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Priming the retrieval of exemplars of semantic categories.

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PRIMING THE RETRIEVAL OF EXEMPLARS OF SEMANTIC CATEGORIES

A Thesis Presented

By

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This work is dedicated to my parents, Dominic and Mary, and to my sister Marianne. Their love and support throughout the years of my education has been an important blessing.

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ABSTRACT

Two priming experiments extending the work of Loftus (1973) and Loftus and Loftus (1974) were conducted to investigate retrieval from semantic memory. Subjects produced a letter-restricted instance from a semantic category on a prime trial, and then were asked to produce a second, different instance from the category on the target trial. The letter-restrictor for the target trial allowed a response that was either high- or low-related to the prime trial response. In addition, in Experiment 1 the dominance of the target response was varied, while in Experiment 2 the dominance of the prime response was varied. High prime-target response relatedness significantly improved target trial performance, but only in conjunction with high target dominance. Target performance was not affected by the dominance of the prime response. These results indicate that the priming of category exemplar retrieval is not simply a matter of category repetition; the interaction of exemplar dominance and its relatedness to a just-retrieved exemplar is an important determinant of retrieval performance. Two activation models are developed to account for the findings.

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CHAPTER I

INTRODUCTION

We continuously interpret and organize information received through the senses, and these mental activities could not proceed without a substantial body of knowledge to support them. Researchers of human cognition refer to this body of knowledge as semantic memory, and since it plays an important role in cognitive events, they have attempted to discover its characteristics. In particular, much of their effort has been directed towards illuminating the process of search for information in semantic memory. If we consider the vast amount of information that is stored, we realize that semantic memory access is remarkably efficient. What are the processes involved in semantic memory search? How do we retrieve information and make it consciously available?

The priming paradigm is a tool that has been used to address these questions. Priming refers to the effect of some preceding event upon a response stimulus. The most common assumption about priming is that a facilitation effect reflects an increase in the availability of information. When a meaningful stimulus is processed, it makes contact with the unit in semantic memory to which it corresponds, and the information represented by the unit becomes activated, or accessible. The assumption necessary to explain priming is that some degree of activation occurs also for semantic units that are related, or "close to" the stimulus. The activation incurred by related semantic units

renders them more accessible for a period of time, facilitating the subsequent processing of related stimuli.

Priming paradigms can provide useful information about semantic memory structure and processing. The degree to which a stimulus primes the response to some second stimulus indicates the degree to which the two stimuli are related and have representations that are close to each other. Priming also reflects which structures in memory have been activated, and this knowledge gives us insight into the operation of retrieval processes. This approach is illustrated especially by Collins and Loftus (1975) who have presented a model of semantic processing in which priming reflects "spreading-activation," a basic retrieval mechanism. It would be helpful to review that model here since it provides our theoretical framework.

The Spreading-Activation Model

This model claims that the semantic memory structure is a network of interrelated clusters of information, or nodes, which represent concepts. Each node has a number of relations, or links, to other nodes in the network. In addition to this conceptual network, or "Encyclopedia," there is another structure, the lexicon, which complements the semantic structure. The lexicon may be characterized as a "dictionary"; it provides a phonemic and/or graphemic listing of the names of concepts.

Processing a concept, that is, listening to, reading, or thinking about the concept will result in a diffuse spread of activation. The

degree to which other concepts are activated depends on a number of factors. Links between concepts are assumed to have different strengths; greater strength implies a stronger spread of activation. Also, there may be a number of paths that link two concepts. The activation of any one concept is assumed to be the summation of the activation that spreads from all paths to the concept. Thus, concepts may be activated by the existence of a single strong link to the originating concept, or there may be a number of paths of varying strengths. The more processing a concept receives, the longer it will serve as a source of spreading activation. It is necessary, however, to assume that as activation spreads it meets with some resistence; the farther a node is from the originally activated concept, the smaller the amount of activation it receives. This prevents the entire network from being activated. When processing ceases, the activation that has accumulated in the network gradually decays, and all activated concepts return to their base levels of accessibility.

To summarize, the more connections between two concepts, and the stronger these connections, the more activation will spread between them. In this way, related concepts will tend to activate and be activated by each other. This is the process that is assumed to underlie priming. In fact, Collins and Loftus (1975) believe the spreading-activation process to be the basic search mechanism of memory. We turn now to an examination of the priming literature to assess this claim.

The Lexical Decision and Sentence Verification Tasks

Lexical decision. In the lexical decision task, subjects are required to judge whether a letter-string is a word. Reaction time (RT) to make the judgement is the dependent variable of interest. In one variation of this task, Meyer and Schvaneveldt (1971) visually presented two letter-strings simultaneously, and instructed subjects to respond "yes" if both strings were words and "no" otherwise. If the two letter-strings were associated words (e.g., "Bread--Butter"), RT was significantly faster than if the two strings were unassociated words ("Bread--Doctor"). In a second variation, lexical decisions were made on single letter-strings presented sequentially. Meyer, Schvaneveldt, and Ruddy (1972) and Schvaneveldt and Meyer (1973) reported that making a positive lexical decision facilitated performance on an associated word on the next trial. Furthermore, there was facilitation, although to a lesser extent, on RT to an associated word. In a different experiment, Meyer et al. (1972) found that the facilitation due to association between two words presented with an intervening four-second delay was one half its magnitude at no delay. All of these results provide support for the spreading-activation model, and the latter two strongly suggest the existence of the assumed activation decay.

Although the lexical decision task has provided interesting results, the task may not be representative of all semantic processing. The amount of semantic information required to perform a lexical decision is minimal; it is necessary only to ascertain if a lexical

entry exists for the letter-string. In addition, work on the locus of the priming effect in this paradigm has indicated that association facilitates the encoding stage of processing rather than the memory search stage (Becker and Killion, 1977; Meyer, Schvaneveldt, and Ruddy, 1975). Thus, priming in the lexical decision task may have limited implications for the study of semantic search.

Sentence verification. This task seems to be a logical candidate for the study of retrieval from semantic memory. In this paradigm, subjects are required to judge the truth value of simple sentences (e.g., "A canary is a bird," "Closets have headlights") as quickly as possible. Obviously, performance depends on the retrieval of semantic information, in contrast to lexical decision. Collins and Quillian (1970) found lower RT to verify that a sentence (the target) is true when a judgement about a related sentence (the prime) appeared on the preceding trial. Furthermore, Ashcraft (1976) found that the facilitation was greater if there was just one unrelated sentence between the prime and target sentences (lag 1) than if there were four unrelated intervening sentences (lag 4). These results are similar to those reported above for lexical decision; they support the spreading-activation model, and the lag effect is accounted for by activation decay.

As with lexical decision, however, there exists the question of which stage of processing is being facilitated in the sentence verification task. Collins and Quillian (1970) repeated the subject noun from the prime sentence in the target sentence. For example,

one of their prime-target pairs was "A canary can fly--A canary is a bird." This procedure allows the encoding of the target sentence to be facilitated since part of it has just been processed. Collins and Quillian (1970) acknowledge that it is not clear whether priming in this task facilitates the "accessibility" of nodes (encoding), "transit time to move between nodes" (search), or both. Unfortunately, these same considerations are true of the Ashcraft (1976) experiments so his data do not clarify matters.

The starting point of this research was the question of how search proceeds in semantic memory. One suggestion was the spreading-activation process proposed by Collins and Loftus (1975). Research on lexical decision and sentence verification paradigms suggests that spreading-activation gives a good account of the facilitation of visual encoding, but we have been unable to evaluate their claim that it is the basic search mechanism of semantic memory. If Collins and Loftus' assertion is true, we should be able to prime performance in all tasks that require the retrieval of semantic information. Lexical decision does not involve extensive search of semantic memory, and the sentence verification studies reported to date have confounded encoding time and search time. In the following section we describe a task that is more amenable to an unambiguous interpretation of priming effects.

