Memory & Cognition
1998, 26 (1), 34-39

Reading "glasses" will prime "vision," but reading a pair of "glasses" will not

JAMES H. NEELY, CHRISTOPHER A. VERWYS, and TODD A. KAHAN
State University of New York, Albany, New York

In a lexical decision task with two primes and a target, the target was preceded 300 msec by the second prime (P2) which in turn was preceded by a brief forward and backward masked first prime (P1). When P1 and P2 were unrelated, reaction times were faster when the target was related to P2 (e.g., *wave SALT . . . pepper*) than when the target was unrelated to P2 (and P1—e.g., *wave LOAN . . . pepper*). However, this semantic priming effect was reduced to statistically nonsignificant levels when P1 and P2 were repetitions of the same word. That is, priming did not occur for *salt SALT . . . pepper* relative to *loan LOAN . . . pepper*. This reduction in priming was observed whether P2 and the target were strongly or weakly related. These findings raise problems for current accounts of semantic priming.

Since Meyer and Schvaneveldt (1971) reported their seminal research, a large body of work has focused on delineating the mechanisms that underlie the semantic priming effect (see Neely, 1991, for a review). In the currently most popular version of this paradigm originated by Neely (1976), a person first silently reads a single prime word and then makes a speeded response to a target that appears after a brief delay. Semantic priming refers to the consistent finding that reaction times (RTs) to a target word are faster when it is preceded by a semantically related prime rather than an unrelated prime.[1]

The present research explores how semantic priming is affected by the prime itself being primed. The study most relevant to this issue was recently reported by Balota and Paul (1996). They examined priming when two primes (1) were both related to the target and each other (e.g., *copper bronze . . . METAL*) or (2) were both related to the target but unrelated to each other (e.g., *kidney piano . . . ORGAN*). In both cases, priming was enhanced, *and to the same degree*, relative to when only the second prime (P2) was related to the target and the two primes were unrelated to each other (e.g., *order bronze . . . METAL* or *wagon piano . . . ORGAN*). The finding that this priming enhancement was of the same magnitude whether P2 was primed (because the first prime, P1, was related to it, as in *copper bronze . . . METAL*), or was not primed (because P1 was unrelated to it, as in *kidney piano . . . ORGAN*) raises problems for automatic spreading activation accounts of semantic priming (e.g., Anderson, 1983; Collins & Loftus, 1975; Neely, 1977; Schvaneveldt & Meyer, 1973). Specifically, according to Anderson (1983, see p. 266), the higher the activation level in the "source node" that initiates the spread of activation (in the present case, the prime's node), the greater the amount of activation that spreads to a related recipient node (in this case, the target's node). Thus, spreading activation theory predicts that semantic priming of P2 by P1 should enhance the amount of P2/target priming. Balota and Paul's results clearly run counter to this prediction.[2]

One possible reason for why Balota and Paul (1996) failed to find enhanced P2/target priming when P2 was primed by P1 is that P1/P2 semantic priming may not have been great enough to add a detectable increment in the amount of P2/target semantic priming observed. To test this, in the present two experiments we primed P2 through repetition priming rather than semantic priming. We did this because immediate repetition priming leads to priming effects that are two to three times greater than semantic priming tested under the same conditions (see, e.g., Dannenbring & Briand, 1982; Friedrich, Henik, & Tzelgov, 1991, Experiment 3; Smith, Besner, & Miyoshi, 1994). Thus, as spreading activation accounts predict, we expected to show that P2/target semantic priming would indeed be enhanced when P2 was primed through immediate repetition priming, relative to when it was preceded by a P1 that was unrelated to it and the target.

