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AN INVESTIGATION OF THE NEGATIVE EFFECTS OF SEMANTIC
PRIMING ON THE RECALL OF SEMANTIC INFORMATION

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AN INVESTIGATION OF THE NEGATIVE EFFECTS OF SEMANTIC PRIMING ON THE RECALL OF SEMANTIC INFORMATION.

A DISSERTATION

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AN INVESTIGATION OF THE NEGATIVE EFFECTS OF SEMANTIC PRIMING

ON THE RECALL OF SEMANTIC INFORMATION

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AN INVESTIGATION OF THE NEGATIVE EFFECTS OF SEMANTIC PRIMING ON THE RECALL OF SEMANTIC INFORMATION

Introduction

The present research was performed to provide evidence that semantic priming can inhibit semantic retrieval in tasks which involve generation rather than verification or identification. In addition, this research was designed to test the hypothesis that any negative effect of semantic priming is caused by response competition rather than the action of a specific inhibitory mechanism.

Priming is an experimental procedure in which the processing of a critical or "target" stimulus is affected by the processing of a previously presented "priming" stimulus. In recent years, investigators have frequently used priming procedures to study the processes and structure of semantic memory, especially in studying the concept of "spreading activation".

Quillian (1962, 1967), Collins and Loftus (1975), and Posner and Synder (1975) have proposed "spreading activation" models of semantic memory in which memory is represented by a network of nodes which correspond to individual concepts, interconnected by relational pathways or linkages. The meaning of a particular concept is defined by the relational linkages which emanate from a concept node in memory and point to other nodes which are related or associated to the node of interest. Therefore any node is always defined in terms of relationships to other concepts stored in the memory network. The theoretical distance between nodes in the network is inversely proportional to their semantic similarity. Thus, the distance between the nodes representing the concepts of "lion" and "tiger" should be less than between "lion" and "alligator".

Retrieval in a semantic net occurs as a result of "activation" of individual nodes. If a node is not being processed in memory, it is assumed to be in a resting or otherwise "inactive" state. A node in the resting state can be made active as a result of either direct sensory input or the processing of semantically related materials. Direct stimulation is assumed to activate the nodes in memory. This activation is then assumed to spread outward along all the linkages emanating from that node, eventually activating the nodes at the end of the linkages. Since this spreading activation is assumed to decrease in strength as a function of the distance it travels, it follows that nodes which are semantically similar and therefore closer to the original site of activation will be activated to a greater extent that those which are semantically dissimilar. For example, presentation of the word "lion" should cause the node corresponding to "tiger" to become more active than the node corresponding to "alligator" since "tiger" is more semantically similar to "lion" than is "alligator". Finally, it is assumed that retrieval probability increases as a function of the activity level associated with a particular node at a given point in time. Thus in the example, "tiger" should be more available for retrieval than "alligator" following tne presentation of "lion".

Priming has often been used to study the concept of spreading activation since the semantic relationship which exists between the priming and target stimuli can be systematically varied. If spreading activation does occur in semantic memory, it is predicted that priming a target with a semantically similar item should increase the activity level of the target node. This increased activity of the target, relative to an unrelated prime or no-prime control condition should facilitate retrieval of the target as measured by task latency or retrieval probability.

One major source of evidence which supports the notion of semantic priming is the facilatory effect of semantic priming upon lexical decision performance. A lexical decision task involves deciding if a presented string of letters is a word. Meyer and Schvaneveldt (1971) presented their subjects pairs of words, pairs of nonwords, and pairs consisting of a word and a nonword. Within the word pairs, the latency to decide that both stimuli were words was reduced if the words were associates of each other. Their results imply that the processing of one word affects another word only if the two are semantically related by association, which is consistent with a spreading activation interpretation of semantic retrieval. Similarly, Neely (1976) found facilitation of lexical decision performance using a true priming paradigm. Target stimuli were either words or nonwords, and the priming stimuli were words which were either related or unrelated to the target stimuli. There was also a neutral priming condition which involved the presentation of a string of "x's" instead of a priming word. The latency to decide if the target item was a word was reduced if the priming stimulus was related to the target as compared to the neutral priming condition. Fischler (1977) demonstrated a facilitation of lexical decision performance using pairs of words which were semantically related yet not associated. Finally, Swinney, Onifer, Prather, and Hirshkowitz (1979) obtained the same facilitation of lexical decision performance when the priming and target stimuli were presented in different modalities. These results suggest the activation or processing of one concept activates both associative and semantically related items in memory, which in turn become more easily processed when they are subsequently presented for processing. Thus, the results of the lexical decision literature are consistent with the predictions of the spreading activation models of memory.

Similar effects of semantic priming have also been reported by Jacobson (1973) and Warren (1977) in experiments involving word naming. These investigators demonstrated that word naming latency was reduced by priming the to-be-named target word with an associative prime as compared to nonassociative primes. In addition, Sperber, McCauly, Ragain, and Weil (1979) have demonstrated the same facilitation of naming latency using picture stimuli. These results are also consistent with the spreading activation model of memory since the reduction in naming latency occured only when associates preceded the presentation of the target word. Presumably the activation of the priming stimulus spread to nearby memory locations, thereby increasing the availability for retrieval of associate but not nonassociate items.

Loftus (1973) and Loftus and Loftus (1974) measured the latency to retrieve an instance of a particular category in response to a category name, followed by the first letter of the to-be-recalled instance. For example, a subject may have been presented the compound stimulus, "Bird-R", to which "robin" would be a correct response. The results showed that retrieval latency was faster when the preceding trial had involved retrieval from the same category as compared to when retrieval had occurred from another category. Thus, the retrieval of one category instance primed the retrieval of another instance from the same category. In addition, the amount of facilitation derived from a previous retrieval was inversely proportional to the number of intervening trials between retrievals from the same category. This research suggests that the presentation of a category name tends to activate all of its instances and this activation makes these instances more available for retrieval for at least a few trials. In a similar experiment, Ashcraft (1976) found that the latency needed to verify property statements was reduced when the previous trial had involved the verification of a semantically similar statement as opposed to a semantically dissimilar statement. This priming effect was found even though the concepts presented in the priming trial were not repeated in the target trial. This demonstrated that the effects of semantic priming are independent of repetition effects and that the activation of one instance of a category will also activate other instances from the same category.

In all of the research discussed to this point, semantic priming has been shown to have a facilatory effect on retrieval latency, thus supporting the predictions of the spreading activation models of semantic memory. One commonality of this research is that at least part of the orthographic features of the target word are present when the target information is retrieved from memory. In contrast, other research involving recall from semantic memory, where the target items is not actually presented at the time of retrieval have shown semantic priming to have an inhibitory effect on retrieval.

For example, Brown (1968) and Karchmer and Winograd (1971) required their subjects to recall as many of the names of the 50 United States as possible in a fixed amount of time. Prior to recall, half of the subjects were told to study a list composed of 25 State names. In both experiments, the probability of recalling the States included on this "priming" list was greater when the list had been studied prior to recall as compared to the control subjects who engaged in light reading prior to the recall test. However, the probability of recall of the nonlisted States was greater in the control condition. These results suggest that priming with instances of a category can actually inhibit the retrieval of other instances from the same category.

Brown and Hall (1979) also found evidence that semantic priming can have an inhibiting effect on recall in a free association task. Subjects free associated four times in response to 20 words and then returned in two days and were again asked to free associate to the the same words. However, in the second session, either zero, one, two, or three of a subjects' previous responses were listed along with the original stimulus word. The presentation of response "cues" was in effect a form of semantic priming since the cues and any potential free associates given during the second session should be semantically related via the stimulus words. Cueing was shown to lower the probability of generating the same free associates that had been generated during the first session as compared to the non-cued condition.

Brown (1979) performed a series of experiments which investigated the effects of semantic priming on recall using a task which required subjects to generate a word in response to its definition. Preceding the presentation of the definition, different types of priming stimuli were also presented. Semantic priming was shown to have an inhibitory effect as compared to a neutral warning stimulus in regard to both generation latency and probability of recalling the correct response. These results provide direct evidence that semantic priming can inhibit or interfere with recall. Similar results were found by Lupker (1979) in a picture naming task. Picture naming latency was slower if a semantically related word was presented with the picture as compared to unrelated words. This finding conflicts with the results of Sperber, et. al. (1979) who found a facilatory effect of semantic priming using successive presentation of the priming and target stimuli rather than a simultaneous presentation as used by Lupker (1979).

In general, semantic priming facilitates retrieval if the orthographic features of the target stimulus are presented in the primed task. However, if the target must be recalled or generated rather than recognized then semantic priming seems to have an opposite inhibitory effect. In order to explain these intuitively contradictory findings, Brown (1979) has proposed the existence of an inhibitory mechanism which operates in the linkages connecting the various nodes in memory. This mechanism is postulated to work in the following manner: When a node is activated in memory, activation is assumed to spread along the pathways which connect that node to other nodes in the semantic network. This spreading activation is assumed to have different effects on the nodes and pathways which it traverses. Any nodes to which any activation spreads are assumed to also be activated, and therefore be more available for retrieval as compared to their previous resting state. In contrast, the linkages or pathways along which the spreading activation travels are assumed to be inhibited in the sense of a refractory period during which these linkages are less available for use. Using this framework, Brown (1979) can explain the facilatory effect of semantic priming in recognition target tasks by appealing to the assumption that retrieval in such tasks does not require the use of the pathways leading from the priming to the target node. Therefore, retrieval in recognition type tasks should be influenced only by the increased activity of the target node caused by the prior presentation of a semantic prime, which should result in a facilatory effect. On the other hand, if the task requires the use of the pathways leading from the target, such as in a recall or generation task, the presentation of a semantic prime should inhibit performance since the pathways will not be as readily available for use as compared to their resting state.

Alternatively, the reported inhibitory effects of semantic priming on recall can be explained by a form of response competition (McGeoch, 1933a,b). This explanation also assumes that the presentation of a semantic prime will activate the target item of a given trial, however, no appeal to an additional inhibitory mechanism is needed to explain the observed "inhibitory" effects of semantic priming. Instead, it is assumed that at the time of the target task, the activation level of the priming node will be relatively greater than that of the target node. If the prime is semantically related to the target, it is conceivable that the prime could function as a potential target or correct response to the retrieval task. Given this were true, the relative higher activation level of the prime should increase the probability that the prime will be retrieved in place of the correct target response, resulting in competition between the two items at the time of response output. This explanation is similar to an explanation for the partial list cuing effect (see Roediger, 1974) proposed by Rundus (1973). The partial list cueing effect was first reported by Slamecka (1968) who had subjects learn a free recall list and then presented part of the list items on a final recall test which were to be used as retrieval cues for the remaining items on the list. The results indicated that recall of the remaining items was actually less if cueing was present on the test trial as compared to a control condition which received no cues. Rundus (1973) reasoned that the presentation of the list cues strengthened or activated these responses in memory as compared to the remaining list items. By assuming that list items are retrieved in a manner similar to sampling with replacement and that the retrieval probability increased as a function of the strength or activation level of the responses, he concluded that the list cues would tend to be recalled more often than the remaining list items. The repeated retrieval of the cues would then further increase the probability of retrieving the cues until the subject attained a criterion number of retrievals for the same item. Once this criterion was met, the search would be terminated since continued retrievals would probably result in no new list items. Thus, the list cues, in effect, were priming stimuli, which activated their corresponding memory locations and competed for retrieval with the nonlisted items. In the present research, this same idea is used as an alternative explanation to the pathway inhibition explanation of the negative effects of semantic priming on recall. Again, the premise is that semantic priming sets up an alternate response which competes with the target item which, in turn, interferes with the retrieval of the target.

Experiment 1

Experiment 1 was designed to distinguish between the pathway inhibition and response competition explanation of the negative effect of semantic priming on recall. This was done by using a task which involves generating a target item from its definition. The crucial test of the pathway inhibition and response competition hypotheses lies in the relative facilitative or inhibitory effects of two priming conditions. The first is the same category prime condition (SC) which involves priming the target definition with the category name of which the target is a member. For example, an actual SC priming stimulus used in the present experiment was "A type of reading material". The second condition is the same category instance prime condition (SCI), which involves priming the target definition with another instance from the same category of which the target is a member. In the case of the "reading material" category, the instance prime was "encyclopedia".

