

Inhibition From Related Primes in Semantic Memory Retrieval: A Reappraisal of Brown's (1979) Paradigm

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The present study was an attempt to replicate and extend Brown's (1979) finding of inhibition in retrieval from semantic memory produced by presentation of semantically related primes. Subjects' speed and accuracy in answering general-knowledge questions (e.g., Who was the first man to walk on the moon?) were measured when the question was preceded by one of four different prime types: neutral (ready), unrelated (alligator), semantically related (John Glenn), or correct (Neil Armstrong). One group of subjects was given all four of the different prime types across the 96 questions, while a second group received only the first three types (i.e., correct primes did not occur). For the first group of subjects, latency to answer the questions was greater following related primes than the other types, replicating Brown's finding of inhibition from semantically related primes. However, for subjects who did not receive any correct primes, latencies were not greater following related primes than following neutral or unrelated primes. Thus the inhibitory priming effect reported by Brown is not due to automatic spreading inhibition (as he suggested). Rather, the inhibition seems due to strategic factors involved in evaluating the prime to determine if it is the correct answer to the question.

Retrieval of information from semantic memory is usually facilitated if people have recently been presented with or have retrieved information semantically related to the retrieval target (e.g., Loftus & Loftus, 1974; Meyer & Schvaneveldt, 1971; Neely, 1977). Such priming effects are easily interpreted within spreading activation models of semantic memory in which retrieval of a concept activates the "node" representing that concept in semantic memory, with this activation spreading to "nearby" (semantically related) nodes (e.g., Collins & Loftus, 1975).

Recently, Brown (1979) has reported a series of experiments revealing the intriguing result of retrieval inhibition from semantically related primes, a finding not easily interpreted within spreading activation models. Brown has argued that his results are anal-

ogous to part-list cuing inhibition in episodic recall (e.g., Roediger, 1973; Slamecka, 1969; Watkins, 1975) and may provide evidence for automatic spreading inhibition in the semantic memory network. The paradigm Brown used in his first two studies usually required subjects to produce the name of a word when given its definition. Each definition was preceded by one of four different types of primes: an unrelated prime, a semantically related prime, an orthographically related prime, or a correct prime (the correct word). If the prime matched the word specified by the definition (as was the case with correct primes), subjects were to respond "yes" as fast as possible; if not, they were to retrieve the correct word as quickly as possible. An example Brown provided of his materials is the definition *to swallow up or eat greedily*, for which the correct response (and correct prime) was *gobble*, the semantically related prime was *cram*, the orthographically related prime was *goggle*, and the unrelated prime was *feud*.

In his first study, Brown (1979) found that subjects correctly retrieved the target word only 3% of the time following the semantically related prime, as compared with 7.8% and 11.5% correct retrievals following the

This research was supported by National Institute of Child Health and Human Development Grant R01 HD-15054. This research was reported at the meeting of the Psychonomic Society, Philadelphia, November 1981. We thank Tom Konechnik for his experimental assistance and Julene Luiken for recording the tapes.

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unrelated and orthographically related primes, respectively. This pattern was replicated in a second study with easier materials, and in this study and later studies Brown also reported that retrieval times were reliably slower following related primes than following the other prime types. Inhibition in correct retrievals in these studies was reliable but rather slight (on the order of 3%–5%, for example, in the first two studies), but the retrieval time differences were sizable. For instance, in Study 2 subjects were 1,810 msec slower in successfully retrieving a target word following semantically related primes than following unrelated primes. Brown interpreted this outcome as evidence for automatic spreading inhibition in the semantic memory network, but the outcome of our present study challenges that interpretation.

Brown's (1979) use of correct primes and having subjects say "yes" to them introduces a potential problem in interpreting his latency results. Because correct primes were included on a quarter of the trials, subjects had to check each prime to determine if it was the correct answer. If it was, subjects provided a response ("yes") qualitatively different from the responses required on other trials. Only in cases in which the prime was not the correct answer would subjects then attempt retrieval of the correct word. However, when the prime was not the correct answer, subjects may have taken different amounts of time to reject the prime as being incorrect before beginning to try to retrieve the correct word. Specifically, because evidence exists showing that it takes longer to reject false information when it is semantically related to the correct answer than when not (e.g., Anderson & Reder, 1974; Schaeffer & Wallace, 1970; Schvaneveldt, Durso, & Mukherji, 1982), subjects may have been slower to reject semantically related primes as incorrect relative to rejection of unrelated primes. If so, they would then be slower to initiate a retrieval attempt following related primes than following unrelated primes. Thus the inhibition from semantically related primes may not have been due to automatic spreading inhibition affecting the retrieval process but rather to a delay in initiation of retrieval produced by slow rejection of the related prime.