Unlike in Balota and Paul's (1996) experiments, we masked P1. We did this because two identifiable presentations of the same prime (e.g., *salt SALT*) would allow more time—that is, the amount of time consumed by the P1/P2 stimulus onset asynchrony (SOA)—for the subject to use the prime to generate an expectancy for a related target. (See den Heyer, Briand, & Dannenbring, 1983, and Neely, 1977.) Thus, if we obtained more priming from a P2 primed by itself than from an unprimed P2, we would not know whether the enhanced priming was due to the priming of P2 by P1 or to expectancy's adding to the amount of priming observed. By masking P1 so that it would be difficult to identify consciously, we hoped to eliminate differences in expectancy-based P1/target priming for the conditions in which P2 was primed or unprimed. To minimize expectancy-based priming from P2,

---

We thank Jeanette Altarriba, David Balota, Tram Neill, and an anonymous reviewer for helpful comments on an earlier draft of this paper. Correspondence concerning this article should be sent to J. H. Neely, Department of Psychology, State University of New York, 1400 Washington Avenue, Albany, NY 12222 (e-mail: jn562@cnsibm.albany.edu).

we used a relatively short, 300-msec P2/target SOA and a low proportion of trials in which the target was related to its preceding primes (see, e.g., de Groot, 1984; Neely, 1977; Stolz & Neely, 1995). Though we would have preferred to use an even shorter P2/target SOA, people had trouble preparing for the target's presentation when the five events in each trial (i.e., the two masks, P1, P2, and the target) were presented at a more rapid pace.

EXPERIMENT 1

In Experiment 1, we used strongly related prime–target pairings in the related priming conditions and tested six different priming conditions that represented three different pairs of conditions in which P2 was either related or unrelated to the target. Examples of the two nonrepeated-Prime 2 (NonRep-P2) conditions are given in the first two rows of Table 1, which appears in the Results section. The NonRep-P2 conditions are similar to the standard priming conditions in that the target (*pepper*) was immediately preceded by either an unrelated word (*LOAN*) or a related word (*SALT*) as P2. However, unlike in the typical single-word-prime condition, each P2 was preceded by a masked P1, which was a word (*WAVE*) that was not a repetition of P2 and was unrelated to both P2 and the target. Because these two conditions were similar to the standard priming conditions and yielded the standard priming effect in Balota and Paul (1996), we expected to find faster RTs in the NonRep-P2/*related* condition than in its NonRep-P2/*unrelated* control condition. However, because we were concerned that an attempt to process the difficult-to-identify masked P1 might interfere with the processing of P2 and hence reduce priming, we also included corresponding Prime 2 only (P2-only) conditions, in which there was only a blank screen separating the two masks in the P1 position. (See the bottom two rows of Table 1.) Thus, if masked P1 processing interferes with P2 processing, priming should be less in the NonRep-P2/*related* condition (relative to its NonRep-P2/*unrelated* control) than in the P2-only/*related* condition (relative to its P2-only/*unrelated* control). However, if there is no such interference, we should see equivalent priming in the nonrep and P2-only conditions.

The final two priming conditions (third and fourth rows of Table 1) were the repeated-Prime 2 (Rep-P2) conditions, in which P2 was primed through repetition priming, as it was preceded by the same word as P1, but in a different type case.[3] The comparison of central interest involved the magnitudes of the priming observed in the Rep-P2/*related* and the NonRep-P2/*related* conditions (relative to their respective *unrelated* controls). This comparison allowed us to test whether Balota and Paul's (1996) failure to support spreading activation theory's prediction of enhanced semantic priming when P2 is primed (relative to when it is not) was due to the *semantic* P1/P2 priming's not having been great enough to produce a detectable enhancement in P2/target priming. If that were so, our much stronger manipulation of *repetition* P2/P1 priming should lead to our finding greater P2/target priming in the Rep-P2/*related* condition than in the NonRep-P2/*related* condition, as spreading activation theory predicts. However, if Balota and Paul's finding of equivalent P2/target priming from a primed versus unprimed P2 is general, priming should be equivalent in the Rep-P2/*related* and NonRep-P2/*related* conditions.[4] Such equivalent priming would pose a serious problem for a spreading activation account of priming.

Method

Subjects. Sixty-six native English speaking University at Albany undergraduates with normal or corrected-to-normal vision participated for partial completion of a research requirement for an introductory psychology class, or for class extra credit. Data from 6 subjects were excluded, owing to their having an error rate greater than 40% in any one condition.

