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THE LOCUS OF THE EFFECTS OF ACTIVATION UPON PROCESSING IN A CATEGORIZATION TASK

A THESIS PRESENTED

By

Patricia Sorce

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Patricia Sorce

Approved as to style and content by

Jerome L. Myers, Chairperson of Committee

Charles Clifton, Jr., Member

Nico Spinelli, Member

Jane Perlmutter, Member

Jerome L. Myers, Department Chairperson

Psychology Department

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ABSTRACT

Two hypotheses were proposed regarding the role of activation in semantic memory upon processing operations of a categorization task. The pre-decision hypothesis stated that if activation produced by priming facilitated encoding and access of information relevant to the categorization task, then activation should have its effect on pre-decision processing stages. The decision hypothesis stated that if activation increased the perceived degree of association between the category and instance, then activation should have its effect upon the decision stage of a categorization task. Activation of the stimulus pairs was produced by priming, where the stimulus pair was repeated at lag 0 or lag 1 in the trial sequence. The results failed to support either hypothesis. Reaction time data from the repeated stimulus pairs were best explained by a processing strategy that utilized the episodic memory trace of the correct response which was formed upon the initial presentation of that pair. The generality of this strategy to other information processing tasks using similar priming procedures was discussed. Alternative experimental procedures for the further investigation of the question of the role of activation in semantic memory was noted.

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The term "activation" has been applied in information processing literature to describe the temporary change in state of a concept in memory as a result of psychological processing. As the metaphor implies, the processing of a concept is assumed to energize its conceptual representation, and this activity dissipates to base level without continued processing. Though this hypothetical construct has often been used to explain results of memory experiments (Meyer, Schvanevelt, and Ruddy, 1972; Collins and Quillian, 1970; Warren, 1972, 1974; Conrad, 1974), little is actually known about activation itself: what causes it, how extensive are its effects in memory, and what are its effects upon further psychological processing of the activated concepts. If more were known about the residual properties of activation, and how to identify it, then it could be used to trace the locus of processing in semantic memory. Before activation can be used to study questions about memory such as what type of information is retrieved when a concept is probed, it must first be known what retrieval and decision processes are influenced by activation.

There is evidence that activation of a concept, by retrieval of that concept from memory, does facilitate continued processing of that item. Does activation of the relationship between two concepts serve to facilitate the pre-decision operations, such as encoding the stimuli and accessing the appropriate memory locations, or does it increase the associative strength between the two concepts, hence affecting the decision operations which depend upon associative strength? The purpose of the present experiment is to investigate the effects of short term activation of two concepts upon the time to make a decision involving those concepts in a categorization task. In the next section, I will review the two major process models of semantic memory that have been proposed which outline the pre-decision and decision processing stages in a categorization task. I will then review recent research concerning the effects of short term activation upon processing in other memory tasks and indicate what processing stages specific to these tasks are affected by activation. This review of the research will provide empirical support for the predicted effects of activation in the proposed experiment and will also demonstrate the applicability and generality of the effects of short term activation in semantic memory research.

Process Models of Semantic Memory. Two types of models of semantic memory have recently been proposed to account for the results of a categorization task: feature models and network models. The most recent and most explicit statement of a feature model is the Feature Comparison model of Smith, Shoben, and Rips (1974), where the conceptual structure is hypothesized to consist of lists of features that define individual concepts. Processing specific to a categorization task in this model are:

(1) encoding the stimuli: the Category (C) and Instance (I) of the category

(2) Stage 1 Comparison features —

(a) retrieve the list of features that define C and I

(b) compare the two lists of features and obtain an index of the degree of similarity between the words

(c) compare this index of similarity to two criteria; if it is over the positive threshold or below a negative threshold, then a fast yes or no is produced. If this index falls between the two criteria, then more comparisons are needed before the Subject (S) can respond

(3) Stage 2 comparison of features —

(a) list the defining features of the two words

(b) compare them

(4) respond on the basis of the second comparison.

The processing stages in this model can be divided into three general classes: (1) encoding, (2) pre-decision operations, and (3) decision operations. The general encoding process would include stage #1 in the above model; the pre-decision processes, #2a, 2b, 3a, 3b, retrieve information regarding the relationship between these concepts; the decision process, stage 2c, evaluates this information to determine if it is sufficient to respond. Categorization time depends upon the probability that this decision operation needs to gather more information via the Stage 2 comparision before a response is made.

The latest statement of a network model of semantic processing is the Spreading Activation model of Collins and Loftus (1974). Concepts are represented as nodes in a network of labelled relations which specify how one concept is related to another. They proposed the following processing stages of a categorization task:

(1) (a) encoding the stimuli

(b) start of a parallel search in memory from the concept nodes

(3) evaluating the intersected pathway to see if it relates the two concepts in the manner defined by the experimental task

(4) decide if that information is sufficient to make a positive or negative response; if so, a response is made on the basis of that evaluation. If not, then more pathways must be evaluated to provide

more information to make the decision.

The general encoding process in this model consists of stage #1a; the pre-decision processes, stages #1b, 2, and 3, consist of the retrieval of information relating the concepts; the decision stage, #4, determines if enough information has been gathered to respond. RT to categorize a word is dependent upon the duration of stage #4, which depends upon the number of pathways needed to be evaluated prior to the response.

Activation Research. A procedure widely used in investigating the short term effects of activation is priming, whereby a concept in memory is activated if it has recently been retrieved. Collins and Quillian (1970) were the first to study the effects of priming upon Reaction Time (RT) in a sentence verification task. They assumed that processing in a verification task consists of (1) encoding the words of a sentence, (2) searching for a pathway in the semantic network that relates the concepts in the sentence, (3) evaluating that pathway, and (4) responding. They found that primed sentences were verified faster than non-primed sentences; activation of the concept nodes in the to-be-verified sentence decreased the time to verify that sentence. Collins and Quillian attributed this effect to the facilitation of the search process in their model, which can be considered part of pre-decision processing. Since priming is assumed to activate the path between the concepts, less time is needed to find an intersection between the concepts, which results in a faster RT to verify a primed sentence.

An alternative interpretation that may have produced similar results was that priming facilitated only the encoding of the concepts. Their conclusion that the locus of the effects of activation via priming was in a post-encoding processing stage seems premature. Regardless of the question of the locus of the effects of activation, Collins and Quillian's results do show that further processing of a previously activated concept is facilitated.

Meyer and his associates have also shown that priming reduces RT in a lexical decision task. RT to verify that two letter strings were words is faster if the words are associated than if they are not (Meyer, Schvanevelt, and Ruddy, 1972). Meyer, Schvanevelt, and Ruddy (1973) investigated the locus of the context effect upon processing in the lexical decision task. They proposed a serial stage model for this task consisting of encoding, memory retrieval, and response execution stages. They reasoned that if two variables affected the same stage in an independent serial stage model, then those two variables should interact when both are varied in an experiment. Since stimulus quality has been shown to affect the encoding stage in a memory search task (Sternberg, 1967), Meyer _et al_ manipulated both stimulus quality and association in a lexical decision task. If associative strength of the word pairs interact with stimulus quality, then it could be concluded that the observed facilitation was a result of encoding the stimulus rather than retrieval of the lexical representation. They found that these variables did interact with each other, such that the effect of association was more pronounced when the stimulus was degraded than when it was intact.

