1975

Experimental separation of facilitation and priming.

Eric Niron Brewer
University of Massachusetts Amherst

EXPERIMENTAL SEPARATION

OF

FACILITATION AND PRIMING

A Thesis Presented

By

Eric Niron Brewer

Submitted to the Graduate School of the

University of Massachusetts in partial

fulfillment of the requirements for the degree of

MASTER OF SCIENCE

March, 1975

Psychology

Experimental Separation of Facilitation and Priming

A Thesis

by

Eric Brewer

Approved as to style and content by:

Charles Clifton, Jr., Chairman of Committee

Nancy Myers, Member

William Eichelman, Member

Jerome Myers, Department Chairman

Psychology Department

March, 1975

ABSTRACT

A theory is advanced and tested which proposes that expectation effects are functionally separable from facilitation effects in processing; *ie*, a word will be facilitated if a similar or identical stimulus preceeds it, but an additional positive effect will be found if there is a high expectation for the word. The Stroop effect was used with a cue word which could be the same as the test word, a different word. or a control word. The probability of the cue being identical to the test word was manipulated to vary the subject's expectancy for a particular Stroop test word. Subjects responded with either the color name or the word name, dependent upon a tone just previous to the test word. Results indicate that an expectancy has its effect by speeding the processing of the expected stimulus (*ie*, the word name) through the limited capacity channel, with a subsequent facilitory effect upon the processing of competing but later stimuli (*ie*, the color name). There was little negative effect of an incorrect expectation upon color naming. The facilitation conditions with no expectation also had very little effect, contradicting Warren's results (1972) of a negative effect upon color naming. Hypotheses are advanced to explain these and other results.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Posner and his associates have proposed a model of human information processing (Posner and Klein, 1973; Posner and Snyder, 1974; Keele, 1973; Posner and Boies, 1971) which identifies two very broad areas of processing, the sensory-memory area and a limited capacity area. Through the sensory-memory area, all sensory inputs enter the processing channels. Long term memory, including graphemic, semantic, and phonemic information, is also identified with this area. The limited capacity channel is where in-depth processing of material supplied by the sensory-memory area takes place.

The primary mechanism in the sensory-memory area will be presumed to be spreading activation (Meyer, Schvaneveldt, and Ruddy, 1972, 1973; Collins and Quillian, 1970, 1972; Schvaneveldt and Meyer, 1973; Pavlov, 1927). This might then be characterized as being relatively strategy free, at least in the conscious sense. Its reliance will rather be on simple "automatic" mechanisms such as activation and facilitation.

For the purposes of this paper, facilitation will be abstractly defined as: a trace or node in the sensory-memory area needing less activation to go over the threshold for <u>full</u> activation due to residual activity from previous similar stimulation (Meyer, Schvaneveldt, and Ruddy, 1973; Keele, 1973). If the same or a "nearby" node (one with little semantic distance, such as water to wet) has been previously activated, the concept will be facilitated in reaching full activation for a short period of time. This means that its semantic and phonemic properties will be available for future processing sooner than if it had not been previously activated. I will use the term facilitation only in connection with the sensory-memory area.

Following the Posner-type theory (Keele, 1973; Posner and Klein, 1973), activity in the sensory-memory area will be presumed to be pre- or at least un- conscious. Instead, conscious thought occurs in the limited capacity channel. Here, strategies might operate a good portion of the time, while problem-solving, sentence comprehension, response preparation, etc. are occurring. Since this is where conscious processing is presumed to occur, it might also be predicted that expectancies will show their effects somewhere in this area. If the word "cookie" is consciously expected to occur, then the limited capacity area can begin preparing so that the word will be processed as efficiently as possible and the response will be ready and waiting.

Expectancy effects and all advance activities which occur or are initiated in the limited capacity area when the subject can reasonably predict what will occur next (on an experimental trial, in a paragraph, or otherwise) will be labeled here as priming effects.

By these definitions, priming effects should be highly separable from facilitation effects. Facilitation occurs automatically (Keele, 1973; Posner and Klein, 1973); there is nothing the subject can do about it, and it occurs with or without conscious expectancy. If the word "cat" is presented on one trial of a "respond-yes-if-the-word-is-an-animal" task, then the word "cat" or even "dog" will be encoded and accessed faster if it occurs on the next trial, since the activation level of both "cat" and "dog" are already high. This occurs whether or not the subject expected "cat" or "dog" to occur next.