Design. For the critical trials from which the data are reported, the design was a 3 (P2 status: Repeated, NonRepeated vs. Only) × 2 (priming: P2 Related vs. Unrelated to the target) completely within-subjects, randomized design.

Materials and List construction. Sixty target words appeared in the six critical conditions from which the data are reported. For each target word, three prime words were selected. The related prime word was selected from the University of South Florida Word Association Norms (Nelson, McEvoy, & Schreiber, 1989) in such a way that the target word had a high probability of being generated from that prime word in a free association test. Specifically, the mean related prime–target association strength was .60 (*SD* = .14; range, .30–.82). The mean Kučera–Francis (1967) frequency count for the targets was 301.3 per million. The two unrelated prime words were unrelated to each other and unrelated to the target, and they were approximately matched on frequency and word length with the related prime. Each target item was rotated through each of the six critical conditions across six stimulus lists, and no target or prime appeared more than once in any one list (except for those cases in which the same prime word was repeated as P1 and P2 within a single trial). With 10 critical items per condition and data being reported from 60 subjects, each cell of the experiment was based on 600 observations.

In addition to the 60 prime–target quadruplets that were created for the *related* and *unrelated* critical trials, 60 other unrelated prime–target sets were created to appear in unrelated buffer trials. The inclusion of these *unrelated* buffer trials yielded a .25 relatedness proportion (the proportion of all word target trials in which P2 was related to the word target; cf. Neely, Keefe, & Ross, 1989). This moderately low relatedness proportion was intended to minimize further the contribution of expectancy to any priming that we observed. Thirty of these *unrelated* buffer trials were analogous to the NonRep-P2/*unrelated* condition, and 30 were analogous to the Rep-P2/*unrelated* condition. Because subjects were to make a lexical decision to the targets, 120 nonword targets were created. The nonword targets were pronounceable and created by changing a single letter in 120 words that did not appear elsewhere in the experiment. The word from which a nonword target was created was not related to either of the two primes that preceded that nonword target. Sixty of the nonword targets were preceded by a repeated word prime, and 60 by two unrelated word primes. Thus, when two primes appeared, the repetition status of P2 provided no information about the lexicality of the target or the target's relatedness to P2. Although, owing to an oversight, the absence of a P1 was always followed by a word target, subjects apparently did not use this information in responding to the target, since RTs and error rates were virtually identical in the corresponding NonRep-P2 and P2-only conditions. The 240 total word and nonword target trials were randomly intermixed and divided into six blocks of 40 trials each. The preceding 24-trial practice list contained the same proportion of trials for each condition as that used in the experiment proper.

Procedure. Each individually tested subject was seated approximately 60 cm away from a VGA monitor from which the task instructions were first read by the subject and then were heard paraphrased by the experimenter. Each visual event within a trial appeared in a nonproportional 12 cpi font and was centered on the screen. Each trial consisted of the following events: (1) a 250-msec fixation point (*), (2) a 500-msec forward mask (XXXXXXXX), (3) a 33-msec lowercase P1 or a blank screen, depending on the condition, (4) a 100-msec backward mask (********), (5) a 300-msec blank screen, (6) a 150-msec uppercase P2, (7) a 150-msec blank screen, and (8) the lowercase target item, which remained on for 1,500 msec or until the subject responded, whichever happened first. Trials were separated by a 2,500-msec blank screen. The subjects were informed of the nature of the masks, but they were never explicitly told about P1. Each subject was told to read the uppercase prime and to respond to the lowercase target by pressing the /? key with the index finger of his or her right hand if the target was a word and by pressing the Z key with the index finger of his or her left hand if the target was a nonword. The subjects were asked to respond as quickly as possible, without making too many errors. Response accuracy and latency (in milliseconds) were collected by MEL software (Schneider, 1988) on a Zenith PC. The subjects were allowed to ask questions both before and after the practice trials and to take self-paced rest breaks between blocks. Each individual session lasted approximately 45 min.

