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Semantic Priming without Association: A Second Look

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It has long been known that a word (e.g., BUTTER) presented shortly after a related word (e.g., BREAD) can be processed more rapidly than when presented shortly after an unrelated word (e.g., TABLE). This phenomenon has come to be referred to as "semantic" priming. To this date, however, only I. Fischler (1977, *Memory & Cognition*, **5**, 335–339) has provided any evidence that this phenomenon is semantically and not associatively based. In the present paper six studies were undertaken in an attempt to generalize Fischler's findings to tasks other than the simultaneous lexical decision task he used. In Experiments 1, 2, and 3 it was determined that semantic category relationships, in which the two words named members of the same semantic category (e.g., DOG–PIG) did little to facilitate naming of the second stimulus. In Experiments 4 and 6, it was determined that a semantic category relationship did nothing to augment the priming from associative relationships in naming and lexical decision tasks, respectively. However, in Experiment 5, in a replication of Fischler's results, semantic relatedness alone did produce priming in a lexical decision task. These results appear to indicate that the role of semantics in the priming process is somewhat limited. Further, these results also indicate that the amount of priming observed is somewhat task dependent. Implications for models of "semantic" priming are discussed. © 1984 Academic Press, Inc.

One of the most replicable (as well as most replicated) findings to appear in the psychological literature in the 1970s is the semantic association effect first reported by Meyer and colleagues (Meyer & Schvaneveldt, 1971; Meyer, Schvaneveldt, & Ruddy, 1975). Using a lexical (word/nonword) decision task these researchers have demonstrated that a word, the "target," processed shortly after an associated word, the "prime," is responded to more rapidly than when that same word is preceded by a nonassociate. To use the classic example, DOCTOR is processed more rapidly following NURSE than following BUTTER. This effect is typically referred to as semantic priming.

In an initial attempt to understand this phenomenon, Meyer et al. (1975) examined the size of the priming effect as a function of two additional factors, the visual quality of the stimulus (clear or degraded) and the type of response required (lexical decision or word naming). Two theoretically important results emerged. First, the size of the priming effect increased when stimuli were degraded (see also Becker & Killion, 1977). According to additive factors logic (Sternberg, 1969) this result indicates that one locus of the priming effect is an early, input stage (i.e., that stage which is affected by degradation). The second finding is that the nature of the response did not affect the size of the priming effect. This independence between these two factors suggests that the priming effect does not have a second locus in a later response-selection stage.

The Meyer et al. results, as well as similar results from other investigators (e.g., Lorch, 1982; Schvaneveldt & McDonald, 1981), have tended to be interpreted within the framework of Collins and Loftus' (1975)

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semantic network/spreading activation model. According to the model each familiar "concept is represented as a node in a network with properties of the concept represented as labeled relational links from the node to other concept nodes" (p. 408). So, for example, the node for a concept like "DOG" would be linked to nodes for concepts that serve to define its meaning like "ANIMAL," "FUR," "TAIL," and so on, as well as to nodes for strong associates like "CAT." Concepts sharing these defining features, like "DOG" and "CAT," would, of course, also be linked through the "ANIMAL" node, the "FUR" node, and so on. In this way a network can be created in which semantically related concepts are closely linked together.

Secondary to the semantic network is the lexical network or lexicon. This network contains names of concepts in the semantic network and, as such, each of its nodes is tied to a node in the semantic network. When a representation of a concept is presented (e.g., the word DOG) it allows access to the networks, activation of the appropriate node(s), and retrieval of the information required by the task. In addition, this activation spills out along the links of the networks raising the activation levels of neighboring nodes. If a representation of a neighboring concept is then presented, access to its lexical and semantic nodes is more rapid due to their heightened activation. However, once access has been accomplished, processing proceeds normally, independent of the effects of priming. As such, the amount of priming observed can be a function of a variable affecting input (e.g., degradation) but should not be a function of a variable affecting output (e.g., response type).

In the late 1970s, Fischler (1977) raised an interesting question with respect to these interpretations. Prior to that point all priming studies had examined priming effects in situations in which the stimulus pairs were associatively related, typically using free association norms to aid in stimulus creation. Fischler argued that words which become frequent associates may attain that status not on the basis of a shared semantic nature but purely from accidents of contiguity. Thus, in order to demonstrate that the semantic network conceptualization of priming is a viable one it would be necessary to show priming with stimulus pairs which were related semantically but not associatively. Although he found constructing such stimulus pairs somewhat difficult Fischler did provide such a demonstration using simultaneously presented stimulus pairs in a double lexical decision task (i.e., are both letter strings words?).

Fischler's findings, in conjunction with the model described above, suggest an additional result. If semantic relationships in the absence of associative relationships can produce priming, and if priming is an input but not an output phenomenon (at least when considering only the lexical decision and naming tasks), purely semantic relationships should produce priming in naming tasks as well. On the other hand, at least one recent description of the priming process suggests that such will not be the case. Fodor (1983) has suggested that a shallow task like naming should not be affected by higher level cognitive structures like those representing meaning relationships. Instead, priming should only be a function of the most basic relationships (like association), ones which can produce priming in an essentially reflexive fashion. Thus, what might appear to be semantic priming in naming tasks would be really nothing more than the effect of uncontrolled associative relationships. At present there appears to be no clear resolution of this issue since in most studies using the naming task the word pairs were specifically selected for their high associative strength (e.g., Becker & Killion, 1977; Meyer et al., 1975).

There are, of course, a few exceptions to this generalization. For example, Massaro, Jones, Lipscomb, and Scholz (1978) reported a study in which category names were used to prime category exemplars.

Sperber, McCauley, Ragain, and Weil (1979) reported two studies (Experiments 2 and 3) in which members of a semantic category were used to prime other category members. Both sets of investigators used a sequential presentation of prime and target, and both reported only a small priming effect (a nonsignificant 7 milliseconds in the nondegraded condition of Massaro et al. and significant 19- and 10-millisecond effects in Experiments 2 and 3 of Sperber et al., respectively). The size of these effects seems to imply that a semantic relationship between the prime and target may have only a minimal influence in a naming task. In fact, even this conclusion may be too strong since in neither case did the researchers attempt to eliminate associated prime–target pairs. Thus, even the small effects these investigators observed may be attributable to residual association strengths.

One other exception which may have had more success at eliminating association effects was reported by Irwin and Lupker (1983). In these studies a sequential presentation technique was also used with subjects being required to either categorize (Experiment 1), name (Experiment 2), or report the color (Experiment 3) of the prime before naming the target. As in the Sperber et al. studies related primes and targets were names of members of the same semantic category. However, the prime–target pairs for these studies were created somewhat differently. Irwin and Lupker selected 12 concepts from each of six common semantic categories. Each concept was used as a prime and a target in each block of any experiment, although in one instance it appeared as a word and the other as a picture. Owing to the use of so many instances from each category, different related and unrelated prime–target pairs could be created for each subject. Thus, although from time to time associated pairs may have arisen (e.g., DOG–CAT) a given prime–target pair in the related condition was much more likely to have very little, if any, associative strength (e.g., GOAT–CAT, ELEPHANT–CAT, etc.). Irwin and Lupker observed nonsignificant priming effects of 26,0, and −12 milliseconds in Experiments 1, 2, and 3, respectively. Thus, these data as well appear to support the notion that semantic relatedness has very little, if any, effect in a naming task.

Although the six studies cited above all seem to point to the same conclusion, caution must be exercised since all three shared a particular methodologically unusual detail, a very long prime–target onset asynchrony. As Posner and Snyder (1975) have suggested, activation can spread from the memory location for the prime's concept to locations for related concepts in two ways. The first is a fast-acting automatic process. This type of activation builds very rapidly (perhaps within a stimulus onset asynchrony (SOA) of 40 milliseconds—Fischler & Goodman, 1978), however it decays rapidly as well unless maintained by active attention (Neely, 1977). The other type of activation is through the use of an active attention process. Neely (1977) demonstrated that this process may take up to 750 milliseconds to build up, however it can allow the activation to be maintained over much longer intervals if the subject is willing to expend the effort. The SOA used by Massaro et al. was 1500 milliseconds while the SOAs used by Irwin and Lupker and Sperber et al. were the response time to the prime plus a 1-second interstimulus interval (ISI), creating a total SOA easily in excess of 1500 milliseconds. Undoubtedly, whatever automatic activation had been available had dissipated by the time the target was presented unless the subjects were highly motivated to continue attending to the automatically activated concepts. As such, the use of a 1500+-millisecond SOA may have substantially diminished the priming that was available.

A second idiosyncrasy found in four of these studies is that pictures and words were randomly mixed as primes and targets. One can certainly suggest that not knowing what type of representation a subject will receive both as a prime and as a target might not allow the subject to make full use of the prime. Thus, before a conclusion about the role of semantic relatedness can be reached the generality of the findings of these six studies must be extended.