The Production Task

The production task has been used extensively by E. Loftus and co-workers to study the retrieval of semantic information (Freedman and Loftus, 1971; Grober and Loftus, 1974; Loftus, 1973; Loftus and Cole, 1974; Loftus and Loftus, 1974; Loftus and Suppes, 1972). In this paradigm, subjects are presented with the name of a semantic category and are asked to produce an instance belonging to that category as quickly as they can. If given the category "Animal," a subject could respond "Dog," "Horse," etc. Typically, the instances retrieved are subject to some constraint such as beginning with a specified letter (hereafter referred to as letter trials) or having a specified property (adjective trials). An example of a letter trial is "Animal--D"; some acceptable responses are "Dog," "Deer," and "Dolphin." An adjective trial example is "Animal--small," to which the responses "Mouse" or "Hamster" are among those that might be given. Before considering production in a priming paradigm, it would be useful to review the literature on the task in the unprimed situation.

Unprimed production. Freedman and Loftus (1971) employed the production task to investigate semantic retrieval and obtained several interesting results. First, dominance, the likelihood that a member of a category will be thought of when listing exemplars of the category, was an important predictor of production RT: As the dominance value of the most dominant of the acceptable responses increased, latency decreased (see also Loftus and Suppes, 1972). If the category was

presented before the restrictor, RT was faster than if the restrictor preceded the category. Lastly, performance on letter trials was the same as that on adjective trials; this was true in all conditions of the experiment.

The implication of the last finding is that the same retrieval process operates in both adjective- and letter-restricted search. Grober and Loftus (1974) and Loftus and Cole (1974) investigated this possibility further. In their experiment, category names always preceded the restrictors, and in addition to presenting adjective and letter trials in a randomly-mixed fashion (as did Freeman and Loftus), they also blocked trials by restrictor type. RT to mixed-block adjective trials, mixed-block letter trials, and blocked adjective trials did not differ. In contrast, the blocked letter condition produced significantly faster RTs than the other three conditions. This result indicates that subjects can use a more efficient retrieval processs on letter trials, but only when they have advance knowledge that the trial will, in fact, be letter-restricted. On the other hand, advance knowledge that a trial will be adjective-restricted does not appear to influence searches of this sort.

These findings are of interest because they led to the development of the "Dictionary-Network" model of the production task (Loftus and Cole, 1974; Collins and Loftus, 1975), so named because it makes use of the lexicon-conceptual network distinction. The basic retrieval process for both adjective and letter trials starts with the activation of category exemplars following category

name presentation. Presumably, the more dominant members of the category are activated first and/or to a greater extent than the less dominant ones. What happens next depends on the trial type. When the trial is letter-restricted, as the category members become activated, their lexical representations are also activated since this information is what is needed to check for the desired initial letter. When the letter is presented and a correct response found, it can be produced without delay because the lexical representation is already available. When the trial is adjective-restricted, an intersection search between the category and adjective concepts must take place in the network. For example, an intersection between "Fruit" and "Yellow" would be "Banana." When an intersection is achieved, the lexical representation of the retrieved concept must be activated to allow its name to be produced. The difference between the two types of search is the amount and type of activation possible during the category-restrictor interval. On letter trials, activation of specific lexical items occurs <u>before</u> the letter is presented. On adjective trials, subjects must wait until the adjective is presented before the intersection search takes place; when an intersection is found still more time is needed to activate the appropriate lexical entry. Even though processing the category name activates category exemplars for both types of trials, in the first case this leads to advantageous lexical activation while in the second case it is too diffuse to be of any help.

The model successfully accounts for the production task data cited above. Dominance-ordered activation explains the increased latency for

low-dominant productions. The superiority of the category-first presentation order reflects the fact that activation of category members is assumed to begin with the presentation of the category name. If the restrictor is presented first, there is little that can occur to be of much use: Adjectives and letters would cause a very diffuse activation, at best. Finally, the model as stated above predicts that when the category name is presented before the restrictor, letter trials should always be responded to faster than adjective trials. This conflicts with the Grober and Loftus (1974) result that mixed-block letter trials are no faster than adjective trials. We need to augment the model to account for the increased mixed-block letter RT. This is done by adding the assumption that activation is a limited-capacity process. To be more specific, if a subject knows that the ensuing trial will be letter-restricted, activating lexical representations of category members is an efficient strategy. Upon making this commitment of processing resources, if the trial is actually adjective-restricted, a re-allocation of resources is necessary to activate the semantic network for an intersection search; this shift in activation strategy would be costly. Faced with the ambiguity of a random presentation of restrictor type, subjects apparently wait to see if they will be presented with a letter-restrictor before activating the lexicon. As a result, RT to mixed-block letter trials becomes slower.

If this explanation is correct, increasing the time interval between the category name and letter should reduce RT in the blocked

condition (since there has been more time to activate concepts and their lexical representations), but not in the mixed condition (since subjects wait for the restrictor before committing capacity to lexical activation). The Grober and Loftus (1974) study confirms this prediction: RT to mixed-block letter trials with either a .5 or 2.5 second category-letter interval did not differ, while blocked letter trials were 180 msec faster with the longer interval.

The dictionary-network model of production was developed to account for the effects of presentation order, dominance, restrictor type, and category-letter interval for the case of single productions. It is essentially a spreading-activation explanation, and it provides our frame of reference as we consider the effect of prior context (priming) on production.

<u>Primed production</u>. Priming in the production task has been investigated in two studies (Loftus, 1973; Loftus and Loftus, 1974). In the basic experimental situation, subjects produced a member of a category beginning with a certain letter ("Animal--D"). Either immediately or several trials later, the same category was paired with a different letter (Animal--C"). The question of interest was whether retrieving one member of a category would facilitate the subsequent retrieval of a different member. Loftus (1973) varied the number of items between successive presentations from a category; the second presentation was either immediate (lag 0), or after one (lag 1) or two other items (lag 2). She found that subjects produced a second instance of a category more quickly than the first, but this facilitation decreased

with increasing lag: The facilitation was 310 msec, 230 msec, and 140 msec for lags 0, 1, and 2, respectively. These results were interpreted as providing support for a spreading-activation process with an activation decay. Unfortunately, in this experiment the category and letter were presented simultaneously, making it impossible to determine the locus of facilitation: Encoding the category name, search, or both.

Loftus and Loftus (1974) modified the Loftus (1973) experiment by adding to manipulations that would allow a separation of the encoding and search stages. The presentation order was either category followed by letter or vice versa, and the interval between the stimulus pair was zero (simultaneous) or 2.5 seconds. When the category appeared before the letter, RT was about 190 msec faster than in the opposite order. The 2.5 second interval resulted in RTs that averaged 370 msec faster than simultaneous presentation. The major finding of the study, however, was the replication of the Loftus (1973) result. There was more facilitation at lag 0 (270 msec) than at lag 2 (65 msec). The three variables, interval, order, and lag, did not interact in any way, indicating that the amount of priming did not depend on the ability to process the category name prior to the presentation of the letter restrictor. Finally, estimates of the durations of processing stages obtained by subtractive methods revealed that only the category search stage was reliably affected by lag.