If the subject had expected "dog" next, then priming effects would also come into play. The subject might prepare the limited capacity channel for the word "dog" by: a) preparing to filter out all non-"dog" stimuli. This ensures that the full processing capacity of the limited capacity channel is directed at the correct stimulus. b) setting up the sequence of operations (the strategy) which will be applied to the word. When the word comes in, the route it should take for most efficient processing has already been decided and the "gates" to channel it that way are already set. c) preparing the proper response, etc.

Given this model, priming and facilitation are not entirely independent. Priming effects cannot occur without facilitation also occurring, since an expectancy for an item will automatically have raised the activation level for that item in the sensory-memory area. Facilitation, however, could occur without causing a priming effect.

This model suggests the following general questions to be investigated: a) Can the rough model be validated or disproven in any way? b) Can priming be functionally or temporally separated from facilitation? c) What is the effect of priming upon information? Does it inhibit unexpected information? Does it speed expected information? d) What is the actual mechanism of priming? Is it a filter or possibly an "operation sequencer" as hinted at above, or exactly what?

Approach. Warren (1972) used the classic Stroop effect (Stroop, 1935) to study stimulus encoding and memory by varying the categorical relation of a priming word to a test word presented soon after. The task was to name the color of ink in which the test word was presented.

In the Stroop effect, a color word such as "blue" is printed in a different color ink, eg. red. The subject's task is to name the color of the ink. Substantial interference has been found to occur in the color naming task (Stroop, 1935; Jensen and Rohwer, 1966). It has also been found that there is a lesser interference, although still easily measurable, by any word printed in color ink (Klein, 1964; Scheibe, Shaver, and Carrier, 1967). The usual explanations involve one form or another of response competition (cf. Dyer, 1973) or encoding differences (eg. Seymour, 1974).

Warren used the Stroop effect to study stimulus encoding and memory by applying the logogen model of Morton (1969). One aspect of Morton's model is that the threshold of availability for a logogen or dictionary unit is set by the past frequency of occurrence of the word. Presentation of a word causes activation of the motor or speech logogens for that word, resulting in an automatic response tendency to say the word. Since the actual task is to name the color of the ink, the logogens corresponding to that color are also activated. Production of the color name will be delayed by an amount dependent upon the extent to which the word name becomes available to the limited capacity channel before the color name.

This involves the assumption that the Stroop effect occurs before a final output stage of processing. Support for this view has recently been provided by Seymour (1974), who has presented evidence that the Stroop effect is caused by the word capturing some of the available processing capacity, thereby delaying the encoding of the display, rather than by covert response competition or response selection problems. (For a more complete discussion of these three hypotheses, see Dalrymple-Alford and Azkoul, 1972).

Klein (1964) has found that interference to color naming increases as the frequency of the word increases, lending support to Morton's (1969) threshold model, since a high frequency word will have a lower threshold and be more likely to reach the limited capacity channel before the color name. Warren then showed that "priming" (facilitation, in my terms) using an associate caused the threshold for the word to be reached sooner, thereby increasing the Stroop interference.

Several interesting hypotheses can be formed relating to priming. If the subject has a high expectancy for a word, there might be an attempt to inhibit or "counter-prime" the word, since the task is to name the color, not the word. At first glance, this would seem to imply that priming would reduce the Stroop effect. However, counter-priming may also occupy limited capacity capabilities, so that inhibiting a word might actually slow the color name's entrance into the channel.

To further complicate the issue is a finding by Klein (1964) that if the response area of the limited capacity channel is allowed to output the word very quickly, then color naming is not interfered with to as great an extent. What Klein did was to have the subjects name the word first, then the color. He found very little increase in color naming; much smaller than it should have been unless the Stroop interference was being reduced. This finding was later validated by Dyer (1971), who varied the pre-exposure of the word prior to coloration, thereby varying the amount of advance word processing relative to color processing. This implies that, even though the word may have taken over the limited capacity channel before the color, if the word can be rushed through and <u>not</u> inhibited then interference can be reduced by clearing the channel faster. Priming might be just the activity to speed the word through the channel.