Experiment 1 was then another attempt to evaluate the role of a semantic relationship between prime and target in a naming task. In this and all subsequent experiments, two concepts were defined as being semantically related if they were members of the same semantic category. Using category membership to define relatedness assures that related concepts will be linked both through the node for the category name as well as through nodes for the defining or, at least, common features of the categories (e.g., Smith, Shoben, & Rips, 1974). The categories and concepts used were the same as those used by Irwin and Lupker. The task itself was basically a replication of the name the prime–name the target task (Experiment 2) from Irwin and Lupker. There were three exceptions: (a) both primes and targets were always words; (b) the prime–target ISI was reduced to 250 milliseconds; and (c) although the prime–target pairings were randomly determined for each subject, associatively related stimulus pairs on both related and unrelated trials were not permitted. This final change was accomplished by consulting Postman and Keppel's (1970) association norms and not pairing any stimuli which appeared together in any of the norms. Since stimulus pairs were created anew for each subject, Fischler's technique of asking for additional association ratings was not used. The present procedure does not, of course, guarantee that there was no associative strength for any pair for any subject. However, it is doubtful that such a guarantee could ever be given, especially when semantically similar words are being paired.

EXPERIMENT 1

Method

Subjects. The subjects were 16 University of Western Ontario undergraduates (8 males and 8 females) who received course credit to appear in this experiment. All were native English speakers.

Stimulus materials and equipment. The 72 items used by Irwin and Lupker were also used in the present study. These items represented 12 common instances from six familiar categories: animals, body parts, clothing, furniture, kitchen utensils, and vehicles. In originally selecting these items care was taken to make sure that each item was clearly not a member of any of the other categories. Since each item was to be presented once as a prime and once as a target in one 72 trial block, two 23.0 × 25.6-cm stimulus cards were prepared for each item with the name printed in upper case in the middle of the card. A complete list of the 72 stimulus items is presented in Appendix A.

To create the related trials, the 72 target stimuli were first split into lists A and B by randomly selecting six items from each category. For the first eight subjects, items in list A received related primes and items in list B, unrelated primes. For the other eight subjects the reverse was true. The actual stimulus pairs for each subject were created by shuffling the target stimuli and then pairing each target with an appropriate prime. In this way each subject received a unique set of prime–target pairs. Care was taken to make sure that no pairs were created in which the prime and target were associates of one another for both the related (e.g., dog–cat, pot–pan) and unrelated (e.g., hand–glove, foot–shoe) conditions. In addition, care was taken to make sure that target items were not preceded by a same category item in the previous two trials. This precaution was taken to avoid intertrial priming. Finally, in order to avoid phonetic priming, primes and targets were not permitted either to begin with the same phoneme or to rhyme.

A Ralph Gerbrands Company (Model 1-3B-1C) three-field tachistoscope was used to present the stimuli. Viewing distance was 77 cm and viewing was binocular. A Hunter Klockounter (Model 120) timer was used to time the subjects' vocal responses. An Electro-Voice Inc. (Model 621) microphone connected to a Lafayette Instruments Company (Model 19010) voice-activated relay controlled the prime stimulus field and stopped the timer at the initiation of the subject's vocal response to the target.

Procedure. Subjects were tested individually. As the subjects arrived at the experiment they were assigned to group 1 (list A on related trials, list B on unrelated trials) or group 2 (opposite mapping). Subjects were told that they would be seeing a series of word pairs. Their job would simply be to say each word as it appeared. They were instructed to respond to each word as rapidly as possible but to avoid making errors.

Each subject received 72 trials. Each trial began with the 750-millisecond presentation of a fixation field consisting of a bullseye. Immediately thereafter the prime appeared and remained in view until the subject named it. Reaction time to this stimulus was not recorded although subjects were not informed of this. After an ISI of 250 milliseconds the target appeared and remained in view for 750 milliseconds regardless of the latency of the naming response. The next trial followed a brief (approximately 5 seconds) interval during which the experimenter recorded the naming latency to the target and reset the equipment. Errors were recorded and those pairs were placed at the end of the trial block for representation. If an error was made to the second presentation of a stimulus pair, the pair was not repeated. The entire session took about 30 minutes.

Results

Errors. A trial was considered an error if (a) the word was pronounced incorrectly; (b) the reaction time was longer than 1300 milliseconds; or (c) the subject was still pronouncing the prime when the target was presented, thus stopping the timer prematurely. There were a total of 22 errors in the 1152 trials in this experiment, 14 in the related condition, 8 in the unrelated condition. In 18 instances the second appearance of the stimulus pair also produced an error and, thus, the reaction times for these pairs were estimated. Since six items from each category were used in each condition, estimation was done by taking the average of the reaction times of the other five members of the category. Given the small percentage of errors, no further analysis of the error trials was undertaken.

Mean reaction times. The 1134 correct and 18 estimated target latencies were submitted to a 2(relatedness) × 2(groups) × 6(category) × 6(items) ANOVA. Items is nested within all three of the other factors while subjects is nested only within the groups factor. Rather than debate the merits of treating items as a random or fixed factor it was analyzed as both in separate analyses. Thus, both F and quasi-F (F') values, as described by Kirk (1968), will be reported. (The appropriate degrees of freedom for the F' analyses were calculated using Myers' (1972) adjustment.)

The central issue of interest is the relatedness effect. Mean latencies were 520 milliseconds on related trials and 527 milliseconds on unrelated trials. This 7-millisecond effect was significant in the standard analysis ($F(1,14) = 6.53$, $p < .025$) but not in the F' analysis ($F'(1,132) = 1.15$, $p > .25$). A number of other effects were also significant in the standard analysis: category ($F(5,70) = 11.44$, $p < .001$), relatedness × groups ($F(1,14) = 14.14$, $p < .005$), and relatedness × groups × category ($F(5,70) = 9.97$, $p < .001$). None of these effects were significant in the F' analysis ($F'(3,163) = 2.15$, $.10 > p > .05$, $F'(1,132) = 2.26$, $p > .10$, and $F'(6,167) = 2.07$, $.10 > p > .05$, respectively).

The marginal category effect seems to arise from the fact that the names of kitchen utensils seem to take slightly longer to pronounce ($\bar{X}$ = 549) than the names of the instances in the other categories ($\bar{X}$ = 519, range 507 to 525). The other two potential effects seem also to be results of item idiosyncrasies. That is, the list A items which were in the related condition for group 1 and the unrelated condition for group 2 seemed to be slightly easier to pronounce than the list B items. Thus, the 7-millisecond priming effect grew to 18 milliseconds for group 1 but shrunk to −4 milliseconds for group 2. Since a number of factors may have gone into the creation of this difference [e.g., word length, frequency, number of syllables (Forster & Chambers, 1973; Frederiksen & Kroll, 1976), all of which seem to work in favor of list A words], differences of this size are not surprising. Nor is it surprising, since the items in each category were split randomly into lists A and B, that only some of the categories showed this exact pattern. In particular, only body parts, kitchen utensils, and animals showed the general pattern of a relatedness advantage for list A stimuli and a reversal of the advantage for list B stimuli. No further analyses of these results will be attempted.

Discussion

The basic result of Experiment 1 was that there was little if any facilitation when targets were preceded by semantically similar primes. The 7-millisecond difference, although significant in the conventional analysis, failed to even approach significance in the F' analysis. As such, at this point it is probably best regarded as a null result. This argument is reinforced if one examines the size of the effect created by a simple division of items into lists A and B. Items were assigned to these lists essentially randomly with the only constraint being that half of the items from each category go into each list. As suggested earlier, it appears that there were differences in the two lists in terms of dimensions like frequency and word length, although these differences would, presumably, be reasonably small. Nonetheless, the words in list A were named 11 milliseconds more rapidly than those in list B, an effect 50% larger than the size of the semantic context effect.

Based on the semantic network/spreading activation model the lack of a context effect in Experiment 1 is, at least, somewhat surprising. Thus, before attempting to interpret this result the question should be asked whether the conditions were optimal for finding such an effect. Neely (1977) has suggested that automatic activation provided by a prime may decay after as little as 400 milliseconds. Thus, unless the subjects in Experiment 1 were willing or able to attend to the automatically activated concepts for the additional 400 milliseconds, or so, before the target appeared, no priming would be expected. One reason why subjects might not have done this would be that they were required to use this time to respond to the prime. Although naming a word is not a highly attention-demanding process, attending to activated concepts while naming the prime may have required more attention than the subjects were willing to expend.

A further consideration of the methodology of Experiment 1 suggests a second reason why no priming might have been detected. As suggested by Shiffrin and Schneider (1977) and Posner and Snyder (1975) automatic activation of concepts is a process which is not available to a subject's consciousness. Thus, controlled attention cannot simply be allocated to the automatically activated concepts. Instead, use of controlled attention demands that subjects first grasp the contingencies of the task and then learn how best to use their attentional capacities. Presumably, this process takes time. Subjects in Experiment 1 had only 72 trials (only 36 using related stimuli) to develop these skills. Thus, evidence for the use of these skills may not have fully emerged during the single trial block.