Loftus and Loftus (1974) and Collins and Loftus (1975) have interpreted these findings as evidence for a spreading-activation

process. According to their interpretation, presenting a category name induces a spread of activation to its associates, a subset of which would be category exemplars. Presumably, those exemplars that are more dominant receive the greatest amount of activation. Retrieval of an item on the second presentation of the category is faciliated by an amount directly proportional to the activation that accumulated on that item during previous processing. Neither Loftus and Loftus (1974) nor Collins and Loftus (1975) proposed a more specific model of priming in the production task. This is unfortunate because there is a question about the source of the activation. If the activation responsible for priming is a consequence only of processing the category label on a previous trial, then it is difficult to explain the large amount of facilitation when there is a 2.5 second interval between the category and letter-restrictor. It would seem that during this long interval subjects could always achieve a high degree of activation for at least the more dominant items of a category, thus attenuating (or even eliminating) the priming effects. Loftus and Loftus (1974) have implicitly acknowledged that it is the act of search itself that is important for priming in the task; their article is entitled "The influence of one memory retrieval on a subsequent memory retrieval." They do not deal with this issue explicitly in the text of their report, however.

In summary, Loftus and Loftus (1974) have provided a clear demonstration that the speed with which we retrieve information from semantic memory can be increased. The construct of spreading-activation

has been used to explain this interesting result, but questions remain. Is priming in the production task a result of residual activation resulting from the presentation of a category name on a previous trial? Or is there something about the act of search itself that facilitates a subsequent search?

One possibility is that it is not the search *per se* that facilitates a subsequent search of the category, but rather, it is the *product* of a successful search, an appropriate response, that will affect later searches. More specifically, the response may serve as a source of activiation for the search on the next trial. If this is the case, we would expect this activation to accumulate most in concepts that are semantically related to the produced response. The implication is that if the category-letter combination of the second presentation allows a response (hereafter referred to as the target) that is closely related to the item produced on the initial presentation of the category (the prime), then this response will be given, and with a smaller RT than if not preceded by a related production.

This is a viable explanation for the facilitation observed by Loftus (1973) and Loftus and Loftus (1974). To support this assertion we must consider their item selection procedure. Two items were chosen from each semantic category used, and the first letters of the items were paired with their category's name to generate the stimuli presented to subjects. The noteworthy aspect of the procedure was that the two items selected were the first- and third-most dominant

instances given in the Battig and Montague (1969) and Shapiro and Palermo (1970) category norms. Our contention is that these instances will tend to be highly related. To see this, we should consider the manner in which the category norms were obtained. Subjects were asked simply to list examples of categories; as they generate responses, they are likely to give instances that are related to the example just produced. Some examples of stimuli generated by selecting the first- and third-most dominant items from a category are: Kitchen Utensil--F(ork), Kitchen Utensil--S(poon); Precious Stone--D(iamond), Precious Stone--E(merald).

A second item selection problem in the Loftus studies is more obvious: The instances were all high-dominant. In response to these two item selection problems, our research will attempt to unconfound the effects of category repetition and relatedness, and investigate the role of dominance. Two experiments are presented, both of which included manipulations of prime-target relatedness and dominance. In Experiment 1, the dominance of the targets was manipulated; in Experiment 2 prime dominance was manipulated. Before reporting these experiments, we describe the normative procedure used to obtain ratings of relatedness.

CHAPTER II

NORMATIVE STUDY AND EXPERIMENTS

Normative Study

Since response relatedness was to be manipulated in our experiments, normative information about the strength of the relationship between category members was required. The purpose of this procedure was to validate the experimenter's intuitions about the relatedness of pairs of category instances.

Method.

Subjects. Sixty-six University of Massachusetts undergraduates were recruited from the Department of Psychology subject pool. They received one experimental credit towards coursework for their participation.

Materials. Materials were selected from the Battig and Montague (1969) and Shapiro and Palermo (1970) category norms. From each of 60 categories three instances were chosen subject to a number of constraints. First, all three instances began with different letters and were common, well-known words. Second, there were no other members of the category that began with the same letter and were of higher dominance than any of the chosen instances. Third, one of the three selected items was designated as the prime and the other two, as targets. (For simplicity's sake, this distinction will be

maintained to describe the stimulus characteristics; it applied only to Experiment 1. The same materials were used in Experiment 2, but the assignment of items to prime and target conditions reversed, as will be explained later.) The two targets were chosen such that one was intuitively highly-related to the prime while the other seemed considerably less so. For example, three items selected from the category "Relative" were "Brother," "Sister," and "Aunt." These items yield two prime-target pairs; the high-related pair is "Brother-Sister" and the low-related pair is "Brother-Aunt." Finally, over all of the items selected, the dominance of the high-related targets was roughly equal to that of the low-related targets.

Procedure. The study was conducted in group sessions that lasted approximately 30 minutes. The 120 potential prime-targets pairs (two each from 60 categories) were ordered randomly and presented in booklet form. Subjects were asked to judge how related the pairs of words were. They made their judgements using a seven-point rating scale (1 = very related, 7 = not at all related) and coded their responses on optical scan sheets. The participants were warned that the members of each pair were from the same category and would seem to be at least minimally related; they were asked to not let this over influence their ratings. To illustrate the point, examples of high- and low-related pairs were given. Half of the subjects worked through the booklets from front to back while the other half worked from back to front.

Results. Data from five subjects were not included in the analysis

because they skipped one or more items. Mean ratings and standard deviations across subjects were computed for each word pair. These means were standardized in the following way:

$$\text{Standardized Rating} = \frac{\text{(Mean Rating - 4)}}{\text{Standard Deviation of the Rating}}$$

(4 is the midpoint of the rating scale).

The difference between standardized ratings of the high- and low-related pairs was computed for each category. The difference represents the perceived disparity in relatedness between the two pairs. For a category to be considered as acceptable for our purposes, the difference had to be in the correct direction, that is, the intuitively chosen high-related pair had to be given a greater relatedness rating than the intuitively chosen low-related pair. Three categories did not meet this criterion. The remaining 57 categories were rank ordered based on the magnitude of their difference in standardized ratings; the 40 categories with the largest difference were selected for use in the experiments. These were chosen because we wished to have the high- and low-related pairs be as different in relatedness as possible. The differences for these categories ranged from 3.66 (for "Dog-Tiger" vs. "Lion-Tiger") to .79 (for "Silk-Wool" vs. "Cotton-Wool"). The items will be described more fully in the specific contexts of the experiments.

Experiment 1

Earlier it was noted that Loftus and Loftus (1974) did not

systematically vary dominance, and they quite possibly confounded the effects of category repetition with relatedness. This experiment was designed to discover if performance on target items was facilitated differentially by these variables. The basic procedure used by Loftus and Loftus (1974) was used. Subjects produced one category instance and on the next trial produced a second, different instance; manipulations of prime-target relatedness and target dominance were included in the design.

Method.

Subjects. Thirty-nine University of Massachusetts undergraduates were recruited from the Department of Psychology subject pool. They received one experimental credit towards coursework for their participation.

Materials and Design. Each of the 40 categories selected on the basis of the normative procedure contributed one prime instance, one high-related target, and one low-related target. Within a category, the targets were categorized according to dominance. One target was higher dominant then the other; if this target was also high-related then it was considered a high-dominant, high-related (HD-HR) target, and the other target instance in that category was a low-dominant, low-related (LD-LR) target. When the higher dominant of the two targets was the low-related one (HD-LR), the lower dominant target was, necessarily, high-related (LD-HR). For each category, Appendix A lists the instances, dominance values for each and the difference in standardized rating for the high- and low-related prime target pairs.

The categories have been divided into two sets: Set A contains categories whose targets are HD-HR and LD-LR while Set B contains those which are HD-LR and LD-HR. In addition to these materials, 140 items from 88 different categories were selected from the category norms to be used as filler. They were interspersed with the test materials to insure that subjects would not come to expect immediate repetitions of categories.