Priming, then, could: a) cause a specific inhibition of the word, decreasing the Stroop interference. b) cause a specific inhibition of the word, thereby "clogging" the limited capacity channel so that the color name's entrance into the channel is slowed even more than with no expectancy for the word. c) cause the word to be output more quickly, freeing the channel to process the color name sooner, or d) produce no measurable effect at all.

Another question being asked implicitly is: what is the effect of processing of the word upon later processing of the color? If priming speeds processing of the word, then will the color name enter the limited capacity channel sooner? In other words, when dealing with processing in the limited capacity channel, is there a dependency upon the time course of preceeding information?

Some of the possible priming effects would not necessarily show up in varying reaction times to the color naming task, however, since much depends upon the exact point in the limited capacity channel at which priming and inhibition are initiated. For instance, suppose that priming occurs and the word is rushed through the channel, but that the priming occurs at some point after the bottleneck which is holding back the color name. Then the color may have entered the channel with its normal interfered with time course and be following through at its normal interfered with speed, even though the channel is relatively clear ahead of it. To take the reverse attack, assume that the word is suppressed, but not until just before a final output stage. Then the color name would be following along the interfered with time course right up to the response stage. So even though priming is having an effect upon the word, there could be little change in color naming reaction time.

Of course, there could be a dramatic change in color naming time if, for instance: a) The word is inhibited fairly early in the limited capacity channel, slowing its flow at that point and abnormally slowing the color name's entrance into the channel. b) The word is primed and rushed through early in the process, allowing the color to get in sooner, or c) The word is suppressed totally right at the start, allowing the color name to capture all of the limited capacity channel.

The present method of differentiating between some of these cases was to introduce a word probe into the task, besides the existing color probe. On a fraction of the trials, the subject was required to name the actual word presented rather than the color in which it was presented. This made it possible to see what happened to the word independently of its effect upon the color name. For instance, if the word was primed at some point after the bottleneck, word naming time would decrease and color naming time would stay the same relative to the facilitated but unprimed condition. If the word was inhibited from the very start, word naming time should increase greatly while color naming time should decrease, and so on.

Probably the most interesting hypothesis is that priming could cause the word to be processed faster, with a resultant improvement in color naming reaction time. This would imply that at least in this situation priming had a distinctly positive effect and that processing in the limited capacity channel _is_ dependent upon the time course of previous information. Given Klein's (1964) and Dyer's (1971) findings, this result would not be entirely unexpected.

METHOD

Subjects. Six people from the University of Massachusetts at Amherst served as subjects (Ss) in the experiment. They were paid $2.00 an hour for a total of ten hours of participation each. Ss were questioned to assure normal vision and hearing with no color blindness.

Materials. Six words and a control "word" (00000) were chosen so that each word began with the same letter, had the same number of letters and syllables, and occurred with approximately the same relative frequency based upon Kucera and Frances (1967) as one of the color names, although not necessarily the same word for each of the above measures. These precautions were to ensure approximately the same absolute naming times for words and color names.

The six colors chosen were: yellow, green, red, orange, blue, and purple; chosen for their discriminability and contrast with a light colored background. The corresponding six test words were: person, output, realm, book, gun, and yankee; chosen as indicated above with the additional constraint that no word should have a color as a strong associate.

Apparatus. Materials were displayed on a back-projection screen by two random-access projectors controlled by a PDP 8-I computer. The words subtended a visual angle of approximately 3.5 degrees. Reaction Times (RTs) were measured by the computer using a voice-actuated Schmitt trigger as the triggering device. After each trial, the S was asked to pull a right lever if s/he responded correctly and a left lever if incorrectly on a response console in front of the person.

Procedure. Subjects participated in one practice day and four data days in each of a priming and a facilitation phase of the experiment. On each day, there were twenty-seven blocks of sixteen trials each, requiring about one hour of participation. On each day of the experiment, the S was first shown sample slides demonstrating each color and its proper name. Sample warning tones were also demonstrated at this time.

Each trial began with a priming slide printed in white on black, presented for two seconds. The S named aloud the word displayed during this period. After a delay of one second, the test slide occurred with one of the possible words printed in one of the six colors. 250 msec. previous to the presentation of the test slide, a 100 msec. tone occurred. The tone was either 200 hertz, indicating that s/he should respond by naming the color that the word was printed in, or 600 hertz, indicating that the proper response was to name the actual word on the screen. After verbally responding, the S indicated whether the response was correct or incorrect by pulling a lever on the response console. With the completion of this response, the test display disappeared and the inter-trial interval began.