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Experiment 2 is a second attempt to detect priming by semantically but not associatively related primes in a naming task. It is essentially a replication of Experiment 1 with two changes. First, a second block of trials will be used in order to give the skills involved in attended processing a chance to develop. Second, subjects will be asked simply to look at the prime but not to name it. The SOA will be set at 800 milliseconds (550 milliseconds for prime display and, as before, a 250-millisecond ISI). A 550-millisecond display time was selected to be approximately equivalent to the average prime display time in Experiment 1.

Experiment 2

Method

Subjects. The subjects were 16 University of Western Ontario undergraduates (7 males and 9 females) who received course credit to appear in this experiment. All were native English speakers. None had participated in Experiment 1.

Stimulus materials and equipment. The stimulus materials and the procedures for pairing stimuli were the same as in Experiment 1. Also the tachistoscope, timer, microphone, and voice-activated relay were the same as used in Experiment 1.

Procedure. The procedure was identical to that used in Experiment 1 with two exceptions. First, subjects were informed that they were simply to look at the prime. The prime remained in view for 550 milliseconds. Second, after the first block of trials was complete subjects were allowed a brief (3 minute) rest after which a second trial block was presented. The second trial block was essentially identical to the first. That is, the stimulus pairings were not altered nor was the order rearranged. However, pairs on which errors were made in the first block were not put back into their original position but were left at the end of the block of trials.

Results

Errors. A trial was considered an error if (a) the word was pronounced incorrectly or (b) the reaction time was longer than 1300 milliseconds. There were a total of 14 errors in the 2304 trials in this experiment, 6 in the related condition, 8 in the unrelated condition. In five instances an error was also made to the second appearance of that stimulus pair. (Four of these were due to one subject.) These five reaction times were estimated using the procedure discussed earlier. Given the small percentage of errors no further analysis of the error trials was undertaken.

Mean reaction times. The 2299 correct and 5 estimated target latencies were submitted to a 2(relatedness) × 2(groups) × 2(blocks) × 6(category) by 6(items) ANOVA. Items is again nested within the factors of relatedness, groups, and category, while subjects is nested within the groups factor. Again both F and F' values will be reported with the degrees of freedom for the F' analysis calculated using Myers' (1972) adjustment.

As before, the central issue is the relatedness effect. Mean latencies were 518 milliseconds on related trials and 525 milliseconds on unrelated trials. This 7-millisecond effect was, again, significant in the standard analysis ($F(1,14) = 14.00$, $p < .005$) but not in the F' analysis ($F'(1,134) = 1.64$, $p > .20$). In addition, the three other effects which were significant in the standard analysis in Experiment 1 were also significant in the standard analysis in Experiment 2: category ($F(5,70) = 15.83$, $p < .001$), relatedness × groups ($F(1,14) = 46.96$, $p < .001$), and relatedness × groups × category ($F(5,70) = 17.71$, $p < .001$). This time, however, all three effects were also significant in the F' analysis ($F'(5,165) = 2.47$, $p < .05$, for category; $F'(1,134) = 5.16$, $p < .025$ for relatedness × groups; $F'(6,157) = 2.72$, $p < .025$ for relatedness × groups × category).

These effects seem to be due to the same differences as in Experiment 1. The category effect seems to be due to the mean naming latency for kitchen utensils ($\overline{X} =$

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540) being longer than the mean naming latency for items in the other categories ($\bar{X}$ = 518, range 505 to 528). The relatedness × groups interaction again seems to stem from the items in list A being easier to name than those in list B. Thus, group 1, having the list A items in the related condition, showed a 21-millisecond relatedness effect while group 2 subjects, who had list B items in the related condition, showed a relatedness effect of −6 milliseconds. The relatedness × groups × category effect again arose because only certain categories (body parts and kitchen utensils) showed the general pattern of a relatedness effect for group 1 with a reversal of the effect for group 2. The other four categories showed a variety of patterns.

Considering the variables discussed above, the results of Experiment 2 provide an almost exact replication of the results of Experiment 1. The main difference in the two analyses is the inclusion of the extra factor, blocks, in Experiment 2. The blocks effect was significant both in the standard analysis ($F(1,14) = 37.69$, $p < .001$) and in the F' analysis ($F'(1,23) = 29.43$, $p < .001$). Average target latency in block 1 was 533 milliseconds while in block 2 it was 510 milliseconds, indicating that subjects improved with practice. However, more important, there was no hint of a blocks × relatedness interaction (both F and $F' < 1.0$) as the relatedness effect was 8 milliseconds in block 1 and 6 milliseconds in block 2. Thus, there is no evidence for the emergence of controlled attending strategies with the extra practice.

Two additional effects were also worth mentioning. Significant in both analyses was the blocks × category interaction ($F(5,70) = 3.67$, $p < .01$ and $F'(8,183) = 2.13$, $p < .05$). Not surprisingly, certain categories showed smaller block effects than others. The size of these effects ranged from 13 milliseconds for items in the animal category to 36 milliseconds for items in the kitchen utensil category. This result is probably best viewed as some sort of repetition effect with shorter, more familiar words showing a smaller effect than longer, less familiar words. Finally, there was a blocks × category × relatedness effect which was significant in the standard analysis ($F(5,70) = 3.24$, $p < .025$) but not in the F' analysis ($F'(9,188) = 1.86$, $.10 > p > .05$). Items in the categories animals and kitchen utensils showed small (13–17 milliseconds) relatedness advantages in both blocks of trials while all other categories showed a relatedness advantage in one block and reversal in the other. No attempt will be made to interpret this result.

Discussion

The results of Experiment 2 provide an almost exact replication of those from Experiment 1. For example, subjects were once again faster at pronouncing the words in list A than those in list B and they were slowest overall at pronouncing the names of kitchen utensils. Most important, however, the size of the relatedness effect was identical to that of Experiment 1, 7 milliseconds. As before, this effect was significant in the conventional analysis but far from significant in the F' analysis. Thus, although the present results do provide at least a bit of evidence for the existence of semantic priming in the present context, the argument is still a weak one. What is clear, however, is that the essential lack of priming in Experiment 1 was not due to the requirement that subjects name the prime.

With respect to the other issue investigated in Experiment 2, there was absolutely no evidence that adding a second block affected the size of the priming effect. Thus, in the framework of Posner and Snyder's (1975) two-process theory there was no evidence that through familiarity with the contingencies of the task subjects were learning to use controlled processes to produce priming. One could, of course, argue that these controlled processes take more than two blocks to develop fully, and with more practice a large priming effect would have emerged. However, at present this argument would be totally without empirical support since, if anything, the data seem to indicate that the effect shrunk slightly from block 1 to block 2.

It appears that there are two reasons why the priming effects in Experiments 1 and 2 were so small. The first is that subjects simply were unable to keep active the concepts which are automatically activated by the prime for the duration of the prime–target interval. The second is that category member primes simply provide essentially no activation, either controlled or automatic to other category members. The obvious way to evaluate these possibilities is to rerun Experiment 2 looking specifically for automatic priming. Using Neely's (1977) methodology as a guide, prime–target SOA was set to 250 milliseconds (200 milliseconds prime viewing time and a 50-millisecond ISI). If a substantial priming effect results it will be evidence that category member primes can and do activate and, thus, facilitate the naming of same category targets. As such, the essential lack of priming in Experiments 1 and 2 can be attributed to the subjects' inability to maintain this activation through appropriate controlled processing.

Experiment 3

Method

Subjects. The subjects were 16 University of Western Ontario undergraduates (8 males and 8 females) who received course credit to appear in this experiment. All were native English speakers. None had appeared in either previous experiment.

Stimulus materials and equipment. The stimulus materials, procedure for pairing stimuli, and the equipment were the same as in Experiments 1 and 2.

Procedure. The procedure was identical to that of Experiment 2 with one exception. The prime remained in view for only 200 milliseconds and the ISI was shortened to 50 milliseconds. Thus, the prime–target onset asynchrony was 250 milliseconds.

Results

Errors. A trial was considered an error, and repeated, if (a) the subject stuttered or mispronounced the target; (b) the subject named the prime; or (c) the subject's response was too soft to stop the timer. There were a total of 44 errors in the 2304 trials in this experiment, 26 on related trials and 18 on unrelated trials. Twenty-eight of these errors (19 on related trials) fell into category c and 4 errors (2 on related trials) fell into category b. Neither of these types of errors seems to have anything to do with the experimental manipulations and, thus, were disregarded. There were only 12 trials (5 related) on which subjects made what is classically thought of as a naming mistake. Given the small percentage of these types of errors no further analysis of these trials was undertaken.

Mean reaction times. The 2304 correct target latencies were submitted to the same ANOVA as in Experiment 2. Again both F and F' values will be reported with the degrees of freedom for the F' analysis calculated using Myers' (1972) adjustment.