Brown (1979) examined this possibility of the different primes requiring differential rejection times. In Study 3 he asked subjects simply to say "yes" or "no" as to whether the primes were the correct answers to the definitions. He found that people were indeed slower to reject semantically related primes than unrelated primes. However, because the difference in rejection latency between related and unrelated primes was much smaller than the differences between these conditions in the earlier experiments when subjects had to retrieve the correct answer, Brown concluded that the semantically related prime inhibited retrieval in addition to slowing the process of rejecting primes prior to retrieval.

It may be, however, that the difference in times to reject related items relative to unrelated items in a simple verification task underestimated the difference in rejecting these types of primes in the more complex word production task. Because producing words from definitions requires more effort than verification, in the former task subjects may check the primes more carefully for a potential match to the correct answer before initiating a retrieval attempt. This more careful check in the production task may increase the difference in times to reject related primes relative to unrelated primes. Thus it remains possible that the inhibitory effect of semantically related primes on response latencies reported by Brown was entirely due to the increased time it took to reject the semantically related prime as incorrect. (We discuss the error rate difference as evidence for inhibition from related primes in the Results section.)

We attempted to verify, by another method, Brown's (1979) conclusion that the inhibitory priming effect is not due only to processes occurring prior to retrieval but represents inhibition in the retrieval process itself. We repeated the essential features of Brown's experiment, but for different groups of subjects we either included trials in which there were correct primes (as Brown did) or omitted correct prime trials altogether. When trials involving correct primes are omitted, there is no need for subjects to determine if the prime is the correct answer, and thus subjects may begin to retrieve the correct target as soon as they hear the definition of the

word. If inhibition from semantically related primes is due to automatic spreading inhibition during retrieval and not due to subjects' strategies, then we should observe it even under conditions in which the correct primes are omitted. On the other hand, if the inhibition from related primes on response latencies was entirely due to slowed rejection of these primes in Brown's experiments, we should find no such inhibition from semantically related primes for those subjects who never received correct primes.

As an additional control, we also included a neutral priming condition to assess any possible facilitation from related primes. Finally, we required subjects to provide the correct answer in all priming conditions rather than to say "yes" following correct primes. This change made it less likely that subjects would evaluate the appropriateness of the prime even in the correct condition, since now the response requirement was the same for all conditions.

Method

Subjects and Design

The 56 subjects were Purdue University undergraduates who participated in order to fulfill part of a course

requirement. The design was a mixed-factor design. The between-subject manipulation was the number of prime types that subjects received. Prior to each general-knowledge question, 24 subjects received one of four types of primes: neutral, unrelated, semantically related, or correct. The other 32 subjects received only neutral, unrelated, and related primes. Variation in the type of prime was manipulated within subjects for both groups.

Materials and Counterbalancing

Ninety-six general-knowledge questions were used in the experiment. They were drawn from a larger pool of 200 questions for which norms had been previously developed with Purdue University students. The questions chosen from this larger pool were those that most subjects were able to answer correctly. The mean percentage of correct responses for the 96 selected items was 92.7%, with a range from 75.9% to 100%. A sample of eight representative items is provided in Table 1.

Four primes were chosen by the experimenters for each question. For example, the correct prime for the question "What yellowish metal is used in making trumpets?" was *brass*; the related prime was *tin*; the unrelated prime was *sheriff*; and the neutral prime was *ready*. Unrelated primes were generated by assigning a related prime for one question to a different question (correct answers to questions were never used as unrelated primes).

Four lists of the 96 questions were constructed for purposes of counterbalancing prime types across questions. All questions were used in all four lists, but each was paired with a different prime across the lists. An unrelated prime was generated for each question by assigning a related prime from another item. When a prime

Table 1
Eight of the 96 Questions on Which Subjects Were Tested and the Various Primes Assigned to Each

Questions	Primes			
	Neutral	Related	Unrelated	Correct
1. Who invented the telephone?	ready	Thomas Edison	heart	Alexander Bell
2. What small vessel tows other larger boats?	ready	tanker	cousin	tugboat
3. Which of your relatives is your father's brother?	ready	nephew	The Cat in the Hat	uncle
4. What lost city is reported resting on the ocean floor?	ready	Pompeii	Rolling Stones	Atlantis
5. What large African animal has an upright horn on its snout?	ready	hippopotamus	doctor	rhinoceros
6. What precious stone comes from oysters?	ready	opal	marijuana	pearl
7. What kind of cloth comes from sheep?	ready	linen	Florida	wool
8. Who was president during the Civil War?	ready	George Washington	Colorado	Abraham Lincoln

Note. Unrelated primes were generated by assigning the related prime of one question to a different question.

served as an unrelated prime, it was separated in the list from the question to which it was related by at least eight other items. Within a list each prime occurred only once, so that when a related prime for one question served as the unrelated prime for a second question in the same list, it never appeared as the related prime for the first question. Items dealing with the same sort of subject matter (e.g., history questions or animal questions) were separated as well. Each subject heard only one list.

