Memory & Cognition
1999, 27 (5), 956-961

Priming in a free association task as a function of association directionality

RENÉ ZEELENBERG
University of Amsterdam, Amsterdam, The Netherlands

RICHARD M. SHIFFRIN
Indiana University, Bloomington, Indiana

and

JEROEN G. W. RAAIJMAKERS
University of Amsterdam, Amsterdam, The Netherlands

Two experiments investigated priming in free association, a conceptual implicit memory task. The stimuli consisted of bidirectionally associated word pairs (e.g., BEACH–SAND) and unidirectionally associated word pairs that have no association from the target response back to the stimulus cue (e.g., BONE–DOG). In the study phase, target words (e.g., SAND, DOG) were presented in an incidental learning task. In the test phase, participants generated an associate to the stimulus cues (e.g., BEACH, BONE). In both experiments, priming was obtained for targets (e.g., SAND) that had an association back to the cue, but *not* for targets (e.g., DOG) for which such a backward association was absent. These results are problematic for theoretical accounts that attribute priming in free association to the strengthening of *target responses*. It is argued that priming in free association depends on the strengthening of cue–target *associations*.

In the memory literature, a distinction is made between *implicit* and *explicit* memory tasks. In typical explicit memory tasks, such as free recall or recognition, participants have to generate items that appeared on a previously presented study list or have to decide whether a test item appeared on the study list or not. An important characteristic of all explicit memory tasks is that reference is made to the preceding study episode. In an implicit memory task, on the other hand, no reference is made to the study episode. For example, in a word stem completion task, a word stem (e.g., MOU__) is presented and the participant is instructed to complete the stem with the *first* word that comes to mind. A common finding is that the stem is completed more often with the target word (e.g., MOUSE) if the target word has previously been studied than if the target word has not been studied (Graf & Mandler, 1984). Facilitation effects for studied targets have also been obtained in a wide variety of other implicit memory tasks (for a review, see Roediger & McDermott, 1993).

A further distinction that is often made in the context of the implicit–explicit distinction is that between *perceptual* memory tasks and *conceptual* memory tasks (Blaxton, 1989; Roediger, 1990). Performance in perceptual tasks relies primarily on the processing of the physical attributes of the presented stimuli. Among perceptual tasks that have been used to study *implicit* memory are perceptual identification (Jacoby & Dallas, 1981; Salasoo, Shiffrin, & Feustel, 1985), word stem completion (Graf & Mandler, 1984; Graf, Squire, & Mandler, 1984), and word fragment completion (Roediger, Weldon, Stadler, & Riegler, 1992). Performance in conceptual tasks, on the other hand, depends mainly on the processing of the meaning of the presented stimuli. Conceptual implicit memory tasks that have been used include free association (Shimamura & Squire, 1984; Weldon & Coyote, 1996), category-exemplar generation (Graf, Shimamura, & Squire, 1985; Weldon & Coyote, 1996), and general knowledge questions (Blaxton, 1989).

In the present study, we focus on one conceptual implicit memory task, *free association* (also called *word association*). In a typical implicit memory experiment investigating priming in free association, one word (e.g., SAND) of an associated word pair is presented in the study phase. In the test phase, the other word (e.g., BEACH) of the pair is presented as a cue and the participant is instructed to respond with the first word that comes to mind. Priming is defined as an increase in the probability of responding with the studied target word (e.g., SAND) relative to an unstudied baseline. The first study, to our knowledge, that obtained priming in a free association task under implicit test instructions was performed by Storms (1958). More recently, several studies have obtained priming in free as-

The research reported in this article was supported by Grant 575-56-072 of the Foundation for Behavioral and Educational Sciences of the Netherlands Organization for Scientific Research. The authors thank Diane Pecher for helpful suggestions on an earlier version of this manuscript. Correspondence should be addressed to R. Zeelenberg, Department of Psychonomics, Roetersstraat 15, 1018 WB Amsterdam, The Netherlands (e-mail: pn_zeelenberg@macmail.psy.uva.nl).

sociation with normal participants (Basden, Basden, & Gargano, 1993; Vaidya et al., 1997; Weldon & Coyote, 1996) as well as with amnesic patients (Shimamura & Squire, 1984; Vaidya, Gabrieli, Keane, & Monti, 1995). Although the priming effect in free association is by now a fairly well established finding, it is still relatively unknown *what* exactly causes an item presented in the study phase to be generated more frequently as an associate to a certain stimulus cue in the subsequent test phase. This paper aims to obtain more detailed knowledge about the mechanisms underlying priming in free association.