If the pathway inhibition hypothesis is correct then both the SC and SCI conditions should produce inhibition relative to a neutral warning stimulus prime condition (NW) which was always a series of asterisks. In addition, the SC primes should produce more inhibition than the SCI primes because the level of activation of the target caused by priming should be greater in the SC than in the SCI condition. This is predicted assuming that 1) the amount of pathway inhibition decreases as a function of the distance between the prime and the target, and 2) that the amount of pathway inhibition increases as a function of the level of activation to which a pathway is subjected. If the SCI primes are chosen so that the prime is not a direct associate of the target, then the distance between the prime and target instances should be greater than between the category name prime and the target. The pathway between a category name and a target instance should always be direct. However, if a nonassociate instance from the same category of the target is used as a prime then the pathway between the prime and the target should be mediated through the category name. Therefore, on the average, the distance the activation must travel to activate the target will be less in the SC condition than in the SCI condition, thus resulting in slower generation latency. If the category name is included in the target's definition, it is reasonable to assume that the pathway from the category to the target will be used to retrieve the target from the definition. If this is true, then the presentation of a SC prime should inhibit a pathway which is used in the act of target retrieval to a greater extent than a SCI prime, resulting in slower target generation latencies in the SC than in the SCI conditions.

Alternatively, if the response competition hypothesis is correct then the SCI condition should produce more inhibition than the SC condition. Category name priming should presumably activate most of the instances subsumed under the category to nearly the same extent. This assumption means that the target instance will be as active as any potential competing responses at the target test and no other competing responses will be more available for retrieval than the target. However, if another instance from the same category as the target is used as a prime, the activation level of the priming instance should be greater than that of the target instance at the time of the target test, thus making the prime more available for retrieval than the target. The availability of the prime will then make it compete with the target, causing the generation latency to increase as compared to a category name prime. The SC condition may even produce a facilitative effect as compared to the NW condition.

In addition, to the SC, SCI, and NW primes, three other priming conditions were also included to control for prediction effects. If all of the primes were predictive of the target, the results may be affected by strategies used by different individuals to outguess the experimenter. The first of these conditions was the different category name priming condition (DC), the prime was a category name of which the target was not a member. For example, in the "reading material" category the DC prime was "A military title". Likewise, in the different category instance priming condition (DCI), the prime was a member of a different category than the target instance. For example, the DCI prime for "reading material" was "sergeant". Finally, the correct response priming condition (CR), the target instance was used as a prime. This condition was included to force the subject to attend to the priming stimuli. If the prime was never the correct response, then subjects may ignore the primes.

The DC and DCI conditions should also produce slower latencies than the NW condition. This is expected as a consequence of Posner and Snyder (1975) who maintain that priming stimuli which are unrelated to the target will result in a longer "memory location switching" latency than with related primes. Thus, an unrelated prime should divert the subjects attention to an irrelevant memory location. The time needed to switch from the priming location to the location specified in the target definition should add additional time needed to retrieve the target as compared to the NW condition. Finally, the CR condition should produce a facilatory effect relative to the NW condition. This should be expected as a result of direct activation of the target node.

Method

Subjects. Thirty-six University of Oklahoma introductory psychology students served as subjects for a course requirement.

Materials. All of the categories and category instances which were used as priming and target stimuli were selected from the Battig and Montague (1969) category norms. Seventeen categories were selected for use in the present experiments. The criteria used for category selection were as follows: 1) The instances of the category had to be readily discriminable from one another on the basis of their definitions. 2) the instances could not be readily included in other categories, and 3) the instances were not proper nouns. In addition, a category was excluded if the experimenter thought that typical subjects would not possess information about that category. Six instances were then selected from each category as target stimuli. The targets were generally high to medium frequency responses to the particular category name and the number of subjects who gave the target responses in the Battig and Montague (1969) norms ranged from 16 to 287 with a mean frequency of 79.9 and standard deviation of 54.3.

The target definitions were taken form the World Book Encyclopedia Dictionary (1963). These definitions were then abbreviated and modified to include the

Battig and Montague (1969) superordinate category name as a part of the definition. This was done to ensure that subjects would use the category name while attempting to retrieve the target. The target and definition stimuli are presented in Appendix B.

The priming stimuli used in the SC and DC conditions were category names used in the Battig and Montague (1969) norms. In the SC condition the target was a member of the priming category name while in the DC condition the target was a member of a different category. These latter 17 categories were different from the category used in the SC condition. The DCI instances were also selected from the 17 categories used in the DC condition, but were paired with target definitions from a different superordinate category. The NW stimulus consisted of a string of eight asterisks, while the CR condition involved the actual target for that trial. Finally, the SCI instances were selected to not be direct associates of the targets with which they were paired. This was insured by presenting each of the SCI priming stimuli to a group of 50 introductory psychology students for free association. If any of the target stimuli for a given category was produced by any of the subjects it was replaced by another target which was not a response given as an associate to the target.

Six different sets of stimuli were constructed so that each of the priming stimuli were counterbalanced with the targets across subjects. The priming stimuli used in experiment 1 are presented in Appendix C.

Procedure. All subjects were run individually in sessions which lasted approximately an hour. As a subject entered the laboratory he/she was seated at a CRT display which was controlled by a Southwest Techinical Instruments Inc.

Model 6800 microcomputer which displayed all of the stimuli and recorded all responses. At the beginning of each session, subjects were presented a random sequence of 20 single digit numbers on the CRT. Subjects were asked to pronounce each number into a microphone which was attached to the top of the CRT screen and was located approximately 6-8 inches from the subjects mouth throughout the experiment. This procedure was used to adjust the microphone level for the subjects voice and give some experience activating the voice key to which the microphone was attached. Subjects repeated this procedure until the voice key was consistently activated. Then, the experimenter presented the instructions for the task. In the instructions, subjects were told 1) to read the priming stimulus outloud unless it was a string of asterisks, 2) to read the definition silently, 3) retrieve and pronounce the word to which the definition belonged, and 4) then type the same response on the CRT keyboard. All subjects were told to respond as quickly and as accurately as possible. In addition, subjects were told the nature of the different types of priming stimuli. Once the instructions were clear to the subject, a series of twelve practice problems were presented to familiarize the subject with the procedure. These problems involved the categories of "a type of doctor" and "a container". Then, the 102 experimental problems were presented in a different random order for each subject.

The practice and experimental problems involved the presentation of a priming stimulus and a definition and also required subjects to type their responses. Each trial began with the presentation of a priming stimulus for 5 seconds. During this interval, the priming stimulus was pronounced outloud to insure that the prime was not actively ignored by the subject. The prime was then erased from the screen and immediately followed by the presentation of the target definition. At this time a real-time clock was started in the computer and continued to run until the subject made a vocal response. Any response triggered a relay which then stopped the clock and thus measured the generation latency for that trial to the nearest 1/100th of a second. Once the clock was stopped, the subject typed the same response on the CRT keyboard. If the subjects response was not correct, the screen was erased and the word "error" was printed along with the correct answer for three seconds, followed by the next trial. Otherwise, the next trial was initiated after only a one second delay.

Design and Analyses. The complete design of experiment 1 was a 6 x 17 x 6 x 6 mixed factorial design. The main independent variable was prime type (SC, DC, SCI, DCI, CR and NW) and was manipulated within subjects. There were also six problems nested within the 17 categories used in the experiment. Finally, each of the six counterbalancing lists were presented to six different subjects. The dependent variable was the latency required to generate the target for each problem. The reaction time (RT) and error data was analyzed usng both subjects and problems as random factors as suggested by Clark (1973). This was done because of the variability introduced into the experiment by using a great number of targets which were not totally equated for ease of retrieval. In addition, analyzing the data using subjects as a random factor introduced a confound between the prime type variable and the specific targets for a particular subject. This confound can be eliminated by using problems as a random factor in which the effect of each prime type can be compared within a specific problem. Thus the "by-problems" and "by-subjects" analyses were performed to assertain the generality of the prime type effects both between subjects and problems.

Results and Discussion.

The RT data was first analyzed with an ANOVA using problems as a random factor. This analysis involved obtaining mean RT from different groups of six subjects which saw a particular problems paired with the different prime types. Thus this analysis involved comparing the effect of the different prime types on a given problem with subjects nested within prime type. If no subjects within a particular priming condition made a correct answer in response to a particular problem, the problem was removed from the analysis. Using this criterion, a total of eleven problems were eliminated from further analyses. This was done to eliminate those problems which were especially difficult for the subjects. These same problems were subsequently removed from all other analyses.

The results indicated a significant main effect of prime type, ($F(5,450)=12.88$, $MSe=17.14$, $p<.01$). The mean RT in seconds obtained for the different priming conditions were: 1) SCI = 9.22, 2) SC = 7.84, 3) DCI = 9.03, 4) DC = 9.12, 5) CR = 5.12, and 6) NW = 7.91. Although the SCI primes did result in longer RT's than the NW control condition, Tukey pairwise comparisons showed that this difference did not attain traditional levels of significance ($t=2.13$). Similarly, the comparison between the SC and NW primes also not significant ($t=.11$). However, the planned comparison between the SCI and SC primes was significant ($t=2.24$).

As expected by the response competition hypothesis, the SCI primes resulted in slower latencies than the SC primes. Although the difference between the SCI and NW primes was not significant, the difference obtained was in the direction predicted by the response competition hypothesis. In addition, the SC primes did not inhibit responding as predicted by the pathway inhibition model.

Another ANOVA was performed on the RT data using subjects as a random factor in which prime type was compared within subjects where problems were nested within prime type. The results showed a significant effect of prime type ($F(5,150)=24.65$, $MSe=2.53$, $p<.01$). The mean RT in seconds for the different priming conditions were: 1) SCI = 8.04, 2) SC = 7.02, 3) DCI = 8.17, 4) DC = 8.14, 5) CR = 4.75, and 6) NW = 7.60. In this analysis Tukey comparisons showed that SCI primes did not significantly increase RT in comparison to NW control primes ($t=1.17$), but SCI primes did significantly increase RT in comparison to SC primes ($t=2.71$). In addition, SC primes did not significantly reduced latencies in comparison to NW control primes ($t=1.54$).

Although the SCI primes did not produce significantly longer latencies than the NW control primes as predicted by the response competition hypothesis, the difference between the SCI and SC primes predicted by response competition was found. Also, the pathway inhibition prediction that the SC primes should cause inhibition relative to the NW control was not verified, in fact the SC primes actually facilitated response time in comparison to the control.

The same analysis resulted in a significant prime type by prime-target pairing interaction, ($F(25,150)=1.68$, $MSe=2.53$, $p<.05$). This interaction suggests that the prime type effect varied as a function of the specific prime-target pairings which were presented to different subjects. The most important aspect of this interaction were the comparisons between SCI and SC prime types for the different prime-target pairings. Two pairing groups (3 and 4) had SCI latencies which were lower than their corresponding SC latencies, however these differences were not significant. These results were probably due to the fact that some priming stimuli affected recall of some targets more than others. In general, the SCI primes resulted in latencies which were slower than or equal to the NW control while the SC primes resulted in latencies which less than or equal to the NW control.

If the SCI primes caused response competition, it is expected that SCI primes should cause more errors than the SC and NW primes because SCI primes should occasionally be erroneously given as correct responses due to semantic similarity between the SCI primes and the targets. In addition, giving the SCI prime as the correct response should result in faster latencies than other types of errors since the SCI prime may compete to the extent that it may serve as the correct answer. The pathway inhibition hypothesis does not predict any difference in the number of errors made in the SCI and SC prime conditions, although both of these conditions would be expected to produce more errors than the NW condition. Errors made as a result of pathway inhibition should be due to guessing because the target in blocked from retrieval. SCI primes should not be given as responses since the pathways leading to these primes should also be blocked and therefore the number of errors should not differ between the SCI and SC conditions.

An initial ANOVA was done on the number of error data using problems as a random factor. There was a significant main effect of prime type, ($F(5,450)=29.94$, $MSe=1.01$, $p<.01$). The mean number of errors (maximum = 6 errors) for each prime type were: 1) SCI = 2.01, 2) SC = 1.48, 3) DCI = 1.30, 4) DC = 1.56, 5) CR = .27, 6) NW = 1.46. Tukey pairwise comparisons showed that significantly more errors were made in the SCI condition than the NW condition ($t=3.68$) and the SC condition ($t=3.54$). The difference between the SC and NW conditions was not significant ($t=.13$). Thus the pattern of results conforms to the predictions of the response competition hypothesis since more errors were made in the SCI condition than in either the SC or NW conditions. The predictions of the pathway inhibition hypothesis were not confirmed since the SC condition did not produce significantly more errors than the NW condition.