The inter-trial interval was of two seconds duration. At the end of sixteen trials the S was told the average reaction time the number of errors made on that block of trials, and a number indicating how well s/he was doing relative to a standard pay-off scheme Ss were instructed to respond as quickly as possible while making as few errors as possible.

Each trial was either a control trial, in which the priming word was "00000", a trial in which the priming word and the test word were the same or a trial in which they were different. During the facilitation phase of the experiment, 12 1/2% of the trials were control, 12 1/2% agreed between priming word and test word, and 75% disagreed. During the priming phase, these probabilities were reversed, again with 12 1/2% control, but 75% agreed and 12 1/2% disagreed. (See table 1).

Throughout the experiment, two-thirds of the trials had a low tone occurring, indicating a color name response was necessary and one-third had a high tone meaning "respond with the word." Priming and facilitation phases of the experiment were counter-balanced between Ss. Subjects in Group 1 underwent a practice day and four days of data collection in facilitation trials,

TABLE 1

Design per Subject

	P1							P2					
	A1		A2		A3			A1		A2		A3	
Day	T1	T2	T1	T2	T1	T2	Day	T1	T2	T1	T2	T1	T2
1	36	18	216	108	36	18	5	216	108	36	18	36	18
2	36	18	216	108	36	18	6	216	108	36	18	36	18
3	36	18	216	108	36	18	7	216	108	36	18	36	18
4	36	18	216	108	36	18	8	216	108	36	18	36	18

G = Counterbalance Group	G1 = P1 then P2, G2 = P2 then P1
N = Subjects	Three in each counterbalance group
P = Predictability	P1 = Facilitation P2 = Priming
B = Block	B1 = Days 1,2 B2 = Days 3,4
A = Agreement	A1 = Same prime and test word
	A2 = Different A3 = Control
T = Test Mode	T1 = Say Color T2 = Say Word

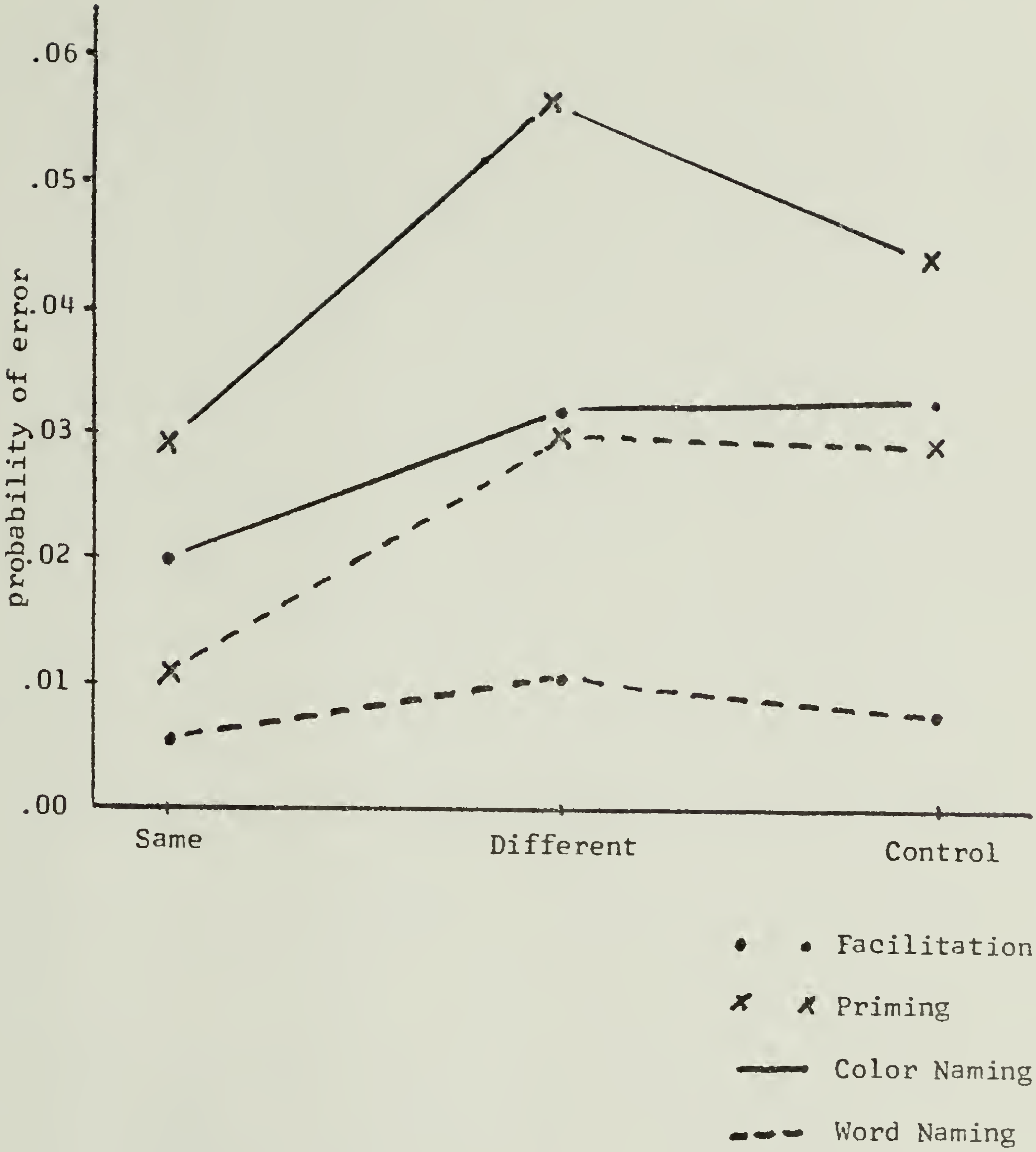
Numbers in each cell represent number of observations.

