THE QUARTERLY JOURNAL OF EXPERIMENTAL PSYCHOLOGY, 2004, *57A* (7), 1211–1231

Priming for new associations in animacy decision: Evidence for context dependency

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In four experiments we investigated the context-dependent nature of semantic memory by looking at priming effects in animacy decision for newly formed associations. The first experiment investigated whether the priming effect depended on the nature of the prior relation between the word pairs. The results showed no such effect, replicating earlier findings. Experiments 2, 3, and 4 investigated the role of context overlap between study and test. In Experiment 2 priming for new associations was found only for word pairs that had been presented in the animacy decision task during study. Experiment 3 showed that in order to obtain priming effects for new associations these associations have to be studied in a study task that is aimed at unitized processing of the word pair at a semantic level. Experiment 4 showed that processing the pairs as separate words at an orthographic level cancelled the priming effect. The results are explained by assuming that priming results from the overlap of features that are activated during both study and test.

To understand language one needs to know the meaning of words such as *coffee* and *cup* and the relations that hold between them. This type of knowledge is assumed to be stored in semantic memory, is well learned, and is retrieved automatically. An important question is to what extent semantic memory is context dependent.

Some researchers have argued that semantic knowledge is abstracted from specific learning experiences (Carr et al., 1993; Dagenbach, Carr, & Barnhardt, 1990a; Tulving, 1984; Tulving & Schacter, 1990). An experience with a concept usually involves not only the concept itself, but also the context in which the concept is encountered. Moreover, the specific instance of

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Part of Experiment 1 was done while the first author was a visiting research scholar at Emory University, Atlanta, USA, on a TALENT stipend from the Netherlands Organization for Scientific Research (NWO).We are grateful to Annemieke Smit for her help with two pilot studies, Larry Barsalou for providing his laboratory at Emory University, and Meghan Mitchell for assistance with Experiment 1. We also thank René Zeelenberg for making useful comments on an earlier version of this manuscript, and Annette de Groot, Tim McNamara, and Richard Shiffrin for useful discussions.

http://www.tandf.co.uk/journals/pp/02724987.html DOI:10.1080/02724980343000738

the concept may vary between experiences. For example, one may drink coffee from a porcelain cup at home, from a paper cup on the train, and as an espresso in a restaurant. After these experiences, what is the semantic representation of *coffee*? The representation may include all the specifics of each experience, or only the abstracted information that is shared by all experiences.

If semantic memory is abstracted from specific episodes through some kind of consolidation process, it follows that contextual information is lost. This would result in quite static representations in semantic memory that are robust to change. For example, the representation of *coffee* would be some generic form that represents the core meaning of *coffee*. Adding another *coffee* experience to memory would not change its representation, because it already contains the core meaning, and the context that distinguishes this new experience from former experiences will not be included in the representation in memory.

Another view, however, is that representations in semantic memory are flexible and context dependent (Barsalou, 1982, 1993, 1999; Pecher & Raaijmakers, 1999; Pecher, Zeelenberg, & Raaijmakers, 1998). According to this view semantic representations are context dependent and may be affected by prior experiences. The representation of concepts such as *coffee* may contain both information that is repeated in many experiences (its core meaning) and contextual information from specific instances. At any point, the activated representation of a concept may contain only a subset of all information in memory. Barsalou (1993) listed three factors that affect the accessibility of semantic features. First, the current context affects which features will be included in a representation. For example, *strong coffee* may activate different features for *coffee* than would *hot coffee*. Second, the frequency of activation for a feature will determine its accessibility. Features that are retrieved often are more available than features that are activated on few occasions. Third, recent experiences may result in a higher accessibility of the features that were relevant in that context.

Even in models that assume storage of contextual information semantic knowledge may gradually become more context independent because it is repeated in many different contexts. In that case, the "semantic" information is much stronger in memory than is the contextual information, because the semantic information is strengthened on each repetition, whereas the contextual information is stored or strengthened only in the specific context. In that case, adding context to the cue will have only a small effect on retrieval of the semantic information. If, however, new semantic information is studied repeatedly in the same context, it will still be context dependent after extensive study, because both semantic and contextual information have been strengthened on each repetition. A previous relation may not be important in this process, because the part of the association that produces the priming effect as a result of study is context dependent.

The context-dependent nature of semantic memory can be studied with the priming for new associations paradigm. In this paradigm previously unrelated word pairs (e.g., *father–flower, dog–apple*) are studied, followed by presentation of these pairs in an associative priming paradigm similar to those that are used to study priming for existing associations (e.g., *rose–flower*). The most common task that has been used is lexical decision (Carroll & Kirsner, 1982; Dagenbach, Horst, & Carr, 1990b; den Heyer, 1986; Durgunoglu & Neely, 1987; Goshen-Gottstein & Moscovitch, 1995; McKoon & Ratcliff, 1979, 1986; Pecher & Raaijmakers, 1999; Schrijnemakers & Raaijmakers, 1997; Smith, MacLeod, Bain, & Hoppe, 1989; see Zeelenberg, Pecher, & Raaijmakers, 2003, for discussion). As has been argued by some studies, the finding of priming for new associations under the same circumstances as those for existing associations indicates that the new associations have been added to semantic memory. Because the study and test contexts are experimentally controlled, this paradigm can show whether semantic information is context dependent.

One problem, however, is that it is not clear to what extent the lexical decision task requires access to semantic memory. Although priming effects are obtained for semantically associated word pairs, the lexical decision task itself does not require retrieval of semantic information. Rather, lexical decision may depend mostly on the global familiarity of orthographic information of the stimulus. This may be problematic for studies that wish to investigate new information in semantic memory. In the present study, therefore, we used the animacy decision task. In this task subjects decide whether a stimulus word refers to something animate (e.g., dog) or inanimate (e.g., hammer). Because performance in this task critically depends on the retrieval of semantic information the animacy decision task seems a better task to study semantic memory than is lexical decision.

In the present study we investigated two issues. First, if new associations are added to semantic memory, the effect of study should be larger for pairs of unrelated words (e.g., *father–flower*) than for words that already have an association in semantic memory (e.g., *rose–flower*). That is, the difference between performance to *father–flower* and performance to *rose–flower* should be larger before both are studied than after both are studied. (Note that both will benefit from study compared to a nonstudied baseline.) Learning effects usually show a negatively accelerated learning curve (e.g., Newell & Rosenbloom, 1981). As materials get better learned, less additional learning results from each study trial. The related word pairs already have a strong associative relation and should thus profit less from study than the unrelated pairs that have no relation before study. We (Pecher & Raaijmakers, 1999) observed that when both unrelated word pairs (e.g., *father–flower*) and word pairs with a preexisting relation (e.g., *rose–flower*) were studied, the effect of study did not interact with relatedness. That is, the effect of study was additive to the effect of preexisting relatedness. This finding is problematic for the view that semantic memory is context independent and thus suggests that contextual information is part of semantic representations.