Broadly speaking, two classes of explanations for priming in free association can be distinguished. The first class attributes facilitation to *target response priming*. According to this explanation, the presentation of a word increases its response strength (Storms, 1958) or accessibility. The future processing of a studied word may be facilitated by lowering the threshold (see, e.g., Morton, 1969) or increasing the activation level (see, e.g., Diamond & Rozin, 1984). An important feature of this explanation is that the effect of studying a word on free association performance is located entirely at the target word. Thus, studying a target word would be expected to result in an increase of the probability of generating the target word to all cues to which it is generated without prior study. For example, presentation of the word BEACH in the study phase of an experiment will strengthen the target response BEACH. If in a subsequent test phase the stimulus cue SAND is presented in a free association task, the probability of producing BEACH will be enhanced.

A second class of explanations attributes priming to the strengthening of cue–target *associations* at the time of study. This account assumes that the presentation of a word will not only result in activation of the word itself, but also in the activation and retrieval of associated words from memory. It further assumes that information relating the presented word and the associated words retrieved from memory is stored and that this storage is *necessary* to obtain priming. This view is advocated by Humphreys, Bain, and Pike (1989). Discussing priming in free association with an extralist cue (i.e., nonstudied stimulus word), they stated, "It appears that the most likely explanation is that participants generate the associate–target pair during study, thereby creating a covert opportunity for cue–target learning" (p. 221). Thus, according to Humphreys et al., when the word SAND is presented for study, participants will think of the word BEACH and store the association BEACH–SAND in memory. On a later free association test, the probability of generating SAND to the cue BEACH will be enhanced because the association BEACH–SAND has been strengthened.

A study by Westbrook (cited in Humphreys et al., 1989) obtained some evidence supporting the explanation of Humphreys et al. In the study phase, individual words were presented under one of two instructions. With *read* instructions, participants had to silently read the presented word. With *associate* instructions, participants had to silently associate to the presented word. In the test phase, performance to a preexperimentally associated extralist cue was investigated. The results showed that the target word was produced more often to the cue if the target had been presented under *associate* instructions than if the target had been presented under *read* instructions. This result was obtained with both students and amnesic patients. This finding suggests that generating the cue to the target and thereby strengthening the cue–target association plays a role in the occurrence of the priming effect. The problem in interpreting these results as support for the theory of Humphreys et al., however, is that associating to a word requires a deeper processing than just reading a word, which renders it possible that the result was due to a levels-of-processing effect instead of strengthening the cue–target association. Using other "deep" processing tasks, Weldon and Coyote (1996) and Vaidya et al. (1997) recently obtained a levels-of-processing effect on priming in free association.[1] This suggests that the results of Westbrook might indeed have been due to the deeper processing of target words presented under *associate* instructions than under *read* instructions.

In the present study, we further tested Humphreys et al.'s (1989) explanation that priming in free association depends on the strengthening of cue–target associations. This explanation assumes that the cue–target association is strengthened because participants covertly generate the cue during the study phase upon presentation of the target. A prediction that follows from this assertion is that if generation of the test cue during the study phase is prevented, then no cue–target strengthening takes place and hence no priming should be observed. This prediction was tested in the present study by using unidirectionally associated word pairs. Unidirectionally associated word pairs are word pairs that according to free association norms are associated in only one direction. For example, according to free association norms (Nelson, McEvoy, & Schreiber, 1994), the word DOG is often produced as a response to the cue BONE, but BONE is never produced as a response to the cue DOG. Therefore, it is highly unlikely that participants will generate the cue BONE when the target DOG is presented for study. This makes it impossible to strengthen the association BONE–DOG. Thus, the account of Humphreys et al. makes the strong prediction that no priming should be observed for unidirectionally associated word pairs. The word DOG should be generated equally often to the cue BONE whether DOG was studied or not.

Explanations that attribute priming in free association to the strengthening of target responses, on the other hand, do predict priming for word pairs that do not have an association from the target response back to the stimulus cue. According to this view, the presentation of a target word results in a *general* increase in the accessibility of the word. Therefore, the presence of a backward association should not affect priming. Priming should be obtained for *any* studied target word that is associated to the cue.