Additional support that the facilitory effect of semantic priming is located in the encoding stage was demonstrated in another experiment by Meyer, Schvanevelt, and Ruddy (1974). They examined the relative size of the effects of stimulus quality and association on both the lexical decision task and a pronunciation task. They assumed that the pronunciation task did not include the memory retrieval stage of the lexical decision task, so that if an interaction of stimulus quality and association was as large in the pronunciation task as the lexical decision task, then they could conclude that the association effect was in only the encoding stage and not in the later stages of processing. They found that the interaction was of the same magnitude in both tasks, and concluded that semantic priming only facilitated encoding of the stimulus.

An alternative explanation for the similarity of the stimulus quality x association interaction in both tasks is that the memory retrieval stage in the lexical decision task is minimal, which constrains the effect of association from greatly influencing the relatively minute post-encoding processes. If another task were used which required extensive pre-decision or decision operations, then possibly priming could be shown to affect these later processing stages. Although this alternative interpretation does not discount the result that activation of a concept through semantic priming does facilitate the encoding of that concept, it does introduce the possibility that activation could affect later processing stages as well.

Warren (1972, 1974) has demonstrated that priming the meaning of the irrelevant word in a Stroop task produced more interference with the naming of the color of that word than when it was not primed. This priming result can best be explained as the facilitation of encoding of the irrelevant word in terms of Morton's (1969) logogen model of memory as summarized in Dyer's (1973) review. According to Morton's model, interference in color naming is produced when the response channel, which can only act on one response program at a time, is occupied by the logogens for reading the irrelevant word prior to those of naming the color. Priming increases the probability that the word-reading logogens become available for input into this response buffer before those of the color naming response. Priming effectively reduces the amount of sensory information required to push the logogens for word reading over the threshold of availability of the response buffer. Activation via priming in the Stroop task facilitates encoding information which competes with the color naming task, therefore producing more interference in the color naming response.

In the experiments reviewed to this point, the evidence showed that activation facilitates retrieval operations implemented in the primed area of memory. Meyer et al have shown directly that these results are due to facilitating the encoding of the stimulus item, and Collins and Quillian's and Warren's data can also be interpreted in this way. Does residual short term activation affect only the time to access the memory nodes before subsequent operations are executed? Two groups of investigators, Perlmutter, Sorce and Myers (1974) and Atkinson and Juola (1974) have assumed that the short term activation plays a larger role than simply facilitating encoding in information processing. They propose that activation produced by retrieval of a memory unit is the basic mechanism for the build up of strength of concepts or between concepts. In the following section, I will review how activation is incorporated into their respective models and note the experimental results that provide evidence that short term activation is used in decision processing.

Perlmutter, Sorce and Myers proposed a strength model of recall of paired associates in which RT to recall the response member of the pair was hypothesized to be an inverse function of strength of the relationship between the stimulus and response. The strength of this relationship, and hence RT, was determined by the recency and frequency of presentation of that pair. We found that RT was fastest when the stimulus item had been presented on the immediately preceding trial (lag 0 repetition); activation of the pair via the retrieval of the response did facilitate the subsequent retrieval of that response. If this reduced RT reflected the increased strength of the relationship between the stimulus and response as assumed in our model, then activation would be shown to influence the response retrieval stage of our three stage process model consisting of stimulus encoding, response retrieval, and response execution stages. But the effect would also be produced if activation facilitated the encoding of the stimulus word. In order to determine the locus of the activation effects, we examined the effects of lag upon a reading task, which we assumed included the encoding but not the response retrieval stage of the recall task. If the effects of activation were due to facilitating the encoding of the stimulus word, then there should be lag effects on the time to read the stimulus word; however, we found that reading time was unaffected by lag.

This provided evidence that activation resulting from recent memory retrieval affected operations other than stimulus encoding.

There appears to be an inconsistency between the read data collected by us and the data from the pronunciation task of Meyer et al. In similar tasks, Meyer found that priming a to-be-read word with an associate decreased RT to read the word, but when a word was primed with itself in the lag 0 condition in our study, RT was not affected. This is a bit unusual, because one would expect more activation, hence a greater facilitation, if a word were primed with itself than if it was primed with an associate. This difference in results could be explained by the differences in intertrial intervals and stimulus materials between the two experiments; in the pronunciation task used by Meyer et al, the interstimulus interval was less than 1000 msec. whereas in our reading task, the interval was greater than 3000 msec. Also, Meyer et al used stimulus words which were novel to the experimental session, but we used words which were well-memorized prior to the experimental session. Both of these variables could have resulted in activation influencing the encoding stage of the pronunciation task of Meyer et al rather than in our read task.

Atkinson and Juola (1974) have also hypothesized that short term activation is the basic mechanism of increasing the strength of a memory node, in their model of word recognition. The familiarity value of the word is proposed to increase upon the presentation of that word in the experimental task. Reaction time to decide whether a word is a member of a well memorized list is a function of the familiarity value of the word in the semantic memory. If this value exceeds a positive threshold, a fast yes or no response is given based solely on the perceived familiarity of the item. If familiarity falls between the two thresholds, Atkinson and Juola proposed that a search of the Event/Knowledge store in LTM is started, in which the S examines the list of memorized words in order to verify if the probe is in the list. If this search is needed, it would add more time to the decision stage of the process, hence producing a longer RT. Their model predicts that as target items (positive probes) are repeated, RT decreases because the familiarity value for that item exceeds the positive threshold more often. The opposite is predicted for distractor items (negative probes), because increasing the familiarity of those items by repeated presentations increases the probability that the slow search is needed to make a decision about the probe.

In the reported experiments, Atkinson and Juola found empirical support for their model. Of particular interest is an unpublished study by Darley and Arabie (reported by

Atkinson and Juola) who investigated the effects of increased familiarity of target and distractors upon recognition time in a short term word recognition memory task. They found that RT to a target item that had been the target item on the previous trial was reduced, but RT to a distractor item that had been a distractor on the previous trial was increased. The inhibition of negative decisions with a high level of activation could not be due to the facilitation of encoding the item; activation must have affected decision-making stages in the word recognition process.