A second issue is that the priming effect for new associations should transfer from one task to the other if semantic memory is context independent. However, we (Pecher & Raaijmakers, 1999) found evidence that prior context plays an important role in finding priming for new associations. In particular, we found that priming depended on the overlap between study and test task. For example, in one experiment the word pairs were presented in a lexical decision task during the study phase. During test, priming effects for new associations were observed in lexical decision, but not in perceptual identification. This would seem to pose problems for theories that assume that semantic knowledge is abstract and does not contain information about the context in which it is encountered (Dagenbach et al., 1990b; Tulving, 1983, 1984). Within such theories, one is forced to assume that the priming effects obtained for new associations are the result of a contribution from the episodic memory system.

Both issues have been studied in lexical decision (Pecher & Raaijmakers, 1999). However, there are some questions as to what extent lexical decision is a semantic memory task. Therefore, in the present study we used the animacy decision task.

In Experiment 1, we also included word pairs that were semantically similar but not associated. An important distinction in the literature is that between associative relations (as measured by free association) and relations that are defined by semantic feature overlap (Fischler, 1977; Lund, Burgess, & Atchley, 1995; Lupker, 1984; McRae, De Sa, & Seidenberg, 1997; Moss, Ostrin, Tyler, & Marslen-Wilson, 1995; Seidenberg, Waters, Sanders, & Langer, 1984; Shelton & Martin, 1992; Williams, 1996). In a pilot study using the animacy decision task we did not observe a difference in priming effects for associates and nonassociated similar words. However, when a new association is learned, the previous relation of the words may be important. In Experiment 1 we presented both types of semantically related word pairs: strong associates that were not members from the same category (e.g., *umbrella–rain*), and similar pairs that were not associated according to association norms (e.g., *pipe–tube*). Together with the unrelated word pairs subjects studied three types of pairs: associatively related, semantically similar, and unrelated word pairs. In the test phase half of each type of word pairs were recombined to form a baseline against which the effect of study could be compared. Priming for new associations is the difference between the intact (studied) pairs and the recombined pairs.

EXPERIMENT 1

Method

Participants

A total of 32 University of Amsterdam students and 32 Emory University students participated in the experiment. All Amsterdam participants were native Dutch speakers, and all Emory participants were native English speakers. They received course credit or a money reward for their participation.

Design

Animacy of the target, semantic relatedness, type of preexisting relation (association vs. similar pair), and prior study (intact vs. recombined word pairs) were all manipulated within subjects in a Latin square design. Examples of the conditions that were used are provided in Table 1.

TABLE 1
Conditions used in Experiment 1

Type of relation		*Study*	*Test*
Associates	Related–intact	nail–hammer	nail–hammer
	Related–recombined	nail–car coat–hammer	nail–hammer
	Unrelated–intact	umbrella–ship	umbrella–ship
	Unrelated–recombined	umbrella–moon harp–ship	umbrella–ship
Similar pairs	Related–intact	goose–turkey	goose–turkey
	Related–recombined	peach–turkey goose–lawyer	goose–turkey
	Unrelated–intact	tulip–turkey	tulip–turkey
	Unrelated–recombined	tulip–corn banana–turkey	tulip–turkey

Stimuli

Two sets of 40 similar word pairs and 40 associated word pairs were created. The first set consisted of Dutch word pairs to be used for the Amsterdam participants, and the second set consisted of English word pairs to be used for the Emory participants. The associatively related word pairs were selected from published free association norms (de Groot, 1980; Lauteslager, Schaap, & Schievels, 1986; Nelson, McEvoy, & Schreiber, 1994; van der Made–van Bekkum, 1973; van Loon-Vervoorn & van Bekkum, 1991). Associations were selected that were not synonyms or members of the same category (e.g., *umbrella–rain*). This was judged by two experimenters. The Dutch set of similar pairs consisted of word pairs that referred either to the same object or to different objects that have a close resemblance (e.g., *thread–string*). The English set of similar pairs consisted of pairs of words from the same category according to norms (Battig & Montague, 1969; Shapiro & Palermo, 1970). Similar pairs were selected with low associative strength. A criterion for selecting word pairs was that the words have as little overlap in meaning as possible with words from other word pairs in the set. Because the animate targets all referred to human, animal, or vegetable things it was important especially in this group to make the targets as dissimilar as possible so that for example not all vegetable things would be fruits. The mean associative strength of the associates was 55% for the Dutch set and 46% for the English set. The mean associative strength of the similar pairs was less than 1% in both sets.

For the study phase 20 pairs of the associative set and 20 pairs of the similar set were rearranged to make unrelated pairs. For the test phase half of the studied word pairs were recombined so that there were four conditions: related-intact, related-recombined, unrelated-intact, unrelated-recombined. Note that intact refers to the new association. Thus, preexisting relatedness and study condition were orthogonally manipulated. All studied pairs consisted of words that were both animate or both inanimate. Counterbalancing was achieved by creating four different lists. All words appeared once in a list. The number of animate targets and the number of inanimate targets was equal in all conditions.

For the animacy decision task an additional list of filler word pairs was created for each language. This list consisted of 40 animate-prime–inanimate-target pairs and 40 inanimate-prime–animate-target pairs. They were added to make sure that the prime could not be used to predict the response to the target. All the filler pairs were unrelated. Together, the experimental list and the filler list consisted of 160 word pairs. For each animacy combination there were 40 word pairs. An additional set of 40 unrelated word pairs was created for use during practice trials for each language. There were 10 pairs of each possible animacy combination. No word appeared more than once in the practice and experimental sets.

Procedure

For each task and each participant the order of word pairs was randomized. The experiment started with an animacy decision task with word pairs from the study list and the list of filler pairs as stimuli. This initial animacy decision task was given in order to make this experiment as similar as possible to previous studies (Pecher & Raaijmakers, 1999; Schrijnemakers & Raaijmakers, 1997). In these studies it had seemed essential that one of the tasks during the study phase was similar to the test task. After the animacy decision task the participants received a study task with instructions to generate a sentence for each word pair, followed by a cued recall task. Then they received a second study task with instructions to name similarities between the words of a pair, again followed by a cued recall task. Finally, the animacy decision task was given, this time with word pairs from the test list and the list of filler pairs as stimuli.