A similar analysis on the number of errors was performed using subjects as a random factor. This analysis also resulted in a significant main effect of prime type ($F(5,150)=35.73$, $MSe=2.14$, $p<.01$). The mean number of errors (maximum = 17 errors) for the different priming conditions were: 1) SCI = 5.08, 2) SC = 3.75, 3) DCI = 3.30, 4) DC = 3.94, 5) CR = .69, and 6) NW = 3.69. Tukey pairwise comparisons showed that significantly more errors were made in the SCI condition than either the NW condition ($t=4.14$) or the SC condition ($t=3.96$). The SC condition did not differ significantly from the NW condition. There also was a significant interaction between prime type and prime-target pairings, ($F(25,150)=2.02$, $MSe=2.14$, $p<.01$). This interaction was characterized by less variability in the means of the CA and NW conditions as compared to the remaining conditions.

Finally, an analysis was performed on the latencies of SCI errors. First, the errors made within the SCI condition were categorized as either 1) being SCI primes given as correct responses or 2) any other error. Mean latencies for both classification errors were found for 31 subjects who made both types of errors. The analysis showed that the latency for SCI prime errors (8.33 sec.) was significantly less ($F(1,30)=17.60$, $MSe=2.14$, $p<.01$) than other types of errors (10.77 sec.). This analysis shows that subjects tended to give fast SCI prime errors, suggesting that the SCI primes directly competed as correct responses. If the SCI errors were guesses which resulted from inhibited pathways, it would be expected that the SCI primes would have latencies as long as other types of guessing errors.

In summary, the results generally support the predictions of the response competition hypothesis even though the expected effects were not consistently found in the different prime-target pairing conditions. SCI primes tended to result in slower latencies and more errors than the NW and SC conditions as expected by the response competition hypothesis. However, SC primes never produced any evidence for producing a inhibiting effect as compared to the NW primes as expected by the pathway inhibition hypothesis.

Experiment 2

Experiment 2 was designed to provide additional evidence for either the pathway inhibition or response competition explanations of the inhibiting effects of semantic priming on recall. This was done by manipulating the number and the typicality of the semantic priming stimuli which preceded the presentation of a word definition. Priming instance typicality was defined in terms of the frequency which a given category instance was given for a particular category. High frequency instances should be more typical of a category than low frequency instances.

If the response competition explanation is correct then increasing the number of SCI primes which are presented on a trial should increase the number of potential competing responses and therefore increase the amount of time needed to retrieve the target. In contrast, the response competition hypothesis would not predict a substantial inhibition effect as a result of manipulating the typicality or frequency that an instance prime is given in response to its category name. Both high and low frequency responses should function as competing responses and therefore should cause equal amounts of inhibition.

However, if the pathway inhibition hypothesis is correct it would be expected that low frequency instances would produce less inhibition than high frequency priming instances. In the case of low frequency instances, little activation and inhibition of the target should occur since the theoretical semantic distance between a low frequency prime and a high frequency target is quite great. On the other hand, a high frequency prime and a high frequency target should be less distant. Any spreading activation should be stronger at the target location when primed by another high frequency prime. Therefore the amount of resulting inhibition should be greater when high frequency instances of the target's category are used as priming stimuli than when low frequency primes are used. The pathway inhibition hypothesis would also predict that the number of primes may influence the amount of inhibition since more than one prime could activate and inhibit the target more than just one prime. However, this effect should be more predominant with high frequency primes than with low frequency primes siince low frequency primes should not inhibit the target to the same extent as high frequency primes.

Method.

Subjects. Thirty-six University of Oklahoma introductory psychology students served as subjects.

Materials. The same 102 target and definition stimuli used in experiment 1 were also used in experiment 2. Within each of the 17 categories, the number of primes and the typicality of the primes as measured by production frequency in the Battig and Montague (1969) norms were manipulated. Of the six problems within a category there were three high frequency priming instances ($f > 20$) and three low frequency instance primes ($f < 12$). Within each frequency type there was a problem with one, two and four priming stimuli. In addition, the Thorndike-Lorge (1944) frequency value was found for all of the high and low production frequency priming stimuli. The Thorndike-Lorge frequency values were generally found to be in accordance with the Battig and Montague (1969) production frequency values. However, in many categories there were high frequency category instances which had low Thorndike-Lorge counts. Occassionally there were also low frequency category instances which had high Thorndike-Lorge counts. The priming stimuli used in experiment 2 are presented in Appendix D.

<u>Procedure</u>. The procedure and apparatus were identical to that used in Experiment 1, except that the priming stimuli were presented on the CRT for five seconds. This priming duration was used to enable subjects to read all of the priming stimuli. Subjects were also told that none of the priming stimuli would be used as correct answers.

<u>Design and Analyses</u>. The complete design of experiment 2 was a 3 x 2 x 17 x 6 x 6 mixed factorial design. Typicality, number of primes, and category type were within subjects variables, while six different counterbalancing lists which varied the specific pairings between the priming stimuli and the targets were a between subjects variable and six subjects were presented each list. Again, the primary dependent variables were the latency required to generate the target from definition onset and the number of erroneous responses made within each condition. All ANOVA's were performed using both subjects and problems as random factors.

<u>Results and Discussion.</u>

An initial ANOVA was done on the correct answer latency data collected in experiment 2 using problems as a random factor. As in experiment 1 any problems which had no observations in any one of the different priming conditions were eliminated from the analysis. This resulted in a total of 96 problems being included in the analysis. These problems were subsequently removed from all other analyses. The results showed no significant effects of either the number of priming stimuli, the production frequency, or any interactions.

A similar analysis was performed using subjects as a random factor. The problems which were eliminated as a result of the initial "by-problems" analysis were also eliminated in the "by-subjects" analysis. The results showed a significant effect of the number of priming stimuli ($F(2,60)=5.84$, $MSe=2.34$, $p<.01$). The mean latency for 1, 2, and 4 primes were 6.52, 6.28, and 7.12 sec., respectively. Tukey pairwise comparisons showed that significantly more time was required to recall a correct answer when the target definition was preceded by four primes as compared to either one prime ($t=2.53$) or two primes ($t=3.54$). Neither the main effect of typicality nor its interaction with the number of primes were significant. The main effect of prime-target counterbalancing was significant, ($F(5,30)=3.16$, $MSe=13.89$, $p<.05$), as was its interaction with the number of primes ($F(10,60)=2.02$, $MSe=2.34$, $p<.05$). The significant interaction was reflected by the fact that the latencies of two counterbalancing groups (1 and 3) increased as a function of the number of prime while the latencies of another two groups (4 and 5) decreased as a function of the number of primes. The two remaining groups (2 and 6) decreased in latency from one to two primes and increased in latency from two to four primes.

The finding that the mean latency increased as a function of the number of primes and that typicality as measured by category production frequency had no effect on recall latency is consistent with the predictions of the response competition hypothesis. However these results must be interpreted with caution. The number of primes effect was significant only in the "by-subjects" analysis and only two of the four counterbalancing groups in this analysis showed the expected monotonic increase in latency as a function of the number of primes.

Another ANOVA was done on the latency data for both correct and incorrectly answered problems. During data collection it was noticed that subjects frequently required more time to recall answers for problems which were preceded by four priming stimuli. However, many of these trials resulted in erroneous answers. It was also observed that these long latencies were not as prevalent for problems preceded by less than four primes. Therefore it was of interest to analyze all of the latency data including the latencies to incorrectly answered problems to capture this observed competition effect.

The "by-problems" analysis of all latency data showed a significant effect of the number of primes, ($F(2,190)=6.15$, $MSe=9.30$, $p<.01$). The mean latencies for the one, two and four prime conditions were 8.34, 8.26 and 9.24 sec., respectively. Tukey pairwise comparisons showed that the four prime condition resulted in significantly longer latencies than either the one prime condition ($t=2.89$) or the two prime condition ($t=3.14$). The difference between the one and two prime conditions was not significant. In addition, the main effect of category typicality and all of its interactions were not significant.

The "by-subjects" analysis also showed a main effect of number of primes ($F(2,60)=6.37$, $MSe=3.53$, $p<.01$). The means for the one, two, and four prime conditions were 8.36, 8.28 and 9.29 sec., respectively. Tukey comparisons showed that the four prime condition resulted in significantly longer latencies that either the one (t=2.97) or the two (t=3.22) prime conditions. There also was a significant effect of prime-target counterbalancing groups, $(F(5,30)=2.89$, $MSe=25.37$, $p<.05)$. Counterbalancing groups 1, 3 and 6 had monotonically increasing latencies as a function of the number of primes.

These analyses based upon the latencies for correctly and incorrectly answered problems do provide some support for the response competition hypothesis since priming with four semantic primes produced longer latencies than fewer number of primes, but the results are not consistent for all subjects. In addition, the typicality of the priming stimuli in relation to the target category had no effect on recall latency. In agreement with the response competition hypothesis, the results of the typicality variable suggest that both high and low frequency primes interfered with semantic recall to the same extent. However, the typicality effect could have been influenced by the fact that the priming stimuli Thorndike-Lorge (1944) frequency counts did not correspond exactly to their respective Battig ad Montague (1969) category frequency values.

Although the results are somewhat in agreement with the response competition hypothesis, recall latency did not monotonically increase as a function of the number of primes. In fact, two primes resulted in slightly faster latencies than one prime. A factor which may have contributed to the weak effect of the number of priming stimuli was the fact that subjects were aware that the priming stimuli never included the correct answer of the problems which they preceded. Neill (1979) has provided evidence that subjects can actively inhibit attending priming stimuli which are not predictive or are irrelevant to the target stimulus. Thus, subjects in the present experiment may have actively inhibited attending the primes even though these stimuli were overtly pronounced on each trial. This speculation suggests that the effects of response competition can be reduced by active attentional mechanisms.

Another contributing factor to these results may have been the use of a five second priming stimulus duration for all priming stimuli. The use of a constant prime duration may have caused subjects to process and therefore activate each individual prime to a lesser extent as the number of priming stimuli increased. Thus, one prime could be processed for 5 seconds when presented alone, for 2.5 seconds when presented in pairs, and only for 1.25 seconds if four primes were presented on a trial. If the potential for response competition is dependent upon prime processing duration, then one would expect small differences between the number of prime conditions. Thus, even though four primes were presented as competing responses, their activation levels may have not been high enough to cause appreciable response competition.

Analyses on the number of errors data may support the same conclusions. If response competition occurred, then the number of errors should increase as a function of the number of primes since theoretically, the amount of response competition should be greater as the number of primes increased. However, if subjects actively inhibited attending the primes and/or if the five second priming interval affected the activation levels of the priming stimuli, then the number of errors may be constant across all of the priming conditions.

The "by-problems" analysis showed no significant effect of number of primes or production frequency. The "by-subjects" analysis showed no significant main effects. There was a significant interaction between the number of primes and the prime-target counterbalancing variable ($F(10,60)=2.77$, $MSe=2.15$, $p<.01$) and a significant interaction between the number of primes, typicality and the counterbalancing variable ($F(10,60)2==2.35$, $MSe=2.35$, $p<.05$). These interactions were not particularly informative. Thus, the error analyses support the conclusion that the results of the present experiment were influenced by methodological considerations. In summary, the results of experiment 2 provided only minimal support for the response competition hypothesis. Apparently, procedural factors may have reduced or eliminated any effect of the number of primes upon recall latency. In addition, the typicality effect may have been influenced by frequency factors.