In the two models, activation was hypothesized to influence strength of a word or a relationship between two words, and RT to make a decision about these activated words depended on that strength. Does short term activation affect the encoding and pre-decision processing stages, such as memory access, and retrieval of the appropriate information necessary to make a decision, or does it also influence decision stages whose duration depends on the strength of the relationship between the items? In an effort to test this question, I propose to investigate the effect of short term activation upon the processing stages in a categorization task, which has been hypothesized to have extensive pre-decision operations, and decision operations that are affected by the associative strength of the C and I. Previous research has indicated that high associative strength between I and C decreased RT to make a positive decision but increased RT to make a negative decision in a categorization task. The locus of the effect of the interaction of associative strength and response type must be in the decision stage of the task, the stage that determines if more information is needed to make a decision. If short term activation contributes to the evaluated strength of the relationship between the items, then manipulation of short term activation should influence RT in a manner similar to manipulation of strength: time to categorize previously activated positives should be decreased and activated negatives should be increased. If activation affects only the time to encode the stimuli, access the proper memory locations, or any other pre-decision process, then the effects of activation should result in an equivalent reduction in RT for both previously activated positive and negative decisions.

In the present categorization task, the S will be presented with a pair of words and s/he must decide if the second word of the pair is a member of the category specified by the first word. These pairs will differ in response type (positive and negative) and degree of association (high and low). Experimental manipulation of short term activation of a C-I pair will be achieved by manipulating lag: the single presentation pairs will be defined as the low activation condition, and lag 0 and lag 1 repetitions of a pair will be defined as the high activation conditions. Lag 1 will be included as a verification of the lag 0 condition in which the S may respond simply on the basis of perceptual pattern matching. In order to eliminate this possibility but retain a high level of activation of the pair, the lag 1 condition will be included in the experiment.

If activation is a component of the evaluated strength between C and I, the effects of lag may be larger for low association C-I pairs than for high association pairs. Low associates will receive a greater increase in strength upon presentation than the already highly related C-I pair, therefore producing larger RT differences with lag for low associates. RT should not vary with lag over high and low association pairs if activation effects only the pre-decision processing operation.

In summary, if activation facilitates the pre-decision processes in a categorization task, then repetition of a pair at lag 0 or lag 1 should reduce RT for both positive and negative pairs and the reduction should be equivalent for high association and low association pairs. If the short term residual activation affects the strength between the C-I pairs, and thus the decision process, then RT to positives should be reduced and RT to negatives should be increased, and the effects of repetition should be more pronounced for low associates than for high associates.

METHOD

Subjects. Twenty four students from the University of Massachusetts at Amherst served as Ss and they received experimental course credit for their participation.

Materials. Two hundred forty C-I pairs were constructed as stimuli, 60 per association (high or low) x response type (true or false) condition. Positive pairs were constructed from the Battig and Montague (1969) Category Norms by pairing a category label with one of the tabled instances. Association of the instance to the category label in these norms were determined by the frequency of production of the instance to the given category. The mean production frequency for the high association positive pairs was 191.4 and the mean for the low association positive pairs was 21.8.

The negatives were constructed by pairing the category labels used in the positive pairs with nouns that were not examplars of the category. High association negative pairs used nouns as potential instances that were either highly associated to the category in other than a subset/

superset relation (e.g. FISH CREEK) or the potential instance was associated to an examplar of the category (e.g. COLOR BLOOD). Degree of association was determined by the intuitions of the experimenter. Low association negative pairs were constructed by pairing the category labels with randomly chosen nouns which had no obvious relationship to the category label with which it was paired. All positive and negative instances were controlled for word length and equated for frequency in the English language (Kucera and Francis, 1964). The mean word frequency for the instances of each association x response type condition were: High Positive (HP) 8.9; High Negative (HN) 15.8; Low Positive (LP) 10.8; Low Negative (LN) 13.8.

A total of sixteen category labels were used, eight for the high association pairs (Metals, Animals, Cloth, Fruit, Birds, Fish, Insects, and Color) and eight for the low association pairs (Flowers, Trees, Vehicles, Weapons, Crime, Tools, Toys, and Sports).

Twenty pairs from each association x response type condition were assigned to each lag condition (single presentation, lag 0 and lag 1 presentations) equating for word frequency of the instance nouns across lag conditions. See Appendix A for the assignments. The 80 pairs assigned to the single presentation condition were presented once in the experimental session; the 80 pairs assigned to lag

0 condition were seen twice in immediate succession, and the 80 lag 1 pairs were seen twice, where a presentation of another C-I pair separated the initial and second presentations of these items. To provide filler pairs for the lag 1 condition, 80 additional pairs were constructed, which used ten category labels that differed from the category labels of the experimental pairs. The instance nouns for the filler pairs were equated for word frequency; half of the pairs were positive and half of them were negative.

Subjects saw all 320 pairs during the experimental session, and including the second presentations of the lag 0 and lag 1 pairs, Ss made a total of 480 categorization decisions in the session.

Design and Analysis. The data were analyzed using an analysis of variance with stimulus pairs, Ss and sets of materials as random effects variables as recommended by Clark (1973), and quasi-F ratios were computed (Myers, 1972). In addition, in order to insure the generality of effects across stimulus pairs, half of the Ss received the reverse assignment for pairs at lag 0 and lag 1. This manipulation produced two sets of materials for the crucial repetition conditions, which yielded an internal replication of the experiment. Sets of materials (2 levels) was a between subjects variable, and lag (3 levels), association (2 levels), response type (2 levels) and pairs/

lag x association x response type (20 levels) were within subjects variables.

Procedure and Apparatus. A Digital Equipment Corporation PDP 8/I computer controlled the sequencing and timing of the trials and recorded the Ss RTs and responses. Stimulus pairs were presented sequentially, with the category label preceding the instance, on a video screen located approximately 24 inches in front of the S. A trial consisted of a warning tone presented 500 milliseconds (msec) prior to the appearance of the category label on the screen. Two hundred msec after the appearance of the category label, the instance noun was presented directly below it. The pair remained on the screen until the S pulled one of the levers on the response console located in front of him or her. The right lever indicated a true response, and the left lever indicated a false response for all Ss. RT was measured from the onset of the instance until one lever was pulled. The Ss' response was followed by a 1200 msec delay, after which the warning tone sounded indicating the beginning of the next trial. There were 48 trials in a block, 10 blocks in the experiment with a practice block of 24 trials beginning the session. If the S made an error, a white light at the center of the response console was illuminated and he or she had to depress it to continue with the rest of the block. Pairs that were responded to incorrectly were replaced and sampled again at some later time in the experimental session.

