Component	Study List Processing		
		Generate	Read	New
Standard ($n = 30$)	inclusion	53	.54	.29
	exclusion	.32	.53	.34
	C	.21	−.01	
	A	.39	.53	
Guided ($n = 30$)	inclusion	.64	.66	.40
	exclusion	.41	.52	.34
	C	.22	.15	
	A	.49	.61	
Toth, Reingold, & Jacoby (1994)	inclusion	56	.61	.32
	exclusion	.21	.40	.31
	C	.34	.21	
	A	.28	.48	

condition (3.83; $t < 1$). Mean ratings of the ease of understanding the instructions in the standard (1.80) and the guided (2.24) instruction conditions also did not differ significantly [$t(57) = 1.55, p > .10$]. However, the participants' estimates of the percentage of test trials on which they properly followed instructions were significantly higher in the guided instruction condition ($M = 87.41\%$) than in the standard instruction condition [$M = 78.83\%$; $t(57) = 2.15, p < .05$]. The higher compliance estimates in the guided condition may be due to differences in the time allowed for the participants in the two instruction conditions to respond on test trials. The participants in the standard instruction condition were allowed 10 sec to complete each stem; the participants in the guided condition were allowed 10 sec to make a recognition decision and another 10 sec to complete the stem. The longer time given to the participants in the guided condition may have allowed them to complete more stems, and it may be this success that was being estimated. Subsequent analyses support this possibility (see the results of the inclusion test condition).

Mean proportions of stems completed to form critical words as a function of the experimental variables are shown in Table 4, together with the data from Toth et al.'s (1994) Experiment 2, shown in the bottom panel. For the inclusion test condition, an ANOVA performed on the combined data of the standard and the guided instruction conditions revealed that, as in Toth et al.'s study, the mean proportion of stems completed to form critical words did not differ for words that were generated or read in Phase 1 ($F < 1$); furthermore, because the interaction of test and instruction condition was not significant ($F < 1$), the participants from both instruction conditions were similarly affected by study list processing. However, a significant main effect of instruction condition [$F(1,58) = 9.60$, $MS_\mathrm{e} = 0.05, p < .01$] indicated that for previously processed words, the participants in the guided instruction condition completed significantly more test stems in forming critical words ($M = .65$) than did the participants in the standard condition ($M = .54$). As was noted earlier, this difference may be due to the participants in the guided condition having had more total time to respond to stems on each test trial than did the participants in the standard condition. Difference in processing time may also account for the higher rate of completing new stems to form critical words in the guided condition than in the standard condition [$F(1,58) = 17.03, MS_\mathrm{e} = 0.01, p < .01$].

For the exclusion test condition, an ANOVA on the combined data of the participants in the standard and the guided instruction conditions for words generated or read during Phase 1 yielded outcomes that resembled those of Toth et al. (1994). A significant main effect of study list processing indicated that, in both instruction conditions combined, stems of generated words were completed less often than stems of words that were read [$F(1,58) = 25.15, MS_\mathrm{e} = 0.01, p < .01$]. However, because the interaction between instruction condition and study list processing approached significance [$F(1,58) = 2.91, MS_\mathrm{e} = 0.03, p < .10$], the participants in the guided condition appeared not to be as affected by study list processing, as were the participants in the standard condition. The main effect of instruction condition was not significant ($F < 1$).