General Discussion

The results of experiment 1 provided evidence for the response competition hypothesis of the negative effects of semantic priming on recall. Priming a definition with an instance from the same category as the definition target resulted in slower recall latencies than priming with a neutral warning stimulus. The response competition hypothesis expects that the activation of an instance from the target category should activate a potential competing response. Because this potential response is more active than the actual target, it is more likely to be retrieved in response to the definition than the target. This, in turn should: 1) increase the latency to recall the correct target, and 2) increase the probability of making an erroneous response. The response competition hypothesis also predicts that priming with a category name should not produce an increase in recall latency. The spreading activation from a category name prime should activate most instances within that category to nearly the same extent. Thus, no one response should predominate the others and recall latency should not be hindered relative to a no-prime control. In addition, since category name priming latencies should be equal to neutral warning latencies, instance priming should be slower than category name priming. Since the category name primes should not cause response competition, the number of errors should be less in this condition as compared to when a category instance serves as a prime. These predictions of the response competition hypothesis for both the latency and error data were verified in experiment 1.

Conversely, the pathway inhibition hypothesis predicts that category name priming should result in latencies which are slower than neutral warning prime latencies. If memory activation causes a temporary inhibition of memory pathways, one would expect that priming with the category name of a target would inhibit all of the pathways emanating from the category name. If a target is then recalled in response to a definition which includes the same category name it follows that recall will be slower than if no prime had been presented. The pathway inhibition hypothesis also predicts that category instance and category name priming should produce equivalent number of erroneous responses. The results of both the latency and error data indicate that this was not the case in experment 1.

Experiment 2 was designed to demonstrate that increasing the number of semantic priming stimuli would increase the number of competing responses and, hence, recall latencies. Although there was some evidence of this expected effect, recall latency did not increase monotonically with the number of priming stimuli across all prime-target counterbalancing groups. One explanation of the results of experiment 2 was the use of a constant priming stimulus duration for all number of primes. However, a more compelling explanation of these results was the fact that subjects were told that the priming instances would never be the correct response. Therefore, subjects may have been able to actively ignore the primes even though they were overtly pronounced. This would also have the effect of diluting the effectiveness of the number of primes manipulation.

The results, which support the response competition hypothesis of the negative effects of semantic priming on recall, have an impact on several areas concerning human memory. First, response competition can explain the current theoretical issue of semantic priming and recall without making additional assumptions to the theory of spreading activation. Thus, only the concept of spreading activation is required to explain the phenomenon in question. In contrast the pathway inhibition hypothesis requires the adoption of another assumption to the already lengthy list of assumptions in Collins and Loftus (1975). Therefore, the response competition hypothesis is more parsimonious to the present accounts of human semantic memory. Second, the response competition hypothesis is also consistent with the documented inhibiting effects of partial list cueing (Slameka, 1968). The present results increase the generality of the finding that the act of retrieval can inhibit subsequent retrieval. Third, since response competition has been offered as an explanation for retroactive inhibition effects in paired-associate learning, (McGeoch, 1933), results which demonstrate response competition in semantic memory would indicate that similar processes occur in both semantic and episodic memory. Finally, a demonstration of response competition as an explanation of recall inhibition by semantic priming has implications for the "functional fixity" effect observed in problem solving by Dunckner (1945). Functional fixity may be the result of an inappropriate problem solution being repeatedly activated in memory, which competes with the correct solution for retrieval. Thus, the present results adds both to the importance and the potential generality of response competition as a factor in human memory.

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Appendix A: Prospectus.

An Investigation of the Negative Effects of Semantic Priming

on the Recall of Semantic Information

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Abstract

Two experiments were performed to discriminate between a pathway inhibition and a response competition explanation of the negative effects of semantic priming on recall. Experiment 1 was designed to differentiate between these explanations by using category name and instance priming stimuli. Differential predictions expected by the pathway inhibition and response competition hypotheses are discussed. Experiment 2 performed the same theoretical function by manipulating the number of priming stimuli and the typicality of priming instances in relation to the category of the correct response. In both experiments subjects generated words in response to a definition which was preceded by different types of semantically similar material. Implications of a demonstration of response competition in semantic memory retireval are also discussed.

The present research was performed to provide evidence that semantic priming can have a negative effect on semantic retrieval in tasks which involve generation rather than verification or identification. In addition, this research was designed to demonstrate that any negative effect of semantic priming is caused by response competition rather than the action of a specific inhibitory mechanism.

Priming refers to an experimental procedure in which the processing of a critical or "target" stimulus is affected by the processing of a previously presented "priming" stimulus. In recent years, investigators have frequently used priming procedures to study the processes and structure of semantic memory, especially in studying the concept of "spreading activation".

Quillian (1962, 1967), Collins and Loftus (1975), and Posner and Synder (1975) have proposed "spreading activation" models of semantic memory in which memory is represented by a network of nodes which correspond to individual concepts, interconnected by relational pathways or linkages. The meaning of a particular concept is defined by the relational linkages which emanate from a concept node in memory and point to other nodes which are related or associated to the node of interest. Therefore any node is always defined in terms of relationships to other concepts stored in the memory network. The distance between nodes in the network is inversely proportional to their semantic similarity. Thus, the distance between the nodes representing the concepts of "lion" and "tiger" should be less than between "lion" and "alligator".

Retrieval in a semantic net occurs as a result of "activation" of individual nodes. If a node is not being processed in memory, it is assumed to be in a resting or otherwise "inactive" state. A node in the resting state can then be made active as a result of either direct sensory input or the processing of semantically related materials. Direct visual or aural stimulation is assumed to activate the nodes corresponding to the sensory input. This activation is then assumed to spread outward along all the linkages emanating from that node, eventually activating the nodes at the end of the linkages. Since this spreading activation is assumed to decrease in strength as a function of the distance it travels, it follows that nodes which are semantically similar and therefore closer to the original site of activation will be activated to a greater extent that those which are semantically dissimilar. For example, presentation of the word "lion" should cause the node corresponding to "tiger" to become more active than the node corresponding to "alligator" since "tiger" is more semantically similar to "lion" than is "alligator". Finally, it is assumed that retrieval probability increases as a function of the activity level associated with a particular node at a given point in time. Thus in the example, "tiger" should be more available for retrieval than "alligator" following the presentation of "lion".

Priming has often been used to study the concept of spreading activation since the semantic relationship which exists between the priming and target stimuli can be systematically varied. If spreading activation does occur in semantic memory, it is predicted that priming a target with a semantically similar item should increase the activity level of the target node before it is actually processed. This increased activity of the target, relative to an unrelated prime or no-prime control condition should facilitate processing of the target as measured by task latency or retrieval probability.

One major source of evidence which supports the notion of semantic priming is the facilitory effect of semantic priming upon lexical decision performance. A lexical decision task involves deciding if a presented string of letters is a word. Meyer and Schvaneveldt (1971) presented their subjects pairs of words, pairs of nonwords, and pairs consisting of a word and a nonword. Within the word pairs, the latency to decide that both stimuli were words was reduced if the words were associates of each other. Although the simultaneous presentation of the word pairs used by Meyer and Schvaneveldt (1971) was not a true priming paradigm, the results imply that the processing of one word affects another word only if the two are semantically related by association, which is consistent with a spreading activation interpretation of semantic retrieval. Similarly, Neely (1976) found facilitation of lexical decision performance using a true priming paradigm. Target stimuli were either words or nonwords, and the priming stimuli were words which were either related or unrelated to the target stimuli. There was also a neutral priming condition which involved the presentation of a string of "x's" instead of a priming word. The latency to decide if the target item was a word was reduced if the priming stimulus was related to the target as compared to the neutral priming condition. Fischler (1977) demonstrated a facilitation of lexical decision performance using pairs of words which were semantically related yet not associated. Finally, Swinney, Onifer, Prather, and Hirshkowitz (1979) obtained the same facilitation of lexical decision performance when the priming and target stimuli were presented in different modalities. These results suggest the activation or processing of one concept activates both associative and semantically related items in memory, which in turn become more easily processed when they are subsequently presented for processing. Thus, the results of the lexical decision literature are consistent with the predictions of the spreading activation models of memory.

Similar effects of semantic priming have also been reported by Jacobson (1973) and Warren (1977) in experiments involving word naming. These investigators demonstrated that the latency required to name a presented word was reduced by priming the to-be-named target word with an associative prime as compared to nonassociative primes. In addition, Sperber, McCauly, Ragain, and Weil (1979) have demonstrated the same facilitaion of naming latency using picture stimuli. These results are also consistent with the spreading activation model of memory since the reduction in naming latency occured only when associates preceded the presentation of the target word. Presumably the activation of the priming stimulus spread to nearby memory locations, thereby increasing the availability for retrieval of associate but not nonassociate items.

Loftus (1973) and Loftus and Loftus (1974) measured the latency to retrieve an instance of a particular category in response to a category name, followed by the first letter of the to-be-recalled instance. For example, a subject may have been presented the compound stimulus, "Bird-R", to which "robin" would be a correct response. The results showed that retrieval latency was faster when the preceding trial had involved retrieval from the same category as compared to when retrieval had occurred from another category. Thus, the retrieval of one category instance primed the retrieval of another instance from the same category. In addition, the amount of facilitation derived from a previous retrieval was inversely proportional to the number of intervening trials between retrievals from the same category. This research suggests that the presentation of a category name tends to activate all of its instances and this activation makes these instances more available for retrieval for at least a few trials. In a similar experiment, Ashcraft (1976) found that the latency needed to verify property statements was reduced when the previous trial had involved the verification of a semantically similar statement as opposed to a semantically dissimilar statement. This priming effect was found even though the concepts presented in the priming trial were not repeated in the target trial. This demonstrated that the effects of semantic priming are independent of repetition effects and that the activation of one instance of a category will also activate other instances from the same category.

In all of the research discussed to this point, semantic priming has been shown to have a facilatory effect on retrieval latency, thus supporting the predictions of the spreading activation models of semantic memory. One commonality of this research is that at least part of the orthographic features of the target word are present when the target information is retrieved from memory. In contrast, other research involving recall from semantic memory, where the target items is not actually presented at the time of retrieval have shown semantic priming to have an inhibitory effect on retrieval.

For example, Brown (1968) and Karchmer and Winograd (1971) required their subjects to recall as many of the names of the 50 United States as possible in a fixed amount of time. Prior to recall, half of the subjects were told to study a list composed of 25 State names. In both experiments, the probability of recalling the States included on this "priming" list was greater when the list had been studied prior to recall as compared to the control subjects who engaged in light reading prior to the recall test. However, the probability of recall of the nonlisted States was greater in the control condition. These results suggest that priming with instances of a category can actually inhibit the retrieval of other instances from the same category.

Brown and Hall (1979) also found evidence that semantic priming can have an inhibiting effect on recall in a free association task. Subjects free associated four times in response to 20 words and then returned in two days and were again asked to free associate to the the same words. However, in the second session, either zero, one, two, or three of a subjects previous responses were listed along with the original stimulus word. The presentation of response "cues" was in effect a form of semantic priming since the cues and any potential free associates given during the second session should be semantically related via the stimulus words. Cueing was shown to lower the probability of generating the same free associates that had been generated during the first session as compared to the non-cued condition.

Brown (1979) performed a series of experiments which investigated the effects of semantic priming on recall using a task which required subjects to generate a word in response to its definition. Preceding the presentation of the definition, different types of priming stimuli were also presented. Semantic priming was shown to have an inhibitory effect as compared to a neutral warning stimulus in regard to both generation latency and probability of recalling the correct response. These results provide direct evidence that semantic priming can inhibit or interfere with recall. Similar results were found by Lupker (1979) in a picture naming task. Picture naming latency was slower if a semantically related word was presented with the picture as compared to unrelated words. This finding conflicts with the results of Sperber, et. al. (1979) who found a facilitory effect of semantic priming using successive presentation of the priming and target stimuli rather than a simultaneous presentation as used by Lupker (1979).

In general, semantic priming facilitates retrieval if the orthographic features of the target stimulus are presented in the primed task. However, if the target must be recalled or generated rather than recognized then semantic priming seems to have an opposite inhibitory effect. In order to explain these intuitively contradictory findings, Brown (1979) has proposed the existence of an inhibitory mechanism which operates in the linkages connecting the various nodes in memory. This mechanism works in the following manner: When a node is activated in memory, activation is assumed to spread along the pathways which connect that node to other nodes in the semantic network. This spreading activation is assumed to have different effects on the nodes and pathways which it traverses. Any nodes to which any activation spreads are assumed to also be activated, and therefore be more available for retrieval as compared to their previous resting state. In contrast, the linkages or pathways along which the spreading activation travels are assumed to be inhibited in the sense of a refractory period during which these linkages are less available for use. Using this framework, Brown (1979) can explain the facilatory effect of semantic priming in recognition target tasks by appealing to the assumption that retrieval in such tasks do not require the use of the pathways leading from the priming to the target node. Therefore, retrieval in recognition type tasks should be influenced only by the increased activity of the target node caused by the prior presentation of a semantic prime, which should result in a facilitory effect. On the other hand, if the task requires the use of the pathways leading from the target, such as in a recall or generation task, the presentation of a semantic prime should inhibit performance since the pathways will not be as readily available for use as compared to their resting state.