Results and Discussion

Because lexical decision RT distributions are positively skewed, geometric means were computed for correct responses of each subject for each of the six critical conditions. The first two data columns of Table 1 give the arithmetic means of the geometric mean RTs and of the percent errors, respectively, for the six critical conditions of Experiment 1, along with the priming effects, which were computed by subtracting RTs or percent errors in the *related* priming condition from the RTs or percent errors from the corresponding *unrelated* priming condition. Because the overall error rates were very low and showed the same pattern of priming effects as did the RT data, we report only the results of the 3 (P2 status) × 2 (priming) within-subjects ANOVA performed on the RT data.[5] Unless otherwise noted, each effect called statistically significant is associated with a two-tailed $p < .05$.

As is shown in the left two data columns of Table 1, substantial and similar priming effects were obtained in the NonRep-P2 and P2-only conditions. This resulted in a significant main effect of priming [$F(1,59) = 59.55$, $MS_e = 1{,}673.43$]. Of particular interest is the finding that contrary to spreading activation theory, repetition priming of P2 reduced, rather than enhanced, priming. The ANOVA yielded a significant P2 status × priming interaction [$F(2,118) = 5.59$, $MS_e = 2{,}158.96$]. Fisher's least significant difference (LSD) tests, based on the MS_e from this interaction, yielded LSDs of 16.8 msec and 23.8 msec for the individual priming effects and the difference between priming effects, respectively. Thus, the 42-msec and 48-msec priming effects in the NonRep-P2 and P2-only conditions were significant and statistically equivalent and were both significantly greater than the statistically nonsignificant 11-msec priming effect in the Rep-P2 condition.[6]

As is typical for lexical decisions, "nonword" responses were slower and less accurate than "word" responses. Although performance on nonwords was virtually identical following repeated and nonrepeated primes, 826 msec (7% errors) versus 822 msec (6% errors), this comparison should be treated with caution, since nonword targets were not counterbalanced across these two conditions.

These data show that the processing of a difficult-to-see masked P1 word that was unrelated to both P2 and the target did not lead to a significant reduction in P2/target semantic priming. Of much greater interest was the finding that P2/target priming was *reduced* by masked repetition priming of P2. This very surprising result would seem to pose a major problem for spreading activation theory, which predicts that priming P2 should have actually enhanced P2/target priming.

EXPERIMENT 2

In Experiment 2, we sought to replicate the counterintuitive finding of Experiment 1 that immediate repetition priming of P2 reduced the amount of semantic priming that it produced to a nonsignificant level. We also wanted to test whether this reduction in semantic priming might turn into enhanced semantic priming if the P2/target semantic priming effect was made smaller by using a relatively weak P2-target association (e.g., *WISH hope*). That is, although repetition priming of P2 might reduce a strong P2/target semantic priming effect, it might enhance a weak P2/target semantic priming effect. Because the priming effects in Experiment 1 were equivalent whether or not there was a masked P1 to process and because we felt we would need more observations to obtain significant priming effects for weakly related prime–target pairs, in Experiment 2 we did not waste critical target items by testing them in the two uninformative P2-only conditions. Thus, we compared Related and Unrelated priming in only the NonRep-P2 and Rep-P2 conditions.

In summary, in Experiment 2 we used weakly related P2–target pairs to determine whether repetition priming of P2 (1) would now have no effect on P2/target semantic priming, which would be a conceptual replication of Balota and Paul's (1996) results, (2) would once again reduce P2/target semantic priming and thereby extend the generality of the results of Experiment 1, or (3) would now enhance P2/target semantic priming, in accord with spreading activation theory.

Method

Subjects. One hundred and sixty-eight subjects with the same characteristics as those of the subjects in Experiment 1 were tested. Data from 16 were discarded because of an error rate exceeding 40% in any one of the critical conditions.

Design. For the critical trials from which the data are reported, the design was a 2 (P2 status: repeated vs. nonrepeated) × 2 (priming:

P2 related vs. unrelated to the target) completely within-subjects, randomized design.