Stimuli were displayed on a standard PC monitor. In the animacy decision task a trial started with a warning signal (* * * * *) displayed for 500 ms. Then the prime was presented for 200 ms, followed by a blank screen for 60 ms, which was followed by the target. Thus the stimulus-onset asynchrony (SOA) was 260 ms. The warning signal, prime, and target all appeared on the same place on the screen. The target remained on the screen until the participant had made a response. Participants were instructed to respond only to the target and to decide whether it was a living or a nonliving thing by pushing a button with their right-hand index finger if the word was animate and pushing another button with their left-hand index finger if the word was inanimate. Something was considered to be animate if it was a living thing (human, animal, or plant, e.g., *father*, *dog*, *rose*), part of a living thing (e.g., *finger*), or a group of living things (e.g., *herd*). If the participant made an error, an error message (FOUT/ERROR) was displayed for 1 s below the target. Otherwise the next trial started 500 ms after the response. Before presentation of the critical trials, 40 practice trials were given. It was stressed that responses should be made as accurately as possible.

The word pairs were presented in two study tasks. In the study tasks each prime–target pair was presented for 8 s. Participants were instructed to study the word pair for a later cued recall test. In the first study task the participants were instructed to generate a sentence that contained the two words and to say this sentence aloud. In the second study task the participants were instructed to name as many similarities between prime and target as they could think of in 8 s. Each study task was followed by a cued recall task. In the cued recall task each prime was presented for 8 s, and the participant was instructed to write down the target they had studied with that prime.

For the Emory participants this procedure was slightly different. During the study task they typed their response (the sentence or the similarity) instead of saying it aloud, and the next word pair was presented as soon as the participant had finished typing. In the cued recall task the prime was presented until the participant had typed the response.

In order to assess priming effects for new associations the intact condition of each type (e.g., unrelated) of word pair was compared to the recombined condition of the same type. All words had received the same amount of study. Therefore any difference between the intact and recombined condition is the result of the new association that is formed between the two words of a pair.

Results

All analyses are based on trimmed means of correct responses. For each subject reaction times were excluded if they were more than 3 standard deviations above or below the subject's mean. Trimming resulted in removal of 1.6% of the responses from the animacy decision task before the study phase and 1.8% of the responses from the results after the study phase.

The data of the animacy decision task before the study phase are presented in Table 2. They show that there is a priming effect for related word pairs. A 2(language, Dutch vs. English) by 2 (type of relation) by 2 (relatedness) by 2 (animacy) analysis of variance (ANOVA)[1] confirmed this. The effect of relatedness was significant, $F(1, 62) = 7.80$, $p < .001$, $MSE = 7{,}867.9$. There was no interaction between type of relation and relatedness. There were no significant effects in the error data.

The data of the animacy decision task after the study phase are presented in Table 3. Note that the priming effects reflect priming due to prior study of the pair and are independent of semantic relatedness. The data show a priming effect for intact word pairs. Responses are faster for targets that are preceded by the prime that they were studied with (the intact condition) than for targets that are preceded by a target that they were not studied with (the

[1] We included the factors type of relation and animacy in this and all subsequent ANOVAs because they cause variance in the reaction times. The targets in these conditions were from different stimulus sets and, in the case of animacy, required different responses. Including these factors in the analysis reduces the amount of variance that is attributed to random error. Because the effects of these variables were not of theoretical interest we do not report the results of these tests.

TABLE 2
Reaction times in animacy decision before the study phase of Experiment 1

	Associations		*Similar pairs*	
	RT	*% error*	*RT*	*% error*
Related	709	7.8	742	9.4
Unrelated	736	8.0	759	8.6
Priming	27		17	

recombined condition). A 2 (language) by 2 (type of relation) by 2 (prior study) by 2 (relatedness) by 2 (animacy) ANOVA of the trimmed reaction time data showed that the difference between the intact and recombined condition was significant, $F(1, 62) = 27.2, p < .001, MSE = 5{,}859.3$. Thus, we obtained priming for new associations. There was a main effect of pre-existing relatedness, $F(1, 62) = 11.0, p < .01, MSE = 6{,}274.0$. None of the interactions reached significance. We were particularly interested in the interaction between relatedness and prior study. This interaction did not even approach significance, $F(1, 62) < 1$. For the associate set the effect of prior study seems to be larger for the unrelated than for the related pairs, whereas for the similar set the effect of prior study seems to be larger for the related than for the unrelated pairs. However, the three-way interaction between type of relation, prior study, and relatedness was not significant $F(1, 62) < 1$. Separate analyses for the associate and the similar set also showed no significant interaction between prior study and relatedness, both Fs < 1.

The analysis of the error data showed no significant main effect for prior study, $F(1, 62) = 2.30, p = .14, MSE = 97.8$. The interaction between relatedness and prior study was not significant, $F(1, 62) < 1$. There was a significant interaction between type of relation and prior study, $F(1, 62) = 4.78, p < .05, MSE = 118.1$. Further analyses showed that the effect of prior study was significant for the associative set, $F(1, 62) = 10.9, p < .01, MSE = 69.1$, but not for the similar set, $F(1, 62) < 1$. There was a main effect of language, $F(1, 62) = 4.27, p < .05, MSE = 398.5$. More errors were made in the Dutch set than in the English set. Finally, there was a significant main effect of relatedness, $F(1, 62) = 13.93, p < .001, MSE = 94.3$.

TABLE 3
Reaction times in animacy decision after the study phase of Experiment 1

		Associations		*Similar pairs*		*Mean*	
		RT	*% error*	*RT*	*% error*	*RT*	*% error*
Related	Intact	662	5.2	678	5.8	670	5.5
	Recombined	690	7.3	699	6.4	694	6.9
	Priming	28		21		24	
Unrelated	Intact	676	7.0	696	8.8	686	7.9
	Recombined	716	9.7	707	8.3	711	9.0
	Priming	40		11		25	

Discussion

In animacy decision there was a significant priming effect for intact word pairs compared to recombined pairs. Together with previous results on priming for new associations in lexical decision and the perceptual identification task (Pecher & Raaijmakers, 1999) we can conclude that priming for new associations is a robust finding that can be obtained under various conditions.

In Experiment 1 we did not obtain a significant interaction between previous relation and study status. We argued that according to context independent views of semantic memory such an interaction might be observed because the pairs with a previous relation already have a strong relation and should benefit less from study. However, the results show that automatic associative priming due to prior study is not different for previously related and previously unrelated pairs. A possible explanation for this lack of interaction is that the effect of study is context-dependent. The new associative information causes facilitation in responding to the target within the specific study context. This effect is independent of previous relations and is probably reduced when the experimental context is changed (Pecher & Raaijmakers, 1999; Schrijnemakers & Raaijmakers, 1997). In the next experiment this context dependency is further explored.