Alternatively, the reported inhibitory effects of semantic priming on recall can be explained by a form of response competition (McGeoch, 1933a,b). This explanation also assumes that the presentation of a semantic prime will activate the target item of a given trial, however, no appeal to an additional inhibitory mechanism is needed to explain the observed "inhibitory" effects of semantic priming. Instead, it is assumed that at the time of the target task, the activation level of the priming node will be relatively greater than that of the target node. If the prime is semantically related to the target, it is conceivable that the prime could function as a potential target or correct response to the retrieval task. Given this were true, the relative higher activation level of the prime should increase the probability that the prime will be retrieved in place of the correct target response, resulting in competition between the two items at the time of response output. This explanation is similar to an explanation for the partial list cuing effect (see Roediger, 1974) proposed by Rundus (1973). The partial list cueing effect was first reported by Slamecka (1968) who had subjects learn a free recall list and then presented part of the list items on a final recall test which were to be used as retrieval cues for the remaining items on the list. The results indicated that recall of the remaining items was actually less if cueing was present on the test trial as compared to a control condition which received no cues. Rundus (1973) reasoned that the presentation of the list cues strenghened or activated these responses in memory as compared to the remaining list items. By assuming that list items are retrieved in a manner similar to sampling with replacement and that the retrieval probability increased as a function of the strength or activation level of the responses, he concluded that the list cues would tend to be recalled more often than the remaining list items. The repeated retrieval of the cues would then further increase the probability of retrieving the cues until the subject attained a criterion number of retrievals for the same item. Once this criterion was met, the search would be terminated since continued retrievals would probably result in no new list items. Thus, the list cues, in effect, were priming stimuli, which activated their corresponding memory locations and competed for retrieval with the nonlisted items. In the present research, this same idea is used as an alternative explanation to the pathway inhibition explanation of the negative effects of semantic priming on recall. Again, the premise is that semantic priming sets up an alternate response which competes with the target item which, in turn, interferes with the retrieval of the target.

Experiment 1

Experiment 1 was designed to distinguish between the pathway inhibition and response competition explanation of the negative effect of semantic priming on recall. This was done by using a task which involves generating a target item from its definition. The crucial test of the pathway inhibition and response competition hypotheses lies in the relative facilitative or inhibitory effects of two priming conditions. The first is the same category prime condition (SC) which involves priming the target definition with the category name of which the target is a member. The second condition is the same category instance prime condition (SCI), which involves priming the target definition with another instance from the same category of which the target is a member.

If the pathway inhibition hypothesis is correct then both the SC and SCI conditions should produce inhibition relative to a neutral warning stimulus prime condition (NW). In addition, the SC primes should produce more inhibition than the SCI primes because the level of activation of the target caused by priming should be greater in the SC than in the SCI condition. This is predicted assuming that 1) the amount of pathway inhibition decreases as a function of the distance between the prime and the target, and 2) that the amount of pathway inhibition is proportional to the level of activation to which a pathway is subjected. If the SCI primes are chosen so that the prime is not a direct associate of the target, then the distance between the prime and target instances should be greater than between the category name prime and the target. The pathway between a category name and a target instance should always be direct. However, if a nonassociate instance from the same category of the target is used as a prime then the pathway between the prime and the target should be mediated through the category name. Therefore, on the average, the distance the activation must travel to activate the target will be less in the SC condition that in the SCI condition, thus resulting in slower generation latency. If the category name is included in the target's definition, it is reasonable to assume that the pathway from the category to the target will be used to retrieve the target from the definition. If this is true, then the presentation of a SC prime should inhibit a pathway which is used in the act of target retrieval to a greater extent than a SCI prime, resulting in slower target generation latencies in the SC than in the SCI conditions.

Alternatively, if the response competition hypothesis is correct then the SCI condition should produce more inhibition than the SC condition. Category name priming should activate most of the instances subsumed under the category to nearly the same extent. This means that the target instance will be as active as any potential competing responses at the target test and no other competing responses will be more available for retrieval than the target. However, if another instance from the same category as the target is used as a prime, the activation level of the priming instance should be greater than that of the target instance at the time of the target test, thus making the prime more available for retrieval than the target. The availability of the prime will then make it compete with the target, causing the generation latency to increase as compared to a category name prime. The SC condition may even produce a facilitative effect as compared to the NW condition.

In addition, to the SC, SCI, and NW primes, three other priming conditions were also included to control for prediction effects. If all of the primes were predictive of the target, the results may be affected by strategies used by different individuals to outguess the experimenter. The first of these conditions was the different category name priming condition (DC), the prime was a category name of which the target was not a member. Likewise, in the different category instance priming condition (DCI), the prime was a member of a different category than the target instance. Finally, the correct response priming condition (CR), the target instance was used as a prime. This condition was included to force the subject to attend to the priming stimuli. If the prime was never the correct response, then subjects may ignore the primes.

The DC and DCI conditions should also produce slower latencies than the NW condition. This is expected as a consequence of Posner and Snyder (1975) who maintain that priming stimuli which are unrelated to the target will result in a longer "memory location switching" latency than with related primes. Thus, an unrelated prime should divert the subjects attention to an irrelevant memory location. The time needed to switch from the priming location to the location specified in the target definition should add additional time needed to retrieve the target as compared to the NW condition. Finally, the CR condition should produce a facilitory effect relative to the NW condition. This should be expected as a result of repetition.

Method

Subjects. Thirty-six University of Oklahoma introductory psychology students served as subjects for a course requirement.

Materials. All of the categories and category instances which were used as priming and target stimuli were selected from the Battig and Montague (1969) category norms. Seventeen categories were selected for use in the present experiments. The criteria used for category selection were as follows: 1) The instances of the category had to be readily discriminable from one another on the basis of their definitions. 2) the instances could not be readily included in other categories, and 3) the instances were not proper nouns. In addition, a category was excluded if the experimenter thought that typical subjects would not possess information about that category. Six instances were then selected from each category as target stimuli. The targets were generally high to medium frequency responses to the particular category name and the number of subjects who gave the target responses in the Battig and Montague (1969) norms ranged from 16 to 287 with a mean frequency of 79.9 and standard deviation of 54.3.

The target definitions were taken form the World Book Encyclopedia Dictionary (1963). These definitions were then abbreviated and modified to include the Battig and Montague (1969) superordinate category name as a part of the definition. This was done to ensure that subjects would use the category name while attmpting to retrieve the target. The target and definition stimuli are presented in Appendix B.

The priming stimuli used in the SC and DC conditions were category names used in the Battig and Montague (1969) norms. In the SC condition the target was a member of the priming category name while in thw DC condition the target was a member of a different category. These latter 17 categories were different from the category used in the SC condition. The DCI instances were also selected from the 17 categories used in the DC condition, but were not paired with the same target class as their superordinates. The NW stimulus consisted of a string of asterisks, while the CR condition involved the actual target for that trial. Finally, the SCI instances were selected not to be direct associates of the targets with which they were paired. This was insured by presenting each of the target stimuli to a group of 50 introductory psychology students for free association. If the chosen SCI priming instance was produced by any of the subjects it was replaced by another instance which was not a response given as a first associate to the target.

Six different sets of stimuli were constructed so that each of the priming stimuli were counterbalanced with the targets across subjects.

Procedure. All subjects were run individually in sessions which lasted approximately an hour. As a subject entered the laboratory he/she was seated at a CRT display which was controlled by a Southwest Techinical Instruments Inc. Model 6800 microcomputer which displayed all of the stimuli and recorded all responses. At the beginning of each session, subjects were presented a random sequence of 20 single digit numbers on the CRT. Subjects were asked to pronounce each number into a microphone which was attached to the top of the CRT screen and was located approximately 6-8 inches from the subjects mouth throughout the experiment. This procedure was used to adjust the microphone level for the subjects voice and to give the subject some experience activating the voice activated relay to which the microphone was attached. This procedure was repeated until the subject consistently tripped the relay mechanism. Once this criterion was attained, the experimenter presented the instructions for the task. In the instructions, subjects were told 1) to read the priming stimulus outloud, 2) to read the definition silently, 3) pronounce the word which belonged with the definition outloud, and 4) then type their response on the CRT keyboard. In addition, all subjects were told to respond as quickly and as accurately as possible. Once the instructions were clear to the subject, a series of twelve practice problems were presented to familiarize the subject with the procedure. Then, the 102 experimental problems were presented in a different random order for each subject.

The practice and experimental problems involved the presentation of a priming stimulus and a definition and also required subjects to type their responses. Each trial began with the presentation of a priming stimulus for 5 seconds. During this interval, the priming stimulus was pronounced outloud to insure that the prime was not actively ignored by the subject. The prime was then erased from the screen and immediately followed by the presentation of the target definition. At this time a real-time clock was started in the computer and continued to run until the subject made a vocal response. Any response triggered a relay which then stopped the clock and thus measured the generation latency for that trial to the nearest 1/100th of a second. Once the clock was stopped, the subject typed the same response on the CRT keyboard. If the subjects response was not correct, the screen was erased and the word "error" was printed along with the correct answer for three seconds, followed by the next trial. Otherwise, the next trial was initiated after only a one second delay.

Design and Analyses. The design of experiment 1 was a 6 x 17 x 6 x 6 mixed factorial design. The main independent variable was prime type (SC, DC, SCI, DCI, CR and NW) and was manipulated within subjects. There were also six problems nested within the 17 categories used in the experiment. Finally, each of the six counterbalancing lists were presented to six different subjects. The dependent variable was the latency required to generate the target for each problem. The ANOVA used to analyze the results was the min F′ suggested by Clark (1973) using both subjects and problems as random factors.

Possible Results and Implications. A finding that the SCI condition inhibits response time relative to the NW condition, while the SC condition produces significantly less inhibition or even facilitation of response time, would cast serious doubt upon the usefulness of the pathway inhibition hypothesis. How could another instance from the target category produce more inhibition than the category name considering that the category name was always included as part of the definition and the pathway between the category and the target should have been inhibited by a SC prime immediately preceding its use in retrieving the target from the definition? Possibily there could have been more of an inhibiting effect from the SCI primes than the SC category names because of direct relations between the instance primes and the targets. This should be unlikely because of the effort to control such direct associations.

Experiment 2

Experiment 2 was designed to provide additional evidence for either the pathway inhibition or response competition explanations of the inhibiting effects of semantic priming on recall. If the response competition explanation is correct then increasing the number of SCI primes which are presented on a trial should increase the number of potential competing responses and therefore increase the amount of time needed to retrieve the target. In contrast, the response competition hypothesis would not predict a substantial decrease in inhibition as a result of manipulating the typicality or frequency that an instance prime is given in response to its category name. Both high and low frequency responses should function as competing responses and therefore cause as much inhibition as high frequency responses.

However, if he results of experiment 1 occurred because the SCI primes directly activated and inhibited the target pathways, it would be expected that low frequency instance primes should produce less inhibition than high frequency instances. In the case of low frequency instances, little activation and inhibition of the target should occur since the semantic distance between a low frequency prime and a high frequency target is quite great. On the other hand, a high frequency prime and a high frequency target should be less distant, therefore any spreading activation should be stronger at the target location when primed by another high frequency prime. Therefore the amount of resulting inhibition should also be greater than when low frequency primes are used. The pathway inhibition hypothesis would also predict that the number of primes may influence the amount of inhibition since more than one prime could activate and inhibit the target more than just one prime. However, this effect should not be as influential as the typicality manipulation if the priming stimuli are selected to minimize direct associations between the primes and target.

Method.

Subjects. Thirty-six University of Oklahoma introductory psychology students served as subjects.