Materials and List construction. Eighty target words appeared in the four critical conditions from which the data are reported. For each target word, three prime words were selected. The related prime word was selected from the University of South Florida Word Association Norms (Nelson et al., 1989) in such a way that the mean related prime–target association strength was .18 (SD = .21; range, .01–.82). The mean Kučera–Francis (1967) frequency count for the targets was 120.4 per million. The two unrelated prime words were selected as in Experiment 1, and each target item was rotated through each of the four critical conditions following the procedures of Experiment 1. With 20 critical items per condition and data being reported from 152 subjects, each cell of the experiment was based on 3,040 observations.

An additional 80 other unrelated prime–target sets were created to appear in *unrelated* buffer trials, once again yielding a .25 P2/target relatedness proportion. Forty of these *unrelated* buffer trials were analogous to the NonRep-P2/*unrelated* condition, and 40 were analogous to the Rep-P2/*unrelated* condition. The 160 pronounceable nonword targets were created in the same fashion as in Experiment 1 and were preceded by a repeated word prime on 80 trials and by 2 unrelated word primes on 80 trials. Thus, once again, the repetition status of P2 provided no information about the lexicality of the target or the target's relatedness to P2. These 320 total word and nonword target trials were randomly intermixed and divided into eight blocks of 40 trials each. The preceding 24-trial practice list contained the same proportion of trials for each condition as that used in the experiment proper.

Procedure. The procedure was identical to that of Experiment 1.

Results and Discussion

The data were treated as in Experiment 1, except that a 2 (P2 status) × 2 (priming) within-subjects ANOVA was used. As is shown in the two rightmost data columns of Table 1, by using weakly related P2–target pairs we were successful in reducing P2/target semantic priming in the NonRep-P2 condition to a level about half of that observed with the strongly related pairs in Experiment 1. However, the data from the Rep-P2 conditions replicated the results of Experiment 1 by showing that repetition priming of P2 once again *reduced*, rather than enhanced, P2/target semantic priming. The P2 status × priming interaction was significant [$F(1,151) = 5.58, MS_e = 1{,}286.69$], showing that this reduction was a genuine effect. A Fisher's LSD test, based on the MS_e from this interaction, yielded an LSD of 8.2 msec for the individual priming effects. Thus, the 20-msec priming effect in the NonRep-P2 condition, which was significantly greater than the 6-msec priming effect in the Rep-P2 condition, was significant, whereas the 6-msec priming effect was not.[7] As in Experiment 1, "nonword" responses were slower and less accurate than "word" responses, and performance on nonwords was virtually identical following repeated and nonrepeated primes, 860 msec (15% errors) versus 863 msec (16% errors). However, once again, this comparison should be treated with caution, since nonword targets were not counterbalanced across these two conditions.

GENERAL DISCUSSION

The results from Experiments 1 and 2 demonstrate a counterintuitive new priming phenomenon that generalizes across both strongly and weakly related P2–target pairings. The phenomenon is that immediate repetition priming of a prime *reduces* the amount of semantic priming which that prime produces to statistically nonsignificant levels. As noted in the introduction, this elimination of semantic priming by repetition priming of the prime runs counter to spreading activation theory (e.g., Anderson, 1983; Collins & Loftus, 1975; Neely, 1977), which predicts that immediate repetition priming of a prime should enhance rather than reduce the amount of semantic priming which that prime produces. Our results also stand in contrast to Balota and Paul's (1996) finding that semantic priming (as opposed to repetition priming) of the prime has no effect on the amount of semantic priming that a prime produces. Thus, these data show that repetition and semantic priming produce dissociable *indirect* effects on semantic priming, thereby extending prior re-

Table 1
Mean Reaction Times (RT, in Milliseconds), Percent Errors (PE), and Priming Effects in Experiments 1 and 2