RESULTS

Error Data. The overall experimental error rate was 5.7%; error rates for each association x response type condition were as follows: HP, 3.5%; HN, 10.4%; LP, 7.0%; LN, 1.9%. The number of errors for each of these conditions for each S were totalled over lag, pairs, and sets of materials and was submitted to a subjects x treatments analysis of variance. The analysis revealed that the main effects of association and response type were not significant, $F(1,23) = 15.32$, $p > .10$, and $F(1,23) = 2.99$, $p > .25$ respectively, but their interaction was significant, $F(1,23) = 73.0$, $p < .001$. Contrasts within each level of response and association were computed using the Bonferroni t statistic (Myers, 1972), and they showed that for high association pairs, negatives produced significantly more errors than positives, $t(23) = 4.46$, $EW < .01$, and for low associates, positives produced significantly more errors than negatives, $t(23) = 4.97$, $EW < .01$. For the positive pairs, low association pairs produced more errors than high association pairs, $t(23) = 4.67$, $EW < .01$, and for negatives, high associates produced more errors than low associates, $t(23) = 7.92$, $EW < .01$.

Reaction Time Data. The means for each association x lag x response type averaged over Ss, stimulus pairs, and sets of materials are presented in Figure 1. The results did not differ over sets of materials, $F'(1,22) = 3.46$, $p > .05$, so all further effects were analyzed disregarding this variable. (See Appendix B for the summary table of complete analysis).

Examining the graph in Figure 1, it was found that positive pairs were categorized faster than negative pairs, $F'(1,73) = 118.46$, $p < .001$, and that a repetition of both positive and negative pairs reduced time to respond relative to the single presentation pairs $F'(2,2) = 99.6$, $p < .01$. The difference in RT for positive and negative judgements varied significantly across the levels of lag, $F'(2,43) = 3.23$, $p < .05$, where the lag 0 repetition observations produced the smallest difference. These results provide preliminary support for the pre-decision hypothesis which predicted a reduction in RT to both positive and negative repeated pairs. The pre-decision hypothesis would be confirmed if an interaction of associative strength and response type is found in both the single presentation and repeated observations. The effects of association will be presented next.

The results of critical experimental importance were the interactions of association with response type and repe-

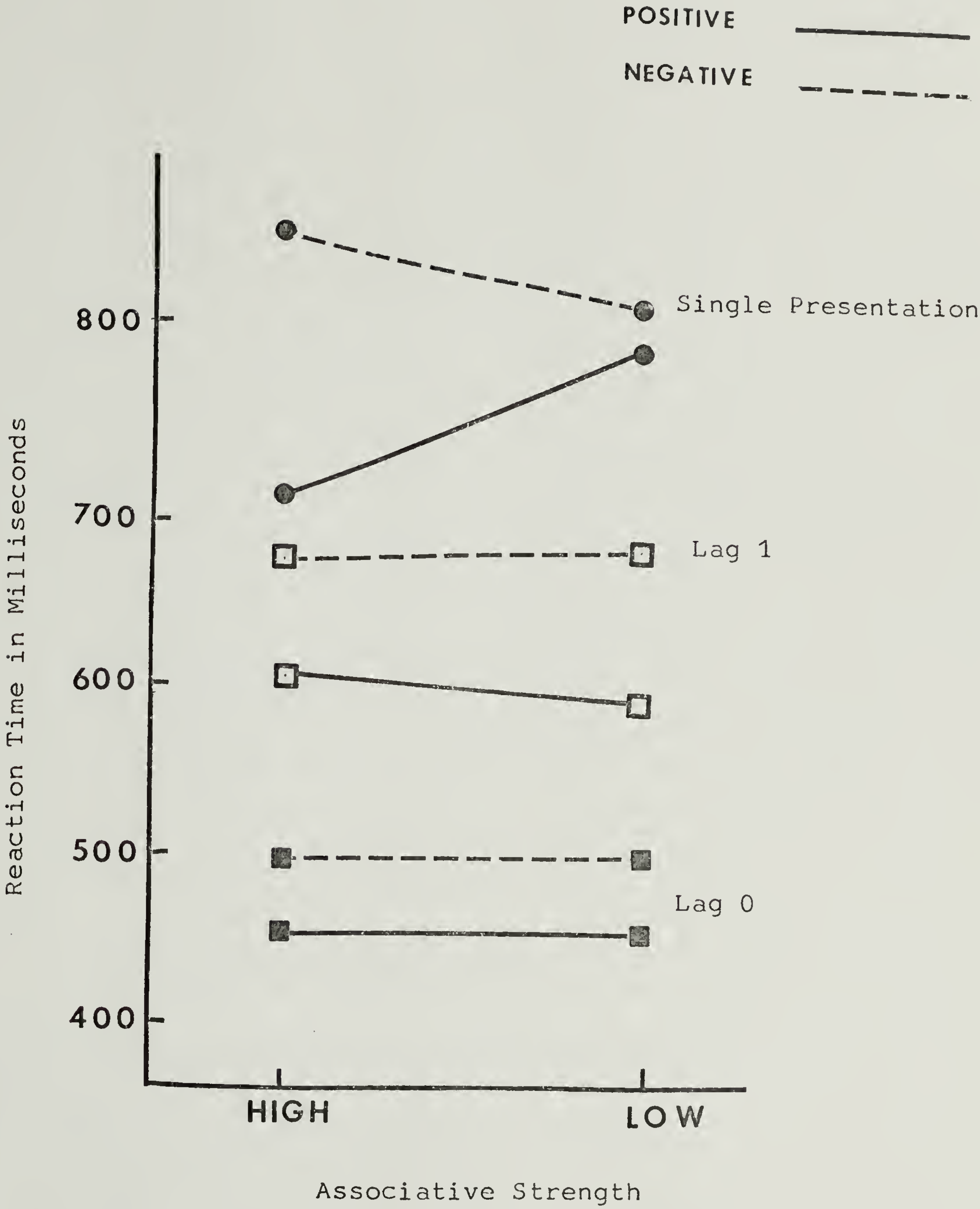

Figure 1. Mean Reaction Time Data

tition. The main effect of association was not significant, $F'(1,76) = .15$, $p > .25$, and the lack of the effect of association was observed over all levels of lag, $F'(2,12) = .27$, $p > .25$. Inspecting Figure 1, it can be seen that association did interact with response type as predicted for the single presentation data as indicated by the significant overall association x response type (AR) interaction, $F'(1,11) = 4.83$, $p > .05$ (.05 significance level = 4.84). High association had the inverse effect on positive and negative judgements: For positives, high association produced shorter latencies to respond than low, but for the negatives, high association produced longer latencies than low. However, this interaction was not found in the repeated presentations as indicated by the highly significant association x response type x lag interaction, $F'(2,61) = 9.14$, $p < .001$. In fact, association seemed to have little effect on both positive and negative decisions involving repeated stimuli. In order to assess the extent of the AR interaction in the single presentation and repeated observations, the data were analyzed separately for single and repeated observations by an analysis of variance similar to the one used in the overall analysis.

In the analysis of the single presentation data, the AR interaction was significant, $F'(1,36) = 8.4$, $p < .01$. Post hoc comparisons were calculated using the Bonferroni t were affected by activation, but the absence of any AR interaction in the lag data failed to provide support for either the pre-decision or decision stage hypothesis.