Collapsing across sets, the targets can be viewed as a two (target dominance) by two (relatedness) design with repeated measures on both factors. The primes form the same two by two design, but target dominance and relatedness are inoperative variables on the primes and cannot affect performance on them.

<u>Procedure</u>. Subjects were run individually in one session lasting approximately 50 minutes. The experiment was controlled by a PDP-8E computer. Following a practice block of 15 filler items, subjects were presented with a random order of five blocks of 40 items each. The stimuli had been randomly assigned to blocks with the constraint that there were 24 filler items and 16 test items. Eight of the filler categories were paired with two different letters (never successively) and the remaining eight filler items were single instances from non-repeated categories. The 16 test items consisted of two each of the four different target types (HD-HR, etc.) with their corresponding primes.

Subjects saw each test category name paired with only two letters. After the prime trial, one of the two targets was chosen at

random and its initial letter was paired with the category name to form the stimulus presented on the next trial; this random selection process was subject to the constraint that there were only two targets of each of the four types per block.

Each trial consisted of the following events. First, there was a 150 msec warning tone followed 500 msec after onset by the presentation of the category name on a video display. One second after category onset, the letter-restrictor for that trial appeared three character spaces to the right and on the same line as the category name. Subjects were instructed to say aloud their response as quickly as possible; their voices activated a voice key which stopped the internal clock of the computer and erased the category and letter from the screen. Latency from letter presentation to voice key activation was recorded. If a response was not produced before 15 seconds had elapsed, the words "Trial Over" appeared briefly on the display. There was a four-second intertrial interval.

The experimenter and computer were in a room separate from the subject, and two types of response coding were performed on-line during the intertrial interval. The first type was an evaluation of response correctness. The trial was coded as being "correct" if the response was a legitimate category member beginning with the given letter; it was coded as an error if it was not, or if a voice key error occurred on that trial (i.e., premature or late voice key activation). The word "Error" appeared on the screen to inform the subject if the response was incorrect or if there had been a voice

key problem. The second type of coding was done only on test trials. If the response to a test item, for example, "Anamal--D," was correct but not the one intended (e.g., "Deer" instead of "Dog"), that response was coded as "unexpected." Subjects were not aware of this additional type of response evaluation during the experiment.

Results and discussion.

Reaction time. RTs of unexpected prime and target responses and errors were not included in the RT analysis. Also excluded were RTs to expected target responses following unexpected prime responses. This was done because in these cases the degree of relatedness between prime and target was unknown.

As a result of allowing up to 15 seconds for a response, the RT data were highly variable. For this reason, geometric cell means were computed for each subject. This procedure minimized the contribution of very large RTs and reduced the variability of the data. The individual geometric means were then averaged (arithmetically) across subjects to yield the cell means presented in Table 1. Cell standard deviations appear in parentheses.

Prime and target RTs did not differ ($F<1$). Separate analyses of variance were performed on the prime and target data. Primes of high dominant targets were responded to faster if they were priming high- rather than low-related targets, but for primes of low-dominant targets the trend was reversed. This interaction was significant ($F(1,38) = 5.58$, $p<.05$, $MS_e = 53,860$). Neither the overall effect of "dominance" (i.e., primes of high-dominant targets versus primes of low-dominant

TABLE 1

Mean reaction times (in msec) and standard deviations (in parentheses) for Experiment 1, complete item set.

PRIMES

	Relatedness to Target	
	High	Low
Primes of High Dominant Targets	944 (283)	1074 (368)
Primes of Low Dominant Targets	1050 (271)	954 (264)

TARGETS

	Relatedness	
	High	Low
High Dominant Targets	719 (182)	1113 (361)
Low Dominant Targets	1134 (350)	1131 (311)

targets) nor the overall effect of relatedness to the coming target was significant. (Complete listings of results obtained in the analyses of variance reported in this paper are given in the tables presented in Appendix B. For the analysis described above, see Table 9.)

Mean RT to HD-HR targets was 400 msec faster than that to the other three types of target items, which had roughly equivalent RTs. The large divergence of the HD-HR mean resulted in the significance of the two main effects: Overall, RT to high-dominant targets was faster than to low-dominant targets ($F(1,38) = 16.90$, $p < .001$, $MS_e = 108{,}427$), and high-related targets were responded to faster than low-related targets ($F(1,38) = 18.93$, $p < .001$, $MS_e = 78{,}917$). That divergence also resulted in a significant target dominance by relatedness interaction ($F(1,38) = 19.33$, $p < .001$, $MS_e = 79{,}718$). (See Table 10.)

The results for the prime RTs present a problem. Since neither the dominance of the target being primed nor the prime-target relatedness should affect prime RT, there should not have been a significant interaction. An examination of our materials revealed a possible explanation for the significant cross-over. It was discovered that there was a tendency for Set A primes (primes of HD-HR and LD-LR targets) to be more dominant than Set B primes (those of LD-HR and HD-LR targets). (See Appendix A.) This unintentional manipulation of prime dominance resulted in RTs of 947 msec for Set A primes versus 1062 msec for Set B primes. This means that the significant interaction obtained may really represents a main effect of prime dominance on the prime RTs; given the difference in dominance between

the two sets of primes, this would not be surprising. Unfortunately, these considerations make the interesting interaction in the target RTs ambiguous; it may represent either a prime dominance <u>or</u> target dominance by relatedness interaction.

Selecting a set of materials from this experiment that was large enough and had the required characteristics was difficult, and it was unlikely that a new set could be chosen that would be able to hold prime dominance constant while manipulating target dominance and prime-target relatedness. Instead, a subset of the materials used in the experiment was chosen such that each prime selected from Set A had a corresponding prime from Set B that matched it closely in dominance. This resulted in a subset consisting of 22 of the original 40 categories, 11 each from Sets A and B, with primes from the two sets now equal in dominance. The stimulus characteristics of the subset remained almost identical to the original sample with respect to the relatedness and target dominance manipulations. (See Appendix A.) All previously reported analyses were redone using the item subset. In addition, analyses of omitted and unexpected target responses were carried out on this subset.

<u>Subset analyses</u>.

<u>Reaction time</u>. Cell means and standard deviations for the experiment were computed as above and are presented in Table 2. Again, prime and target RTs did not differ ($\underline{F} < 1$). In constrast to the results with the complete item set, the mean prime RTs for the subset are all about equal; no effects approached significance (see Table 11).

TABLE 2

Mean reaction times (in msec) and standard deviations (in parentheses) for Experiment 1, item subset.

PRIMES	Relatedness to Target	
	High	Low
Primes of High Dominant Targets	963 (337)	971 (431)
Primes of Low Dominant Targets	910 (336)	1080 (611)

TARGETS	Relatedness	
	High	Low
High Dominant Targets	766 (233)	1111 (491)
Low Dominant Targets	1057 (421)	1025 (342)

Although the mean for primes of LD-LR targets is about 130 msec slower than the other three points, the large, but not significant, difference is entirely attributable to two subjects whose mean for that cell exceeded 3000 msec. Removing these subjects' data reduced the cell mean from 1080 to 962 msec (and lowered the standard deviation from 611 to 337 msec) without signficiantly altering the pattern of data or the results of the analyses. The important point is that the prime RT analysis indicates that our subset provides the desired set of items; items that do not differ with respect to prime dominance while allowing a manipulation of relatedness and target dominance.