EXPERIMENT 2

In this experiment we investigated the influence of presenting the word pairs in the priming task before the study phase. Previous research has shown that the priming effect for new associations is sensitive to the prior context in which these associations have been studied. Pecher and Raaijmakers (1999) showed that the effect was greatly reduced if the priming task at test was different from the task at study. For example, when we used lexical decision both as a study task and as a test task, we found reliable priming for new associations in the lexical decision task but a very small and nonsignificant effect in the perceptual identification task that was used only as a test task and not as a study task. Thus, priming for new associations was found only if the word pairs had been presented in the same task during study as the one used at test. In these experiments the contextual overlap was manipulated by introducing a new task at test. In the present experiment we did not introduce a new test task, but manipulated whether individual word pairs had been presented in the animacy decision task at study. Word pairs were presented in the animacy decision task, the study task, or both. If presentation of the word pairs in the same task during study and test is important for the priming effect for new associations, then we expect a difference between the word pairs that were presented in the animacy decision task during study and those that were not.

Method

Participants

A total of 72 students of the University of Amsterdam participated in the experiment. They received course credit for their participation.

Design

The three study conditions (animacy only, paired-associate study task only, animacy and study task), relatedness (related and unrelated), and prior study (intact and recombined) were all manipulated within subjects. Examples are provided in Table 4.

Materials

A set of 120 word pairs was created. Of these, 60 word pairs were associated according to norms; another 60 were unrelated. These word pairs were divided in three groups, one group for each study condition. Each group consisted of 20 associates and 20 unrelated word pairs. A total of 10 associates and 10 unrelated word pairs in each group were recombined during the study phase; the other word pairs remained intact. Six different lists were created to ensure counterbalancing of the materials across the three study conditions and two prior study (intact vs. recombined) conditions. In each condition the number of animate targets was equal to the number of inanimate targets. Another set of 120 word pairs was created to form the filler conditions. A total of 30 word pairs were related; the remaining 90 were unrelated. For all filler word pairs the animacy of prime and target differed, and in each filler condition the number of animate targets was equal to the number of inanimate targets.

TABLE 4
Conditions in Experiment 2

	Study phase		*Test phase*
Condition	*Animacy decision 1*	*Paired-associate study*	*Animacy decision 2*
	Animacy only		
Related–intact	nail–hammer	–	nail–hammer
Related–recombined	nail–car	–	nail–hammer
	coat–hammer	–	
Unrelated–intact	umbrella–ship	–	umbrella–ship
Unrelated–recombined	umbrella–moon	–	umbrella–ship
	harp–ship	–	
	Study task only		
Related–intact	–	nail–hammer	nail–hammer
Related–recombined	–	nail–car	nail–hammer
	–	coat–hammer	
Unrelated–intact	–	umbrella–ship	umbrella–ship
Unrelated–recombined	–	umbrella–moon	umbrella–ship
	–	harp–ship	
	Animacy and study		
Related–intact	nail–hammer	nail–hammer	nail–hammer
Related–recombined	nail–car	nail–car	nail–hammer
	coat–hammer	coat–hammer	
Unrelated–intact	umbrella–ship	umbrella–ship	umbrella–ship
Unrelated–recombined	umbrella–moon	umbrella–moon	umbrella–ship
	harp–ship	harp–ship	

Procedure

The procedure was identical to that of Experiment 1, with the exception that not all word pairs were presented in both animacy decision and the paired-associate study tasks. One set of 40 word pairs was presented in the animacy decision task before the paired-associate study tasks, but not in the paired-associate study tasks and cued recall tests. This set formed the *animacy only* condition. Another set of 40 word pairs was not presented in the first animacy decision task, but it was presented in the paired-associate study tasks and the cued recall tests. This set formed the *study task only* condition. The remaining 40 word pairs were presented in all tasks in the study phase. This set formed the *animacy and study task* condition. Thus, the word pairs were varied in whether they were presented in the animacy decision task during the study phase and whether they were presented in the paired-associate study tasks and cued recall test. In the test phase all word pairs were presented in the animacy decision task. For each condition, half of the pairs were recombined.

Results

A 3 (study condition) by 2 (prior study) by 2 (relatedness) by 2 (animacy) ANOVA was done on the trimmed means. Trimming resulted in removal of 1.4% of the reaction times. The reaction time and error data are presented in Table 5. Note that the priming effects reflect the effect of prior study and are independent of preexisting relatedness. Because the effect of relatedness did not interact with any of the other effects, the data for related and unrelated pairs were combined in Table 5.

There was no main effect of study condition, $F(2, 142) < 1$. There was a main effect of prior study; responses were faster to intact than to recombined word pairs, $F(1, 71) = 9.19$, $p < .01$, $MSE = 4{,}392.8$. The interaction between study condition and prior study approached significance, $F(2, 142) = 2.33$, $p = .10$, $MSE = 3{,}429.3$. Simple effects analyses showed that there was significant priming for the word pairs that were presented in both animacy decision and the study task during the study phase, $F(1, 71) = 10.6$, $p < .01$, $MSE = 3{,}259.8$, and for word pairs that were presented only in animacy decisions, $F(1, 71) = 4.08$, $p < .05$, $MSE = 5{,}274.0$, but not for word pairs that were presented only in the study tasks, $F(1, 71) < 1$. The analysis of the

TABLE 5
Reaction times in Experiment 2

		Related		*Unrelated*	
		RT	*% error*	*RT*	*% error*
Animacy only	Intact	587	3.7	624	4.6
	Recombined	602	2.9	634	3.1
	Priming	15		10	
Animacy + study task	Intact	584	5.1	622	6.4
	Recombined	605	5.0	632	5.1
	Priming	21		10	
Study task only	Intact	597	4.0	629	6.7
	Recombined	598	5.1	630	6.5
	Priming	1		1	

error data showed a main effect of study, $F(2, 142) = 9.12$, $p < .01$, $MSE = 93.3$. Fewer errors were made in the animacy only condition than in the other two conditions. No other effects were significant. Note that the previously related and the previously unrelated word pairs came from different sets. Therefore we cannot compare the data for these conditions directly in order to assess the priming effect for preexisting relatedness.

Thus, the reaction time data show that priming for new associations is found only for word pairs that were presented in the animacy decision task during the study phase. For word pairs that were presented only in the paired associate study task no priming effect was found. This is in accordance with our previous findings that priming for new associations is greatly reduced when it is tested in priming tasks that were not used in the study phase. The present experiment shows that prior context affects priming for specific word pairs. For each target there is some change in its representation that produces the priming effect, and this change is sensitive to context. We return to this in the General Discussion.

An interesting result from Experiment 2 is that again there is no interaction between study and relatedness, confirming our results from Experiment 1. The priming effects in Experiment 2 are smaller than those in Experiment 1. At present we have no explanation for this difference, except that responses seem both faster and more accurate in Experiment 2 than in Experiment 1. With faster responses the magnitude of the priming effects might be smaller. Most important, however, is that the pattern of results is consistent with earlier findings.