Once again the central issue is the relatedness effect. Mean latencies were 513 milliseconds on related trials and 519 milliseconds on unrelated trials. As before, this 6-millisecond difference was significant in the standard analysis ($F(1,14) = 8.59, p < .025$) but not in the F' analysis ($F'(1,134) = 1.10$, n.s.). In addition, the same three effects which were significant in Experiments 1 and 2 were again significant here: category ($F(5,70) = 22.22$, $p < .001$, and $F'(5,150) = 2.79$, $p < .025$), relatedness × groups ($F(1,14) = 35.25$, $p < .001$, and $F'(1,134) = 4.16$, $p < .05$), and relatedness × groups × category ($F(5,70) = 35.77$, $p < .001$, and $F'(5,142) = 3.24$, $p < .01$). These effects again seem to have arisen from the same sources. That is, the category effect was due to the mean naming latency for kitchen utensils ($\bar{X} = 536$) being longer than the mean naming latency for the other five categories ($\bar{X} = 512$, range 499 to 524). The relatedness × groups interaction was again due to group 1 subjects showing a 20-millisecond relatedness effect while group 2 subjects showed a −6-millisecond relatedness effect. The relatedness × groups × category interaction was due to only the body parts and kitchen utensils categories showing the general pattern of a relatedness effect for group 1 and a reversal of the effect for group 2. The other four categories showed a variety of patterns.

Two other effects were significant in both analyses, groups ($F(1,14) = 6.02$, $p < .05$, and $F'(1,16) = 5.73$, $p < .05$) and blocks ($F(1,14) = 9.89$, $p < .01$, and $F'(1,20) = 8.38$, $p < .01$). The groups effect simply reflects the fact that subjects in group 1 had longer naming times ($\overline{X} = 549$) than those in group 2 ($\overline{X} = 483$). The blocks effect simply reflects the fact that subjects improved with practice ($\overline{X} = 523$ for block 1, $\overline{X} = 509$ for block 2). No other effects reached significance in either analysis (all p's $> .05$).

Discussion

The issue being investigated in Experiment 3 was whether directly tapping the subjects' automatic processing mechanisms would produce a change from the results of Experiments 1 and 2. The answer is unequivocally negative as Experiment 3 provided an almost exact replication of Experiments 1 and 2. In particular, once again the relatedness effect was a minimal 6 milliseconds. This essential lack of a relatedness effect in the present circumstances indicates that a purely semantic relationship between prime and target can provide very little automatic facilitation in a naming task. As such, the minimal priming observed in Experiments 1 and 2 cannot be ascribed to the rapid decay of automatic activation, since minimal activation seems to have been available in the first place.

The approximately 7-millisecond relatedness effect has now been replicated over three groups of subjects over the time period of nearly 1 year. This replicability coupled with the fact that the effect was always significant in the standard ANOVA does suggest that although the effect is small and, perhaps, restricted to stimulus pairs which are semantically very similar, it may very well be real. In fact, Seidenberg (1983) has presented precisely this point of view based on his finding of a small priming effect with Fischler's (1977) stimuli in a naming task. On the other hand, when items was regarded as a random factor crossed with subjects within groups and an F' analysis was used, the effect never even approached significance. This result, coupled with the fact that it may never be possible to produce prime–target pairs which have absolutely no associative strength for at least some subjects, argues that it may be better to regard this effect as a null one. In any case, however, what is clear is that the role of semantic similarity alone in providing facilitation in a naming task is a very minor one.

The above conclusion then raises an interesting question. That is, does a purely semantic relationship play *any* role in a naming task? It is certainly possible that although it may not produce facilitation in the absence of an associative relationship, it may augment the priming available from an associative relationship when both are present. On the other hand, priming in these naming tasks may be solely a function of associative relationships (e.g., Fodor, 1983) with semantics having no effect in and of themselves. This is the main issue investigated in Experiment 4.

A secondary issue which will also be investigated in Experiment 4 is whether subjects in these experiments are actually accessing lexical information in order to name the targets. If naming were being accomplished only through the use of spelling to sound transformation rules (Baron, 1977) no priming of any sort would be expected. The existence of an associative priming effect in Experiment 4 will argue that an explanation of this type cannot account for the lack of semantic priming effects in Experiments 1, 2, and 3.

Experiment 4

Method

Subjects. The subjects were 16 University of Western Ontario undergraduates (9 males and 7 females) who received course credit to appear in this experiment. All were native English speakers and none had appeared in any of the previous experiments.

Stimulus materials and equipment. Sixty word pairs were selected from Postman and Keppel's (1970) word association norms such that the target stimulus in each pair was either the first or second ranking associate of its prime. For 30 of these pairs the prime and target were both members of one of the semantic categories defined by Battig and Montague (1969). For the other 30 pairs the prime and target clearly belonged to separate categories. Since each prime and each target were to be presented twice to each subject, once in each trial block, two 23.0 × 25.6-cm stimulus cards were prepared with the word printed in upper case in the middle of the card. A complete list of the stimulus pairs is presented in Appendix B.

To create the appropriate stimulus pairings, each list of 30 pairs was arbitrarily divided into two sets of size 15. For both lists the associated pairs in one set were presented together on one trial block, creating the related trials, while the pairs in the other set were scrambled to create the unrelated pairs. In the other block the reverse was true with the second set being used to create the related trials and the first set pairs being scrambled to create the unrelated trials. In order to complete the counterbalancing two groups of subjects had to be designated. One group received the two trial blocks in one order and the other group in the reverse order. The order of stimuli within a block was randomly determined by shuffling the targets before pairing them with an appropriate prime. The prime–target pairings for unrelated trials were randomly determined so that each subject received a unique set of unrelated pairs. Care was taken to make sure that there was no associative, semantic, or phonetic relationship between the primes and targets on unrelated trials. The tachistoscope, timer, microphone, and voice-activated relay were the same as those used in previous experiments.

Procedure. The procedure was identical to that of Experiment 2 with two exceptions. First, there were only 60 trials per block. Second, the two blocks were different in that those targets appearing in a related context in the first block appeared in an unrelated context in the second block and vice versa.

Results

Errors. A trial was considered an error and rerun if (a) the word was pronounced incorrectly; (b) the reaction time was longer than 1300 milliseconds; (c) the subject named the prime; or (d) the subject's response was too soft to stop the timer. There were a total of 30 errors in the 1920 trials in this experiment. However, only 13 of these fell into categories classically thought of as errors (i.e., a and b). Of these 13 no more than 4 occurred in any of the four major conditions of the experiment. Given the small percentage of errors no further analysis of these trials was undertaken.

Mean reaction times. The 1920 correct target latencies were submitted to a 2(associative relatedness) × 2(semantic category membership) × 2(blocks) × 2(groups) × 15(items) ANOVA. Items is nested within all of these factors while subjects is nested only within groups. Again both F and F' values will be reported with the degrees of freedom for the F' analysis calculated using Myers' (1972) adjustment.

The only effect which was significant in both analyses was the associative relatedness effect ($F(1,14) = 78.81$, $p < .001$, and

$F'(1,217) = 10.52$, $p < .005$). Mean latencies were 523 milliseconds on related trials and 541 milliseconds on unrelated trials. There was no evidence that the size of this effect varied as a function of semantic category membership (525 milliseconds vs 544 milliseconds for category members and 521 milliseconds vs 539 milliseconds for nonmembers).

Three other effects reached significance in the standard analysis: associative relatedness × groups ($F(1,14) = 6.22$, $p < .05$), associative relatedness × category membership × blocks ($F(1,14) = 4.89$, $p < .05$) and the four-way interaction of associative relatedness, category membership, blocks, and groups ($F(1,14) = 21.51$, $p < .001$). None of these effects, however, were significant in the F' analysis (all p's $> .05$). The associative relatedness by groups effect arose because one group showed a 21-millisecond priming effect while the other group showed only a 16-millisecond priming effect. There would seem to be no particular reason to attach any importance to this result. No attempt will be made to interpret the two higher order interactions.

Discussion

The main purpose of Experiment 4 was to determine if the existence of a semantic relationship between prime and target would augment whatever priming is derived from an associative relationship in a naming task. The answer was quite clearly negative as the size of the priming effects with and without a category relationship were essentially identical. The secondary purpose of Experiment 4 was simply to demonstrate the existence of associative priming in order to validate the assumption that lexical access is involved in the present tasks. The significant relatedness effect nicely validates this assumption. Thus, these results, together with the results of Experiments 1 to 3, strongly suggest that simple semantic similarity can provide very little, if any, facilitation in a naming task.

This conclusion is actually quite in line with most of the relevant studies reported earlier (e.g., Massaro et al., 1978; Irwin & Lupker, 1983; and to some extent Sperber et al., 1979), all of which found very minimal effects of semantic priming in a naming task. In addition, it supports Fodor's (1983) suggestion that priming in naming tasks is essentially an associative phenomenon. However, it seems quite incompatible with the explanations of priming provided by the semantic network/spreading activation models, given Fischler's (1977) findings. These models attempt to account for priming by postulating that the prime serves to raise the activation level of "related" concepts in memory. When a word representing one of those concepts is then presented access to its memory location is more rapid due to its heightened activation. Since both naming and lexical decisions involve this access process as one of their components, whatever type of relationship primes one type of response should also prime the other type of response. Further, if we accept the suggestion of Meyer et al. that this is the sole source of priming, these two types of response should be primed to the same degree. The contrast between Fischler's results using a lexical decision task and the present results using a naming task show quite dramatically that there are problems with this account.