Materials. The targets and definitions used in experiment 1 were also used in experiment 2. Within each of the 17 categories, the number of primes and the typicality of the primes as measured by production frequency in the Battig and Montague (1969) norms were manipulated. Of the six problems within a category there were three high frequency priming instances (> 20) and three low frequency instance primes (f< 12). Within each frequency type there was a problem with one, two and four primes.

Procedure. The procedure and apparatus was identical to that used in Experiment 1, except that the priming stimuli were presented on the CRT for five seconds. This amount of time was used to enable subjects to read all of the priming stimuli.

Design and Analyses. The complete design of experiment 2 was a 2 x 3 x 17 x 6 x 6 mixed factorial design. Typicality, number of primes, and category type were within subjects variables, while six different counterbalancing lists were a between subjects variable and six subject were presented each list. Again, the dependent variable was the latency required to generate the target from definition onset. ANOVA's were performed using both subjects and problems as random factors.

Possible Results and Implications. Again, it is expected that the predictions of the response competition hypothesis will be supported. Such results would also be damaging to the pathway inhibition hypothesis.

General Implications

Results which support the response competition hypothesis would have an impact on several areas concerning human memory. First, response competition can explain the negative effects of semantic priming on recall without the inclusion of additional assumptions to the spreading activation theories of semantic memory, (Collins and Loftus, 1975). Thus, only the concept of activation is needed to explain the phenomonon in question. In contrast the pathway inhibition explanation requires the adoption of another assumption. Therefore, the response competition explanation is more parsimonious than the pathway inhibition explanation in terms of the present theoretical accounts of semantic memory. Second, the response competition explanation is also consistent with the well documented inhibiting effects of partial list cueing (Slameka, 1968). The present experiments would increase the generality of fact that recall or activation of one item can inhibit the recall of another, and also provide an explanation which is consistent with the explanation given by Rundus (1973) to explain partial list cuing and output interference. Third, response competition has been offered as an explanation for retroactive inhibition effects in paired associate learning, (McGeoch, 1933), and a demonstration of this same phenomenon in a semantic memory task would indicate that the same processes may be involved in both semantic and episodic memory. Finally, a demonstration of response competition as an explanation of recall inhibition by semantic priming also has implications for the "functional fixity" effect observed in problem solving by Dunckner (1945). Functional fixedness may be the result of an inproper problem solution being repeatedly activated in memory, which would then compete with other alternative solutions. Thus, demonstrating response competition in semantic memory would add to the generality and importance of response competition in general.

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Appendix B: Definition and Target Stimuli.

Appendix B: Definition and Target Stimuli.
(Target frequency in Battig and Montigue (1969) norms in parentheses.)

Category 1. A type of reading material.

Problem 1.

Target - Pamphlet (200)

Definition - A type of reading material which has only a few pages, is bound by paper covers, and is often given away by groups.

Problem 2.

Target - Novel (103)

Definition - A type of reading material which is a complex story, complete with characters and plot.

Problem 3.

Target - Journal (39)

Definition - A type of reading material which is a written account of thoughts and events, especially scientific ones.

Problem 4.

Target - Comic Book (57)

Definition - A type of reading material which consists of a series of drawings with amusing narrative.

Problem 5.

Target - Poem (24)

Definition - A type of reading material which is arranged in in lines with a regular or repeated accent.

Problem 6.

Target - Article (36)

Definition - A type of reading material which is a complete composition on a special topic which often appears in magazines.

Appendix B. (Cont.)

Category 2. A four-footed animal.

Problem 1.

Target - Elephant (182)

Definition - A four-footed animal with a long, muscular snout of which two species exist. Noted for its size and strength.

Problem 2.

Target - Bear (129)

Definition - A four-footed animal with thick, coarse hair, a short tail, and claws. Noted for its sleeping habits.

Problem 3.

Target - Wolf (55)

Definition - A wild, North American, four-footed animal which eats meat and is charaterized as being vicious and cruel.

Problem 4.

Target - Sheep (85)

Definition - A four-footed anima which is raised for meat and also for its hair. Its young are considered gentle.

Problem 5.

Target - Zebra (70)

Definition - A wild, four-footed animal which is a swift, hoofed equine of southern and eastern Africa.

Problem 6.

Target - Pig (142)

Definition - A four-footed animal which is raised for meat and is often characterized as being dirty.

Appendix B. (Cont.)

Category 3. A fruit.

Problem 1.

Target - Peach (249)

Definition- A juicy, nearly round fruit with downy skin, sweet pulp and a pit. Often it is canned in slices or halves.

Problem 2.

Target - Cherry (183)

Definition - A small, round, juicy and usually round fruit which has smooth skin and a pit. It is used to make pies.

Problem 3.

Target - Pineapple (98)

Definition - A fairly large, oblong fruit which has rough skin and is crowned by small leaves. Grown in tropical climates.

Problem 4.

Target - Watermelon (47)

Definition - A large, oblong fruit which has sweet, juicy pulp and many seeds. It also has a hard and thick rind.

Problem.5.

Target - Raspberry (28)

Definition - A small, hollow fruit which is either red or black and grows on a thorny bush. It is used to make jam.

Problem 6.

Target - Plum (167)

Definition - A roundish, juicy fruit with smooth skin of either blue, red or purple color and a pit. It is grown on trees.

Appendix B. (Cont.)

Category 4. A Weapon.

Problem 1.

Target - Sword (110)

Definition - A weapon which is usually made of metal that has a long, sharp blade fixed to a hilt or handle.

Problem 2.

Target - Club (112)

Definition - A weapon which is a long, heavy piece of wood that is thicker at one end than the other.

Problem 3.

Target - Whip (27)

Definition - A weapon which has either a flexible switch or lash and is used by making a sudden movement. Used with animals.

Problem 4.

Target - Axe (34)

Definition - A weapon which has a bladed head attached to a long handle. It is used for hewing and cleaving.

Problem 5.

Target - Hand Grenade (Grenade) (37)

Definition - A small explosive or chemical weapon which is normally thrown at a target.

Problem 6.

Target - Pistol (92)

Definition - Any of a variety of small gun weapons which are designed to be held and fired using only one hand.

Appendix B. (Cont.)

Category 5. A Type of Human Dwelling.

Problem 1.

Target - Trailer (107)

Definition - A small, furnished human dwelling which rests on either two or four wheels which allows it to be moved.

Problem 2.

Target - Mansion (75)

Definition - A large, stately human dwelling which is usually located on a large tract of land or estate.

Problem 3.

Target - Cabin (55)

Definition - A small, roughly built human dwelling which usually has one story and only a few rooms. Often made of tree trunks.

Problem 4.

Target - Cottage (66)

Definition - A human dwelling which is a small and modest house and usually is a one family residence. Associated with cheese.

Problem 5.

Target - Dormitory (63)

Definition - A human dwelling which usually has several stories with many sleeping rooms, a lounge, and a cafeteria.

Problem 6.

Target - Motel (81)

Definition - A type of human dwelling which provides sleeping and, often, eating accomodations for highway travelers.

Appendix B. (Cont.)

Category 6. A Carpenters tool.

Problem 1.

Target - Chisel (103)

Definition - A carpenters tool which is used for chipping and has a long metal plade with a sharp edge at the end.

Problem 2.

Target - Square (37)

Definition - A carpenters tool which is used for laying out and testing right angles and parallel lines. Often it has a ruler.

Problem 3.

Target - Drill (52)

Definition - A carpenters tool which is used by cranking and is adjustable to fit different sized bits.

Problem 4.

Target - Sawhorse (29)

Definition - A carpenters tool which is used to lay wood on while it is being cut or worked on.

Problem 5.

Target - Lathe (21)

Definition - A carpenters tool which is used for holding and turning wood against a cutting tool.

Problem 6.

Target - Sandpaper (20)

Definition - A carpenters tool which has a gritty or abrasive substance and is used to clean, smooth or polish wood.

Appendix B. (Cont.)

Category 7. A Member of the Clergy.

Problem 1.

Target - Bishop (168)

Definition - A clergy member of high rank in a local area, who has the power to ordain and is the leader of a church district.

Problem 2.

Target - Pastor (121)

Definition - A clergy member who is the minister or reverand of a single Protestant church.

Problem 3.

Target - Rabbi (287)

Definition - A clergy member who is a teacher and the spiritual leader of a synagogue.

Problem 4.

Target - Deacon (46)

Definition - A clergy member who helps with church duties other than preaching. Usually they are members of the church.

Problem 5.

Target - Chaplain (16)

Definition - A clergy member authorized to perform religious services in public institutions or in the armed service.

Problem 6.

Target - Cardinal (119)

Definition - A clergy member who is a high official in the Catholic Church who is appointed by the Pope and wears red.

Appendix B. (Cont.)

Category 8. A Flavoring for Food.

Problem 1.

Target - Cloves (94)

Definition - A strong, fragrant food flavoring obtained from dried flowers. They are often stuck into a ham.

Problem 2.

Target - Oregano (73)

Definition - A food flavoring which is the crushed leaves of an aromatic herb. It is often used in Italian cooking.

Problem 3.

Target - Mustard (61)

Definition - A yellow Paste or powder which is a popular American food flavoring. It has a pungent odor and taste.

Problem 4.

Target - Garlic (120)

Definition - An extremely strong smelling food flavoring which comes from the bulblike root of a small plant. Usually it is crushed.

Problem 5.

Target - Vinegar (39)

Definition - A sour, liquid food flavoring produced by fermentation of cider or wine and consists mostly of acetic acid.

Problem 6.

Target - Ketchup (68)

Definition - A food flavoring which is a thick, usually red sauce which is poured on meat or eaten with French fries.

Appendix B. (Cont.)

Category 9. A Natural Earth Formation.

Problem 1.

Target - Cliff (77)

Definition - A natural earth formation which is a very long, steep slope of rock.

Problem 2.

Target - Cave (69)

Definition - A natural earth formation which is a hollow space underground with an opening into a hill or mountain.

Problem 3.

Target - Plain (68)

Definition - A natural earth formation which is a flat, broad expanse of treeless land located at low altitude.

Problem 4.

Target - Glacier (23)

Definition - A natural earth formation which is a large mass of ice formed from years of snow accumulation.

Problem 5.

Target - Plateau (64)

Definition - A natural earth formation which is a flat area of land located in a mountainous region.

Problem 6.

Target - Volcano (65)

Definition - A natural earth formation which is an opening in the earth located at the top of a cone-shaped mountain.

Appendix B. (Cont.)

Category 10. A Sport.

Problem 1.

Target - Soccer (160)

Definition - A sport played between two eleven-man teams in which a a round ball may not be touched by the hands.

Problem 2.

Target - Hockey (130)

Definition - A sport in which two teams attempt to hit a rubber disk into a goal using curved sticks.

Problem 3.

Target - Bowling (96)

A sport in which a player attempts to knock down pins by rolling a ball at them.

Problem 4.

Target - Skiing (45)

Definition - A sport which involves gliding over snow on long, thin and flat pieces of wood.

Problem 5.

Target - Wrestling (87)

Definition - A sport in which each of two opponents try to throw or force each other to the ground.

Problem 6.

Target - Volleyball (76)

Definition - A sport played with a ball and a net in which the hands are used to keep the ball in the air.

Appendix B. (Cont.)

Category 11. A Part of a Building.

Problem 1.

Target - Foundation (51)

Definition - A building part on which the rest of the structure is supported. It is often made of concrete.

Problem 2.

Target - Stairs (64)

Definition - A building part which is a series of steps going from one floor to another.

Problem 3.

Target - Chimney (60)

Definition - A building part which is an upright structure used to vent smoke from a fireplace.

Problem 4.

Target - Closet (23)

Definition - A building part which is a small room with no windows which is used to store personal items.

Problem 5.

Target - Basement (108)

Definition - A building part which is the lowest story of a building. It is usuallv located underground.

Problem 6.

Target - Attic (30)

Definition - A building part which is the space located just beneath the roof. Often it is used for storage.

Appendix B. (Cont.)

Category 12. A Musical Instrument.

Problem 1.

Target - Banjo (77)

Definition - A four or five stringed musical instrument which is often associated with the Southern United States.

Problem 2.

Target - Harp (105)

Definition - A large musical instrument with many strings which are set in a triangular base. It is played by plucking.

Problem 3.

Target - Trombone (173)

Definition - A large brass musical instrument which has a telescoping tube which is moved to produce different notes.