				Experiment 1		Experiment 2	
Condition	P1	P2	Target	RT	PE	RT	PE
NonRep-P2/unrelated	wave	LOAN	pepper*	661	1.9	671	4.0
NonRep-P2/related	wave	SALT	pepper	619	1.0	651	3.2
Priming				+42†	+0.9	+20†	+0.8
Rep-P2/unrelated	loan	LOAN	pepper	643	1.0	666	4.8
Rep-P2/related	salt	SALT	pepper	632	0.8	660	3.5
Priming				+11	+0.2	+6	+1.3
P2-only/unrelated	—	LOAN	pepper	669	1.9	—	—
P2-only/related	—	SALT	pepper	621	0.3	—	—
Priming				+48†	+1.6	—	

Note—P1, Prime 1; P2, Prime 2; Prime 1 was only 33 msec in duration and was forward and backward masked. Rep-P2, repeated prime 2; NonRep-P2, nonrepeated Prime 2; P2-only, Prime 2 only. *These are examples of the strongly related P2–target pairings used in Experiment 1. In Experiment 2, the P2–target pairings were more weakly related. See Method sections for details. †$p < .05$.

sults showing that repetition and semantic priming themselves yield dissociable effects (e.g., Dannenbring & Briand, 1982; Friedrich et al., 1991; Smith et al., 1994).

The present findings also pose problems for Ratcliff and McKoon's (1988) compound cue theory (see also McNamara, 1994, vs. Ratcliff & McKoon, 1995), which provides the major alternative to spreading activation theory's account of the semantic priming effects obtained under the conditions of the present experiments (i.e., a low relatedness proportion and a relatively short prime SOA). According to compound cue theory, subjects use the combined target–prime pair as a cue for memory search. Because words are more familiar than nonwords on the average, subjects base their lexical decisions on the familiarity of this compound cue (cf. Balota & Chumbley, 1984). Priming occurs because related pairs are more familiar than unrelated pairs. To account for why repetition priming is greater than semantic priming, compound cue theory would assume that the compound cue of a repeated word is more familiar than the compound cue of a semantically related word pair. Thus, this theory predicts that semantic or repetition priming of the prime could either have no effect on semantic priming (when P1 is not included in the target–P2 compound cue) or increase semantic priming (when P1 is included in the compound cue). Without ad hoc assumptions, it cannot predict that either repetition or semantic priming of the prime will *reduce* semantic priming.

One theoretical approach that could be extended to account for the present results has been proffered by Carr and Dagenbach (1990) and Dagenbach and Carr (1994). By their "center–surround" account, when subjects have difficulty in their attempt to retrieve the meaning of a masked word, they focus their attention on that word's representation (the "center"), with the result that the meanings of semantically similar words (the "surround") receive lateral inhibition. Congruent with their interpretation, when subjects are induced to try to retrieve a masked word's meaning, that masked word produces facilitatory repetition priming but inhibitory semantic priming (Carr & Dagenbach, 1990). If (1) our subjects tried to retrieve the masked P1's meaning and failed, (2) this inhibition was not "released" by the easy-to-see unmasked presentation of the nominally identical P2, and (3) the perseverating inhibition from the masked P1 summed with the unaffected facilitation from P2, one would expect the reduction/elimination of semantic priming that we observed. Because this "center–surround" account is based on the foregoing three ad hoc assumptions, it must be accepted with considerable caution until these assumptions are directly tested and supported.

No matter how the "center–surround" theory ultimately fares as an account of our finding that repetition priming of the prime reduces semantic priming, this new phenomenon poses a serious challenge to spreading activation and compound cue accounts of semantic priming. Moreover, given the low relatedness proportion and the relatively short P2–target SOA that we used, it seems unlikely that this new phenomenon can be gracefully accounted for by appealing to the operation of two strategic mechanisms—that is, expectancy and semantic matching of the target to the prime—that some (e.g., Neely & Keefe, 1989; Neely et al., 1989) have argued can also contribute to semantic priming. Clearly, the finding that immediate repetition priming of the prime reduces semantic priming is for now a theoretical mystery whose solution must await the collection of more clues in the form of data that delineate this finding's boundary conditions and experiments that directly test the speculative "center–surround" account that we have offered. Thus, we hope that others will be as intrigued by this mystery as we are and join us in searching for these clues.