EXPERIMENT 1

In Experiment 1, we investigated priming for unidirectionally associated cue–target pairs and bidirectionally associated cue–targets pairs. The target words of each pair were presented in the study phase. The question of interest was whether these words would, later in the test phase, be produced more frequently in a free association task. If Humphreys et al.'s (1989) explanation is correct, priming should be observed only for word pairs for which there is an association from the target word (e.g., SAND) back to the cue word (e.g., BEACH). No priming should be observed for targets (e.g., DOG) for which there is no association back to the cue (e.g., BONE). Explanations that attribute priming in free association to an increased response strength or accessibility of words predict priming regardless of the presence/absence of a backward association.

Method

Participants. The participants were 56 Indiana University students. They received $6 for their participation. Participants were run in groups ranging from 1 to 4.

Stimulus Materials. Materials were selected using the Nelson et al. (1994) norms. The critical stimuli consisted of 32 unidirectionally associated cue–target pairs (e.g., BONE–DOG, BEET–RED, DELIVER–MAIL, TOBACCO–SMOKE) and 32 bidirectionally associated cue–target pairs (e.g., BEACH–SAND, FUN–PARTY, JUDGE–COURT, SKY–BLUE). The two types of pairs were matched on forward association frequency (from the cue to the target) and log frequency of the target words. The mean forward association frequency was .25 (*SD* = .11) for the unidirectionally associated pairs and .24 (*SD* = .10) for the bidirectionally associated pairs. Word frequency counts were obtained from the Kučera and Francis (1967) norms. The mean log frequency per million of the target words was 1.95 (*SD* = .47) for the unidirectionally associated pairs and 1.90 (*SD* = .53) for the bidirectionally associated pairs. The mean backward association frequency (from the target to the cue) was .00 (*SD* = .00) for the unidirectionally associated pairs and .29 (*SD* = .18) for the bidirectionally associated pairs.

Twenty-eight additional words were selected to serve as fillers. In the study phase, 18 filler words were used. The remaining 10 filler words were used in the test phase. Stimulus presentation was done on IBM-compatible personal computers.

Procedure. The procedure closely followed the one used by Weldon and Coyote (1996). The experiment consisted of three phases: a study phase, a filler phase, and a test phase. Participants were told that they would participate in three small experiments and were not told that the study phase and test phase were related.

The study phase consisted of an incidental learning task in which participants gave pleasantness ratings to 50 words. A total of 18 fillers and 32 critical words were presented in the study phase. The 32 critical target words consisted of 16 response terms (e.g., SAND) from the set of bidirectionally associated word pairs and 16 response terms (e.g., DOG) from the set of unidirectionally associated pairs. Five buffer words were inserted at the beginning and the end of the list to control for recency and primacy effects. The 32 critical words together with the 8 remaining filler words were presented in the middle of the list. Four different counterbalanced lists were constructed so that across participants each word occurred equally often in the studied and nonstudied condition.

The 50 words in the study phase were presented one at a time for 5 sec on a computer screen. Participants gave pleasantness ratings to each word by typing a number between 1 (*very unpleasant*) and 5 (*very pleasant*) on the keyboard. After the first presentation of the list, the complete list was presented again in a different random order. Words were presented in a different random order to each participant.

The pleasantness rating task was followed by a filler task that lasted about 7 min. The filler task consisted of an unrelated problem-solving task. In the test phase, a free association task was given. Seventy-four words were presented one at a time on the screen, and participants were instructed to write down the first related word that came to mind. The next stimulus appeared after the participant pressed the space bar. The first 10 words in the free association task were filler words followed by the 64 critical cue words, half of which were in the studied condition and half of which were in the nonstudied condition. A different random order was presented to each participant. Instructions emphasized that participants should write down just one word, that this should be the first word that came to mind, and that they should try to do the task as quickly as possible.