DISCUSSION

The locus of the effects of activation upon the processing stages of categorization for a repeated C-I pair was explored in this experiment. Activation of the concept nodes of the pair in semantic memory was produced by priming the stimulus pair with a recent presentation of itself. Two hypotheses which predicted that activation affected either the pre-decision or decision processing stages were compared. The decision stages hypothesis predicted that if activation contributed to the evaluated strength of the relationship between the concepts, then RT to categorized repeated negative pairs would increase and RT to positive pairs would decrease over pairs presented only once. If, on the other hand, activation affected the pre-decision operations of encoding, accessing the correct concept nodes, or retrieving semantic features, it was predicted that RT to categorize both positive and negative pairs would be reduced over single presentation pairs. In addition, both hypotheses predicted an interaction of associative strength with response type for the repeated judgements. For the decision stage hypothesis, this interaction would be manifested in a greater increase in RT to low association negatives than high association negatives. This prediction was based on the assumption that there is a maximum value of strength between items; for high associates, the value of strength is near the maximum and these pairs will gain less of an increase in strength with priming than low associates. The same argument applies for repeated positive pairs, where reduction in RT would be greater for low associates than high associates. Thus, if activation influenced the decision stage, the RT function relating associative strength and response type would be flatter for repetitions than single presentations, with repeated negative decisions showing an increase in RT and positives showing a decrease.

Alternatively, if activation influenced the pre-decision operations, the pattern of interaction of associative strength with response type would be of the same magnitude for initially presented and repeated items. This would be observed because the decision stage would remain unaffected and therefore would yield the identical AR interaction in the repeated observations. The RT function would show equivalent interaction effects of association with response type for single and repeated presentations, with the lag observations decreased by a constant amount for both positive and negative pairs over the single presentation pairs.

The results showed that RT to both positive and negative pairs was reduced for repeated C-I pairs and that there was no interaction of associative strength with response type for these repeated observations. The reduction in RT to both negative and positive pairs presented at lag 0 and lag 1 provided evidence for the rejection of the decision stage hypothesis. However, the alternative hypothesis that activation influenced the pre-decision operations also was not supported due to the absence of any AR interaction for the repeated pairs.

Since the evidence failed to support either hypothesis, this leads one to question the validity of the processing assumptions stated for the repeated judgements. The predictions of the two hypotheses were based on the assumption that Ss re-categorized the repeated pairs, so that the processing of single presentation items as described by the categorization models of Smith, Shoben, and Rips (1974) and Collins and Loftus (1974) was equivalent to processing of repeated items. An alternative processing strategy for repeated items is that upon the initial presentation of a C-I pair, an episodic memory trace is created which includes information about the correct response to that pair. When the pair is repeated a short time later, the S accesses the episodic memory trace and bases his or her response upon the memory of the correct answer for that pair. The pair need not be re-categorized, as assumed in this study, in order for the S to respond. This alternative process model (which will be called the Episodic Retrieval Process (ERP)) would predict that the associative strength between the category and its instance would not affect RT for repeated judgements. RT would be affected by the strength of the episodic trace, which is assumed to decrease as the number of intervening items increases between the initial and subsequent presentations of the pair. Both of these predictions were in accord with the results of this study, where RT for repeated positive and negative pairs did not vary with associative strength and where the lag 0 repetition was faster than the lag 1 repetition. The ERP is also supported by Ss' introspections.

If the ERP was used by Ss for the repeated items, then this study failed to test the effect of experimentally produced activation upon processing in a categorization task. The priming of a pair with itself not only produced activation between those concepts in semantic memory but also produced an episodic memory trace containing the correct response to that pair. This processing strategy for repeated items in a verification or recognition task seems intuitively reasonable and may be used in other information processing tasks. In order to assess the generality of the

ERP as an optimal processing strategy for repeated stimuli, the results of word recognition experiments will be examined.

Fischler and Juola (1971) and Atkinson and Juola (1974) investigated the effects of probe repetition upon positive and negative probes in a word recognition task. They found that repeated positive probes were recognized faster than initially presented probes but that repeated negative probes were rejected more slowly than initially presented ones. The ERP would predict that RT to both repeated positive and negative probes would be reduced; obviously the ERP was not used by Fischler and Juola's and Atkinson and Juola's Ss. However, upon examination of their procedures, these results may not conflict with the predictions of the ERP. In these experiments probe repetitions occurred across blocks of trials resulting in lags of 12 or greater. This procedure utilizing long lags would allow the episodic trace to decay to a low level which would reduce the effectiveness of the ERP as a processing strategy. Instead, repeated items would be processed similarly to the initially presented probes which was modelled by Atkinson and Juola (1974). To summarize their model briefly, the probe word is encoded and its representation in lexical memory is accessed, where the familiarity value of the item is determined. If this value exceeds a high criterion c_1, then a fast yes response is made; if it lies below a low criterion c_0, then a fast no is made. If it falls between c_1 and c_0, then an exhaustive search of the items in the list in E/K is made. When a probe is repeated, its familiarity

value is increased. Hence the familiarity value of repeated positive probes will exceed the c_1 criterion more often than initially presented probes, resulting in faster positive responses. Likewise, the familiarity value of repeated negative probes will exceed the c_0 criterion, indicating that a search is necessary to respond, which produces slower negative responses. This model explains Fischler and Juola's and Atkinson and Juola's data quite well, and hence restricts the generality of the ERP as a processing strategy to stimuli repeated at short lags.

However, this conclusion may be premature when the results of recent word recognition studies are considered. Juola (1972), Juola, Taylor, and Young (1974), and Homa and Fish (1975) employing similar word recognition paradigms using long and short lags (3-24) have not replicated the result of an increase in RT to repeated negative probes. The inability to replicate the original results sheds considerable doubt on the validity of Atkinson and Juola's model. In an effort to salvage the model, Juola, Taylor, and Young extended it to account for the reduced RT's to repeated negatives by proposing that repetition facilitated the encoding stage of the word recognition task. They point out that depending on the relative duration of the encoding and decision stages, reduced RTs to negative probes could be produced. But as Homa and Fish noted, decrease in RT for negatives should be accompanied by a corresponding increase in error rate. This increase would result from the upper end of the familiarity distribution for repeated negative probes exceeding the C_1 threshold, therefore producing a higher probability that familiar negative probes will be incorrectly verified. Homa and Fish found a decrease in RT to repeated negative probes without an increase in error rate. These results provide little support for the Atkinson and Juola model and are evidence against any general model of recognition or verification which predicts an increase in RT with stimulus repetition. In addition, these results support the ERP as a general processing strategy in tasks employing repeated presentations of stimuli.