For subjects in the group receiving correct primes, each type of prime—correct, related, unrelated, and neutral—was represented 24 times in the list of 96 questions. The primes were rotated so that across the four lists each question was paired with each type of prime. The counterbalancing for subjects who did not receive correct primes was the same, except that all correct primes were replaced with related primes. Thus these subjects received 48 trials with related primes, and 24 each with unrelated and neutral primes. Because correct primes are semantically related to the question with which they are paired, it seemed best to substitute related primes for correct primes to maintain the same proportion of semantically related primes across groups.

Procedure

A female with professional voice training recorded all materials on eight cassette tapes. Two tapes were constructed for each of the four lists, one for the subjects in the condition including correct primes, and one for the condition omitting them. Subjects were tested individually in a session that lasted about 1 hr. They were told that they would be listening to a tape that contained questions preceded by prime words. They were further instructed to repeat the prime aloud after its presentation and to answer the question as quickly as possible after hearing it in its entirety. Subjects were given one practice trial with each prime type prior to testing and thus were aware of the types of primes they would be hearing. However, they did not know which type of prime they would receive for any given trial.

All experimental trials were presented in the following manner. The subject first heard the trial number (e.g., "Trial 1"), which was followed by a 2-sec pause. Then the prime occurred followed by a 3-sec period during which subjects were to repeat it. The subject then heard the question and answered aloud during the subsequent 8 sec of silence. After the 8-sec interval the subject heard "stop," and the next trial began after a 2-sec period. All 96 trials proceeded in this manner, with a short break after 48 trials.

Response timing and data storage were controlled by a Cromemco Z-80 microcomputer system. The experimenter could read the question silently (as well as hear it) while the subject listened to it. Upon hearing the last word of the question, the experimenter initiated a timer in the microcomputer. As soon as the subject responded to the question, the experimenter stopped the timer. After 8 sec the experimenter made a response that recorded whether the subject's answer to the question (if any) was correct. The two experimenters were given extensive practice with the timing procedure before actual testing began. Trials on which either an incorrect answer was given or the subject's response time exceeded the 8-sec limit were dropped from the main analysis.

Table 2
*Mean of the Median Reaction Times (in msec)
for Correct Answers to Questions Following
Different Types of Prime*

Prime group	Type of prime			
	Cor- rect	Neu- tral	Unre- lated	Re- lated
Correct	1,180	1,492	1,504	1,702
No correct	—	1,422	1,512	1,388

Results

The means of the median response times for trials on which the subjects' answers were correct are presented in Table 2. For the group of subjects who received correct primes (top row of Table 2), answers were quickest following correct primes and slowest following related primes. A one-way analysis of variance (ANOVA) performed on the data yielded a main effect for prime type, $F(3, 69) = 13.42$, $MS_e = 83,152.4$. (The confidence level for each reliable effect is $p < .05$ unless otherwise noted.) Individual a priori contrasts were made using the overall error term from the ANOVA. The finding that subjects were slower to respond following related primes than following unrelated primes was reliable, $F(1, 69) = 5.59$, as was the difference between the neutral and related priming conditions, $F(1, 69) = 6.36$. Also, subjects responded reliably faster following correct primes than following neutral primes, $F(1, 69) = 14.04$. Latencies for neutral and unrelated primes were virtually identical. Thus the data for our subjects who were tested with all four prime types provide a conceptual replication of Brown's (1979, Studies 1 and 2) finding of inhibition from semantically related primes in semantic memory retrieval.