Problem 4.

Target - Tuba (119)

Definition - A large brass musical instrument which is particularly noted for its extremely low pitch.

Problem 5.

Target - Harmonica (43)

Definition - A small, oblong musical instrument which is played by. inhaling and exhaling the breath through metal reeds.

Problem 6.

Target - Harpsichord(20)

Definition - A keyboard musical instrument in which the strings are plucked rather than struck. Used in Baroque music.

Appendix B. (Cont.)

Category 13. A Science.

Problem 1.

Target - Sociology (46)

Definition - The science that studies human society, its institutions, and other group processes.

Problem 2.

Target - Meteorology (21)

Definition - The science that studies the atmosphere, especially as it relates to weather phenomena.

Problem 3.

Target - Anatomy (73)

Definition - The science that studies the structure of the human body. It is based on dissection and involves memorization.

Problem 4.

Target - Geology (76)

Definition - The science that studies the crust of the earth, its layers and their history.

Problem 5.

Target - Anthropology (18)

Definition - The science that studies the development, the races, and the customs of Homo Sapiens.

Problem 6.

Target - Astronomy (114)

Definition - The science that studies the stars, sun, moon, planets and other heavenly bodies.

Appendix B. (Cont.)

Category 14. A Vegetable.

Problem 1.

Target - Cabbage (94)

Definition - A vegetable whose white or purple leaves are closely folded into a round head that grows from a short stem.

Problem 2.

Target - Cauliflower (71)

Definition - A vegetable which is a white, solid head consisting of many small flowers. It is either cooked or eaten raw.

Problem 3.

Target - Beets (63)

Definition - A vegetable which is a red, fleshly root. Other varieties are grown to produce sugar.

Problem 4.

Target - Squash (60)

Definition - A vegetable which comes in many shapes and colors and grows on a vinelike plant. Its flesh is yellow and stringy.

Problem 5.

Target - Radish (46)

Definition - A vegetable which is a small, crisp root of either red, white, or black color and is often served as a relish.

Problem 6.

Target - Cucumber (40)

Definition - An oblong vegetable which has green skin and firm, white flesh. It is often sliced and put into a salad.

Appendix B. (Cont.)

Category 15. A Flower.

Problem 1.

Target - Violet (147)

Definition - A purple or blue flower obtained from a houseplant which was originally from Africa.

Problem 2.

Target - Lily (108)

Definition - A white, bell-shaped flower with six petals which is often used as a symbol of purity.

Problem 3.

Target - Dandelion (75)

Definition - The flower of a common weed which has yellow petals and a hollow stem. Its seeds blow in the wind.

Problem 4.

Target - Orchid (135)

Definition - An exotic, queerly shaped flower which is bred to produce many colors. It is used as a corsage and is expensive.

Problem 5.

Target - Petunia (101)

Definition - A funnel-shaped flower of red, white, pink or purple color and is from a low, straggling flowerbed plant.

Problem 6.

Target - Poppy (22)

Definition - A delicate, usually red flower which forms a pod containing many seeds. One variety is used to produce drugs.

Appendix B. (Cont.)

Category 16. A Disease.

Problem 1.

Target - Polio (126)

Definition - A crippling disease characterized by inflammation of the spinal cord. It has been eliminated by a vaccine.

Problem 2.

Target - Leukemia (63)

Definition - A cancerous disease characterized by an excess of white blood cells in the blood.

Problem 3.

Target - Malaria (54)

Definition - A disease caused by mosquitoes, characterized by chills, uncontrollable shaking and fever.

Problem 4.

Target - Pneumonia (50)

Definition - A disease in which the lungs become inflamed and fill with liquid. It was often fatal before antibiotics.

Problem 5.

Target - Diabetes (26)

Definition - A disease characterized by excessive blood-sugar levels, weight loss, and extreme thirst and hunger.

Problem 6.

Target - Leprosy (44)

Definition - A chronic, mildly infectious disease characterized by white, scaly scabs. Carriers used to be placed in colonies.

Appendix B. (Cont.)

Category 17. A Vehicle

Problem 1.

Target - Bicycle (193)

Definition - A lightweight vehicle with a metal frame, two wheels, handles, and a seat.

Problem 2.

Target - Truck (223)

Definition - A motor vehicle designed primarily for carrying things other than people.

Problem 3.

Target - Tractor (35)

Definition - A vehicle used to pull various types of equipment on a farm or on a highway.

Problem 4.

Target - Tank (16)

Definition - An armored vehicle which carries weapons and moves on caterpillar tracks.

Problem 5.

Target - Taxi (32)

Definition - A vehicle which is for hire, outfitted with a meter for recording the amount of money to be paid.

Problem 6.

Target - Subway (17)

Definition - A vehicle which is an electric railway running beneath the streets of a city.

Appendix C: Priming Stimuli used in Experiment 1.

Appendix C: Priming Stimuli used in Experiment 1. Frequency in Battig and Montague (1969) norms are presented in parentheses. (Correct Answer (CA) and Neutral Warning (NW) primes not shown.)

CATEGORY #	SCI Prime	SC Prime	DCI Prime	DC Prime
1	ENCYCLOPEDIA (28)	TYPE OF READING MATERIAL	SERGEANT	MILITARY TITLE
2	BUFFALO (34)	4-FOOTED ANIMAL	SILK	TYPE OF CLOTH
3	TANGERINE (110)	A FRUIT	SOFA	TYPE OF FURNITURE
4	BAZOOKA (18)	A WEAPON	EMERALD	A PRECIOUS STONE
5	CASTLE (30)	TYPE OF HUMAN DWELLING	WHISKEY	AN ALCOHOLIC BEVERAGE
6	SCREWDRIVER (214)	A CARPENTERS TOOL	SENATOR	AN ELECTIVE OFFICE
7	NUN (104)	A MEMBER OF THE CLERGY	THEFT	A CRIME
8	VANILLA (120)	A FOOD FLAVORING	COAL	TYPE OF FUEL
9	CANYON (81)	AN EARTH FORMATION	DENTIST	A PROFESSION

Appendix C. (Cont.)

10	TENNIS (329)	A SPORT	OXYGEN	A CHEMICAL ELEMENT
11	CEILING (167)	A PART OF A BUILDING	ROCK'N'ROLL	A TYPE OF MUSIC
12	CLARINET (259)	A MUSICAL INSTRUMENT	CHICKEN	A BIRD
13	PHYSICS (327)	A SCIENCE	WALTZ	A TYPE OF DANCE
14	POTATO (224)	A VEGETABLE	FRANCE	A COUNTRY
15	TULIP (209)	A FLOWER	SUBMARINE	A TYPE OF SHIP
16	MEASLES (168)	A DISEASE	SHARK	A FISH
17	TRAIN (257)	A VEHICLE	COBRA	A SNAKE

Appendix D: Priming Stimuli used in Experiment 2.

Appendix D: Priming Stimuli used in Experiment 2. Frequency in Battig and Montague (1969) norms are presented in parentheses.

	PRIME 1	PRIME 2	PRIME 3	PRIME 4
A TYPE OF READING MATERIAL				
1-H	BOOK (370)			
2-H	NEWSPAPER (295)	LETTER (35)		
4-H	MAGAZINE (375)	TEXTBOOK (75)	PLAY (31)	ENCYCLOPEDIA (28)
1-L	THESIS (9)			
2-L	MANUSCRIPT (8)	EDITORIAL (6)		
4-L	AUTOBIOGRAPHY (3)	CATALOGUE (3)	MANUAL (2)	ALMANAC (2)
A FOUR-FOOTED ANIMAL				
1-H	DOG (426)			
2-H	CAT (412)	DEER (95)		
4-H	RAT (112)	LION (225)	HORSE (348)	GIRAFFE (82)
1-L	CHIPMUNK (9)			
2-L	ANTEATER (8)	LIZARD (4)		
4-L	KANGAROO (4)	COYOTE (9)	OPOSSUM (8)	FROG (3)
A FRUIT				
1-H	ORANGE (390)			
2-H	BANANA (283)	GRAPE (247)		
4-H	LEMON (134)	PEAR (326)	APRICOT (102)	STRAWBERRY (58)
1-L	PAPAYA (8)			
2-L	CRANBERRY (1)	GUAVA (1)		
4-L	NECTARINE (2)	DATE (9)	KUMQUAT (10)	MUSKMELON (1)

Appendix D. (Cont.)

A WEAPON

2-H	KNIFE (405)	CANNON (66)		
4-H	RIFLE (163)	ARROW (20)	MISSILE (28)	FISTS (46)
1-L	TORPEDO (7)			
2-L	TOMAHAWK (4)	HARPOON (3)		
4-L	BULLET (6)	CROSSBOW (6)	FLAMETHROWER (6)	SABER (6)

A TYPE OF HUMAN DWELLING

1-H	APARTMENT (316)			
2-H	TENT (189)	CASTLE (30)		
4-H	HOUSE (396)	HUT (121)	SHACK (81)	HOME (82)
1-L	LODGE (6)			
2-L	SHANTY (4)	VILLA (3)		
4-L	BARRACKS (9)	WIGWAM (4)	FORT (4)	INN (6)

A CARPENTER'S TOOL

1-H	SAW (394)			
2-H	HAMMER (431)	WRENCH (61)		
4-H	SCREWDRIVER (214)	PLIERS (58)	PLANE (147)	LEVEL (168)
1-L	TAPE MEASURE (9)			
2-L	MITER BOX (7)	MALLET (3)		
4-L	HACKSAW (5)	STAPLER (3)	NAIL PUNCH (4)	PUTTY KNIFE (1)

A MEMBER OF THE CLERGY

1-H	FATHER (142)			
2-H	NUN (104)	MONK (76)		
4-H	PRIEST (400)	BROTHER (71)	PREACHER (84)	POPE (179)
1-L	EVANGELIST (9)			
2-L	MISSIONARY (7)	PARSON (6)		
4-L	FRIAR (12)	SAINT (3)	CLERIC (2)	ACOLYTE (1)

Appendix D. (Cont.)

A FOOD FLAVORING

1-H	PEPPER (411)			
2-H	SALT (412)	PAPRIKA (90)		
4-H	CINNAMON (118)	ONIONS (62)	CHOCOLATE (43)	SUGAR (168)
1-L	CURRY (7)			
2-L	BASIL (9)	SESAME (4)		
4-L	CAYENNE (3)	MARJORAM (4)	SACCHARINE (5)	ANISE (6)

A NATURAL EARTH FORMATION

1-H	VALLEY (227)			
2-H	RIVER (147)	HILL (227)		
4-H	LAKE (98)	DESERT (36)	MOUNTAIN (401)	ISLAND (24)
1-L	DELTA (8)			
2-L	GEYSER (7)	BUTTE (5)		
4-L	PENINSULA (9)	WATERFALL (9)	MESA (5)	BOULDER (5)

A SPORT

1-H	BASEBALL (376)			
2-H	SWIMMING (277)	FOOTBALL (396)		
4-H	GOLF (153)	BASKETBALL (360)	BADMINTON (96)	ARCHERY (49)
1-L	SKIN DIVING (3)			
2-L	CANOEING (6)	CRICKET (6)		
4-L	CAMPING (2)	DISCUS THROW (1)	SKY DIVING (3)	TETHERBALL (1)

A PART OF A BUILDING

1-H	DOOR (322)			
2-H	BRICK (101)	FLOOR (238)		
4-H	WALL (242)	ROOM (161)	CEILING (167)	WINDOW (338)
1-L	SHUTTERS (7)			
2-L	SHINGLES (6)	BALCONY (4)		
4-L	INSULATION (3)	FURNACE (5)	AWNING (4)	RAIN GUTTER (3)

Appendix D. (Cont.)