Their (Meyer et al.) suggestion that lexical access is the only locus of priming was based on the fact that they found equivalent priming in naming and lexical decision tasks. However, a survey of the more recent literature seems to suggest that the Meyer et al. results may be an anomaly. In studies using associated word pairs, priming effects in lexical decision tasks tend to range from 40 to over 100 milliseconds, while the priming effects in naming tasks tend to be somewhat smaller, as observed in Experiment 4. These differences themselves may, of course, be explainable in terms of different methodological pro-

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cedures across studies. However, in the face of results such as these, a number of investigators have suggested that lexical decisions may also benefit from a related context at a second, postaccess level (Forster, 1981; Koriat, 1981; Myers & Lorch, 1980; West & Stanovich, 1982) at which semantics may be important. If such a suggestion were correct, the discrepancy between the present results and those of Fischler could be easily explained.

On the other hand, at this point one could still question the generalizability of Fischler's results. His study appears to be the only study which attempted to eliminate the effects of association and one can certainly question the extent to which he, or anyone, can be successful. Further, Fischler's task was a simultaneous lexical decision task in which the decision is whether two simultaneously presented letter strings are both words, rather than the standard sequential task. The simultaneous presentation may induce subjects to analyze the two letter strings quite differently than when they are presented sequentially. For example, subjects may find it easier to determine first whether there is a relationship between the two strings as an aid in the subsequent lexical decisions. As a result, related trials may be faster than unrelated trials which would suffer from an unsuccessful search. This, or other possible strategies, may produce "priming" in a simultaneous task which would not be found with sequential prime–target presentations.

Experiment 5 was an attempt to demonstrate semantic priming without association in a sequential lexical decision task. The stimuli were those used in Experiments 1, 2, and 3. In those experiments it was demonstrated quite clearly that these stimuli produce little, if any, priming in a naming task. Thus, if they can produce priming in a lexical decision task it can be taken as strong evidence that the effects of a semantic relationship are task dependent, and thus, that the basic account of priming as discussed above is incomplete.

Experiment 5

Method

Subjects. The subjects were 18 University of Western Ontario undergraduates (10 males and 8 females) who received course credit to appear in this experiment. All were native English speakers and right-handed. None had appeared in any of the previous experiments.

Stimulus materials and equipment. The 72 stimulus items used in Experiments 1, 2, and 3 were also used in the present study. In addition a nonword target was created from each of the 72 words by slightly altering the spelling of the word. A 23.0×25.6-cm card was prepared for each of the nonwords with the nonword printed in upper case in the middle of the card. The list of nonwords is presented in Appendix A.

As in the first three experiments the 72 concepts were split into lists A and B. The nine subjects in the first group were to receive the 36 targets from list A on related trials and the 36 targets from list B on unrelated trials. For the second group the reverse was true. However, for any given subject only 24 of the targets in each list were words. For the other 12 targets in the list the matched nonword target was substituted for the word target. Thus, each block of trials had 24 related word targets, 24 unrelated word targets, 12 "related" nonword targets, and 12 "unrelated" nonword targets. The nonwords to be used for a given subject were selected by first creating three sets of 12 items from each list such that each set contained two members from each category. Each set of 12 was used in substitution for the matched words for three subjects in each group. Thus, a given nonword target was presented to exactly six subjects, three of whom saw it in a "related" context and three of whom saw it in an "unrelated" context. Each word target was seen by the other twelve subjects, again half of whom saw it following a related prime.

The actual prime–target pairings were created as before. The targets being used for each subject were shuffled and then each target was paired with either a related or unrelated prime word (the primes were always words). In this way each subject received a unique set of prime–target pairs. Again, care was taken to make sure that there were no associative or phonetic relationships between primes and targets. Finally, care was also taken to make sure that no target items were preceded by a same category item in the previous two trials.

The tachistoscope and timer were the same as in the previous studies. Since responding was manual, a board with two telegraph keys was placed on the table in front of the subject. Depression of either key served to stop the timer.

Procedure. The basic procedure was the same as in Experiment 2. The only differences were that (a) subjects were required not to name the target but to decide whether or not it was an English word, and (b) they were to depress the right key with their right index finger if it was a word and the left key with their left index finger if it was not.

Results

Word Trials

Errors. A trial was considered an error and rerun if (a) the incorrect button was depressed; (b) the reaction time was longer than 1500 milliseconds; or (c) the subject did not depress the button enough to stop the timer. There were a total of 61 errors on word trials (3.5%). Three of these fell into category c and were, thus, disregarded. Of the remaining 58 errors, 24 were on related trials and 34 were on unrelated trials, a difference which failed to reach significance ($t(17) = 1.02$, n.s.). Owing to the very small number of errors it was felt that an analysis of error reaction times would be meaningless. However, it may be noted that after removing the two related and one unrelated trials in which reaction times were greater than 1500 milliseconds, mean error latencies were 697 milliseconds on related trials and 682 milliseconds on unrelated trials. Thus, there is little evidence of a difference between related and unrelated trials to be found in the error data.

It should be noted that 6 of the 61 errors, 3 in each condition, were errors to the second occurrence of the same stimulus pair. Rather than presenting the pair a third time its reaction time was estimated. The estimated reaction time was the mean reaction time of the other three members of the same category in the same condition.

Mean reaction times. The 1722 correct and 6 estimated target latencies were submitted to a 2(relatedness) × 2(groups) × 2(blocks) × 6(category) × 4(items) ANOVA. Items were again nested within the factors of relatedness, groups, and category, while subjects were nested within groups. As before both F and F' values will be reported and Myers' (1972) adjustment will be used.

The central issue is again the relatedness effect. Mean latencies were 548 milliseconds on related trials and 574 milliseconds on unrelated trials, a difference which was significant in both analyses ($F(1,16) = 15.68$, $p < .005$, and $F'(1,80) = 4.98$, $p < .05$). Thus the reaction time data do show nice evidence for a difference between related and unrelated contexts.

Three other effects were also significant in both analyses: blocks ($F(1,16) = 21.11$, $p < .001$ and $F'(1,20) = 18.73$, $p < .001$), category ($F(5,80) = 16.85$, $p < .001$, and $F'(6,109) = 3.87$, $p < .005$), and the blocks × category interaction ($F(5,80) = 3.00$, $p < .025$, and $F'(8,152) = 2.01$, $p < .05$). The blocks effect reflects the fact that subjects improved with practice. The category effect reflects the fact that kitchen utensils were much more difficult to make lexical decisions about ($\overline{X} = 609$) than members of the other categories ($\overline{X} = 551$, range 535 to 572). The interaction reflects the fact that this difference between kitchen utensils and the other categories was much smaller in block 2 than block 1.

There were three other interactions which were significant in the standard analysis: relatedness × groups ($F(1,16) = 7.34$, $p < .025$), relatedness × groups × category ($F(5,80) = 3.82$, $p < .001$), and relatedness × blocks by category ($F(5,80) = 2.73$, $p < .025$). However, none of these reached significance in the F' analysis (all p's $> .05$). The first two of these effects also appeared in Experiments 1, 2, and 3. The source of the relatedness × groups interaction in the present experiment seems to be the same as in the first three experiments. That is, group 1 subjects who received list A stimuli in their related condition and list B stimuli in their unrelated condition showed a large, 44 millisecond, priming effect, while group 2 subjects who had the reverse showed only an 8-millisecond effect. The relatedness × groups × category interaction reflects the fact that not every category showed this basic pattern of a smaller priming effect for group 2 subjects. In particular, kitchen utensils and vehicles showed the trend most clearly while furniture and clothing showed the opposite trend. Finally, the relatedness × blocks × category interaction seemed to stem from the fact that two categories (body parts and, in particular, kitchen utensils) showed larger priming effects in block 1 than block 2, while the reverse was true for the other four categories.

Nonword Trials

Errors. There were a total of 99 errors on nonword trials (11.3%), 55 on "related" trials, and 44 on "unrelated" trials. This difference was not significant ($t(17) = 1.29$, n.s.). After removing the one related and two unrelated reaction times greater than 1500 milliseconds, mean reaction times were 695 milliseconds on related trials and 655 milliseconds on unrelated trials. Although these means were based on a reasonable number of trials, no analysis of this difference was undertaken. The reason for this was that there tended to be wide variability in the number of these types of errors among subjects. Thus, unless the individual reaction times were ignored and the analysis was done on subject means, serious independence problems would have existed. However, an analysis based on subject means also seemed inadvisable since only half the subjects had more than one error on both related and unrelated trials.

It should be noted that 17 of the 99 errors, 11 on related trials and 6 on unrelated trials, were errors to the second occurrence of a stimulus pair. Rather than presenting the pair a third time, its reaction time was estimated. The estimated reaction time was the mean reaction time of the other 11 nonword targets in the same condition.