REFERENCES

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

Balota, D. A., & Chumbley, J. I. (1984). Are lexical decisions a good measure of lexical access? The role of word frequency in the neglected decision stage. *Journal of Experimental Psychology: Human Perception & Performance*, **10**, 340-357.

Balota, D. A., & Paul, S. T. (1996). Summation of activation: Evidence from multiple primes that converge and diverge within semantic memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **22**, 827-845.

Carr, T. H., & Dagenbach, D. (1990). Semantic priming and repetition priming from masked words: Evidence for a center–surround mechanism in perceptual recognition. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **16**, 341-350.

Chiarello, C., Burgess, C., Richards, L., & Pollock, A. (1990). Semantic and associative priming in the cerebral hemispheres: Some words do, some words don't... sometimes, some places. *Brain & Language*, **38**, 75-104.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Collins, A. M., & Loftus, E. (1975). A spreading-activation theory of semantic processing. *Psychological Review*, **82**, 407-428.

Dagenbach, D., & Carr, T. H. (1994). Inhibitory processes in perceptual recognition: Evidence for a center–surround attentional mechanism. In D. Dagenbach & T. H. Carr (Eds.), *Inhibitory processes in attention, memory, and language* (pp. 327-357). New York: Academic Press.

Dannenbring, G. L., & Briand, K. (1982). Semantic priming and the word repetition effect in a lexical decision task. *Canadian Journal of Psychology*, **36**, 435-444.

de Groot, A. M. B. (1984). Primed lexical decision: Combined effects of the proportion of related prime–target pairs and the stimulus-onset asynchrony of prime and target. *Quarterly Journal of Experimental Psychology*, **36A**, 253-280.

den Heyer, K., Briand, K., & Dannenbring, G. L. (1983). Strategic factors in a lexical-decision task: Evidence for automatic and attention-driven processes. *Memory & Cognition*, **11**, 374-381.

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

Friedrich, F. J., Henik, A., & Tzelgov, J. (1991). Automatic processes in lexical access and spreading activation. *Journal of Experimental Psychology: Human Perception & Performance*, **17**, 792-806.

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

McNamara, T. P. (1994). Theories of priming: II. Types of primes. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **20**, 507-520.

Meyer, D., & Schvaneveldt, R. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology*, **90**, 227-234.

Moss, H. E., Ostrin, R. K., Tyler, L. K., & Marslen-Wilson, U. D. (1995). Accessing different types of lexical semantic information: Evidence from priming. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **21**, 863-883.

Neely, J. H. (1976). Semantic priming and retrieval from lexical memory: Evidence for facilitatory and inhibitory processes. *Memory & Cognition*, **4**, 648-654.

Neely, J. H. (1977). Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited-capacity attention. *Journal of Experimental Psychology: General*, **106**, 226-254.

Neely, J. H. (1991). Semantic priming effects in visual word recognition: A selective review of current findings and theories. In D. Besner & G. U. Humphreys (Eds.), *Basic processing in reading: Visual word recognition* (pp. 264-336). Hillsdale, NJ: Erlbaum.

Neely, J. H., & Keefe, D. E. (1989). Semantic context effects on visual word processing: A hybrid prospective/retrospective processing theory. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 24, pp. 207-248). New York: Academic Press.

Neely, J. H., Keefe, D. E., & Ross, K. (1989). Semantic priming in the lexical decision task: Roles of prospective prime-generated expectancies and retrospective semantic matching. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **15**, 1003-1019.

Nelson, D. L., McEvoy, C. L., & Schreiber, T. (1989). *The University of South Florida word, rhyme and word fragment norms*. Unpublished manuscript.

Ratcliff, R., & McKoon, G. (1988). A retrieval theory of priming in memory. *Psychological Review*, **95**, 385-408.

Ratcliff, R., & McKoon, G. (1995). Sequential effects in lexical decision: Tests of compound-cue retrieval theory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **21**, 1380-1388.