Repeated items in the present experiment were not processed according to a categorization process so the models of Smith, Shoben and Rips (1974) and Collins and Loftus (1974) cannot be evaluated in terms of their ability to incorporate the effects of short term activation. The results from the single presentation observations are consistent with these models and past research and do not offer any additional information about the effects of association upon positive and negative decisions. Even though the categorization models cannot be evaluated in this experiment, the lack of support for the Atkinson and Juola model, which is incorporated into the decision stage of Smith et al's model, does lead one to question the validity of Smith et al's model. However, Atkinson and Juola's model is of recognition in episodic memory (which they label the Event/Knowledge store) whereas Smith et al's is of categorization in semantic memory. These conceptually different memories may have operations that are specific to only one of them, so that the unacceptability of the recognition model does not imply the unacceptability of the categorization model.

A way to test these semantic memory models concerning the proposed question of the locus of the effects of activation in a categorization task might be to use extremely long lags between pair repetitions, which would allow the decay of the episodic trace to that pair. With the episodic trace essentially dysfunctional, processing for the repeated pairs would be similar to processing of initially presented pairs. However, along with reducing the strength of the episodic trace, the longer lags would reduce the amount of experimentally produced activation between the category and the instance, so that the failure to find any effect of pair repetition could be attributed to the inability of creating a potent experimental manipulation. A recent study by Forbach, Stanner, and Hochhaus (1974), which evaluated the effects of repeating words and CCVCC's in a lexical decision task, demonstrated that recognition of repeated words was facilitated up to ten minutes. Activation from a prior presentation of a stimulus may be powerful enough to influence the categorization time for repeated items with long lags. However, the results of the word recognition tasks reviewed previously indicated that even at long lags the episodic trace may be potent enough to influence processing of repeated items. Since the ERP may be used in this procedure, this procedure may not be appropriate to test the models.

A more desirable alternative procedure to test these models which has the advantage of producing a great amount of activation in semantic memory without the disadvantage of the utilization of other processing strategies in responding, is to prime the stimulus pairs on the immediately preceding trial with a pair that is highly associated to it. Recent research cited in the introduction of this study has shown that priming with an associate increased the activation in that area of semantic memory. With associated priming, the activated pair would be unique to the experimental session so the response must be based on the

the categorization of that pair and not on the retrieval of the correct response from episodic memory.

In conclusion, the question of the locus of the effect of activation upon the processing stages of a categorization task was not successfully answered in the present experiment. The procedure of priming at a short lag with the identical stimulus pair produced a situation that optimized the utilization of a different processing strategy for repeated stimuli. Other experimental procedures for avoiding this strategy shift were proposed that may provide a fruitful approach to the answering of this question.

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LIST OF APPENDICES

APPENDIX A

CATEGORY-INSTANCE STIMULUS PAIRS

I. High Association Positives		Word Frequency of Instance	Battig Montague Production Frequency of Instance
COLOR	BLUE	14	438
CLOTH	SILK	12	292
METAL	STEEL	45	281
CLOTH	DACRON	–	153
INSECT	WASP	2	108
FRUIT	APRICOT	1	102
FISH	SALMON	3	142
ANIMAL	MOUSE	10	118
BIRD	CROW	2	149
COLOR	VIOLET	7	153
CLOTH	WOOL	10	347
FISH	TROUT	4	216
CLOTH	COTTON	38	404
COLOR	PINK	4	224
CLOTH	LINEN	6	142
INSECT	FLEA	2	50
FISH	HERRING	2	161
ANIMAL	RAT	6	112
BIRD	ROBIN	2	377
ANIMAL	GOAT	6	76
INSECT	MOTH	1	62
FRUIT	LEMON	18	134

		Word Frequency of Instance	Battig Montague Production Frequency of Instance
METAL	IRON	43	353
FRUIT	CHERRY	6	183
FISH	PERCH	1	143
BIRD	PIGEON	3	56
COLOR	PURPLE	1	282
CLOTH	NYLON	1	210
INSECT	SPIDER	2	177
METAL	ZINC	10	130
FRUIT	GRAPE	3	247
COLOR	GRAY	8	94
CLOTH	SATIN	5	78
METAL	BRONZE	11	78
METAL	SILVER	29	253
INSECT	ROACH	2	123
COLOR	ORANGE	2	387
ANIMAL	ZEBRA	17	70
COLOR	GREEN	11	431
CLOTH	RAYON	-	225
FISH	CARP	-	61
ANIMAL	LION	17	225
BIRD	WREN	-	83
ANIMAL	DEER	13	95
BIRD	HAWK	14	111
COLOR	YELLOW	15	387

		Word Frequency of Instance	Battig Montague Producing Frequency of Instance
INSECT	BEETLE	1	161
METAL	COPPER	13	309
FRUIT	PEAR	6	326
FISH	BASS	16	195
ANIMAL	TIGER	7	203
BIRD	CANARY	-	134
METAL	BRASS	19	97
FISH	COD	6	69
ANIMAL	SHEEP	23	85
BIRD	PARROT	1	72
INSECT	ANT	6	258
METAL	TIN	12	173
FRUIT	PEACH	3	249
FRUIT	APPLE	9	429

II. Low Association Positives

SPORT	HIKING	2	6
CRIME	BRIBERY	-	6
VEHICLE	TRACTOR	24	35
FLOWER	ASTER	1	12
TOY	PUZZLE	10	40
VEHICLE	FERRY	11	1
TOY	BALLOON	10	18

		Word Frequency of Instance	Battig Montague Production Frequency of Instance
VEHICLE	VAN	32	10
CRIME	BIGAMY	-	13
FLOWER	AZALEA	2	33
WEAPON	MISSLE	4	28
TOY	PUPPET	6	5
TOOL	LATHE	1	21
TREE	CYPRESS	7	10
SPORT	SAILING	2	15
CRIME	FELONY	1	25
TREE	HEMLOCK	1	8
SPORT	POLO	4	24
TOY	PLANE	-	50
WEAPON	LANCE	3	10
TOY	YO-YO	-	18
FLOWER	PEONY	3	38
WEAPON	SHOTGUN	8	15
CRIME	FRAUD	8	21
FLOWER	LILAC	1	18
CRIME	FORGERY	1	22
FLOWER	ZINNIA	-	21
WEAPON	DAGGER	-	12
TOOL	CROWBAR	-	18
TREE	WILLOW	9	41

		Word Frequency of Instance	Battig Montague Production Frequency of Instance
SPORT	ARCHERY	1	49
SPORT	FISHING	32	30
WEAPON	HATCHET	4	11
VEHICLE	CYCLE	24	11
TOY	JACKS	–	40
FLOWER	CROCUS	–	8
VEHICLE	TAXI	116	32
CRIME	SLANDER	1	6
FLOWER	POPPY	2	22
SPORT	RACING	2	15
TOOL	VISE	1	14
TREE	ASH	–	45
WEAPON	GRENADE	3	8
TOOL	RASP	2	5
TREE	CEDAR	1	37
TOOL	FILE	81	26
TREE	SEQUOIA	2	13
SPORT	SKATING	2	4
TOY	CRAYONS	1	12
VEHICLE	JET	29	24
TOOL	AWL	–	18
TREE	BEECH	6	29