Mean reaction times. The 847 correct and 17 estimated reaction times were submitted to a 2(relatedness) × 2(groups) × 2(block) × 12(items) ANOVA. Items was nested within relatedness and groups while subjects was nested within groups. Both F and F' values were calculated and Myers' (1972) adjustment was used.

The most interesting question which these data can focus on concerns the "relatedness" effect. That is, would nonwords orthographically and phonetically similar to real words be influenced by primes semantically related to the real words? While the error data hinted that semantically related primes may hinder lexical decisions, the correct reaction time data suggest that such was not the case. Mean reaction times were 663 milliseconds on related trials and 664 milliseconds on unrelated trials. As such, the main effect of relatedness did not approach significance.

Only one effect, blocks, was significant in both analyses ($F(1,16) = 60.42$, $p < .001$, and $F'(1,28) = 44.48$, $p < .001$). This effect simply indicates that subjects improved with practice. One other effect, the relatedness × groups interaction, was significant in the standard analysis ($F(1,16) = 8.02$, $p < .025$) but not in the F' analysis ($F'(1,56) = 3.48$, $.10 > p > .05$). This result is derived from group 1 subjects showing a

26-millisecond "relatedness" effect while group 2 subjects showed a −24-millisecond "relatedness" effect. Given the group differences observed previously, these results are most likely attributable to the fact that different nonwords appeared in the related and unrelated conditions for the two different groups.

Discussion

The purpose of Experiment 5 was to determine whether a semantic relationship alone could produce priming in a sequential lexical decision task. The answer appears to be affirmative as a significant 26-millisecond relatedness effect was obtained. This result backs up Fischler's findings and reinforces the conclusion that the effects of a semantic context are task dependent.

This task dependence obviously poses a problem for the basic account of priming offered by the semantic network/spreading activation model discussed earlier. If priming is solely an input phenomenon, both naming and lexical decision making should have benefited to the same degree from a semantic context. The fact that lexical decision making benefited substantially more would seem to indicate, as a number of investigators (Forster, 1981; Koriat, 1981; Myers & Lorch, 1980; West & Stanovich, 1982) have argued, that it can be primed at a second, postaccess level. In fact, the results of Experiments 1 to 5 are consonant with the idea that input priming, which is observed in naming tasks, may be influenced solely by associative relatedness while semantic factors determine the amount of priming available at this second level. Such a suggestion would, of course, require a reasonable explanation of how semantic context would aid this second, postaccess process.

Experiment 6 was designed to investigate these ideas. The task was lexical decision and the stimuli used were the same as those in Experiment 4. The related pairs in Experiment 4 were all strong associates. In addition, half the pairs were composed of two members of the same semantic category. If input priming is a function of associative strength, all pairs should enjoy this facilitation. Presumably, the amount of facilitation would be reasonably equivalent to that observed in Experiment 4. In addition, if second level priming is a function of semantic similarity, only the pairs sharing semantic features should receive a benefit from this process. Thus, the semantically similar pairs should produce a larger priming effect than pairs which are just associatively related.

One additional issue that the data from Experiment 6 will focus on concerns the "related" nonwords. Each nonword used in Experiment 5 was a slight transformation of one of the words used. For each subject half of the nonwords presented appeared in a context that would be called related if the untransformed word has been presented instead. For purposes of discussion this group of nonwords can be referred to as "related" with the other group referred to as "unrelated." Lapinski and Tweedy (1976) reported that related nonwords in a lexical decision task can be responded to more rapidly than unrelated nonwords. If the generality of this effect can be established it would shed a considerable amount of light on the processes that go into making a lexical decision and help to define this second, postaccess process. However, other researchers (Schvaneveldt & McDonald, 1981) have reported a small, nonsignificant effect in the opposite direction. The results of Experiment 5 are similar. That is, there was absolutely no evidence of such facilitation in the correct reaction time data while the error data, if anything, hinted that the reverse might be true. Experiment 6 will once again address this issue by using nonwords constructed in a similar manner. If Lapinski and Tweedy's (1976) results can be generalized such an effect should show up in Experiment 6.

Experiment 6

Method

Subjects. The subjects were 18 University of Western Ontario undergraduates (9 males and 9 females) who received course credit to appear in this experiment. All were native English speakers and right-handed. None had appeared in any of the previous experiments.

Stimulus materials and equipment. The 60 stimulus pairs used in Experiment 4 were also used in the present study. In addition a nonword target was created from each of the 60 word targets by slightly altering the spelling of the word. Since each target was to appear in both trial blocks, two 23.0 × 25.6-cm cards were prepared for each nonword with the nonword printed in upper case in the middle of each card. The list of nonwords used is presented in Appendix B.

As in Experiment 4 each list of 30 stimulus pairs was split into two sets of size 15. For both lists the associated pairs in one set were to be presented together on one trial block creating the related trials while the pairs in the other set were scrambled to create the unrelated trials. In the other trial block the roles of each set were reversed. As before, counterbalancing was completed by creating two groups of subjects, one group to receive the blocks in one order, the other to receive the blocks in the reverse order. The difference between the present study and Experiment 4 was that ten of the word targets in each list were replaced by their nonword counterparts, five in the related condition, five in the unrelated condition. The nonwords had been divided into three sets of size 10, so that each set was presented to one-third of the subjects in each group on both trial blocks. Thus, a given nonword was presented to exactly six subjects, three of whom saw it in a related context in block 1 and an unrelated context in block 2 and three of whom saw it in the opposite circumstance. Each word target was seen by twelve subjects, six of whom saw it in a related context in block 1 and an unrelated context in block 2 and six of whom saw it in the opposite circumstance.

The order of stimuli within a block was randomly determined by shuffling the targets for each block before pairing them with the appropriate primes. The prime–target pairings for unrelated trials were randomly determined so that each subject received a unique set of unrelated pairs. Care was taken to make sure that there was no associative, semantic, or phonetic relationship between the primes and targets on unrelated trials. The tachistoscope, timer, and response board were the same as those used in Experiment 5.

Procedure. The procedure was identical to that of Experiment 5 with two exceptions. First, there were only 60 trials per block. Second, the two blocks were different in that those targets appearing in a related context in the first block appeared in an unrelated context in the second block and vice versa.

Results

Word Trials

Errors. A trial was considered an error and rerun if (a) the incorrect button was depressed; (b) the reaction time was longer than 1500 milliseconds; (c) the subject did not press the button far enough to stop the timer; or (d) the subject responded to the prime. There were a total of 40 errors on word trials (2.8%). Five of these fell into categories c and d and were disregarded. Of the remaining 35 errors, 6 were on related trials and 24 were on unrelated trials, a difference which was significant ($t(17) = 3.24$, $p < .01$). In addition, the errors on unrelated trials tended to occur more for the noncategory word targets (20) than for the category word targets (9). Errors on related trials were divided 4 and 2 between the category word and noncategory word targets, respectively. However, given the small number of errors, especially on related trials, no further analyses of these results or the reaction time results were undertaken.

It should be noted that 5 of the 35 errors, all in the unrelated condition, were errors to the second occurrence of a stimulus pair. Rather than presenting the pair a third time its reaction time was estimated. The estimated reaction time was the mean reaction time of the other nine trials in the same cell of the semantic category relationship by associative relationship matrix.

Mean reaction times. The 1435 correct and 5 estimated target latencies were submitted to a 2(associative relatedness) × 2(semantic category membership) × 2(groups) × 2(blocks) × 10(items) ANOVA. Items was again nested within all of these factors while subjects was only nested within groups. Again both F and F' values will be reported with the degrees of freedom for the F' analysis calculated using Myers' (1972) adjustment.

There were only two effects which were significant in both analyses: associative relatedness ($F(1,16) = 35.53$, $p < .001$, and $F'(1,45) = 20.79$, $p < .001$) and blocks ($F(1,16) = 13.30$, $p < .005$, and $F'(1,43) = 8.16$, $p < .01$). The latter effect simply reflects the fact that subjects improved with practice. The former effect reflects the fact that reaction times on related trials ($\bar{X} = 538$) were 47 milliseconds faster than on unrelated trials ($\bar{X} = 585$). However, there was no hint of an associative relatedness × semantic category membership interaction as the relatedness effects for the two types of targets were virtually identical (538 milliseconds vs 584 milliseconds for the category members, 538 milliseconds vs 585 milliseconds for nonmembers).

Only one other effect, the associative relatedness × category membership × groups × blocks interaction was significant in the standard analysis ($F(1,16) = 5.17$, $p < .05$) but not in the F' analysis ($p > .10$). No attempt will be made to interpret this result.

Nonword Trials

Errors. A trial was considered an error and rerun if it fell into any of the categories listed above. There were a total of 55 errors on nonword trials (7.4%). Four of these fell into category d and, thus, were disregarded. Of the remaining 51 errors, 26 were on related trials and 25 were on unrelated trials, a nonsignificant difference ($t(17) = .12$, n.s.). An analysis of the reaction times was once again not undertaken since only three subjects made more than 1 error on both related and unrelated trials. However, it can be noted that after removing the two related and four unrelated reaction times greater than 1500 milliseconds, mean reaction times were 605 milliseconds on related trials and 673 milliseconds on unrelated trials.