Schneider, W. (1988). Micro Experimental Laboratory: An integrated system for IBM PC compatible. *Behavior Research Methods, Instruments, & Computers*, **20**, 206-217.

Schvaneveldt, R. W., & Meyer, D. E. (1973). Retrieval and comparison processes in semantic memory. In S. Kornblum (Ed.), *Attention and performance IV* (pp. 395-409). New York: Academic Press.

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

Smith, M. C., Besner, D., & Miyoshi, H. (1994). New limits to automaticity: Context modulates semantic priming. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **20**, 104-115.

Snow, N., & Neely, J. H. (1987, November). *Reduction of semantic priming from inclusion of physically or nominally related prime–target pairs*. Paper presented at the 27th Annual Meeting of the Psychonomic Society, Seattle.

Stolz, J. A., & Neely, J. H. (1995). When target degradation does and does not enhance semantic context effects in word recognition. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **21**, 596-611.

NOTES

1. To avoid the awkward, but precise terminology *semantic and/or associative* priming, we use *semantic priming* as a generic term for priming that occurs when the prime and target share either a semantic or an associative relation or both (see, e.g., Chiarello, Burgess, Richards, & Pollack, 1990; Fischler, 1977; Moss, Ostrin, Tyler, & Marslen-Wilson, 1995; Shelton & Martin, 1992).

2. It should be noted that this is our conclusion and not Balota and Paul's (1996). In their discussion, Balota and Paul focused on the implications that their results have for how words having multiple meanings are represented in lexical and semantic memory and how their different meanings are accessed.

3. We used different type cases for P1 and P2 because Snow and Neely (1987) and other data from our lab have shown that with unmasked primes the inclusion of a high proportion of physically identical primes and targets in a list results in the elimination of semantic priming whereas a high proportion of nominally identical primes and targets does not. To protect ourselves against the unlikely event that this effect generalizes to the inclusion of a moderate proportion of physically identical primes, neither of which is responded to and one of which is masked, we had P1 and P2 appear in different letter cases.

4. For this equivalence in priming to occur, the P1/target SOA used here must preclude a *direct* semantic priming effect from the masked P1 to its related target in the Rep-P2/*related* condition. Thus, if we obtain more priming in the Rep-P2/*related* condition than in the NonRep-P2/*related* condition, we will need to test for and rule out such direct P1/target priming before we can conclude that P1 was enhancing priming via its effect on P2/target priming.

5. We only performed ANOVAs in which subjects, not items, were treated as random effects because (1) all targets appeared in all conditions so that differences among conditions cannot be due to the specific target items that appeared in them and (2) the scheme that we used to rotate items through conditions made it very difficult to associate a specific target with the RT that it yielded. However, the priming effects that we report were consistent over the six different counterbalancing lists, and when list was included as a between-subjects factor, all interactions including list and priming yielded Fs < 1.63 for both Experiments 1 and 2. In reply to one reviewer's concern, we also note that the variations in priming observed across the three different P1/P2 conditions were quite similar across the first and second halves of the session, with the Fs for the priming × P2 status × half of session interaction being < 1 for both Experiments 1 and 2. Though overall priming was somewhat greater in the second half than in the first half of the session in Experiment 1, this increase was not statistically significant and did not occur in Experiment 2.

6. Our failure to detect a priming effect in the Rep-P2/*related* condition was not due to low statistical power. If the true priming effect in that condition was of the same magnitude as that obtained in the NonRep-P2/*related* condition—that is, was a priming effect with a Cohen's d of .639 (see Cohen, 1988)—our power to detect it (with a one-tailed $p < .05$) was greater than .96.

7. Because we tested so many subjects, our failure to detect a priming effect in the Rep-P2/*related* condition was once again not due to low statistical power. If the true priming effect in that condition was of the same magnitude as that obtained in the NonRep-P2/*related* condition—that is, was a priming effect with a Cohen's d of .391 (see Cohen, 1988)—our power to detect it (with a one-tailed $p < .05$) was greater than .94.

(Manuscript received June 30, 1997;
revision accepted for publication September 16, 1997.)