A quite different pattern of results emerged from subjects tested under conditions in which no correct primes were provided (bottom row of Table 2). In contrast to the inhibitory priming effect found for related prime trials for subjects who received correct primes, the data for subjects who did not receive correct primes indicated a small amount of facilitation with related primes. An ANOVA was marginally reliable for the means of the median response times, $F(2, 62) = 2.56$, $p < .10$, $MS_e = 50,743.1$. Individual a priori con-

Table 3
*Percentage of Errors in Answering Questions
 Following Different Types of Prime*

Prime group	Type of prime			
	Cor- rect	Neu- tral	Unre- lated	Re- lated
Total errors				
Correct	2.78	12.01	10.86	15.02
No correct	—	9.38	11.83	11.78
Response omissions				
Correct	2.54	3.81	3.19	1.56
No correct	—	2.51	4.51	2.27
Incorrect responses				
Correct	.23	8.20	7.67	13.46
No correct	—	6.87	7.32	9.50

trasts showed that correct responses following related primes were reliably faster than those in the unrelated priming condition, $F(1, 62) = 4.79$, but not from those in the neutral condition $F(1, 62) = .36$. Thus there was reliable facilitation following related primes only when compared with the unrelated priming condition and not when compared with the usual baseline for assessing facilitation, namely, the neutral priming condition. As in the condition in which subjects received correct primes on some trials, retrieval times for correct answers following neutral and unrelated primes did not differ reliably, $F(1, 62) = 2.50$.

The percentage of correct answers provided in our experiments was generally greater than that in Brown's (1979) paradigm requiring definitions. Thus we examined subsets of items varying in their difficulty as indexed by the proportion of subjects answering the item correctly in the neutral condition. These analyses showed that, for both easy and difficult items, no inhibition from related primes occurred for errors or retrieval speed under conditions in which subjects did not receive correct primes.

Total error rates (percentage of omissions and incorrect answers) are presented in the top two rows of Table 3. An ANOVA on errors

for subjects who received all four prime types (top row) indicated reliable variation among conditions, $F(3, 69) = 15.15$, $MS_e = 43.22$, but error rates for subjects who never received correct primes (second row) did not differ reliably, $F(2, 62) = 1.75$, $MS_e = 35.87$. A priori contrasts for subjects who received correct primes on some trials showed that subjects made fewer errors following the correct primes than following neutral primes, $F(1, 69) = 23.59$. Also, the error rate following related primes was greater than that following unrelated primes, $F(1, 69) = 4.80$. Thus there is some evidence that the inhibition following semantically related primes found in response times for subjects who sometimes received correct primes also extends to error rates. This finding replicates Brown's finding and may represent evidence for automatic spreading inhibition following related primes in this paradigm. However, further analyses lead us to believe that this interpretation is unlikely.

Presented in the bottom four rows of Table 3 are the two components of the total error rate shown in the top two rows: (a) the percentage of response omissions, or that portion of the trials in each condition when subjects failed to respond during the 8-sec response interval (middle rows), and (b) the percentage of incorrect responses given by the subject in each condition (bottom rows). It is clear that the increased number of total errors in the related priming condition relative to the unrelated priming condition for subjects who received correct primes is due entirely to an increased number of incorrect responses (and not response omissions). A likely source of these incorrect responses in the related priming condition is subjects providing the related prime as the answer to the question. That is, when provided a related prime (e.g., John Glenn) before a relatively hard question (Who was the first man to walk on the moon?), subjects may have sometimes given the related prime as the correct answer since they knew that many primes were correct. Such errors would not be expected in the neutral and unrelated priming conditions nor for subjects who never were given correct primes. Indeed, the number of incorrect responses in these conditions is roughly equivalent. Unfortunately, the experimenters did

not record what the incorrect responses were, so we cannot provide conclusive evidence that the increased number of incorrect responses in the related priming condition was due entirely to subjects giving the related primes as answers. (However, the experimenters report that such errors did occur relatively frequently.) At any rate, given these considerations, it would be dangerous to use the error rate data to argue for automatic spreading inhibition following related primes; more likely, the increase in errors was due to subjects confusing the related prime with the correct answer for some questions.

Discussion

The primary finding of the present research is that whether semantically related primes produced inhibition in a task modeled after Brown's (1979) word production task depended on the other types of primes that subjects were presented. For subjects who received correct primes in addition to neutral, unrelated, and related primes, we found that related primes reliably slowed subjects' answers to general-knowledge questions. Thus, we replicated Brown's finding, even though our procedure required subjects to produce the answer on all trials rather than respond "yes" following correct primes. However, for the other group of subjects who never received correct prime trials, there was no evidence of inhibition from semantically related primes.

This difference in outcome between conditions may be explained in several different ways. Our preference is to appeal to different operations that subjects probably used in processing primes when correct primes did or did not occur on some trials. Specifically, when subjects knew that correct primes would sometimes occur, they likely checked to see if the prime was the correct answer before attempting to retrieve the answer. Since it takes longer to reject a related prime than an unrelated prime (Brown, 1979, Study 3), subjects were slower to initiate retrieval following related primes than following unrelated primes. Thus the difference in time to evaluate related and unrelated primes as answers to questions probably accounts for Brown's and our finding of inhibition from semantically related primes.