Of the 51 errors, 5 were errors to the second occurrence of a stimulus pair (2 in the related condition). Rather than presenting the pair a third time its reaction time was estimated. The estimated reaction time was the mean reaction time of the other four trials in the same cell of the semantic category relationship × associative relationship matrix.

Mean reaction times. The 735 correct and 5 estimated reaction times were submitted to a 2(associative relatedness) × 2(semantic category membership) × 2(groups) × 2(blocks) × 5(items) ANOVA. Nestings were the same as in the word analysis. Again both F and F' values will be reported and Myers' (1972) adjustment will be used.

The most interesting question concerns the "relatedness" effect. Mean latencies were 673 milliseconds on "related" trials and 674 milliseconds on "unrelated" trials. This effect, obviously, did not approach significance.

The only main effect which was significant in both analyses was the blocks effect ($F(1,16) = 36.49$, $p < .001$ and $F'(1,43) = 21.20$, $p < .001$). Again subjects seemed to improve with practice. However, this effect seems to be due to more than simply practice since three higher order interactions involving blocks were also significant in one or both analyses: blocks × category membership × groups ($F(1,16) = 9.40$, $p <$

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.001, and $F'(1,65) = 4.16, p < .005$); blocks × category membership ($F(1,16) = 5.53, p < .005$, and $F'(1,65) = 2.66, .10 > p > .05$); and blocks × associative relatedness × groups ($F(1,16) = 6.23, p < .025$, and $F'(1,46) = 3.79, .10 > p > .05$). These results would appear to reflect differential practice and repetition effects for different nonwords in different conditions. Since there would presumably be a large degree of variability in subjects' initial familiarity with the different nonwords, such effects are not at all surprising. As such, no attempt will be made to provide a further analysis or interpretation of these effects.

Discussion

The purpose of the present paper was to investigate the role of a purely semantic context in single word priming situations. In terms of the semantic network model, there are a rich set of connections between concepts that are members of the same semantic category. According to the spreading activation hypothesis, these connections should enable category members to prime other members in tasks of the sort used in the present paper. Finally, according to the notion of priming as an input phenomenon (an assumption not actually part of the original model), equivalent priming should be found in the two tasks under investigation.

Two generalizations which can be drawn from the results of the present set of studies cause a certain amount of trouble for this simple interpretation. First, while semantic similarity alone can prime lexical decision making, it has very little effect in a naming task and does nothing to augment the priming provided by associative relationships in either task. Thus, the majority of the activation which spreads to neighboring nodes appears to spread along direct, associative links. Any activation spreading along the semantic links between infrequently associated concepts would have to be assumed to have a very restricted range. That is, nodes for concepts like HORSE and PIG would presumably be connected along two-link paths through many other nodes like those for ANIMAL, TAIL, MAMMAL, and so on. Yet, as the naming task data suggest, if any activation is traveling these paths it must have tailed off substantially by the time it had traversed the second link.

The data from the lexical decision tasks do not necessarily point to the same conclusion since purely semantic relationships can produce priming. However, these priming effects appear to be different from those observed in the naming task, in any case. That is, the second generalization that can be drawn is that the amount of priming provided by a related stimulus pair is task dependent. The amount of priming observed in the lexical decision tasks (Experiments 5 and 6) was substantially larger than that observed in naming tasks using the same stimuli (Experiments 1–4). These results merge with a number of other results which have been reported recently which indicate that much of the priming in a lexical decision task is due to a postaccess process. This second process appears to be the locus of the "semantic" priming. However, as Experiment 6 indicates it is also predominantly influenced by associative relationships.

The model which appears to follow most directly from these results would be one which proposes two primeable processes. The first would be a preaccess process that can be facilitated by activation spreading along the links of a network of direct associations. Semantic links between infrequently associated concepts would play no part in this network. This is essentially the suggestion put forth by Fodor (1983). This process would be the only process which can be primed in naming tasks. The second would be a postaccess process which can be influenced by more general semantic contexts. A model very much like this has been proposed by Forster (1981). In Forster's conceptualization there is a preaccess process which can be primed and is

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responsible for the facilitation observed in naming tasks. In addition, in lexical decision tasks there is this second process in which the subject makes an attempt to integrate the word into the context that has been created. Related words, presumably, fit well and, thus, a decision can be easily made. Unrelated words do not match the context, necessitating further processing before a correct decision can be made.

Such a model would account for the present results reasonably well. However, the model would appear to have insufficient flexibility to be extended beyond the tasks it was created to explain, naming and lexical decision. To explain priming in other tasks, for example, the categorization tasks of Irwin and Lupker (1983) or Guenther, Klatzky, and Putnam (1980), additional mechanisms would be needed. Thus, perhaps a better model of this second, postaccess process would be one in which the demands of the task are considered more closely and perhaps, thought about within a depth-of-processing (Craik & Lockhart, 1972) framework.

The lexical decision task was initially proposed as a task which would allow the study of how subjects access their mental lexicon. It was theorized that a lexical decision could be made simply on the basis of finding a lexical entry to match the presented word. Nonword decisions were presumably based on the termination of an unsuccessful search. It is now clear that an adequate description of this task must include a second process. The fact that this second process is needed indicates that simply arriving at a lexical entry is insufficient to conclude that a letter string has word status. As such, it must be the case that nonwords can also allow access to lexical entries. From this argument a number of predictions arise which have previously found support in the literature. First, nonwords which are wordlike should be more likely to access the lexicon and thus, should be harder to classify as nonwords (Rubenstein, Lewis, & Rubenstein, 1971). Second, when wordlike nonwords are used the second process must play a greater role, thus: (a) word decision latency will rise, and (b) the size of the priming effect will increase (Shulman & Davison, 1977).

The fact that the second, postaccess process *can* lead to a successful decision, however, indicates that once access is accomplished, there must be word–nonword differences in subsequent processing. In particular, whatever retrieval processes are being invoked, there must be a difference in the way a correctly spelled word and an incorrectly spelled word allow those processes to operate. In fact, this difference must be the key to successful decision making. That is, a homophonic nonword like KAR would undoubtedly allow a subject to retrieve the same information that a word like CAR would, although at a different rate and, perhaps, in a slightly different fashion. Thus, it must be the fashion and ease in which the information is retrieved that allows the decision to be made.

The proposal then is that this second process is one in which subjects make a judgment as to the ease with which information can be retrieved from memory on the basis of the presented word. For associated pairs this process would be primed by the same mechanism that primes access. That is, the spread of activation which activat memory locations of the prime's associate would also activate retrievable information about these concepts as well. In this sense, these memory locations are being thought of simply as files of information about each concept (Theios & Muise, 1977). This activation makes the information about a related target easier to retrieve upon presentation, thus, facilitating the decision.

Since the argument is being advanced that this spread of activation is associatively but not semantically based, this mechanism could not account for the "semantic" priming observed in Experiment 5. However, a very similar mechanism could.

This notion of two slightly different mechanisms being at work here is, in fact, reinforced by the major finding in Experiment 6, that a semantic relationship on top of an associative relationship provides no additional facilitation. If both associative and semantic relationships drove this process through exactly the same mechanism, together they should provide more facilitation than either alone. The fact that the associative effect tends to overwhelm the semantic effect suggests that the associative effect is driven by the primary mechanism, while the semantic effect derives from a different and somewhat secondary source.

The effect of this second mechanism would, of course, be the same as that of the first, to ease the retrieval of information about certain (in particular, semantically related) targets. The suggestion for how this might work would go as follows. Interference paradigms have indicated that even a to-be-ignored word is semantically processed to some extent. That is, some semantic information is retrieved. In particular, as picture-word interference results indicate, for concepts which are familiar members of common semantic categories much of this information is common to members of the category (Lupker, 1979; Rosinski, 1977). The same would presumably be true about primes in a lexical decision task. Thus, when a semantically similar target follows, as in Experiment 5, the retrieval operations will seem easier because very similar operations have just recently been undertaken. The ease of retrieval will be high, and the lexical decision will be facilitated. Semantic similarity would not augment an associative relationship, however. Much of the relevant information would have already been activated by the associative relationship, thus, the effects of the semantic relationship would be essentially redundant.

The suggestion is then that both associative and semantic relationships can facilitate this second process although in slightly different ways while only associative relationships can facilitate lexical access and, thus, aid naming. One more issue, however, needs to be dealt with. If homophonic nonwords do allow access to the lexical entry for their word counterpart why was no "priming" obtained in the nonword trials in Experiment 6? That is, since a prime like TRUCK causes CAR to access the appropriate lexical entry faster than a prime like SALT, should not the same be true for KAR? One explanation would be that what KAR gains during access it may lose during the second process. It might be somewhat easier for a nonword to retrieve from an activated entry than a nonactivated entry making the nonword decision harder to reach. On the other hand, rather than postulating compensatory processes, the question should at least be raised as to whether the lexical access process itself can actually be facilitated.