EXPERIMENT 3

In Experiment 3 we investigated what variables of the study task affect priming for new associations. In this experiment two variables are manipulated that affect the way in which the words are processed during study. First, the processing level of the study tasks was manipulated by using study tasks that focused attention on the meaning of the words (deep study tasks) or on the orthographic aspects of the words (shallow study tasks). Second, the study tasks were varied with respect to the emphasis on unitization. The unitized study tasks promoted processing of the word pair as a whole, whereas the separated study tasks promoted processing of the word pair as two separate words. Because deep and unitized processing are both assumed to be important for establishing strong semantic relations, we expect that priming for new associations will be largest in this condition.

Method

Participants

A total of 88 students of the University of Amsterdam participated in the experiment. They received course credit for their participation.

Design

In order to keep the length of the study lists within reasonable proportions, unitization (unitized/separate) was manipulated between subjects. The level of processing of the study task, the relatedness of the word pairs, and prior study were all manipulated within subjects.

Materials

A stimulus list of 80 word pairs was created. Of these, 40 word pairs were strong associates; the other 40 word pairs were unrelated. For the study phase four different lists were created so that the words could be counterbalanced across conditions. For each list 20 pairs of the associates and 20 pairs of the unrelated set were recombined. From each type of word pair, 10 were assigned to be studied in deep study tasks, and 10 were assigned to the shallow study tasks. Thus, there were 40 word pairs for each type of study task. In each condition there were 5 animate and 5 inanimate word pairs. An additional set of 80 filler word pairs was created. A total of 40 word pairs consisted of an animate prime and an inanimate target. The remaining 40 filler pairs consisted of an inanimate prime and an animate target. The fillers were used in the animacy decision task.

Procedure

At the start of the experiment the experimental word pairs and the filler word pairs were presented in the animacy decision task. The procedure for the animacy decision task was the same as the one used in Experiment 1.

After the animacy decision task the experimental word pairs were presented in the study tasks. There were four types of study task: Unitized-deep, unitized-shallow, separate-deep, and separate-shallow. For each type of study task there were three different tasks. The *unitized-deep* tasks were (1) to find a similarity between the two words of a pair, (2) to make a sentence that contained both words of a pair, and (3) to think of a profession that was related to both words. The *unitized-shallow* tasks were (1) to make a new word from letters of both words of the pair, (2) to find the letters that have an enclosed space (such as O and B, but not C and I) and to say which they have in common, and (3) to find the consonants that the words have in common. The *separate-deep* tasks were (1) to say the first property of each word that came to mind, (2) to decide which of the two words was encountered most recently (outside the experiment), and (3) to decide which word referred to the largest object. The *separate-shallow* tasks were (1) to make a new word that had no letters in common with either word from the pair, (2) to count the total number of letters with an enclosed space in the pair, and (3) to decide which of the two words came first alphabetically if they were written in reverse. In Experiments 1 and 2 the word pairs were presented in two study tasks and two cued recall tasks. In the present experiment only one cued recall task was given after the study tasks were completed (so as not to interfere with the study manipulations), and therefore an additional study task was given.

Each participant received two types of study task. The two types were either the unitized tasks or the separate tasks. Thus, unitization was manipulated between subjects, and level of processing was manipulated within subjects. Each participant performed three deep and three shallow tasks. The deep and shallow tasks were presented in alternation so that the interval between study and test for a word pair was not confounded with this variable. The type of task that was presented first was counterbalanced across subjects. At the start of each study task an explanation of the task was presented on the computer screen. Then followed presentation of the word pairs. A word pair was presented on the screen, and the participant typed the required response. The participants were allowed to take as much time as they needed to produce the response. In each task 40 word pairs were studied. In all deep tasks the same 40 word pairs were presented, and in all shallow tasks another set of 40 word pairs was presented. Thus, all 80 word pairs were studied three times, and each word pair was presented in the same level of processing on each presentation. The participants were informed that a cued recall test would follow after the study phase and were instructed to read each word pair carefully before typing their response. The participants were randomly assigned to one of the two between-subject conditions. There were 44 participants in each condition.

The cued recall test was given after all study tasks were completed. The procedure for this task was the same as that for the cued recall test in Experiment 1. After the cued recall test a second animacy decision task was given. All word pairs were presented in this task. The word pairs in the intact conditions were presented in the same combination as that in which they were studied. The word pairs in the recombined condition were recombined so that the prime and target had not been studied together as a pair. Presentation of the word pairs was the same as that in the first animacy decision task.

Results

The main data of interest are the reaction times in the animacy decision task. Prior to the analyses, the data were trimmed using the same procedure as that in the previous experiments. Trimming resulted in removal of 1.5% of the reaction times. The mean reaction times and error percentages are shown in Table 6. For each study condition we tested the difference between the intact and recombined conditions. The associative priming effect due to prior study was significant only in the deep-unitized condition, $F(1, 43) = 9.16$, $p < .01$, $MSE = 2{,}724.5$. In the other three conditions there was no significant difference, all Fs < 1. Analysis of the error data showed no significant effects.

In Experiment 1 we obtained priming for new associations. In the present experiment we found that this priming effect is sensitive to the type of study task in which the word pairs are presented. We manipulated two study task variables: unitization and levels of processing. We found that priming for new associates is obtained only if word pairs are studied in deep processing tasks that promote processing of the word pair as a unit. Both aspects are necessary, because in all other conditions there was no reliable priming effect. These results are in accordance with the results of Experiments 1 and 2 and of previous research (Pecher & Raaijmakers, 1999) in which priming was obtained after study tasks that focused on deep and unitized processing.

The effect of levels of processing on priming for new associations is consistent with the transfer-appropriate processing framework. Blaxton (1989) has shown that performance on both implicit and explicit conceptual memory tests benefited from the processing of meaning during study. Because animacy decision is a conceptual task, manipulation of the degree to

TABLE 6
Reaction times in Experiment 3

		Level			
		Deep		*Shallow*	
Study task		*RT*	*% error*	*RT*	*% error*
Unitized	Intact	592	6.1	594	5.8
	Recombined	608	6.0	596	4.8
	Priming	16		2	
Separate	Intact	621	6.3	619	6.3
	Recombined	616	6.3	621	6.1
	Priming	–5		2	

which word pairs have been processed at a conceptual level at study will affect priming effects in this task.

The effect of unitization on priming for new associations has also been observed by others (Graf & Schacter, 1989; Micco & Masson, 1991). However, these studies have used word stem completion, which is a quite different task. In word stem completion participants have to focus on perceptual features of the stimuli, whereas in animacy decision they should focus on the meaning of the stimuli. Moreover, performance in word stem completion is not under time pressure, and this leaves room for conscious processes such as explicit retrieval (Reingold & Goshen-Gottstein, 1996). In animacy decision responses are much faster, and thus the influence of explicit retrieval strategies is minimized. With the short SOA of 260 ms that we used it is unlikely that participants will have used the prime to explicitly retrieve the target from memory in order to enhance their performance.