The mean target RTs for the subset look very much like those of the complete item set. Referring to Table 2 we see that, again, the HD-HR targets have a much smaller mean RT than that of the three other target types, which had approximately the same mean RT. The variability was somewhat larger than with the complete set, so the high-dominant targets were only marginally faster than the low-dominant targets ($\underline{F}(1,38) = 3.57$, $.05 < \underline{p} < .10$, $\underline{MS}_e = 115{,}364$), but high-related targets were, on the average, faster than the low ($\underline{F}(1,38) = 7.01$, $\underline{p} < .05$, $\underline{MS}_e = 136{,}503$). As with the complete item set, these main effects reflect only the disparity of the HD-HR mean; their interpretation must be qualified in light of the significant target dominance by relatedness interaction ($\underline{F}(1,38) = 7.89$, $\underline{p} < .01$, $\underline{MS}_e = 175{,}408$). (See Table 12.) Notable in the pattern of target means is the counter-intuitive result that RT to HD-LR targets was as slow

as that to LD-LR targets. This finding will be considered further in the General Discussion.

One other aspect of the RT data merits a brief comment. Target RTs were no faster than prime RTs, but this need not be interpreted as the absence of a priming effect. It should be noted that the targets were somewhat lower in mean dominance than the primes (average prime dominance was 72.5 percent; target dominance, averaged over high (76%) and low (47%) dominance conditions, was 61.5 percent); the difference in dominance presumably cancelled any facilitation due to category repetition.

In summary, the major finding from the RT data is that target RTs are responded to quickly only if there are both high-dominant and high-related; neither high-dominance nor high-relatedness alone decreased target RT. That this result was obtained for both the complete item set and subset analyses is noteworthy because it indicates that the unintentional manipulation of prime dominance had no effect on target RTS. This issue will be considered further in Experiment 2 in which prime dominance is intentionally (and more strongly) manipulated.

<u>Proportion of target omissions</u>. The omissions data were prepared for analysis in the following way. For each subject the proportion of target omission following expected prime responses was computed for the four target types. Since a number of subjects had a proportion equal to zero in one or more of the target conditions, the data were transformed using the correction (Myers, 1979, p. 73):

$$\underline{Y}' = \frac{(k\underline{Y} + 3/8)}{(\underline{k} + 3/4)}$$

where $\underline{Y}'$ is the corrected proportion, $\underline{Y}$ is the original proportion, and $\underline{k}$ is the number of observations on which $\underline{Y}$ is based. Next, the corrected proportions were themselves transformed using the arc sine of the square root (i.e., ARCSIN $\sqrt{Y'}$) so that the data would be more amenable to parametric analysis. Table 3 shows retransformed mean proportions and standard deviations.

It is immediately evident from Table 3 that the target omissions data and the target RT data are very similar; they exhibit the same pattern of means. The combination of high target dominance and high relatedness yielded the smallest mean while the other three means are larger and approximately equal. The target dominance by relatedness interaction was reliable ($\underline{F}(1,38) = 5.61$, $\underline{p} < .05$, $\underline{MS}_e = 32.75$), but the main effects of dominance and relatedness failed to approach significance (See Table 13).

The concordance of the patterns of means for target RT and omissions is not surprising; RT reflects retrieval difficulty as does the subject's ability to produce a response. A difference between the two analyses is the non-significant omissions main effects. Note, though, that the ability to produce a response is a cruder measure of retrieval difficulty than RT, and there were fewer data points available for the omissions analysis, so the difference between the two is inconsequential.

Proportion of unexpected target responses. Of interest in this section is the proportion of target trials on which a subject gave

TABLE 3

Mean proportions and standard deviations (in parentheses) of targets response omissions following expected prime responses for Experiment 1, item subset.

		Relatedness	
		High	Low
Target Dominance	High	.08 (.003)	.11 (.016)
	Low	.11 (.020)	.10 (.006)

an unexpected response following an expected prime. The proportions were transformed in the same way as for omissions, and were submitted to a similar analysis. The retransformed mean proportions and standard deviations are shown in Table 4. Subjects gave fewer unexpected responses when a response that was high-related to the prime was possible ($\underline{F}(1,38) = 28.37$, $\underline{p} < .001$, $\underline{MS}_e = 78.51$). Neither target dominance nor its interaction with relatedness reliably affected the number of unexpected responses (see Table 14).

Unexpected responses may occur for two different reasons: For a particular subject, the unexpected response may actually be more dominant than the one intended by the experimenter, contrary to the category norms. Another possiblility is that the unexpected response is more related to the prime for that subject than the intended one is. To say which is the more correct interpretation is not possible; it is conceivable that a different times both things can occur, either separately or in conjunction. It seems safe to say, though, that this dependent variable is not a reliable measure of retrieval difficulty.

To summarize the major findings of this experiment, subjects quickly retrieved the expected target response only if it was both high-dominant and high-related to the prime. If either or these conditions was not met, RTs became uniformly slower, and the proportion of omissions increased. Finally, high relatedness decreased the likelihood of an unexpected target response for both high- and low-dominant items.

TABLE 4

Mean proportions and standard deviations (in parentheses) of unexpected target responses following expected prime responses for Experiment 1, item subset.

		Relatedness	
		High	Low
Target Dominance	High	.12 (.024)	.21 (.038)
	Low	.13 (.025)	.24 (.031)

Experiment 2

In Experiment 1 we assessed the effects of target dominance and relatedness on target performance. In this experiment we investigated the effects of prime dominance and relatedness on target performance. We would like to know if the "depth," or effort spent on a category search, influences a subsequent search of the same category.

Method.

Subjects. Thirty-eight University of Massachusetts undergraduates were recruited from the Department of Psychology subject pool. They received one experimental credit towards coursework for their participation.

Materials and design. The materials used in Experiment 1 were used again in this experiment with one change; within each category the assignment of items to prime and target conditions reversed. The items listed as primes in Appendix A were used as targets and vice versa. Thus, the primes were either high- or low-dominant, and the targets that followed were either high- or low-related to the primes. Use of the terms high- or low-dominant when referring to a target merely indicates the dominance of the prime that preceded it; for instance, "HD-HR target" now denotes a high-related target that followed a high-dominant prime. The prime data formed a two (prime dominance) by two (relatedness to target) design but only the dominance manipulation was operative; the target data were viewed as forming

the same design with prime dominance and relatedness as factors.

Procedure. The procedure for this experiment was essentially identical to that of Experiment 1. The only difference was that instead of randomly selecting one of two targets, one of the two primes was randomly selected. As in Experiment 1, the selection and presentation of stimuli were controlled by the PDP-8E.

Results and discussion.

Reaction time. RTs of unexpected prime and target responses and errors were not included in this analysis. Also excluded were RTs to expected target responses following unexpected prime responses. Data from one subject were discarded because of an empty cell. Means and standard deviations were computed in the same way as for Experiment 1 and are shown in Table 5.

In contrast to Experiment 1 results, target RTs were much faster than prime RTs ($F(1,36) = 54.99$, $p < .001$, $MS_e = 51{,}691$). This supports our earlier contention that the lack of an observable priming effect in Experiment 1 was due to lower dominance for the targets. In this study, the targets benefited by being both primed and higher in dominance than the primes.

High-dominant primes were responded to faster than low-dominant primes ($F(1,36) = 11.56$, $p < .01$, $MS_e = 102{,}237$). As should have been the case, there was no effect of relatedness (an inoperative variable on the primes). There was a tendancy for HD-LR primes to be slower than the HD-HR ones, and the LD-HR were somewhat slower than the LD-LR primes. This interaction only approached significance, however

TABLE 5

Mean reaction times (in msec) and standard deviations (in paretnthses) for Experiment 2, complete item set.