C and *A* estimates for the guided and the standard instruction conditions revealed patterns similar to those obtained by Toth et al. (1994). For both instruction conditions combined, generation led to higher mean *C* estimates than did reading [$F(1,58) = 9.00, MS_\mathrm{e} = 0.06, p < .01$], a pattern that did not differ significantly over instruction conditions ($F < 2$). The absence of a significant main effect of instruction [$F(1,58) = 2.29, MS_\mathrm{e} = 0.08, p > .10$] indicates that the mean *C* estimate for the guided and the standard instruction conditions was not significantly dif-

Table 5
Experiment 2: Proportions of Stems Judged Old as a Function of Test Condition and Study List Processing

	Study List Processing					
	Generate		Read		New	
Test Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*
Inclusion	.59	.22	.42	.22	.15	.17
Exclusion	.53	.19	.41	.28	.17	.20

ferent. An ANOVA performed on A estimates revealed that reading led to significantly higher means than did generation for both instruction conditions combined [$F(1,58) = 25.45$, $MS_e = 0.02$, $p < .01$] and that this pattern of effects did not differ significantly between the two instruction conditions ($F < 1$). The main effect of instruction condition approached significance [$F(1,58) = 3.38$, $MS_e = 0.07$, $p < .10$], possibly reflecting a tendency for A estimates to be higher in the guided than in the standard instruction condition, due to reduced reliance on a generate–recognize strategy by the participants in the guided test condition.

The stem recognition data available for the participants in the guided instruction condition are shown in Table 5. As was expected, there was a significant main effect of study list processing on mean proportion of stems recognized [$F(1,29) = 59.61$, $MS_e = 0.06$, $p < .01$] but no significant main effect of test condition ($F < 1$) or interaction of test condition and study list processing ($F < 2$). The absence of an effect of test condition (i.e., inclusion or exclusion) was expected, because stem recognition occurred before test stimuli were differentiated between test conditions. Planned comparisons performed on the combined inclusion and exclusion conditions revealed that the mean proportion of stems recognized of generated words differed significantly from that of words read during Phase 1 [$F(1,29) = 14.16$, $MS_e = 0.04$, $p < .01$] and that the mean proportion of stems recognized of the words read during Phase 1 differed significantly from that of new stems [$F(1,29) = 46.88$, $MS_e = 0.04$, $p < .01$].

The proportions of stems completed to form critical words, conditional on stem recognition, are shown in Table 6. Of principal interest were the proportions of not-recognized stems completed to form critical words. To determine whether there was again a negative priming effect for the deeply processed (i.e., generated) words and a positive priming effect for the shallowly processed (i.e., read) words, the mean proportion of stems not recognized but completed to form critical words in the inclusion and the exclusion test conditions of new words were separately compared with those that were generated and read during Phase 1. Analysis of the mean proportion of not-recognized stems of generated words completed to form critical words ($M = .25$) differed significantly from that of new stems [$M = .35$; $F(1,29) = 7.72$, $MS_e = 0.05$, $p < .05$]. Neither the main effect of test condition nor the interaction of study list processing and test condition was significant (both Fs < 2). For the read versus new conditions, the main effect of study condition was significant [$F(1,29) = 7.97$, $MS_e = 0.03$, $p < .01$]; again, neither the main effect of test condition nor the interaction of study list processing and test condition was significant (both Fs < 2). Thus, as in Experiment 1B, deeply processed words whose stems were not recognized were less likely than unstudied words to be completed to form critical words, whereas the opposite was true of shallowly processed words.

EXPERIMENT 3

A key finding in the experiments described here is that in the exclusion test condition the participants tested with the guided procedure exhibited a smaller reverse levels-of-processing effect than that obtained with the standard method of implementing the PDP. The interpretation is that a generate–recognize strategy contributes to producing the reverse levels-of-processing effect and that, by reducing participants' reliance on a generate–recognize strategy, the guided procedure reduces the reverse levels-of-processing effect. Experiment 3 further tested this assumption by modifying the testing procedure in a way that encouraged the participants to adopt a generate–recognize strategy. The testing procedure in Experiment 3 differed from that of the prior studies in that it included a word recognition task whenever a participant completed a stem. Thus, the participants in the guided instruction condition could make three responses on each test trial: stem recognition, stem completion, and word recognition. It was expected that the participants' knowledge that their stem recognition response would be evaluated at the end of the trial would induce them to evaluate their stem recognition response more thoroughly by generating candidate completions and verifying their old–new status. As a result,