If the inhibition from related primes for subjects who sometimes received correct primes is due to their checking primes as potential answers before initiating retrieval, then one might expect that retrieval times would be longer in all priming conditions for subjects receiving correct primes than for those who never did. A glance at Table 2 indicates that this only happened with related primes and not with unrelated and neutral primes. However, this outcome is not inconsistent with our proposal. Recall that the prime was given 3 sec prior to the question and that presentation of the question itself was extended over several more seconds. Thus, it is likely that in the unrelated and neutral prime conditions, in which the prime was quite dissimilar from the correct answer, the subject would already have rejected the prime as the correct answer by the time the question was read and the timer started. According to this reasoning, processing of the prime extended beyond the end of the question only for related prime trials, thus increasing retrieval time for these answers.

For subjects who were never tested with correct primes, presentation of related primes seemed to have a slight facilitating effect. However, we do not think this facilitation should be taken too seriously for several reasons. First, we found it relative to the unrelated prime condition rather than to the neutral prime condition usually considered the appropriate baseline. Second, the facilitation did not occur in the error rates. Third, and most important, another experiment in our laboratory and an unpublished study by Brown (Note 1) failed to yield significant facilitation from related primes when no correct primes were included even in latencies and even in comparison with the unrelated priming condition. In these experiments subjects were tested with neutral, unrelated, and semantically related primes that varied in number (one or two in our experiment, one or three in Brown's).

The finding that Brown's (1979) inhibition from semantically related primes may be specific to the situation in which correct primes occur on some trials is disappointing, because Brown's method is a straightforward test for such inhibitory priming effects. It may be that with further refinements the method

may yet prove useful, though we have not hit on the right combination of factors to produce the inhibition effect in our laboratory. For example, it may be that the 3-sec interval between the prime and question permitted activation to decay, if subjects were not actively processing the prime in the no-correct-primers condition. Thus, if the prime occurred closer to the question, inhibition (or facilitation) from related primes might be found. A second possibility is that with more difficult questions, or with questions that have a dominant but erroneous response, inhibition from related primes may occur even when correct primes never appear on some trials. Third, any inhibition produced by related primes may be masked by compensatory facilitating processes that such primes might also engender. Of course, this notion of offsetting positive and negative factors that balance one another to produce a null effect is completely gratuitous in the absence of converging evidence. However, such an idea is not entirely preposterous in the present instance since other research has shown that related primes can produce both facilitation and inhibition in retrieval from semantic memory (see Roediger & Neely, 1982).

Regardless of the specific factors that caused the inhibition to disappear in the condition when no correct primes were provided, the important point is that the presence or absence of inhibition from related primes was influenced by the types of primes that occurred on other trials. This finding suggests that strategic factors of some sort are involved in Brown's inhibition effect and that the inhibition is not automatic as he argued. That the type of prime occurring on other trials should affect semantic priming in Brown's paradigm is not surprising. Indeed, other researchers have also shown that the effect of semantic relatedness on particular trials in semantic memory experiments depends on how relatedness varies on other trials in the experiment (Becker, 1981; McCloskey & Glucksberg, 1979; Tweedy, Lapinski, & Schvaneveldt, 1977). These results have also been interpreted as implicating strategy differences.

Although we were unable to find inhibitory priming effects with our modification of

Brown's paradigm, reliable inhibition from semantically related primes has been obtained in other paradigms testing both episodic and semantic memory (see Roediger & Neely, 1982, for a review). For example, within the domain of semantic memory retrieval, Brown (1981) has shown that if people are asked to retrieve exemplars repeatedly from a semantic category when given initial letters as cues, they become increasingly slow as more items from the category are retrieved. Blaxton and Neely (in press) have confirmed this observation and shown that the greatest inhibition occurs when subjects must actively generate (rather than read) both primes and targets. Brown (1981) also reported a similar inhibitory effect when subjects were asked to name pictured objects from a category. Thus, even though the present research calls into question the usefulness of Brown's (1979) paradigm for studying inhibition from semantically related primes, the phenomenon is probably not illusory and may be profitably studied by other methods. If so, the results could have important implications for theories postulating automatic spreading activation among nodes in a semantic memory network, since the usual evidence for such activation is facilitation from semantically related primes. However, these matters must await further research.

Reference Note

1. Brown, A. Personal communication, October 1982.

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Received May 10, 1982

Revision received October 28, 1982 ■