PRIMES

		Relatedness to Target	
		High	Low
Prime Dominance	High	929 (263)	1013 (321)
	Low	1163 (294)	1136 (308)

TARGETS

		Relatedness	
		High	Low
Dominance of Prime	High	714 (174)	960 (312)
	Low	916 (478)	873 (286)

($\underline{F}(1,36) = 3.18$, $.05 < \underline{p} < .10$, $\underline{MS}_e = 35,937$). (See Table 15.)

Target RTs were not significantly affected by the dominance of the prime when averaged over both levels of relatedness. High-related targets had smaller RTs than low-related targets ($\underline{F}(1.36) = 4.63$, $\underline{p} < .05$, $\underline{MS}_e = 82,413$), but this main effect primarily reflects the behavior to targets of high-dominant primes. Low-dominant primed targets show a slight reversal of this trend, and the interaction of prime dominance and relatedness was significant ($\underline{F}(1,36) = 13.60$, $\underline{p} < .01$, $\underline{MS}_e = 56,690$). (See Table 16.)

In the first experiment, Set A primes were more dominant than Set B primes. Since the assignment of primes and targets has been reversed in this experiment, there is now an unintentional manipulation of target dominance. (Set A includes HD-HR and LD-LR targets; Set B includes HD-LR and LD-HR targets.) As a result, the dominance of the prime may, in fact, be interacting with relatedness, or we may have only a main effect of item sets due to the difference in target dominance (Set A target RT = 794 msec; Set B target RT = 938 msec). The results of the previous experiment suggest that prime dominance is not an important factor on target RT; an analysis of the previously used subset of items (which now balances target dominance) should further clarify the issue.

Subset analyses.

Reaction time. Data from three additional subjects were deleted, two for having empty cells, and one for having a cell mean over 6000 msec (more than three standard deviations from the mean).

Means and standard deviations for the subset are shown in Table 6.

Target RTs remained, on the whole, much faster than prime RTs ($\underline{F}(1,33) = 44.99$, $\underline{p} < .001$, $\underline{MS}_e = 100{,}733$). The mean prime RTs show a change of pattern, though; they should vary only with dominance, and three out of the four means conform to our expectations. The fourth mean, the LD-LR one, is about 200 msec faster than we could expect, given the other means. Neither main effect approached significance, although the prime dominance by relatedness interaction was marginally reliable ($\underline{F}(1,33) = 4.15$, $.05 < \underline{p} < .10$, $\underline{MS}_e = 102{,}654$). (See Table 17.) The fast mean RT to LD-LR primes is probably best described as being a chance occurrence.

The target data present a clear, consistent picture. High-related targets were responded to faster than low related targets ($\underline{F}(1,33) = 4.94$, $\underline{p} < .05$, $\underline{MS}_e = 52{,}668$). Neither prime dominance nor its interaction with relatedness reliably affected target RT (see Table 18). These findings fit nicely with the Experiment 1 result that high relatedness facilitated target RT only when the target dominance was high also. The targets used in this experiment were high-dominant (almost as high as the high-dominant targets of Experiment 1), and when relatedness was high, we observed facilitation relative to the low related targets. The unique contribution of these data is the finding that prime dominance did not affect RT to the subsequent target.

<u>Proportion of target omissions</u>. The proportions were caluculated and transformed as in Experiment 1. Means and standard

TABLE 6

Mean reaction times (in msec) and standard deviations (in parentheses) for Experiment 2, item subset.

PRIMES

		Relatedness to Target	
		High	Low
Prime Dominance	High	1001 (276)	1028 (435)
	Low	1170 (372)	974 (255)

TARGETS

		Relatedness	
		High	Low
Dominance of Prime	High	729 (222)	827 (309)
	Low	753 (193)	830 (278)

deviations are presented in Table 7. Once again, the omissions and RT data have the same pattern of results. Subjects were less likely to make omissions on high- rather than low-related targets trials ($\underline{F}$(1, 36) = 4.74, $\underline{p} < .05$, $\underline{MS}_e$ = 29.57). No other effects were significant (see Table 19). The combination of high target dominance and high relatedness facilitated performance, while prime dominance had no effect.

Proportion of unexpected target responses. These data were treated as above. Means and standard deviations are shown in Table 8. Considering targets that followed a low dominant prime, unexpected responses were more than twice as likely with low rather than high relatedness. The strength of this effect results in a significant main effect of relatedness ($\underline{F}$(1,36) = 9.55, $\underline{p} < .01$, $\underline{MS}_e$ = 101.34), even though there was a slight reversal of this trend for targets following high dominant primes. The interaction of prime dominance by relatedness was significant ($\underline{F}$(1,36) = 23.02, $\underline{p} < .001$, $\underline{MS}_e$ = 72.61). The overall effect of prime dominance was not reliable (see Table 20). As mentioned above, the significance of these data is unclear.

TABLE 7

Mean proportions and standard deviations (in parentheses) of targt omissions following expected prime responses for Experiment 2, itemsubset.

		Relatedness	
		High	Low
Prime Dominance	High	.08 (.004)	.11 (.013)
	Low	.08 (.002)	.09 (.005)

TABLE 8

Mean proportions and standard deviations (in parentheses) of unexpected target responses following expected prime responses for Experiment 2, item subset.

		Relatedness	
		High	Low
Prime Dominance	High	.15 (.024)	.13 (.016)
	Low	.11 (.018)	.26 (.050)

CHAPTER III

GENERAL DISCUSSION

We have chosen the production task as a vehicle to investigate retrieval from semantic memory. Other investigators have found that a production can be facilitated by preceeding it with a production from the same semantic category. The present research was conducted to specify more precisely what variables play a role in this priming. Our suggestion was that prime-target response relatedness is one such variable. Also, manipulations of dominance are known to produce potent effects on production RT, but there has been no information forthcoming on prime or target dominance effects in the priming situation. We noted that the materials used in the Loftus studies tended to be both high dominant and high related; a manipulation of these variables was necessary to determine whether production priming was a result of category repetition alone or the presence of an advantageous combination of dominance and relatedness.

Our experiments indicate that prime dominance does not affect target performance. Further, only when both target dominance and relatedness are high is performance improved; category repetition alone is not enough. A basic model for this task has been developed that has two variations. The first of these will be referred to as the "Residual Activation" model, and the second, the "Re-Activation" model. The basic model assumes that category search starts with the activation of the most dominant items and then proceeds, if necessary,

in order to items that are less dominant. This assumption is reasonable since it describes subjects' performance when not primed (Grober and Loftus, 1974).

The Residual Activation Model

This model places emphasis on the existence of residual activation on items related to the prime response. After the presentation of the category label on the target trial, high dominant items are activated. Some of these items still may be activated somewhat from the previous trial because of their relatedness to the prime. The residual activation and the new category label activation for an item summate in some way (there may be a differential weighting). The item that is most ac-activated by these two sources is "prepared" (invested with a large portion of attentional capacity) at the expense of the other items. If a letter-restrictor consistent with the prepared response is presented, the response can be output quickly. Otherwise, RT is considerably slower.

The single item preparation feature of the model allows it to account for the poor performance on low dominant and HD-LR targets that was observed. Low dominant items will not receive enough activation from the category label to be prepared even if they are highly related to the prime (and have a fair amount of residual activation). Given this, some high dominant item will be prepared; this will be determined by the strength of its relationship to the prime. Since HD-LR items have a low degree of relationship, their chances of being prepared are slight; they will be responded to no faster than low dominant items.

The Re-Activation Model

This model is similar to the residual activation model in that it incorporates the same assumptions about category search and item preparation. It differs in its explanation of the role of relatedness. After the category label is presented on the target trial, the same activation of high dominant items occurs as was assumed before. At this point, the subject, realizing that s/he is having a category repetition, may recall the prime response to help with the coming trial. This conscious remembrance occasions a new spread of activation with the prime as its source. Activation summates, and the most activated item is prepared.