Reading words is certainly one of the most overlearned behaviors humans engage in. As such, some investigators (e.g., Theios & Muise, 1977) have suggested that the path from print to memory is so automatic that little, if anything, can influence it. The main evidence we have that priming influences this process is the well-documented finding that relatedness effects are larger when target presentations are impoverished (Becker & Killion, 1977; Meyer et al., 1975). According to additive factors logic (Sternberg, 1969) this result indicates that these two factors are affecting at least one stage in common, presumably the input stage. Such may very well be the case when conditions are impoverished. That is, because the normal print to memory process is retarded subjects may make use of the activated memory locations to aid in access. Thus, related words would suffer much less than unrelated words from the impoverished conditions. However, it is actually only speculation to suggest that relatedness affects the input process when conditions are not impoverished. The argument can certainly be made that lexical access is accomplished in the normal fashion with all the priming occurring in postaccess processing.

This argument would, of course, explain why there was no "priming" on nonword trials. If access is not facilitated by relatedness, there would be no way for nonwords to benefit. Further, it would have no trouble with the finding that associative relationships facilitate naming while semantic relationships do not. Since associative relationships activate the entire lexical entry, they activate the information pertinent to producing the word's name. Thus, this information should be easier to retrieve. Semantic relationships, on the other hand, may prime the retrieval of information useful in making lexical decisions but they would not prime the name. Thus, no facilitation would be expected. This appears to be an idea worth further investigation.

Before concluding, a couple of cautionary notes should be issued. Forster (1981) and West and Stanovich (1982) have recently put forth a case against using the lexical decision task in sentence priming experiments. The findings that emerged from the present studies underline these investigators' point. Lexical decision making does appear to involve some sort of ease of retrieval judgment. There may be at least two ways to make retrieval easier, by activating the information, as associative relationships appear to do, or by activating the process, as semantic relationships appear to do. With sentence contexts there may be additional reasons why a lexical decision is facilitated or retarded quite apart from what an investigator thinks he or she may be studying. The naming task appears to be somewhat better in this regard. Whether access is facilitated or not, naming appears to be facilitated only when the target's memory location itself is activated. Thus, this task is probably better suited for determining the circumstances in which memory locations receive activation.

The second cautionary note concerns the implications of the present definitions of semantic and associative relationships. An attempt was made to keep these definitions consistent with those used by previous researchers (e.g., Smith et al., 1974). However, it is clear that the definitions are somewhat fuzzy, particularly that for an associative relationship. What may be a fairly strong associative relationship for one individual may be a weak one for another. Further, all of these have developed basically through repetition, suggesting that it would be possible, with enough trials, to make any pair of words strong associates of one another. Intermediate levels of strength are, of course, also possible. Finally, certain sentence frames (e.g., "The carpenter used the hammer to drive the ______.") may actually be serving as the first member of what is essentially an associated pair. That is, presumably we would have memorial representations for concepts like a carpenter hammering, although they could not be represented physically in a simple fashion such as by a single word. These locations would be associatively linked to locations for other concepts (like "nail" and, perhaps, "sore thumb") and, as such, could act simply as another file in the network. Thus, the type of priming attributed to "associative relationships" is probably somewhat pervasive and not solely a product of word pairs like those used in Experiments 4 and 6.

The initial purpose of the present paper was to investigate what seemed to be an obvious prediction of the semantic network/spreading activation model of "semantic" priming, that a semantic relationship alone could facilitate target naming. The fact that this prediction did not hold while priming could be found in other circumstances suggested that the model's account of priming was incomplete. The extensions offered focused almost entirely on a postaccess process about which the model said little, if anything. Further, this focus is not unique as a number of similar suggestions (e.g., Forster, 1981) have recently started to appear in the literature. At this point it seems apparent that a complete understanding of the nature of priming will involve a much more thorough analysis of what the subject must do with the word after making lexical access.

Appendix A: Stimuli in Experiments 1, 2, 3, and 5

List A

Body parts	*Kitchen utensils*	*Furniture*
EAR–(EIR)	PAN–(PON)	PICTURE–(PICHURE)
NOSE–(NOAS)	BOWL–(BOEL)	PIANO–(PEANO)
EYES–(ESES)	BLENDER–(BLENDAR)	LAMP–(LANP)
HEAD–(HEOD)	KNIFE–(KNIEF)	TABLE–(TABEL)
FINGER–(FENGER)	POT–(POS)	DRESSER–(DRESOR)
HAND–(HOND)	LADLE–(LADAL)	STOOL–(STOUL)
Animals	*Vehicles*	*Clothing*
ELEPHANT–(ELEPHENT)	CANOE–(CANU)	GLOVE–(GLUVE)
FOX–(FAX)	TRACTOR–(TRECTER)	PANTS–(PENTS)
HORSE–(HORES)	TRAIN–(TRANE)	SCARF–(SKARF)
COW–(CEW)	CAR–(CER)	HAT–(HET)
CAMEL–(CAMLE)	BUS–(BOS)	OVERALLS–(OVERAL)
PIG–(POG)	SHIP–(SHAP)	SOCKS–(SOCS)

List B

Body parts	*Kitchen utensils*	*Furniture*
KNEES–(KNEAS)	SPOON–(SPONE)	BED–(BEK)
THUMB–(THOMB)	EGGBEATER–(EGBEETER)	TELEVISION–(TELAVISION)
LEG–(LIG)	KETTLE–(KETLE)	SOFA–(SOAFO)
FOOT–(FOAT)	SPATULA–(SPETULA)	CHAIR–(CHEIR)
SKULL–(SCILL)	TOASTER–(TOESTER)	DESK–(DASK)
ARM–(IRM)	FORK–(FURK)	BOOKCASE–(BOKCASE)
Animals	*Vehicles*	*Clothing*
TIGER–(TIGOR)	PLANE–(PLAEN)	MITTEN–(MITAN)
SQUIRREL–(SQARRAL)	BICYCLE–(BYCICLE)	SKIRT–(SCIRT)
LION–(LIAN)	MOTORCYCLE–(MOTORCICLE)	SHOE–(SHOU)
CAT–(CIT)	BOAT–(BOET)	VEST–(VIST)
MOOSE–(MOASE)	JEEP–(JEAP)	BOOT–(BUUT)
DOG–(DEG)	TRUCK–(TROCK)	DRESS–(DRES)

Appendix B: Stimuli in Experiments 4 and 6

First Set

Semantic category members	*Nonmembers*
BALL–BAT (BAAT)	BEE–STING (STIN)
BUTTERFLY–MOTH (MOHT)	CAMEL–HUMP (HAMP)
CHAIR–TABLE (TABEL)	CIRCUS–CLOWN (CLOUN)
COTTAGE–HOUSE (HOOSE)	COW–MILK (MULK)
DOG–CAT (CET)	FOOT–SHOE (SHOU)
HEAD–HAIR (HAER)	HARBOR–BOAT (BOET)
LETTUCE–TOMATO (TOMETO)	MOSQUITO–BITE (BIET)
MOUNTAIN–HILL (HIL)	NET–FISH (FICH)
RIVER–STREAM (STREM)	PILOT–PLANE (PLAME)
SEA–OCEAN (OSEAN)	PRIEST–CHURCH (CHORCH)
SLEET–SNOW (SMOW)	SHEEP–WOOL (WOAL)
STEEL–IRON (IREN)	SPIDER–WEB (WIB)
STORM–RAIN (RAEN)	STORK–BABY (BEBY)
TRUCK–CAR (KAR)	TERMITE–WOOD (WOUD)
VEST–SUIT (SUOT)	ZEBRA–STRIPES (STRITES)

Second Set

Semantic category members	*Nonmembers*
ARM–LEG (LIG)	AUTHOR–BOOK (BOAK)
BREAD–BUTTER (BULTER)	BEET–RED (RUD)
CEILING–FLOOR (FLOR)	CANARY–YELLOW (YOLLOW)
COAT–HAT (HET)	CLOAK–DAGGER (DEGGER)
DOCTOR–NURSE (NERSE)	DENTIST–TEETH (TEATH)
KING–QUEEN (QOEEN)	HAND–GLOVE (GLUVE)
LION–TIGER (TIGOR)	HARPOON–WHALE (WHAL)
NOSE–FACE (FASE)	MORTGAGE–HOUSE (HOOSE)
SALT–PEPPER (PEPFER)	OSTRICH–FEATHER (FEETHER)
SHIRT–TIE (TEI)	PLUMMER–PIPE (PIEP)
SOLDIER–SAILOR (SALOR)	RAKE–LEAF (LEFE)
STICK–STONE (STOME)	SLEEP–BED (BEB)
TANGERINE–ORANGE (ORONGE)	STOMACH–FOOD (FOUD)
VANILLA–CHOCOLATE (CHOCOLITE)	STOVE–FIRE (FIER)
YAM–POTATO (PATATO)	TRAIN–TRACKS (TROCKS)

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