Results and Discussion

Table 1 shows the results of Experiment 1. A 2 (uni- vs. bidirectional) × 2 (studied vs. nonstudied) analysis of variance (ANOVA) was performed on the percent generated target words. The main effect of pairs (uni- vs. bidirectional) was significant [$F(1,55) = 7.94$, $MS_e = 3.25$, $p < .01$]. This effect was obtained even though the baseline conditions were matched on association frequency and shows that there was some variation between association frequencies according to the norms (Nelson et al., 1994) and those obtained in this experiment, probably due to population differences. The difference in baselines is not of critical importance since each condition will be compared with its own baseline. The ANOVA also showed a significant priming effect [$F(1,55) = 11.85$, $MS_e = 2.18$, $p < .01$]. Finally, the interaction was significant [$F(1,55) = 8.80$, $MS_e = 1.83$, $p < .01$], indicating that the priming effect was larger for the bidirectionally associated word pairs than for the unidirectionally associated words. Planned comparisons showed a significant priming effect for the bidirectionally associated word pairs [$F(1,55) = 22.61$, $MS_e = 1.83$, $p < .0001$], but not for the unidirectionally associated word pairs [$F(1,55) < 1$, $MS_e = 1.83$, $p = .58$].

The results of Experiment 1 show that a priming effect was obtained only for the bidirectionally associated word pairs. For the unidirectionally associated word pairs, for which there was no association from the target back to the cue, no priming effect was obtained. These results con-

Table 1
Mean Percentage of Targets Generated in the Free Association Task of Experiments 1 and 2

	Experiment	
Condition	1	2
Unidirectional		
Studied	26.0	22.9
Nonstudied	25.1	22.2
Priming	0.9	0.7
Bidirectional		
Studied	25.1	29.0
Nonstudied	17.5	20.9
Priming	7.6	8.1

strain to a large degree the possible models that could account for priming in free association. Because of the importance of these results, we decided to run a replication with a different set of stimuli and a different student population.

EXPERIMENT 2

Method

Participants. The participants were 52 University of Amsterdam students. They received course credit or 10 Dutch guilders (about $5) for their participation.

Stimulus Materials. A new stimulus set was created using published norms (de Groot, 1980; Lauteslager, Schaap, & Schievels, 1986; van Loon-Vervoorn & Van Bekkum, 1991). The critical stimuli consisted of 30 unidirectionally associated cue–target pairs (e.g., STORK–BABY, POISON–DEATH, PROFIT–MONEY) and 30 bidirectionally associated cue–target pairs (e.g., KNIFE–SHARP, FIRE–SMOKE, WET–RAIN). A few of these pairs were (Dutch) translations of the critical (English) cue–target pairs used in Experiment 1, but most pairs were completely new. As in Experiment 1, the two types of pairs were matched on forward association frequency and log frequency of the target words. The mean forward association frequency was .20 (*SD* = .12) for the unidirectionally associated pairs and .19 (*SD* = .10) for the bidirectionally associated pairs. The log frequencies of the target words were derived from the frequency counts of the Centre for Lexical Information (CELEX) in Nijmegen, The Netherlands (Burnage, 1990). The mean log frequency per million of the response words was 1.92 (*SD* = .55) for the unidirectionally associated pairs and 1.92 (*SD* = .64) for the bidirectionally associated pairs. The mean backward association frequency was .00 (*SD* = .00) for the unidirectionally associated pairs and .39 (*SD* = .22) for the bidirectionally associated pairs. Twenty words were used as fillers in the study phase and an additional 14 words were used as fillers in the test phase.

Stimulus presentation was done on Apple LC II computers programmed in Authorware. Participants were run in groups ranging from 1 to 8. All other aspects of the method were identical to those of Experiment 1.

Results and Discussion

The results of Experiment 2 are shown in Table 1. An ANOVA revealed a significant priming effect [$F(1,51) = 8.14$, $MS_e = 2.82$, $p < .01$]. The main effect of pairs (uni- vs. bidirectional) was not significant [$F(1,51) = 1.57$, $MS_e = 4.19$, $p = .22$]. As in Experiment 1, the results show that the priming effect was larger for the bidirectionally associated pairs than for the unidirectionally associated pairs. This was confirmed by a significant interaction [$F(1,51) = 8.16$, $MS_e = 1.91$, $p < .01$]. Planned comparisons showed that the priming effect was significant for the bidirectionally associated pairs [$F(1,51) = 19.94$, $MS_e = 1.91$, $p < .0001$], but not for the unidirectionally associated pairs [$F(1,51) < 1$, $MS_e = 1.91$, $p = .67$]. In summary, Experiment 2 replicated the findings of Experiment 1, showing that the present results are robust.