The two models are discriminable. The reactivation model places emphasis on re-activation based on an active remembrance during the category-letter interval. Since remembrance takes time to occur, presenting the category name and letter simultaneously should eliminate the relatedness effect. Preparation would occur based only on the activation of items from the category label, and there would be only a dominance effect on target performance. On the other hand, simultaneous presentation would not affect the amount of activation on category exemplars if it is viewed as being residual.

Future Directions

If the residual activation model is supported by the results of the simultaneous presentation variation of the task, we can ask further is the residual activation is being consciously maintained. If

so, the interpolation of some effortful activity during the intertrial interval would greatly decrease it, and preparation would occur based mostly on the activation incurred from the category label. Thus, HD-LR target performance would improve since only dominance, not dominance plus relatedness, would determine which items are prepared.

The manipulations described above should help in selecting a model for this task. There are two drawbacks in using this particular paradigm, however. First, when a subject gives an unexpected response on a priming trial, we lose both the prime and target trials because of uncertainty about the degree of relatedness between the two. A significant amount of our data was lost in this way. To combat this, subjects could receive a small amount of training with the items they would later produce, and perhaps the semantic variables still would have the same strong effects. But a second and more bothersome drawback is that there is no neutral baseline against which to measure facilitation (or interference). In our case, facilitation had to be defined as the difference between prime and target RT; this would depend on the stimulus characteristics of both the prime and the target items.

Both of these drawbacks could be sidestepped by altering the paradigm. Instead of having one production followed by another, in this situation subjects would be presented with a single word cue. After a variable delay, they would be asked to do a production. For example, if the production stimulus was "Seasoning--P(epper)" the primes could be neutral ("Blank"), high related ("Salt"), low related ("Garlic"), or miscues ("Dog"). The differences between neutral-cued

and the other conditions would be true indications of facilitation. In addition to type of cue, the dominance of the target could be easily manipulated.

Another advantage of this cuing paradigm would be its ability to address the issue of automaticity in the production task more directly than the interference manipulation described above. By varying the cue-production stimulus onset asynchrony we could assess the effect of different amounts of cue processing on production. Work of this sort has been done with lexical tasks (Posner and Snyder, 1975; Neely, 1977), but until recently (Myers and Lorch, in press) the investigation of automaticity and priming in tasks emphasizing retrieval has been neglected. This is unfortunate because outside of the laboratory we are more often asked to produce information than to decide if letter strings are words. If we wish a better understanding of how knowledge is retrieved, a more complete understanding of the production task is indicated.

REFERENCES

Ashcraft, M. H. Priming and property dominance effects in semantic memory. Memory and Cognition, 1976, 4, 490-500.

Battig, W. F., & Montague, W. E. Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. Journal of Experimental Psychology Monograph, 1969, 80(3, pt. 2)

Becker, C. A., & Killion, T. H. Interaction of visual and cognitive effects in word recognition. Journal of Experimental Psychology: Human Perception and Performance, 1977, 3, 389-401.

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

Collins, A. M. & Quillion, M. R. Facilitating retrieval from semantic memory: The effect of repeating part of an inference. In A. F. Sanders (Ed.), Attention and Performance III. London: North-Holland Publishing Company, 1970.

Freedman, J. L. & Loftus, E. F. The retrieval of words from long-term memory. Journal of Verbal Learning and Verbal Behavior, 1971, 10, 107-115.

Grober, E., & Loftus, E. F. Semantic memory: Searching for attributes versus searching for names. Memory and Cognition, 1974, 2, 413-416.

Loftus, E. F. Activation of semantic memory. American Journal of Psychology, 1973, 86, 331-337.

Loftus, E. F., & Cole, W. Retrieving attribute and name information from semantic memory. Journal of Experimental Psychology, 1974, 102, 1116-1122.

Loftus, G. R., & Loftus, E. F. The influence of one memory retrieval on a subsequent memory retrieval. Memory and Cognition, 1974, 2 467-471.

Loftus, E. F., & Suppes, P. Structural variables that determine the speed of retrieving words from long-term memory. Journal of Verbal Learning and Verbal Behavior, 1972, 11, 770-777.

Meyer, D. E., and Schvaneveldt, R. W. Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. Journal of Experimental Psychology, 1971, 90, 227-234.

Meyer, D. E., Schvaneveldt, R. W., & Ruddy, M. G. Activation of lexical memory. Paper presented at the Psychonomic Soceity Meetings, St. Louis, November, 1972.

Meyer, D. E., Schvaneveldt, R. W., & Ruddy, M. G. Loci of contextual effects on visual word recognition. In P. Rabbitt & S. Dornic (Eds.) Attention and Performance V. New York: Academic Press, 1975.

Myers, J. L. Fundamentals of Experimental Design. Boston: Allyn & Bacon, 1979.

Myers, J. L., & Lorch, R. F., Jr. Interference and facilitation effects of primes upon verification processes. Memory and Cognition, in press.

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

Posner, M. I. & Snyder, C. R. R. Facilitation and inhibition in the processing of signals. In P. Rabbitt and S. Dornic (Eds.), Attention and Performance V. New York: Academic Press, 1974.

Schvaneveldt, R. W., & Meyer, D. E. Retrieval and comparison in processes in semantic memory. In S. Kornblum (Ed.), Attention and Perfromance VI. New York: Academic Press, 1973.

Shapiro, S. I., & Palermo, D. S. Conceptual organization and class membership: Normative data for representatives of 100 categories. Psychonomic Monograph Supplements, 1970, 3(11, Whole No. 43).

APPENDIX A

Stimulus materials used in Experiments 1 and 2.

SET A

Prime-Target pairs having HD-HR or LD-LR relationships

Category	Prime	Dominance[a]	HD-HR Target	Dominance	LD-LR Target	Dominance	ΔR[b]
Weapon	Rifle	37	Gun	89	Bomb	28	3.02
Kitchen Utensil[c]	Spoon	83	Fork	79	Pan	55	2.96
Ice Cream Flavor	Chocolate	96	Vanilla	91	Peach	15	2.88
Part of the Body[c]	Legs	91	Arms	90	Head	70	2.81
Unit of Time	Second	96	Minute	97	Year	96	2.66
Article of Furniture	Chair	100	Table	92	Bed	74	1.87
Foreign Country[c]	France	73	England	53	Japan	15	1.85
Title of Royalty	Queen	82	King	86	Duke	31	1.81
Dessert[c]	Pie	72	Cake	74	Jello	31	1.62
Type of Human Dwelling	Apartment	71	House	90	Igloo	14	1.55
Profession	Doctor	82	Lawyer	61	Teacher	35	1.50
Food Seasoning	Pepper	94	Salt	91	Garlic	36	1.50
Part of a Building[c]	Window	76	Door	73	Roof	60	1.44
Sport Using a Ball[c]	Football	89	Soccer	41	Tennis	33	1.37

Arithmetic Operation[c]	Addition	48	Subtraction	45	Division	44	1.27
Ocean[c]	Pacific	94	Atlantic	94	Indian	83	1.16
Science[c]	Biology	61	Zoology	56	Geology	17	1.15
Piece of Farm Equipment	Tractor	94	Plow	68	Hoe	26	1.01
Direction on a Compass[c]	South	99	North	99	East	95	.93
Kind of Cloth[c]	Wool	79	Cotton	91	Silk	66	.79
	Mean:	80.85		78.00		46.20	1.76
Subset Statistics:		78.64		72.27		51.73	1.58