		Word Frequency of Instance	Battig Montague Production Frequency of Instance
SPORT	SKIING	-	45
WEAPON	SPEAR	-	51
VEHICLE	AUTO	22	34
TREE	POPLAR	22	45
WEAPON	BAYONET	6	27
TOOL	AXE	6	14
VEHICLE	JEEP	16	25
CRIME	PERJURY	3	18

III. High Association Negatives

INSECT	WEB	6
ANIMAL	HOOF	2
FRUIT	DESSERT	7
COLOR	RAINBOW	4
INSECT	BUZZ	13
CLOTH	TIE	23
INSECT	STING	5
ANIMAL	BARN	29
COLOR	BLOOD	121
BIRD	WORM	4
METAL	RUST	10
FRUIT	PIT	14

		Word Frequency of Instance
FISH	FILETS	1
BIRD	HATCH	5
METAL	PENNY	25
CLOTH	STITCH	3
BIRD	EGG	12
METAL	CABLE	–
FISH	CREEK	14
CLOTH	THREAD	1
FISH	DOCK	8
COLOR	BLOOD	121
BIRD	NEST	20
CLOTH	SEW	6
FISH	TAIL	24
FRUIT	RIPE	14
FISH	SWIM	15
CLOTH	LOOM	6
CLOTH	WEAVE	4
INSECT	HIVE	2
COLOR	HUE	1
BIRD	FEATHER	6
METAL	PAN	16
INSECT	BIRD	31
ANIMAL	SADDLE	25

		Word Frequency of Instance
FRUIT	HARVEST	11
INSECT	ANTENNA	13
BIRD	CHIRP	-
ANIMAL	MINERAL	12
FRUIT	CANDY	16
METAL	SHINE	5
CLOTH	RUG	13
ANIMAL	HAIR	13
FRUIT	PEEL	3
METAL	PIPE	20
BIRD	BEAK	-
METAL	ORE	3
ANIMAL	STEAK	10
FRUIT	STEM	29
FISH	NETS	3
COLOR	SKY	58
INSECT	SWARM	3
ANIMAL	HAY	19
FISH	FINS	5
COLOR	GRASS	53
FRUIT	ORCHARD	3
FISH	GILLS	2
INSECT	HONEY	25
COLOR	PIGMENT	9

		Word Frequency of Instance
BIRD	WING	18

IV. Low Association Negatives

FLOWER	KNOCK	15
TOOL	PURSE	14
SPORT	COMPASS	13
TREE	BLANK	14
VEHICLE	REMEDY	13
TOY	DILL	12
WEAPON	LAGOON	15
CRIME	CONE	13
CRIME	PATCH	13
FLOWER	DAD	15
TOOL	YARN	14
WEAPON	SUNSET	14
CRIME	WAX	14
FLOWER	RAZOR	15
TOY	SLICE	13
WEAPON	MIST	14
CRIME	ARCH	13
FLOWER	CLIENT	15
TOY	ALIEN	16
SPORT	TOWER	13
TREE	LYRICS	15

		Word Frequency of Instance
VEHICLE	EMBRACE	13
TOY	POSTURE	13
WEAPON	ELDER	15
CRIME	GLOBE	13
FLOWER	BOW	15
TOOL	PROSE	14
SPORT	MATCHES	13
SPORT	DENTIST	12
TREE	RESCUE	15
VEHICLE	PEPPER	13
TOOL	NEON	14
SPORT	CURTAIN	13
CRIME	BUBBLE	12
FLOWER	TROOP	16
TOOL	CLOVER	16
SPORT	BLADE	13
TREE	COP	15
VEHICLE	INCEST	13
TOY	DEBT	13
WEAPON	LAWN	15
CRIME	COUCH	12
FLOWER	TENNIS	15
TOOL	GOWN	16
SPORT	GRIN	13

		Word Frequency of Instance
TREE	ODOR	14
VEHICLE	ACID	13
TOY	PENSION	13
TOY	CURB	13
WEAPON	STRAW	15
TREE	CHILL	14
VEHICLE	CAKE	13
TOY	FUSION	13
SPORT	CLERGY	12
TREE	CLUE	15
VEHICLE	GENTILE	13
TOY	MEDIA	13
WEAPON	REWARD	15
CRIME	TOILET	13
FLOWER	TRICK	15

V. Lag 1 Positive Filler Pairs

JEWEL	TOPAZ	-
JEWEL	RUBY	-
JEWEL	PEARL	9
JEWEL	OPAL	-
JEWEL	JADE	1
DRINK	MILK	49
DRINK	PUNCH	5

		Word Frequency of Instance
DRINK	COFFEE	78
DRINK	TEA	28
DRINK	SODA	3
FUEL	OIL	93
FUEL	METHANE	-
FUEL	GAS	32
FUEL	WOOD	25
FUEL	PROPANE	-
DANCE	WALTZ	1
DANCE	POLKA	1
DANCE	TANGO	2
DANCE	TWIST	18
DANCE	FOXTROT	-
MUSIC	JAZZ	99
MUSIC	POP	34
MUSIC	OPERA	47
MUSIC	BLUES	22
MUSIC	BAROQUE	11
SCIENCE	PHYSICS	22
SCIENCE	BIOLOGY	7
SCIENCE	GEOLOGY	5
SCIENCE	BOTANY	3
SCIENCE	ANATOMY	9

		Word Frequency of Instance
DISEASE	MEASLES	2
DISEASE	MUMPS	-
DISEASE	FLU	8
DISEASE	MALARIA	3
SNAKE	RATTLER	1
SNAKE	COBRA	3
SNAKE	GARTER	2
SNAKE	PYTHON	14
SNAKE	BOA	-

VI. Lag 1 Negative Filler Pairs

JEWEL	ABSURD	17
JEWEL	BALLS	17
JEWEL	FLEET	17
JEWEL	HORROR	17
JEWEL	STREAM	17
DRINK	BASKET	17
DRINK	COLLAR	17
DRINK	GRAPH	17
DRINK	VOYAGE	17
DRINK	BUNK	18
FUEL	BREED	17
FUEL	COPS	17
FUEL	LOGIC	17

		Word Frequency of Instance
FUEL	PORTER	17
FUEL	SUICIDE	17
DANCE	BUNCH	17
DANCE	CEREAL	17
DANCE	QUOTE	17
DANCE	TUMOR	17
MUSIC	CHEERS	17
MUSIC	DEPUTY	17
MUSIC	GRASP	17
MUSIC	NURSE	17
MUSIC	BAR	18
SCIENCE	CHIP	17
SCIENCE	MORALE	17
SCIENCE	SHOPS	17
SCIENCE	BISHOP	18
SCIENCE	CANDLE	18
DISEASE	CODES	17
DISEASE	DOME	17
DISEASE	PASTOR	17
DISEASE	WAGONS	17
DISEASE	CHORUS	18
SNAKE	CONSENT	17
SNAKE	KISS	17