However, there is one finding that seems contradictory. In Experiment 2 there was priming for pairs that had been presented in the animacy decision task but not in the paired associate study task during the study phase. Thus, presentation of the word pair in the animacy decision task alone was sufficient to produce a small priming effect. In the present experiment all word pairs in all conditions were presented in the animacy decision task during the study phase, but there was only priming for word pairs that were studied in study tasks that focused on deep and unitized processing. It seems that the effect of presenting the word pair in animacy decision is cancelled by later shallow or separate processing of the word pairs. Thus, to obtain priming for new associations it may be better to have no study task between the two animacy tasks than to have study tasks that focus on the wrong type of processing.

This hypothesis was tested in the next experiment. In this experiment word pairs were presented either only in animacy decision or in both animacy decision and the separate-shallow study tasks that were also used in Experiment 3. If it is the case that the effect of study in the animacy decision task is cancelled by later irrelevant processing, than we should find priming in the *animacy decision only* condition, but not in the *animacy decision plus study* condition.

EXPERIMENT 4

Method

Participants

A total of 60 students of the University of Amsterdam participated in the experiment. They received course credit for their participation.

Materials

The same materials were used as those in Experiment 3. For each list the critical word pairs that had been assigned to the deep study tasks in Experiment 3 were now assigned to the animacy decision only condition. Word pairs were counterbalanced across conditions.

Procedure

The procedure was similar to that of Experiment 3, except that only the separate-shallow study tasks were used. They were (1) to make a new word that had no letters in common with either word from the pair,

(2) to count the total number of letters with an enclosed space in the pair, and (3) to decide which of the two words came first alphabetically if they were written in reverse. All word pairs were presented in animacy decision during the study phase. Half of the word pairs were presented for study in the study tasks.

Results

The main data of interest are the reaction times in the animacy decision task. Prior to the analyses, the data were trimmed using the same procedure as that in the previous experiments. Trimming resulted in removal of 1.52% of the reaction times. The mean reaction times and error percentages are shown in Table 7. A 2 (study condition) by 2 (prior study) by 2 (relatedness) by 2 (animacy) ANOVA was done on the trimmed means. There was no main effect of study condition, $F < 1$, and a marginally significant effect of prior study, $F(1, 59) = 2.80$, $p = .10$, $MSE = 2{,}807.6$. The interaction between study condition and prior study was significant, $F(1, 59) = 4.58$, $p < .05$, $MSE = 2{,}612.0$. Simple effects showed that the difference between intact and recombined pairs was significant for the Animacy decision only condition, $F(1, 59) = 7.94$, $p < .05$, $MSE = 2{,}470.7$, but not in the Animacy decision plus study condition, $F < 1$. Analyses of the error data showed no significant effects of study condition or prior study.

Thus, these results confirm that the priming effect can be cancelled by the study task if that task focuses on the "wrong" type of processing. This again shows that new semantic information is very sensitive to context. Barsalou (1993) has argued that a semantic representation can be affected by both present and recent prior contexts. If there is no other study task than animacy decision, the only recent context is the animacy decision task (and perhaps some recent experiences outside the experiment, but for the moment we consider that negligible noise). However, if there are irrelevant study tasks, the most recent prior context is irrelevant or even harmful to processing in the animacy decision task in the test phase. During test, the interpretation of the target will be related to the study task. If that interpretation focuses on irrelevant features such as orthography, this will not enhance processing in a semantic task. Dagenbach et al. (1990b) have focused on the question of how many repetitions are necessary to form new semantic associations. They assumed that semantic memory is abstracted from specific learning episodes. However, the present results suggest that priming due to learning new associations is not a matter of the number of repetitions, but of the specific type of processing.

TABLE 7
Reaction times in Experiment 4

		Related		*Unrelated*	
		RT	*% error*	*RT*	*% error*
Animacy only	Intact	569	5.8	582	6.8
	Recombined	578	6.7	599	8.2
	Priming	9		17	
Animacy + study task	Intact	570	6.3	595	8.8
	Recombined	659	7.2	593	6.8
	Priming	–1		–2	

GENERAL DISCUSSION

The aim of the present study was to investigate what variables affect priming for new associations. In particular we investigated two issues. The first question was whether priming for studied pairs was larger for previously unrelated pairs than for previously related pairs. The second question was whether the priming effect was context independent. Our results provided negative answers to both these questions. In none of the experiments did we obtain an interaction between prior study and semantic relatedness. And in Experiments 2, 3, and 4 we obtained evidence that priming was context dependent.

The idea that semantic representations are abstract and context independent is central to multiple systems accounts of semantic memory that distinguish between an episodic system and a semantic system (e.g., Tulving, 1983, 1984). Tulving described episodic memory as context dependent and semantic memory as context independent. The animacy decision task used in the present experiments is a semantic memory task. The decision whether a word represents an animate or inanimate entity must be based on semantic information. However, the evidence shows that priming for new associations is sensitive to prior context and that the effect of study on priming does not interact with preexisting relatedness. Under the assumption of Dagenbach et al. (1990b) that priming for new associations indicates the storage of new information in semantic memory, the simplest conclusion that one may draw from the present results is that retrieval from semantic memory is context dependent rather than context independent as assumed by Tulving (1983). However, this poses a problem since context independence is the most important distinguishing characteristic of the semantic memory system.

Another version of the multiple memory systems theory has distinguished yet another memory system, the perceptual representation system (Tulving & Schacter, 1990). This system is assumed to be responsible for repetition priming or implicit memory effects. However, according to Tulving and Schacter, priming in conceptual tests (such as the animacy decision task used in the present study) is not explained by this system and thus has to be located in semantic memory. Again, the results are not compatible with the distinction between episodic and semantic memory in terms of context dependency. Therefore, the present results argue against current conceptualizations of the multiple memory systems theory.

One could argue that our results show that the studied word pairs are not stored in semantic memory but in episodic memory, and that the priming effect reflects the influence of episodic memory. This would explain why the effect does not interact with prior relation and why the effect is context dependent. However, there are two problems with that assumption. First, the animacy decision task that we used relies on retrieval of semantic information. There seems to be no a priori reason why episodic information should play a role in this task. The task is to decide whether a word refers to an animate or an inanimate entity. Whether a word pair is intact or recombined should not matter for this decision. Second, episodic memory is usually assumed to be relatively slow compared to the fast retrieval from semantic memory as observed in, for example, lexical decision and the present experiments. Therefore, one would not expect to find an influence of episodic memory in tasks where the effect of the prime on target processing is both fast and automatic. Nevertheless, we have obtained priming for new associations with short SOAs (260 ms in the present experiments, 140 ms in Pecher &

Raaijmakers, 1999) and with masked primes (Pecher & Raaijmakers, 1999). Both findings provide strong evidence that the priming effect for new associations is fast acting and that it is the result of automatic processes. This is problematic for the view that priming for new associations is the result of retrieval from episodic memory.