SET B

Prime-Target pairs having HD-LR or LD-HR relationships

Category	Prime	Dominance[a]	HD-LR Target	Dominance	LD-HR Target	Dominance	ΔR[b]
Four-Footed Animal[c]	Tiger	46	Dog	96	Lion	51	3.66
Relative[c]	Brother	80	Aunt	98	Sister	79	3.31
Type of Exercise[c]	Running	60	Push-up	53	Jogging	13	2.49
Part of a Bicycle[c]	Wheel	80	Handle Bars	71	Tire	22	2.28
Kitchen Appliance	Mixer	33	Toaster	41	Blender	21	2.17
Vegetable	Lettuce	43	Pea	70	Tomato	49	2.08
Weather Phenomenon	Tornado	69	Snow	60	Wind	19	1.93
Bird	Hawk	25	Robin	85	Eagle	36	1.91
Article of Female Clothing	Dress	58	Blouse	66	Skirt	65	1.73
Insect	Bee	51	Ant	58	Wasp	24	1.63
Building Material	Brick	74	Wood	83	Cement	34	1.43
Part of a Face[c]	Mouth	85	Eyes	97	Lips	20	1.33
Emotion	Anger	29	Love	76	Hate	68	1.27

Fruit	Lemon	30	Apple	97	Orange	88	1.24
Military Title[c]	General	77	Private	70	Admiral	33	1.23
Carpenter's Tool[c]	Hammer	98	Saw	89	Nail	56	1.17
Unit of Distance[c]	Inch	93	Mile	99	Foot	94	1.15
Musical String Instrument[c]	Violin	90	Guitar	77	Cello	47	.95
Metal[c]	Iron	80	Copper	70	Steel	64	.87
Color[c]	Yellow	88	Blue	99	Orange	86	.81
	Mean:	64.45		77.75		48.45	1.73
	Subset Statistics:	79.72		83.55		51.36	1.74

[a]Dominance is expressed as the percentage of the normative sample that gave that response.

[b]ΔR is the difference between standardized rating for low-and high-related pairs.

[c] Denotes a Category used in the item subset.

APPENDIX B

Analysis of Variance tables for Experiments 1 and 2.

TABLE 9

Analysis of Variance on prime reaction times for Experiment 1, complete item set.

Source of Variance	df	Mean Square	F
Total	155	90,158.96	
Subjects (S)	38	136,714.92	
Dominance (D)	1	38,684.52	.35
S x D	38	109,925.32	
Relatedness (R)	1	2,718.18	.05
S x R	38	58,259.48	
D x R	1	300,363.87	5.58*
S x D x R	38	53,860.07	

*$p < .05$

TABLE 10

Analysis of Variance on target reaction times for Experiment 1, complete item set.

Source of Variance	df	Mean Square	F
Total	155	125,056.07	
Subjects (S)	38	114,928.67	
Dominance (D)	1	1,832,937.77	16.90*
S x D	38	108,426.68	
Relatedness (R)	1	1,493,881.83	18.93*
S x R	38	78,917.42	
D x R	1	1,541,238.75	19.33*
S x D x R	38	79,717.56	

*$p < .001$

TABLE 11

Analysis of Variance on prime reaction times for Experiment 1, item subset.

Source of Variance	df	Mean Square	F
Total	155	196,464.97	
Subjects (S)	38	244,842.04	
Dominance (D)	1	30,810.53	.16
S x D	38	192,914.37	
Relatedness (R)	1	309,348.13	1.58
S x R	38	195,247.54	
D x R	1	259,439.10	1.70
S x D x R	38	152,587.42	

TABLE 12

Analysis of Variance on target reaction times for Experiment 1, item subset.

Source of Variance	df	Mean Square	F
Total	155	162,175.43	
Subjects (S)	38	161,796.18	
Dominance (D)	1	411,743.91	3.57*
S x D	38	115,363.88	
Relatedness (R)	1	956,824.48	7.01**
S x R	38	136,503.21	
D x R	1	1,383,920.48	7.89***
S x D x R	38	175,407.85	

*$.05 < p < .10$

**$p < .05$

***$p < .01$

TABLE 13

Analysis of Variance on transformed proportions of target omissions for Experiment 1, item subset.

Source of Variance	df	Mean Square	F
Total	155	37.60	
Subjects (S)	38	31.34	
Dominance (D)	1	68.84	1.52
S x D	38	45.30	
Relatedness (R)	1	29.04	.79
S x R	38	36.57	
D x R	1	183.67	5.61*
S x D x R	38	32.75	

*$p < .05$

TABLE 14

Analysis of Variance on transformed proportions of unexpected target responses for Experiment 1, item subset.

Source of Variance	df	Mean Square	F
Total	155	109.95	
Subjects (S)	38	125.90	
Dominance (D)	1	83.23	1.22
S x D	38	68.41	
Relatedness (R)	1	2,227.71	28.37*
S x R	38	78.51	
D x R	1	1.75	.02
S x D x R	38	114.78	

*$p < .001$

TABLE 15

Analysis of Variance on prime reaction times for Experiment 2, complete item set.

Source of Variance	df	Mean Square	F
Total	147	95,489.99	
Subjects (S)	36	169,228.43	
Dominance (D)	1	1,181,491.13	11.56*
S x D	36	102,236.90	
Relatedness (R)	1	30,742.58	.67
S x R	36	45,667.11	
D x R	1	114,298.60	3.18**
S x D x R	36	35,936.92	

*$p < .01$
**$.05 < p < .10$

TABLE 16

Analysis of Variance on target reaction times for Experiment 2, complete item set.

Source of Variance	df	Mean Square	F
Total	147	115,854.50	
Subjects (S)	36	213,273.78	
Dominance (D)	1	120,959.14	1.42
S x D	36	85,318.46	
Relatedness (R)	1	381,466.49	4.63*
S x R	36	82,412.67	
D x R	1	771,161.02	13.60**
S x D x R	36	56,690.23	

*$p < .05$
**$p < .01$

TABLE 17

Analysis of Variance on prime reaction times for Experiment 2, item subset.

Source of Variance	*df*	Mean Square	*F*
Total	135	120,460.65	
Subjects (S)	33	144,406.13	
Dominance (D)	1	111,680.57	1.02
S x D	33	109,503.46	
Relatedness (R)	1	240,355.29	2.13
S x R	33	112,659.04	
D x R	1	425,794.05	4.15*
S x D x R	33	102,654.35	

*$.05 < p < .10$

TABLE 18

Analysis of Variance on target reaction times for Experiment 2, item subset.

Source of Variance	df	Mean Square	F
Total	135	65,256.46	
Subjects (S)	33	105,407.24	
Dominance (D)	1	5,933.93	.09
S x D	33	67,633.44	
Relatedness (R)	1	206,198.76	4.94*
S x R	33	52,668.14	
D x R	1	3,862.33	.12
S x D x R	33	33,067.76	

*$p < .05$

TABLE 19

Analysis of Variance on transformed proportions of target omissions for Experiment 2, item subset.

Source of Variance	df	Mean Square	F
Total	147	21.46	
Subjects (S)	36	18.16	
Dominance (D)	1	10.39	.51
S x D	36	20.36	
Relatedness (R)	1	140.19	4.74*
S x R	36	29.57	
D x R	1	29.88	2.05
S x D x R	36	14.54	

*$p < .05$

TABLE 20

Analysis of Variance on transformed proportions of unexpected target responses for Experiment 2, item subset.

Source of Variance	df	Mean Square	F
Total	147	107.58	
Subjects (S)	36	85.49	
Dominance (D)	1	240.11	2.40
S x D	36	99.89	
Relatedness (R)	1	967.43	9.55*
S x R	36	101.34	
D x R	1	1,671.33	23.02**
S x D x R	36	72.61	

*$p < .01$
**$p < .001$