A MUSICAL INSTRUMENT

1-H	DRUM (322)			
2-H	TRUMPET (279)	GUITAR (231)		
4-H	SAXOPHONE (176)	PIANO (329)	OBOE (144)	VIOLIN (271)
1-L	MANDOLIN (6)			
2-L	CASTANETS (2)	TYMPANI (6)		
4-L	BONGOS (8)	AUTOHARP (2)	TAMBOURINE (9)	MARIMBA (6)

A SCIENCE

1-H	PHYSICS (327)			
2-H	BIOLOGY (270)	PHYSIOLOGY (21)		
4-H	PSYCHOLOGY (272)	CHEMISTRY (367)	ZOOLOGY (248)	GENETICS (14)
1-L	CRIMINOLOGY (3)			
2-L	RADIOLOGY (1)	PHARMACOLOGY (3)		
4-L	AGRONOMY (3)	ARCHAEOLOGY (6)	VIROLOGY (2)	EMBRYOLOGY (6)

A VEGETABLE

1-H	CARROT (316)			
2-H	CORN (247)	BEANS (237)		
4-H	PEA (308)	LETTUCE (189)	POTATO (224)	SPINACH (163)
1-L	EGGPLANT (8)			
2-L	RHUBARB (4)	WATERCRESS (2)		
4-L	ARTICHOKE (5)	OKRA (5)	MUSHROOM (2)	PARSNIPS (2)

A FLOWER

1-H	CARNATION (183)			
2-H	DAISY (176)	TULIP (209)		
4-H	IRIS (53)	ROSE (421)	PEONY (38)	GARDENIA (89)
1-L	POINSETTIA (9)			
2-L	HOLLYHOCK (3)	FORSYTHIA (3)		
4-L	BEGONIA (9)	DAHLIA (4)	4-O'CLOCK (4)	CROCUS (8)

Appendix D. (Cont.)

A DISEASE

1-H	CHICKEN POX (116)			
2-H	FLU (48)	MEASLES (168)		
4-H	TYPHOID (43)	MUMPS (115)	TUBERCULOSIS (210)	SMALLPOX (71)
1-L	TETANUS (8)			
2-L	ASTHMA (5)	BRONCHITIS (5)		
4-L	HEMOPHILIA (7)	EMPHYSEMA (7)	RABIES (9)	SCURVY (7)

A VEHICLE

1-H	BUS (300)			
2-H	AIRPLANE (280)	WAGON (86)		
4-H	WAGON (86)	BOAT (145)	TRAIN (257)	MOTORCYCLE (174)
1-L	LIMOUSINE (7)			
2-L	RICKSHAW (4)	SURREY (2)		
4-L	BUGGY (5)	AMBULANCE (2)	SEDAN (2)	WHEELBORROW (2)

Appendix E. Instructions.

Appendix E. Instructions.

Experiment 1.

Microphone practice. You will be presented a series of digits one at a time on the screen. The digits will always be between zero and nine. Your job is to say each digit outloud into the microphone. If you activate the microphone the screen will be cleared and the next digit will be presented. If you do not activate the microphone the digit will remain on the screen until you say it loud enough to activate the microphone. Do you have any questions?

Practice problems. Ok, you are now ready for the practice problems. The basic task in this experiment is to recall a word in response to a definition, However, before you ever see the definition on a given trial you will first be presented what is known as a priming stimulus. Most of the time the priming stimulus will be either a word or a category name, but sometimes it will be a string of stars. If the prime is a word or words, I want you to say them outloud. You will be given three seconds to do so. If the prime is a string of stars then you do not have to say anything. After the three seconds are finished you will be presented a definition. I want you to read the definition silently and try to think of the word to which the definition belongs. When you think of the word, say it into the microphone. It should have the immediate effect of clearing the screen and then it will say "enter response". If the screen does not clear say your response into the microphone as quickly as possible. Then I want you to type the word you just said in response to the definition. The word must be spelled correctly, so if you have any spelling questions feel free to ask me. Once you finish typing, press the "return". If the response was correct the computer will present the next priming stimulus. However, if the answer is incorrect or spelled wrong then the computer will print "error" along with the correct answer. Following this the next priming stimulus will be presented. Do you have any questions? Now going back to the priming stimuli. Sometimes the prime will be the correct answer to the definition it precedes, however other times the prime may be a word which is very close in meaning to the correct answer but not quite correct. Other times the prime will be the category name of the answer. other times the prime may be an irrelevant category name or word and still other times the prime will be a string of stars. Do you have any questions?

Experimental problems. Ok, the problems which are coming up are just like the ones you have been doing except that the definitions will be two lines long rather than just one. Remember that the object is to make an accurate response as quickly as possible. There are 102 problems so keep up a fairly fast pace so you will not get bogged down. Finally, all of the words you will try to recall should be fairly familiar, thus the experiment is not a difficult vocabulary test. In addition, none of the answers will be repeated during the experiment. Do you have any questions?

Experiment 2.

Microphone practice. Identical to instructions in experiment 1.

Practice problems. Ok, you are now ready for the practice problems. The basic task in this experiment is to recall a word in response to a definition. However, before you see the definition, you will be presented either one, two or four words on the screen. I want you to say each of these words outloud and you will be given five seconds to do so. After the five seconds are up the definition will be printed on the screen. I want you to read the definition silently and try to think of the word to which the definition belongs. When you think of the word say it into the microphone. It should clear the screen and print "enter response". If the screen does not clear then say the word again as quickly as possible. Then type the word you just said in response to the definition on the keyboard. The word must be spelled correctly, so if you have any spelling questions feel free to ask me. Once you finish typing, press the "return". If the response was correct, the computer will present the next series of words which you must read. If the response was incorrect or if it was spelled wrong then the computer will print "error" along with the correct answer. Following this the next set of words will be presented. Do you have any questions? Ok, now back to the words which you pronounce before the definition is presented. These words will never be the correct answer to the definition which follows. I want you to just read them outloud. Are there any questions?

Experimental problems. Identical to instructions of experiment 1.

Appendix F. Summary of Analyses of Variance

Appendix F. Summary of Analyses of Variance

Analysis of correct answer latencies using problems as a random factor in experiment 1.

Source	df	SS	MS	F	p
PR	90	17017.54	189.08	-	-
PT	5	1104.58	220.91	12.88	<.01
PR/PT	450	7714.86	17.14	-	-

PR=PROBLEMS
PT=PRIME TYPE

Analysis of correct answer latencies using subjects as a random factor in experiment 1.

Source	df	SS	MS	F	p
CB	5	70.43	14.08	.83	>.05
SS/CB	30	508.84	16.96	-	-
PT	5	313.02	62.60	24.65	<.01
PTxCB	25	107.18	4.25	1.68	<.05
SS/PTxCB	150	380.96	2.53	-	-

CB=PRIME-TARGET COUNTERBALANCING
PT=PRIME TYPE
SS=SUBJECTS

Appendix F. (Cont.)

Analysis of the number of errors using problems as a random factor in experiment 1.

Source	df	SS	MS	F	p
PR	90	469.68	5.21	-	-
PT	5	151.92	30.38	29.94	<.01
PR/PT	450	456.57	1.01	-	-

PR=PROBLEMS
PT=PRIME TYPE

Analysis of the number of errors using subjects as a random factor in experiment 1.

Source	df	SS	MS	F	p
CB	5	34.07	6.81	.95	>.05
SS/CB	30	213.08	7.10	-	-
PT	5	384.02	76.80	35.73	<.01
PTxCB	25	108.72	4.34	2.02	<.01
SS/PTxCB	150	322.41	2.14	-	-

CB=PRIME-TARGET COUNTERBALANCING
PT=PRIME TYPE
SS=SUBJECTS

Appendix F. (Cont.)

Analysis of latencies for instance and other types of errors in experiment 1.

Source	df	SS	MS	F	p
SS	30	499.02	16.63	-	-
ET	1	92.06	92.06	17.60	<.01
SS/ET	30	156.90	5.23	-	-

SS=SUBJECTS
ET=TYPE OF ERROR (INSTANCE PRIME VS. OTHER)

Appendix F. (Cont.)

Analysis of correct answer latencies using problems as a random factor in experiment 2.

Source	df	SS	MS	F	p
PR	95	4478.99	47.14	-	-
NP	2	41.49	20.74	1.58	$>.05$
PR/NP	190	2487.08	13.08	-	-
FR	1	18.33	18.33	1.11	$>.05$
PR/FR	95	1557.98	16.39	-	-
NPxFR	2	50.79	25.39	1.34	$>.05$
PR/NPxFR	190	3585.50	18.87	-	-

PR=PROBLEMS
NP=NUMBER OF PRIMES
FR=INSTANCE TYPICALITY MEASURED BY CATEGORY FREQUENCY

Analysis of correct answer latencies using subjects as a as a random factor in experiment 2.

Source	df	SS	MS	F	p
CB	5	219.85	43.97	3.16	$<.05$
SS/CB	30	416.78	13.89	-	-
NP	2	27.38	13.69	5.84	$<.01$
NPxCB	10	47.48	4.74	2.02	$<.05$
SS/NPxCB	60	140.53	2.34	-	-
FR	1	.20	.20	.09	$>.05$
FRxCB	5	18.92	3.78	1.70	$>.05$
SS/FRxCB	30	66.67	2.22	-	-
NPxFR	2	4.12	2.06	1.02	$>.05$
NPxFRxCB	10	26.90	2.69	1.34	$>.05$
SS/NPxFRxCB	60	120.32	2.00	-	-

CB=PRIME-TARGET COUNTERBALANCING
SS=SUBJECTS
NP=NUMBER OF PRIMES
FR=TYPICALITY MEASURED BY CATEGORY FREQUENCY

Appendix F. (Cont.)

Analysis on correct and incorrect answer latencies using problems as a random factor in experiment 2.

Source	df	SS	MS	F	p
PR	95	6207.91	65.34	-	-
NP	2	114.42	57.21	6.15	<.01
PR/NP	190	1767.10	9.30	-	-
FR	1	.02	.02	.001	>.05
PR/FR	95	1524.82	16.05	-	-
NPxFR	2	11.80	5.90	.47	>.05
PR/NPxFR	190	2376.59	12.50	-	-

PR=PROBLEMS
NP=NUMBER OF PRIMES
FR=TYPICALITY MEASURED BY CATEGORY FREQUENCY

Analysis of correct and incorrect answer latencies using subjects as a random factor in experiment 2.

Source	df	SS	MS	F	p
CB	5	366.88	73.37	2.89	<.05
SS/CB	30	761.38	25.37	-	-
NP	2	45.04	22.52	6.37	<.01
NPxCB	10	63.28	6.32	1.79	>.05
SS/NPxCB	60	211.90	3.53	-	-
FR	1	.0003	.0003	.0001	>.05
FRxCB	5	21.60	4.33	1.23	>.05
SS/FRxCB	30	104.95	3.49	-	-
NPxFR	2	5.14	2.70	.52	>.05
NPxFRxCB	10	37.54	3.75	.73	>.05
SS/NPxFRxCB	60	306.86	5.11	-	-

CB=PRIME-TARGET COUNTERBALANCING
SS=SUBJECTS
NP=NUMBER OF PRIMES
FR=TYPICALITY MEASURED BY CATEGORY FREQUENCY

Appendix F. (Cont.)
Analysis of the number of errors using problems as a random factor in experiment 2.

Source	df	SS	MS	F	p
------	--	--	--	-	-
PR	95	665.49	7.00	-	-
NP	2	.33	.16	.17	>.05
PR/NP	190	181.32	.95	-	-
FR	1	.39	.39	.34	>.05
PR/FR	95	107.10	1.12	-	-
NPxFR	2	.94	.47	.58	>.05
PR/NPxFR	190	154.05	.81	-	-

PR=PROBLEMS
NP=NUMBER OF PRIMES
FR=TYPICALITY MEASURED BY CATEGORY FREQUENCY

Analysis on the number of errors using subjects as a random factor in experiment 2.

Source	df	SS	MS	F	p
------	--	--	--	-	-
CB	5	13.27	2.65	.26	>.05
SS/CB	30	299.05	9.96	-	-
NP	2	.77	.38	.18	>.05
NPxCB	10	59.77	5.97	2.77	<.01
SS/NPxCB	60	129.44	2.15	-	-
FR	1	1.18	1.18	.55	>.05
FRxCB	5	17.75	3.55	1.66	>.05
SS/FRxCB	30	64.05	2.15	-	-
NPxFR	2	2.81	1.40	.55	>.05
NPxFRxCB	10	60.07	6.00	2.35	<.05
SS/NPxFRxCB	60	153.11	2.55	-	-

CB=PRIME-TARGET COUNTERBALANCING
SS=SUBJECTS
NP=NUMBER OF PRIMES
FR=TYPICALITY MEASURED BY CATEGORY FREQUENCY