This is not to say that there is no possible multiple systems approach that could account for the present data. A theory that assumes that both episodic and semantic memory are context dependent may well be able to explain our results. However, rather than trying to decide whether memory should be viewed as a single system or a multiple system, what is needed is a detailed description of the mechanisms that cause memory to be context dependent. For example, a model is needed that explains how context is stored with words without making that word inaccessible in a completely different context. The theories that we have described so far do not have such detailed descriptions. Data from studies such as the present one may help to develop and constrain such models, whether they are single memory or multiple memory systems.

There is more evidence that retrieval of semantic information is context dependent. A number of studies have shown that the context in which a word is presented affects its interpretation (i.e., the representation that is activated at a certain moment; Anderson & Ortony, 1975; Anderson et al., 1976; Cabeza, 1994; Conrad, 1978; Pecher, Zeelenberg, & Raaijmakers, 1998; Vriezen, Moscovitch, & Bellos, 1995). Later processing of the same word is enhanced if the same interpretation is activated. Vriezen et al. found that priming effects for single words are sensitive to the overlap in processing between the study and test task. For example, they did not find priming in a classification task (*size decision*) if the study task also was a classification task but concerned a different semantic domain (*man-made decision*) but significant priming was obtained if the study task was also a classification task and concerned the same semantic domain (*dimension decision*). Cabeza also found that priming was affected by the degree of overlap between study and test tasks. He used two implicit conceptual memory tasks: category production and free association. More priming was observed for words that had been produced in the same task during study and test than for words that were produced in a different task at study. In addition, there is evidence that context influences which features of a word are activated. Conrad observed that priming effects for semantic properties were larger if these properties were appropriate in the context. For example after the sentence *The man tuned the piano* there was more priming for the word *string*, whereas after the sentence *The man lifted the piano* there was more priming for the word *heavy*.

Barsalou (1993) has argued that the features of concepts differ in accessibility. This accessibility determines which features are retrieved on a particular occasion. Both recency and present context affect the accessibility of features. Features that are relevant in a particular context have a higher probability of being retrieved than features that are irrelevant in that context. Likewise, features that have recently been activated have a higher probability of being retrieved than features that have not recently been activated. Pecher, Zeelenberg, and Raaijmakers (1998) have shown that prior activation of features related to an object's shape results in priming effects for words that have overlap in these features (e.g., *ball–orange*). This indicates that both recent experiences and present context determine which features of words are activated.

This assumption of varying accessibility may provide an explanation for the results of the present experiments. Possibly priming for new associations is obtained because the prime affects which features of the target are activated. Thus, for intact pairs the activated features of the target are more similar at study and test than for recombined pairs. The task in which a word pair is presented will also affect which features are activated. If the word pair has been presented in the same task during study and test, the effect of the prime on activation of features of the target during study is more relevant to the test task. In general, the more similar the study and test task are, the larger the overlap in activated features of the target between study and test, and the less similar the study and test task are, the smaller the overlap in activated features of the target between study and test. This explains why levels of processing affected priming in Experiments 3 and 4. Finally, the amount of unitization that the study task asks for will affect to what extent the prime affects activation of features of the target.

Micco and Masson (1991; see also Masson & MacLeod, 1992) have proposed a similar mechanism for priming on implicit memory tests. They propose that during study two types of process play a role: the initial interpretation of stimuli and subsequent elaboration of stimuli. Priming occurs when implicit tests rely on the same type of interpretative process as that during study, whereas explicit memory tests also rely on elaborative processing. Interpretative processes are used to construct an initial interpretation of a stimulus. This initial interpretation is context dependent. Thus, initial interpretation of the target will be influenced by the prime and the study task. According to Micco and Masson, priming effects in implicit memory tests reflect the reenactment of the interpretative processes that were used during study. They propose a framework in terms of a connectionist model with distributed representations for conceptual, orthographic, and phonological aspects of the stimulus. Their framework (or a similar model) might be able to explain the present results.

The REM model that is currently being developed (Schooler, Shiffrin, & Raaijmakers, 2001; Shiffrin & Steyvers, 1997) may also be able to explain the present results. The REM model explains repetition priming effects by context features that are stored in the representation of a concept. In this model memory is represented by vectors of feature values. Some features represent content (the visual form or semantic information of a word), and some represent context. For each event a new vector is stored in which each feature has a certain probability that its value will be included in the vector. If the current event is similar enough, information will also be added to previous vectors of the word with a certain probability. Thus, over time these vectors will accumulate information and become more and more accurate. In this way the model has noisy episodic vectors (based on a few events) and more accurate lexical/semantic vectors (based on many events). Memory search is performed using a cue that is also represented as a vector. Identification and retrieval are based on the number of matches and mismatches between the cue and a vector in memory.

Because the vectors also contain features that represent context, the REM model predicts that retrieval of semantic information can be context dependent. When a word is studied, there is a probability that some context features are included in its lexical/semantic vector. On the test that follows, the cue will include similar context features, and this results in a better match for studied words that have the same context features stored in their vector. This assumption provides an explanation for word repetition effects in masked identification (Schooler et al., 2001). REM might be extended to explain associative priming effects. The important point is that REM is a formal model that allows the retrieval of semantic information to be sensitive to context.

In sum, the present results show that retrieval of semantic information is context dependent. In order to explain these results models of semantic memory will have to include a mechanism that explains how contextual features and recent semantic interpretations affect the processing of the target item in a semantic memory task. A simple way to do this would be based on the assumption that semantic memory representations are not static but dynamic—that is, they are constantly updated to reflect the nature of recent encounters with that word.

REFERENCES

Anderson, R. C., & Ortony, A. (1975). On putting apples into bottles—a problem of polysemy. *Cognitive Psychology*, *7*, 167–180.

Anderson, R. C., Pichert, J. W., Goetz, E. T., Schallert, D. L., Stevens, K. V., & Trollip, S. R. (1976). Instantiation of general terms. *Journal of Verbal Learning and Verbal Behavior*, *15*, 667–679.

Barsalou, L. W. (1982). Context independent and context-dependent information in concepts. *Memory and Cognition*, *10*, 82–93.

Barsalou, L. W. (1993). Flexibility, structure, and linguistic vagary in concepts: Manifestations of a compositional system of perceptual symbols. In A. F. Collins, S. E. Gathercole, M. A. Conway, & P. E. Morris (Eds.), *Theories of memory*. Hove, UK: Lawrence Erlbaum Associates Ltd.