GENERAL DISCUSSION

The results of the present study are very clear. Priming in free association was obtained for word pairs for which there was an association from the target (e.g., SAND) presented at study back to the cue (e.g., BEACH) presented at test. Priming was absent for targets (e.g., DOG) that did not have an association back to the cue (e.g., BONE). This counterintuitive finding is challenging for theories of implicit memory.

These results pose serious problems for theories that attribute priming in free association to *target response priming*. If response priming were responsible for the increase in probability of a certain target response to a stimulus cue, this increase should be observed regardless of the existence of an association from the target back to the cue. Any response that is associated to a stimulus cue should be generated with a higher probability in a free association task if it has been processed previously. Consider, for example, ACT* (Anderson, 1983). Although ACT* was not developed as a model of implicit memory, Anderson has argued that a unitary memory system underlies performance in both episodic and semantic memory tasks. Furthermore, ACT* has been used in the context of free association data (McNamara, 1992). In ACT* two words are associated or not, and the strength of an association is entirely determined by node strength. There are no separate strengths for nodes and associations. If two nodes A and B are associated, the strength of the association A→B is determined by the strength of node B relative to the sum of the strengths of all nodes that are associated to A. If B has been presented just prior to the free association test and we assume that the presentation of B leads to the strengthening of the B node, then B should be produced with an increased probability. This is predicted because the strength of the association A→B depends on the strength of node B, and it is this strength that determines the probability of generating the response B to the cue A. Thus, ACT* predicts priming irrespective of the presence/absence of a backward association.

The results of the present study are consistent with the hypothesis of Humphreys et al. (1989) that priming in free association is due to the strengthening of cue–target associations. Priming was obtained only for target words that had an association back to the cue that was later presented for free association in the test phase. For these targets, participants could covertly have generated the later presented test cue and thereby have strengthened the cue–target association. The strengthening of the cue–target associations would lead to an increase in the probability of generating the target to the cue in the subsequent free association test. The absence of priming for targets that had no association from the target back to the cue points to the importance of strengthening cue–target associations. For these pairs, it was highly unlikely that in the study phase participants generated the test cue upon presentation of the target, because there was no association from the presented target to the cue.

Other results reported in the literature can also be interpreted as providing evidence for the view that the strengthening of cue–target associations underlies priming in conceptual implicit memory tasks. Westbrook (cited in Humphreys et al., 1989) found larger priming effects for target words to which participants associated than for targets words that were just read by the participants. It was hypothesized that under instructions to associate to the target, participants would be more likely to generate the test cue and that this provided an opportunity of cue–target strengthening. This result seems to support the hypothesis that strengthening cue–target associations underlies priming in free association. However, as we argued earlier, the results of Westbrook might be due to a levels-of-processing effect instead of the strengthening of cue–target associations.

A study by Cabeza (1994), although not aimed at testing the present issue, also produced converging evidence supporting the explanation of Humphreys et al. (1989). Cabeza studied whether priming in free association and category-exemplar generation was affected by the type of study task. In the study phase, target words were presented in either a classification task (i.e., participants generated words under which the target could be classified) or a free association task (i.e., participants generated associates to the target). In the test phase, more priming was observed in a free association task for targets that had been presented in a free association task during the study phase than for targets that had been presented in a category classification task during the study phase. In the category-exemplar generation test, more priming was obtained for targets previously presented in a classification task than for targets previously presented in a free association task. These results are not easily explained by a levels-of-processing account. The study task manipulation had *opposite* effects on two conceptual priming tasks. If the findings were due to a levels-of-processing effect, a similar effect of study task on performance on both priming tasks would have been expected. However, the effect of study task on the amount of priming might have been mediated by the strengthening of cue–target associations. This interpretation receives support from an additional analysis in which priming was calculated conditionalized on "successful" processing at study. Successful processing in the classification task was defined as generating the category name that was later used as a cue in the category-exemplar generation test. Likewise, successful processing in the free association task was defined as generating one or more of the three cues that were later used in the free association test.[2] The analysis showed that the effect of study task on the amount of priming was present only for targets successfully processed at study and not for targets unsuccessfully processed at study. This further supports the view that generating the *cue* to the target at the time of *study* underlies the increase in probability of producing the *target* to that cue at *test*.