Table 6
Experiment 2: Mean Proportions of Stems Completed to Form Critical Words as a Function of Study List Processing Condition, Test Condition, and Recognition Decision

Processing Condition	Test Condition	Recognized?	No. Old	Mean Participant Proportion
			No. Yes/No	
Generate	inclusion	yes	5.13/5.87	.88
		no	1.23/4.13	.25
	exclusion	yes	3.10/5.33	.55
		no	1.03/4.67	.24
Read	inclusion	yes	3.67/4.23	.88
		no	3.00/5.77	.46
	exclusion	yes	2.53/4.07	.60
		no	2.64/5.93	.43
New	inclusion	yes	1.40/2.93	.46
		no	6.67/17.07	.40
	exclusion	yes	1.33/3.47	.39
		no	5.37/16.53	.32

the previously found interaction of instruction condition (guided or standard) and study list processing (semantic or nonsemantic) on proportion of stems completed to form targets in the exclusion condition should disappear.

Method

Participants. Sixty-two volunteer undergraduate students at Eastern Washington University served as participants and received extra credit in a class as compensation. The data of 3 participants were removed either because they had previously participated in a similar study ($n = 2$) or because, in the judgment of the experimenter, they were not sufficiently fluent with English ($n = 1$).

Materials and Design. The experiment used the same materials and design as those in Experiments 1A and 1B. However, test instructions now included the new information, for the participants in both instruction conditions, that after completing each test stem to form a five-letter word, they would be asked to verify whether they remembered previously having rated the word that they had just formed. The participants were instructed to press the 1 key to signal *yes*, and the 2 key to signal *no*.

Procedure. The participants were assigned randomly to a standard or a guided instruction condition. As in Experiments 1A and 1B, the participants in Phase 1 processed four lists of words alternately for pleasantness or to count the number of ascending or descending letters. The memory test was presented in Phase 2. After reading instructions for the test, the participants rated the ease of understanding the test instructions. The experimenter then demonstrated possible sequences of test stimuli and prompts, using index cards, and verified that the participant completely understood the procedure. During testing, no time limit was imposed for the participants to respond on the word recognition task. As soon as the participant made an allowed response, the test trial ended.

For the guided condition, each test trial consisted of the following sequence of events: (1) presentation of a word stem in lowercase letters centered horizontally on the screen, together with the prompt "Do you remember rating a word that begins like this?" and the prompt "1 = yes 2 = no"; (2) presentation of the word stem together with a suitable prompt indicating how to complete the stem (e.g., "What was the word?" "Form a word that you have NOT previously rated," or "What word begins like this?"); and (3) if the participant typed in two letters to complete the stem, the five-letter word completed by the participant was presented together with the question "Do you remember rating this word?" and the prompt "1 = yes 2 = no."

For the standard condition, each trial consisted of this sequence: (1) presentation of a word stem in lowercase letters centered horizontally on the screen, with the words OLD or NEW centered three lines above the word stem, and (2) if the participant typed in two letters to complete the stem, presentation of the question "Do you remember rating this word?" together with the five-letter word completed by the participant and the prompt "1 = yes 2 = no." After testing was completed, the participants assessed the percentage of test trials on which they had correctly followed instructions.

Results and Discussion

Analysis of the data for ease of understanding test instructions revealed that the mean rating of participants in the guided instruction condition (3.23) differed significantly from that in the standard instruction condition [2.39; $t(57) = 2.38, p < .025$]. The higher difficulty rating signaled by the participants in the guided instruction condition may have been due to the requirement that they make a recognition decision to both the stem and the completed word, a process that may have appeared redundant and, thus, puzzling to them. Mean estimates of the percentage of test trials on which the participants in the guided (83.62%) and the standard (83.00%) instruction conditions properly followed instructions did not differ significantly ($t < 1$).