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences*, *22*, 577–660.

Battig, W. F., & Montague, W. E. (1969). Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. *Journal of Experimental Psychology Monograph*, *80*, 1–46.

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

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

Carr, T. H., Dagenbach, D., VanWieren, D., Carlson Radvansky, L. A., Alejano, A. R., & Brown, J. S. (1993). Acquiring general knowledge from specific episodes of experience. In C. Umiltà & M. Moscovitch (Eds.), *Attention and performance XV: Conscious and nonconscious information processing*. Cambridge, MA: MIT Press.

Carroll, M., & Kirsner, K. (1982). Context and repetition effects in lexical decision and recognition memory. *Journal of Verbal Learning and Verbal Behavior*, *21*, 55–69.

Conrad, C. (1978). Some factors involved in the recognition of words. In J. W. Cotton & R. L. Klatzky (Eds.), *Semantic factors in cognition* (pp. 103–121). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Dagenbach, D., Carr, T. H., & Barnhardt, T. M. (1990a). Inhibitory semantic priming of lexical decisions due to failure to retrieve weakly activated codes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*, 328–340.

Dagenbach, D., Horst, S., & Carr, T. H. (1990b). Adding new information to semantic memory: How much learning is enough to produce automatic priming? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*, 581–591.

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

den Heyer, K. (1986). Manipulating attention-induced priming in a lexical decision task by means of repeated prime–target presentations. *Journal of Memory and Language*, *25*, 19–42.

Durgunoglu, A. Y., & Neely, J. H. (1987). On obtaining episodic priming in a lexical decision task following paired-associate learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *13*, 206–222.

Fischler, I. (1977). Semantic facilitation without association in a lexical decision task. *Memory and Cognition*, *5*, 335–339.

Goshen-Gottstein, Y., & Moscovitch, M. (1995). Repetition priming effects for newly formed associations are perceptually based: Evidence from shallow encoding and format specificity. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 1249–1262.

Graf, P., & Schacter, D. L. (1989). Unitization and grouping mediate dissociations in memory for new associations. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*, 930–940.

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.

Lund, K., Burgess, C., & Atchley, R. A. (1995). Semantic and associative priming in high-dimensional semantic space. In *Proceedings of the Cognitive Science Society* (pp. 660–665). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Lupker, S. J. (1984). Semantic priming without association: A second look. *Journal of Verbal Learning and Verbal Behavior*, *23*, 709–733.

Masson, M. E. J., & MacLeod, C. M. (1992). Reenacting the route to interpretation: Enhanced perceptual identification without prior perception. *Journal of Experimental Psychology: General*, *121*, 145–176.

McKoon, G., & Ratcliff, R. (1979). Priming in episodic and semantic memory. *Journal of Verbal Learning and Verbal Behavior*, *18*, 463–480.

McKoon, G., & Ratcliff, R. (1986). Automatic activation of episodic information in a semantic memory task. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *12*, 108–115.

McRae, K., De Sa, V. R., & Seidenberg, M. S. (1997). On the nature and scope of featural representations of word meaning. *Journal of Experimental Psychology: General*, *126*, 99–130.

Micco, A., & Masson, M. E. J. (1991). Implicit memory for new associations: An interactive approach. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *17*, 1105–1123.

Moss, H. E., Ostrin, R. K., Tyler, L. K., & Marslen-Wilson, W. D. (1995). Accessing different types of lexical semantic information: Evidence from priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 1–21.

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

Newell, A., & Rosenbloom, P. S. (1981). Mechanisms of skill acquisition and the law of practice. In J. R. Anderson (Ed.), *Cognitive skills and their acquisition*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Pecher, D., & Raaijmakers, J. G. W. (1999). Priming effects for new associations in lexical decision and perceptual identification. *Quarterly Journal of Experimental Psychology*, *52A*, 593–614.

Pecher, D., Zeelenberg, R., & Raaijmakers, J. G. W. (1998). Does pizza prime coin? Perceptual priming in lexical decision and naming. *Journal of Memory and Language*, *38*, 401–418.

Reingold, E. M., & Goshen-Gottstein, Y. (1996). Separating consciously controlled and automatic influences in memory for new associations. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 397–406.

Schooler, L .J., Shiffrin, R. M., & Raaijmakers, J. G. W. (2001). A Bayesian model for implicit effects in perceptual identification. *Psychological Review*, *108*, 257–272.

Schrijnemakers, J. C. M., & Raaijmakers, J. G. W. (1997). Adding new word associations to semantic memory: Evidence for two interactive learning components. *Acta Psychologica*, *96*, 103–132.

Seidenberg, M. S., Waters, G. S., Sanders, M., & Langer, P. (1984). Pre- and postlexical loci of contextual effects on word recognition. *Memory and Cognition*, *12*, 315–328.

Shapiro, S. I., & Palermo, D. S. (1970). Conceptual organization and class membership: Normative data for representatives of 100 categories. *Psychonomic Monograph Supplements*, *3*, 107–127.

Shelton, J. R., & Martin, R. C. (1992). How semantic is automatic semantic priming? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *18*, 1191–1210.

Shiffrin, R. M., & Steyvers, M. (1997). A model for recognition memory: REM-retrieving effectively from memory. *Psychonomic Bulletin and Review*, *4*, 145–166.

Smith, M. C., MacLeod, C. M., Bain, J. D., & Hoppe, R. B. (1989). Lexical decision as an indirect test of memory: Repetition priming and list-wide priming as a function of type of encoding. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*, 1109–1118.

Tulving, E. (1983). *Elements of episodic memory*. New York: Oxford University Press.

Tulving, E. (1984). Precis of elements of episodic memory. *Behavioral and Brain Sciences*, *7*, 223–268.

Tulving, E., & Schacter, D. L. (1990). Priming and human memory systems. *Science*, *247*, 301–306.

van der Made–van Bekkum, I. J. (1973) *Nederlandse woordassociatienormen* [Dutch Word association norms]. Amsterdam: Swets & Zeitlinger.

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

Vriezen, E. R., Moscovitch, M., & Bellos, S. A. (1995). Priming effects in semantic classification tasks. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 933–946.

Williams, J. N. (1996). Is automatic priming semantic? *European Journal of Cognitive Psychology*, *8*, 113–161.

Zeelenberg, R., Pecher, D., & Raaijmakers, J. G. W. (2003). Associative repetition priming: A selective review and theoretical implications. In J. Bowers & C. Marsolek (Eds.), *Rethinking implicit memory* (pp. 261–283). Oxford, UK: Oxford University Press.

Original manuscript received 19 June 2001
Accepted revision received 25 July 2003
PrEview proof published online 9 January 2004