Rappold and Hashtroudi (1991) also obtained results that might be explained within the framework of Humphreys et al. (1989). Rappold and Hashtroudi studied the influence of organization on priming. In the study phase of their experiments, category exemplars were presented in either a blocked (e.g., SOFTBALL, SKIING, BOXING, VOLLEYBALL, POLO, HUNTING) or a random (e.g., SOFTBALL, TABLE, APPLE, BOAT, TIGER, SKIING) order. On a later category-exemplar generation task, more priming was observed for targets studied in the blocked presentation condition than for targets in the random presentation condition. A possible interpretation of the influence of study list structure on the amount of priming is that the blocked presentation condition increases the probability that participants retrieve the category name from memory because the blocked structure of the list makes it more obvious that the targets on the list can be grouped into categories. Thus, participants might be more likely to strengthen category-exemplar associations in the blocked presentation condition than in the random presentation condition.

Rappold and Hashtroudi (1991) performed one experiment that according to them argues against such an interpretation. In this experiment, they manipulated the instruction given to the participants instead of the list structure. One group of participants (the no-instructions group) was given the category names before presentation of the list and was instructed that learning the category names might improve performance. The other group of participants (the organizational instructions group) received the additional instruction that they should try to group the members of the categories. Targets were presented in random order for both groups. The results showed more priming for participants in the organizational instructions condition than for participants in the no-instructions condition. Rappold and Hashtroudi argued that it is unlikely that this difference was caused by the detection of category names and strengthening of category-exemplar associations because both groups were given the category names. However, a case can be made for the view that category-exemplar associations were strengthened more in the organizational instructions group. For instance, one way in which participants might group the members of the categories on the study list is to retrieve the category name to each presented word. The category name might then be used as a cue to retrieve the other category members on the list. If participants in the organizational instructions condition group the targets on the list in this way, they will be more likely to strengthen category-exemplar associations than participants in the no-instructions condition. Thus, it is possible that category-exemplar associations were strengthened more in the organizational instructions condition than in the no-instructions condition and that this caused the larger priming effect for the former condition.

The results of the present study clearly show that priming in free association is due to the strengthening of cue–target associations. According to the proposal of Humphreys et al. (1989), participants will think of the test cue during study of the target, creating the possibility of strengthening the cue–target associations. Whether it is necessary that participants actually think of the cue in order to strengthen the cue–target association is not entirely clear. An alternative possibility is that cue–target associations can be strengthened by the activation of shared *semantic features*. The strengthening of shared features will lead to a stronger association between the cue and the target and result in a priming effect.

It is an open question why exactly it is necessary to strengthen the cue–target association, rather than the target alone, to affect production probability. The answer will probably depend on the development of a model for the free association task. It is possible that the cue word selects a response from the lexicon, but the strengthening of the target is too weak to affect selection. Alternatively, the cue word may be used to access codes for *pairs* of words containing the cue word. Such pair codes would be strengthened only if the cue–target combination is accessed at the time of study.

In sum, the present study showed that priming in free association depends on the presence of an association from the target back to the cue. Priming is obtained if such a backward association is present, but no priming is obtained if a backward association is absent. This result is problematic for all explanations of priming in free association in terms of target response strengthening.[3] Theories such as that proposed by Humphreys et al. (1989), which attribute priming to the strengthening of the cue–target association, can account for the present results. This account also seems able to explain the results obtained in other studies on priming in free association and category-exemplar generation (Cabeza, 1994; Rappold & Hashtroudi, 1991).

REFERENCES

Anderson, J. R. (1983). A spreading activation theory of memory. *Journal of Verbal Learning & Verbal Behavior*, **22**, 261-295.

Basden, B. H., Basden, D. R., & Gargano, G. J. (1993). Directed forgetting in implicit and explicit memory tasks: A comparison of methods. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **19**, 603-616.

Blaxton, T. A. (1989). Investigating dissociations among memory measures: Support for a transfer appropriate processing framework. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **15**, 657-668.

Burnage, G. (1990). *CELEX: A guide for users*. Nijmegen: SSN.

Cabeza, R. (1994). A dissociation between two implicit conceptual tests supports the distinction between types of conceptual processing. *Psychonomic Bulletin & Review*, **1**, 505-508.

de Groot, A. M. B. (1980). *Mondelinge Woordassociatienormen: 100 woordassociaties op 460 Nederlandse zelfstandige naamwoorden* [Oral word association norms: 100 word associations to 460 Dutch nouns]. Lisse, The Netherlands: Swets & Zeitlinger.

Diamond, R., & Rozin, P. (1984). Activation of existing memories in anterograde amnesia. *Journal of Abnormal Psychology*, **93**, 98-105.