		Word Frequency of Instance
SNAKE	STATUE	17
SNAKE	COSMIC	18
SNAKE	DRIFT	18

APPENDIX B

Analysis of Variance Design

Source	df	EMS
total	mnalrp-1 = 5759	
Between	mn-1 = 23	
M	1	$narlp\,\sigma^2_{m} + arlp\,\sigma^2_{s/m} + n\,\sigma^2_{mp/ARL} + \sigma^2_{sp/ARLM} + \sigma^2_{e}$
S/M	22	$arlp\,\sigma^2_{s/m} + \sigma^2_{sp/ARLM} + \sigma^2_{e}$
Within	mn(alrp-1) = 5736	
A	1	$mrlnp\,\theta^2_{A} + rlp\,\sigma^2_{AS/M} + mn\,\sigma^2_{P/ARL} + \sigma^2_{SP/ARLM} + n\,\sigma^2_{MP/ARL} + \sigma^2_{AM} + e$
R	1	$malnp\,\theta^2_{R} + alp\,\sigma^2_{RS/M} + mn\,\sigma^2_{P/ARL} + \sigma^2_{SP/ARLM} + n\,\sigma^2_{MP/ARL} + \sigma^2_{RM} + \sigma^2_{e}$
L	2	$marnp\,\theta^2_{L} + arp\,\sigma^2_{LS/M} + mn\,\sigma^2_{P/ARL} + \sigma^2_{SP/ARLM} + n\,\sigma^2_{MP/ARL} + \sigma^2_{LM} + e$
AR	1	$mnlp\,\theta^2_{AR} + lp\,\sigma^2_{ARS/M} + mn\,\sigma^2_{P/ARL} + \sigma^2_{SP/ARLM} + n\,\sigma^2_{MP/ARL} + \sigma^2_{ARM} + \sigma^2_{e}$
AL	2	$mrnp\,\theta^2_{AL} + np\,\sigma^2_{ALS/M} + mn\,\sigma^2_{P/ARL} + \sigma^2_{SP/ARL} + n\,\sigma^2_{MP/ARL} + \sigma^2_{ALM} + \sigma^2_{e}$
RL	2	$anp\,\theta^2_{RL} + ap\,\sigma^2_{RLS/M} + mn\,\sigma^2_{P/ARL} + \sigma^2_{SP/ARLM} + n\,\sigma^2_{MP/ARL} + \sigma^2_{RLM} + e$
ARL	2	$mnp\,\theta^2_{ARL} + p\,\sigma^2_{ARLS/M} + mn\,\sigma^2_{P/ARL} + \sigma^2_{SP/ARLM} + n\,\sigma^2_{MP/ARL} + \sigma^2_{ARLM} + \sigma^2_{e}$

Source	df	EMS
P/ARL	228	$mn\sigma^2_{P/ARL} + n\sigma^2_{MP/ARL} + \sigma^2_{SP/ARLM} + \sigma^2_e$
AM	1	$nlrp\sigma^2_{AM} + n\sigma^2_{MP/ARL} + pln\sigma^2_{AS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$
RM	1	$nlap\sigma^2_{RM} + n\sigma^2_{MP/ARL} + pla\sigma^2_{RS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$
LM	2	$narp\sigma^2_{LM} + n\sigma^2_{MP/ARL} + par\sigma^2_{LS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$
ARM	1	$nlp\sigma^2_{ARM} + n\sigma^2_{MP/ARL} + pl\sigma^2_{ARS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$
ALM	2	$nrp\sigma^2_{ALM} + n\sigma^2_{MP/ARL} + pr\sigma^2_{ALS/M} + \sigma^2_{AP/ARLM} + \sigma^2_e$
RLM	2	$apn\sigma^2_{RLM} + n\sigma^2_{MP/ARL} + pa\sigma^2_{RLS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$
ARLM	2	$np\sigma^2_{ARLM} + n\sigma^2_{MP/ARL} + p\sigma^2_{ARLS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$
MP/ARL	228	$n\sigma^2_{MP/ARL} + \sigma^2_{AP/ARLM} + \sigma^2_e$
AS/M	11	$rlp\sigma^2_{AS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$
RS/M	11	$alp\sigma^2_{RS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$
LS/M	22	$arp\sigma^2_{LS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$
ARS/M	11	$lp\sigma^2_{ARS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$

Source	df	EMS
ALS/M	22	$rp\sigma^2_{ALS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$
RLS/M	22	$ap\sigma^2_{RLS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$
ARLS/M	44	$p\sigma^2_{ARLS/M} + \sigma^2_{SP/ARLM} + \sigma^2_e$
SP/ARLM	5016	$\sigma^2_{SP/ARLM} + \sigma^2_e$

APPENDIX C

Error Terms for Quasi F Ratios

Source	df	ms	F	for Quasi F's: denom. df	for Quasi F's: Components of error term
M	1	10,945,693	3.45	22	S/M + MP/ARL - SP/ARLM
S/M	22	3,110,334	75.75		SP/ARLM
A	1	8,815	.15	76.6	AM + P/ARL - MP/ARL
R	1	6,983,527	118.45	73.5	RM + P/ARL - MP/ARL
L	2	28,748,629	99.7	2	LM + P/ARL - MP/ARL
AR	1	382,332	4.83	11.5	ARM + P/ARL - MP/ARL
AL	2	25,678	.28	12.7	ALM + R/ARL - MP/ARL
RL	2	219,800	3.23	43.7	RLM + P/ARL - MP/ARL
ARL	2	581,346	9.1	61.5	ARLM + P/ARL - MP/ARL
P/ARL	228	92,073	2.61		MP/ARL
AM	1	660	.019		AS/M + MP/ARL - SP/ARLM
RM	1	2,158	.062		RS/M + MP/ARL - SP/ARLM
LM	2	432,347	3.45	22.8	LS/M + MP/ARL - SP/ARLM
ARM	1	22,388	.62		ARS/M + MP/ARL - SP/ARLM
ALM	2	35,292	1.3		ALS/M + MP/ARL - SP/ARLM
RLM	2	11,250	.29		RLS/M + MP/ARL - SP/ARLM
ARLM	2	6,808	.16		ARLS/M + MP/ARL - SP/ARLM

				for Quasi F's	
Source	df	ms	F	denom. df	Components of error term
MP/ARL	228	35,277	.86		SP/ARLM
AS/M	11	40,461			SP/ARLM
RS/M	11	48,114			SP/ARLM
LS/M	22	262,891			SP/ARLM
ARS/M	11	41,997			SP/ARLM
ALS/M	22	33,215			SP/ARLM
RLS/M	22	43,318			SP/ARLM
ARLS/M	44	46,086			SP/ARLM
SP/ARLM	5016	41,060			SP/ARLM