Proportions of stems completed to form target words as a function of experimental variables are shown in Table 7. Mean proportions of stems completed to form studied targets as a function of study list processing (semantic or nonsemantic) and test instruction condition (guided or standard) were analyzed separately for the inclusion and the exclusion test conditions. Of most importance for the hypothesis being investigated here was the finding that, for the exclusion test condition, there was a significant main effect of study list processing [$F(1,57) = 10.81$, $MS_e = 0.03, p < .01$] but no significant interaction of study list processing and instruction condition ($F < 1$). Thus, the participants in the two instruction conditions did not differ significantly in their tendency to complete fewer stems of semantically versus nonsemantically processed words with target words in the exclusion condition. The main effect of instruction condition on proportion of these stems completed to form target words did not differ significantly ($F < 1$).

Table 7
Experiment 3: Mean Proportions of Stems Completed to Form Critical Words, *C* Component, and *A* Component as a Function of Instruction Condition, Test Condition, and Study List Processing Condition

Experiment	Instruction Condition	Test Condition/ Component	Study List Processing		
			Semantic	Nonsemantic	New
3	standard ($n = 29$)	inclusion	.60	.34	.24
		exclusion	.31	.40	.33
		C	29	−.06	
		A	.39	.37	
	guided ($n = 30$)	inclusion	.69	.53	.33
		exclusion	.30	.41	.31
		C	.39	.12	
		A	.46	.47	
Toth, Reingold, & Jacoby (1994)	standard	inclusion	.60	.47	.29
		exclusion	.33	.43	.26
		C	.27	.03	
		A	.42	.45	

For the inclusion test condition, similar analyses revealed there was a significant main effect both of study list processing [$F(1,57) = 43.65, MS_e = 0.03, p < .01$] and of instruction condition [$F(1,57) = 14.37, MS_e = 0.03, p < .01$] but no significant interaction of the two variables [$F(1,57) = 2.17, MS_e = 0.06, p > .10$]. Thus, the participants in the guided instruction condition completed significantly more stems of previously processed words in forming target words than did the participants in the standard instruction condition, but the participants in the two instruction conditions did not differ significantly in the extent to which these completions occurred more frequently for semantically than for nonsemantically processed words. As was noted previously, the main effect of instruction condition may have been due to the fact that the participants given guided instructions were allowed 10 sec for making a recognition decision to a stem and another 10 sec for completing the stem; the participants given standard instructions were allowed only 10 sec for completing each stem.

These analyses are consistent with the idea that the word recognition task increased the tendency of the participants in the guided instruction condition to use a generate–recognize strategy, thus making their data more like those of the participants in the standard instruction condition. An unexpected outcome of the study, however, was that the participants in the standard instruction condition completed significantly fewer new stems in forming target words in the inclusion than in the exclusion test condition [$F(1,28) = 16.38, MS_e = 0.01, p < .01$]. This pattern of results, opposite to what is typically considered characteristic of a generate–recognition strategy (e.g., Jacoby, 1998; but see Bodner et al., 2000) and not found in other studies reported here, may reflect added hesitancy by the participants in the standard instruction condition to complete stems to form words that they do not have good reason to believe are old. That is, knowledge that a word recognition test will occur may have caused the participants in the standard instruction condition to attempt to complete stems cued with the word OLD more exclusively with old words than they otherwise would have. This tendency may also have contributed to the previously reported significant main effect of instruction condition on the mean proportion of stems completed to form target words in the inclusion test condition.