Graf, P., & Mandler, G. (1984). Activation makes words more accessible, but not necessarily more retrievable. *Journal of Verbal Learning & Verbal Behavior*, **23**, 553-568.

Graf, P., Shimamura, A. P., & Squire, L. R. (1985). Priming across modalities and priming across category levels: Extending the domain of preserved function in amnesia. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **11**, 386-396.

Graf, P., Squire, L. R., & Mandler, G. (1984). The information that amnesic patients do not forget. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **10**, 164-178.

Humphreys, M. S., Bain, J. D., & Pike, R. (1989). Different ways to cue a coherent memory system: A theory for episodic, semantic and procedural tasks. *Psychological Review*, **96**, 208-233.

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **13**, 306-340.

Kučera, H., & Francis, W. N. (1967). *Computational analysis of present-day American English*. Providence, RI: Brown University Press.

Lauteslager, M., Schaap, T., & Schievels, D. (1986). *Schriftelijke woordassociatienormen voor 549 Nederlandse zelfstandige naamwoorden* [Written word association norms for 549 Dutch nouns]. Lisse, The Netherlands: Swets & Zeitlinger.

McNamara, T. P. (1992). Theories of priming: I. Associative distance and lag. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **18**, 1173-1190.

Morton, J. (1969). Interaction of information in word recognition. *Psychological Review*, **76**, 163-178.

Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (1994). *The University of South Florida word association, rhyme and word fragment norms*. Unpublished manuscript.

Rappold, V. A., & Hashtroudi, S. (1991). Does organization improve priming? *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **17**, 103-114.

Roediger, H. L., III (1990). Implicit memory: Retention without remembering. *American Psychologist*, **45**, 1043-1056.

Roediger, H. L., III, & McDermott, K. B. (1993). Implicit memory in normal human subjects. In F. Boller & J. Grafman (Eds.), *Handbook of neuropsychology* (Vol. 8, pp. 63-131). Amsterdam: Elsevier.

Roediger, H. L., III, Weldon, M. S., Stadler, M. L., & Riegler, G. L. (1992). Direct comparison of two implicit memory tests: Word fragment and word stem completion. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **18**, 1251-1269.

Salasoo, A., Shiffrin, R. M., & Feustel, T. C. (1985). Building permanent memory codes: Codification and repetition effects in word identification. *Journal of Experimental Psychology: General*, **114**, 50-77.

Shimamura, A. P., & Squire, L. R. (1984). Paired-associate learning and priming in amnesia: A neuropsychological study. *Journal of Experimental Psychology: General*, **113**, 556-570.

Storms, L. H. (1958). Apparent backward associations: A situational effect. *Journal of Experimental Psychology*, **55**, 390-395.

Vaidya, C. J., Gabrieli, J. D. E., Keane, M. M., & Monti, L. A. (1995). Perceptual and conceptual memory processes in global amnesia. *Neuropsychology*, **9**, 580-591.

Vaidya, C. J., Gabrieli, J. D. E., Keane, M. M., Monti, L. A., Gutiérrez-Rivas, H., & Zarella, M. M. (1997). Evidence for multiple mechanisms of conceptual priming on implicit memory tests. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **23**, 1324-1343.

van Loon-Vervoorn, W. A., & Van Bekkum, I. J. (1991). *Woordassociatie lexicon* [Word association lexicon]. Lisse, The Netherlands: Swets & Zeitlinger.

Weldon, M. S., & Coyote, K. C. (1996). Failure to find the word picture superiority effect in implicit conceptual memory tests. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **22**, 670-686.

NOTES

1. Vaidya et al. (1997) obtained a significant levels-of-processing effect only for weak associations and not for strong associations.

2. A somewhat unusual procedure was used in the free association task. Three word cues were presented and participants had to generate words that were associated to two or three of the cue words. This procedure differs from that used in most studies, which typically provide only one cue word in a free association task.

3. Note that we do not claim that target representations are not strengthened in one way or another. Nor do we make the claim that, in general, priming effects in implicit memory tasks are not due to the strengthening of target words. We do claim, however, that the results of the present study show that priming in free association cannot be explained by the strengthening of the target word (i.e., a general increase in the accessibility of the target response).

(Manuscript received September 9, 1997;
revision accepted for publication November 11, 1998.)