Analysis of mean estimates of C as a function of study list processing and instruction condition revealed a significant main effect of instruction condition [$F(1,57) = 8.50, MS_e = 0.06, p < .01$], a significant main effect of study list processing [$F(1,57) = 52.39, MS_e = 0.09, p < .01$], and no significant interaction of these variables ($F < 1$). Thus, the participants in the guided instruction condition had higher C estimates than did those in the standard instruction condition (due to the higher proportion of stems completed to form old words by the participants receiving guided test instructions in the inclusion test condition), but for the participants in both instruction conditions combined, mean C estimates were higher for semantically than for nonsemantically processed words. Similar analyses for the A estimates revealed no significant main effect of study list processing ($F < 1$) and no interaction of study list processing and instruction condition ($F < 1$); however, the main effect of instruction condition approached significance [$F(1,56) = 3.15, MS_e = 0.09, p < .10$], indicating a possible trend toward higher mean A estimates for the participants in the guided versus the standard instruction condition (again, possibly due to the higher proportion of stems completed to form old words by the participants receiving guided test instructions in the inclusion test condition; see Equation 4). It is noteworthy that, even with the additional recognition task, the pattern of A means obtained in the standard instruction condition, unlike the data reported by Richardson-Klavehn et al. (2002), replicates that of Toth et al. (1994).

The guided instruction condition allowed calculation of a number of additional measures of memory performance. Mean proportions of word stems recognized as a function of processing and test task are shown in Table 8. Planned comparisons of combined means of inclusion and exclusion test conditions within each study list processing condition revealed that the proportion of stems recognized in the semantic processing condition ($M = .60$) differed significantly from that in the nonsemantic processing condition [$M = .19$; $F(1,29) = 41.48, MS_e = 0.06, p < .01$], and the mean proportion of stems recognized in the nonsemantic condition differed significantly from that for stems of new words [$M = .13$; $F(1,29) = 7.45, MS_e = 0.01, p < .025$].

Number of stems completed to form target words as a function of processing and test task, contingent on whether the word stems were recognized, is shown in Table 9. As in the previous experiments reported here, an analysis that compared the mean proportion of unrecognized stems completed to form target words in the combined inclusion and exclusion test conditions of the semantically processed ($M = .19$) versus new items ($M = .31$) revealed a significant negative priming effect [$F(1,29) = 11.89, MS_e = 0.02, p < .01$], and a similar analysis of the nonsemantic ($M = .43$) and new items revealed a significant positive priming effect [$F(1,29) = 18.36, MS_e = 0.01, p < .001$].

GENERAL DISCUSSION

The purposes of this report were to describe a guided procedure for implementing process dissociation, designed to be easier for participants to comprehend and

Table 8
Experiment 3: Proportions of Stems Judged Old as a Function of Test Condition and Study List Processing

	Study List Processing					
	Generate		Read		New	
Test Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*
Inclusion	.64	.22	.20	.16	.14	.13
Exclusion	.55	.21	.18	.22	.11	.11

Table 9
Experiment 3: Mean Proportions of Stems Completed to Form Critical Words as a Function of Study List Processing Condition, Test Condition, and Recognition Decision

Processing Condition	Test Condition	Recognized?	No. Old No. Yes/No	Mean Participant Proportion
Semantic	inclusion	yes	5.87/6.43	.90
		no	1.00/3.57	.28
	exclusion	yes	2.45/5.50	.45
		no	0.53/4.50	.10
Nonsemantic	inclusion	yes	1.50/1.97	.61
		no	3.71/8.03	.46
	exclusion	yes	0.83/1.77	.26
		no	3.27/8.23	.40
New	inclusion	yes	1.33/2.77	.33
		no	5.17/17.20	.30
	exclusion	yes	0.70/2.27	.24
		no	5.40/17.73	.31

carry out than the standard procedure, and to compare the outcome of the guided and the standard procedures. We presented no data to support the claim that the guided procedure is more comprehensible to participants than the standard procedure. Instead, we assumed that, because the guided procedure prompts participants to respond to test stems using a sequence of two questions, each of which provides complete details of the information to be supplied, responding would be facilitated.

Estimates of *C* and *A* obtained with the guided procedure were generally found to be affected in the same way by study list processing as were estimates obtained with the standard procedure. In Experiments 1A and 1B, for both testing methods, words rated for pleasantness produced higher *C* estimates on the stem completion test than did words whose ascending and descending letters were counted; the study manipulation had no significant effect on the *A* components for both testing methods in both of these experiments. In Experiment 2, for both testing methods, words generated rather than read led to significantly higher *C* estimates and significantly lower *A* estimates. Data from the standard instruction conditions of Experiments 1A and 1B are, by themselves, noteworthy in that, unlike the data reported by Richardson-Klavehn et al. (2002), they replicated the results of Experiment 1 of Toth et al. (1994); furthermore, the outcome of the standard instruction condition in our Experiment 2, like that obtained by Reingold (1995, Experiment 4), replicated the results of Toth et al.'s Experiment 2.

The data presented here also support the claim that, as compared with the standard method, the guided procedure reduces participants' use of a generate–recognize strategy. Relevant data showed an interaction of study list processing (deep or shallow) and instruction condition (standard or guided) on proportion of stems completed, due to the fact that participants who received guided instructions exhibited smaller reverse levels-of-processing effects in the exclusion condition than did those who received standard instructions. Although the interaction was significant only in Experiment 1A, it approached significance in both Experiments 1B and 2, thus establishing a consistent pattern. Larger reverse levels-of-processing effects are characteristic of a generate–recognize strategy because, if participants who initially fail to recognize a studied word's stem generate the word during testing and subsequently recognize it and if recognition is more likely for deeply than for shallowly processed words, fewer stems of old words will be produced under exclusion testing of deeply than of shallowly processed words. Experiment 3 provided further support for the claim that the guided procedure ordinarily reduces participants' use of a generate–recognize strategy by demonstrating that a task designed to promote a generate–recognize strategy during testing eliminated differences in the reverse levels-of-processing effect of participants tested with guided and standard instructions in the exclusion test condition.

There are two mechanisms by which the guided procedure (implemented without an additional word recognition test) may reduce use of a generate–recognize strategy. First, the initial prompt in the guided procedure requests that participants make a recognition decision to a stem, thus corresponding to what Jacoby et al. (1993) termed a direct retrieval process. Jacoby (1998) has shown that data produced by the PDP differs considerably when participants are instructed to use each test stem as a cue to recall a studied word (direct retrieval), rather than as a cue to generate a complete word that is then subjected to a recognition test (generate–recognize). The guided procedure may also reduce use of a generate–recognize strategy, because it never allows unrecognized stems to be identified as an inclusion or an exclusion item. Instead, participants are prompted to complete all stems that are not recognized with a suitable word that comes to mind. Consequently, the participant has no reason to differentially withhold a word generated and recognized in the exclusion versus inclusion test condition.

Another advantage of the guided procedure is that it yields additional measures of memory unavailable with the standard procedure. One such measure is proportion of correct stem recognition. The other is the proportion of stems completed with target words conditional on stem recognition. In Experiments 1B, 2, and 3, for stems that were not recognized, these data showed an expected positive priming effect for shallowly processed words and an unexpected negative priming effect for words that had been deeply processed. Although the main point here is to illustrate that the guided procedure can yield interesting measures that would otherwise be unavailable, and not to explore the ramifications of these data, two possible reasons for this negative priming effect will be noted. First, participants may better recognize deeply rather than shallowly processed targets generated to unrecognized stems and differentially withhold them, because they realize that their previous recognition response was incorrect and they wish to properly comply with instructions. Alternatively, as Curran and Hintzman (1995) suggested, there may be an item-based correlation between the C and the A components (e.g., words that produce high C values also produce high A values), so that the pool of unrecognized stems of deeply processed words consists of items with disproportionately low A components.

What underlying processes distinguish direct retrieval from generate–recognize in the PDP? Although we do not propose a full account, we suggest that the degree to which context information is included in the retrieval cue may be critical in the distinction. Perhaps direct retrieval is engaged when participants' cues consist primarily of information about the test stem, together with information about study list context, whereas generate–recognize is initiated when cues consist primarily of information about the test stem. As Hintzman (1988) has noted, including context information in a cue can "greatly suppress the activation of traces formed in nonspecific contexts" (p. 528). Generate–recognize, by incorporating less context information in the cue, may contact traces corresponding to both experimental and nonexperimental experiences. We assume that the retrieval strategy participants adopt are ordinarily determined by the test task and any directions for carrying out the task. The guided procedure (without an added recognition test) encourages direct retrieval, because the task initially requires deciding whether the test stem corresponds to a word previously encountered in the context of the experiment; the influence of a generate–recognize strategy is minimized in the guided procedure, because when the task is to generate any suitable word from an unrecognized stem, the opportunity for a positive recognition decision to influence the estimate of the A component has passed.

In sum, the guided procedure described here produces estimates of C and A that are similar to those of the standard procedure. Its outcome differs in ways that appear to better correspond to the important underlying assumption of process independence. Because the guided procedure does not rely on participants' understanding and memory of how to interpret the NEW and OLD cues, its results may be more valid than those of the standard procedure, particularly when participants cannot be relied on to properly attend to and follow complex instructions. In addition, the guided procedure may be advantageous because it produces additional measures of memory performance unavailable with the standard procedure.

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APPENDIX

Test Instructions for the Standard Instruction Condition

You are now going to be shown a series of word cues. The cues will be the first 3 letters of 5-letter words. For example, one cue may be

sli__

You are to use this cue (we'll call it a word stem) to form an English word. Don't use plurals or proper names as completions for a word stem.

There's another requirement for completing word stems. Sometimes, you'll be asked to form a word that you were shown previously in this study. For example, suppose you previously rated the word slime for pleasantness. If you see the prompt OLD presented with the word-stem sli__ you should complete the stem to form the word slime. Whenever you see the prompt OLD and you cannot remember a suitable word from earlier in the study, complete the stem with the first 5-letter word that comes to mind. Some stems will be paired with the prompt NEW. In these cases, avoid using a word that you recall seeing earlier in the study to complete the stem. Thus, if you previously rated the word slime for pleasantness, you might complete the word-stem sli__ to form the word slice. Whenever you cannot think of a suitable new word to complete a word stem under these conditions, leave the stem blank.

In summary, you will be given word stems to complete. If the stem is paired with the prompt OLD, use a word you recall having rated for pleasantness or a word whose ascending or descending letters you counted earlier in the study. If you cannot recall a suitable word, and there will be cases where no previously presented word is suitable, complete the stem with the first word that comes to mind. If the stem is paired with the prompt NEW, don't use a word you remember rating for pleasantness or one whose ascending and descending letters you counted as a completion. Try to complete as many stems as possible. You will be given 10 seconds to complete each stem. Type your responses for each stem using the computer keyboard.

Test Instructions for the Guided Instruction Condition

You are now going to be shown a series of word cues. The cues will be the first 3 letters of 5-letter words. For example, one cue may be

sli__

You are to use this cue (we'll call it a word stem) to form an English word. Don't use plurals or proper names as completions for a word stem.

Before you complete each word stem, you will first be asked whether or not you remember previously evaluating a word that begins with the three letters. If the word stem reminds you of a word you previously rated for pleasantness, or one whose ascending or descending letters you counted, press the 1 key on your keyboard. If it does not, press the 2 key.

Next, you will be asked to type in letters that make the word stem into an English word. If you signaled you remember seeing a word that begins with the 3 letters, you might be asked to provide that word. The instructions will read, "What was the word?" Alternatively, you might be asked to form a different word that begins with those 3 letters. The instructions will read, "Form a word that you have not previously rated." Finally, if you signaled you don't remember rating a word that begins with those letters, you will be asked to form any suitable English word. The instructions will read, "What word begins like this?" Whenever you can't think of suitable letters to make the stem into a word, press the ENTER key and the next test item will be presented. You will have 10 seconds to make each response in the test sequence.

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