followed by a practice day and four days in priming trials. Group 2 Ss went through priming trials first, then facilitation.

RESULTS

Data were averaged for each condition to produce one mean reaction time per subject per condition per two-day block. Error trials were eliminated from all analyses. There were no patterns in the error data to indicate a divergence from the RT data, other than the difference between different and control for color naming in the primed condition (nonsignificant, T (10 d.f.) = 1.44, p>.10, two-tailed). See figure 1 for error data. Two five-factor analyses of variance were performed separately on the color naming and word naming means, using as factors: counter-balancing group; subject within group; predictability - facilitation or priming; blocks - days one and two or days three and four; and agreement - same, different, or control. Separate analysis of variance tests were also performed on the priming and facilitation phases of the experiment for both word naming and color naming RTs. In addition, difference scores were computed, showing the effect of the "same" condition relative to the control and the "different" condition relative to the control. These difference scores were subjected to the same analysis of variance tests as the mean RTs. The results of these analyses are summarized in Appendix 1.

The difference scores present the clearest reading of the



2.7% Total Error Rate

3.7% Color Naming Error Rate

1.7% Word Naming Error Rate

Error rates range from .5% to 5.6% for each data point

Figure 1. Error Data

data. Figure two shows, first, that Warren's results (Warren, 1972) were not replicated There is no difference between the "same" and "different" points in the facilitation data for word naming (F (1,4) > 1), but for color naming, "same" difference RTs are slightly (7 msec.) but significantly (F (1,4) = 7.64, p<.05) faster than "different" scores. Warren's results predict that color naming should be slowest in the "same" condition and fastest in the control, the opposite of the present results. This interesting contradiction will be addressed in greater depth later.

The priming data present an altogether different picture. When the S knows what word to expect and this expectation is fulfilled, word naming time drops by 50 msec. and color naming time drops by 28 msec. relative to their respective controls. If this expectation is not fulfilled, word naming time increases by approximately 28 msec.; color naming, however, is changed only slightly (+6.6 msec.) by an unfilled expectancy for a particular word. These major differences between "same" and "different" result in a significant Agreement effect for priming data in both color and word naming (F (1,4) = 40.64, p<.05 and F (1,4) = 221.38, p<.05, respectively).

Figure three indicates that the data are not quite as neat as they appear when summarized as difference scores. Looking at the mean RTs, the group by predictability interaction can be seen to be significant (F (1,4) = 16.68, p<.05 for color naming

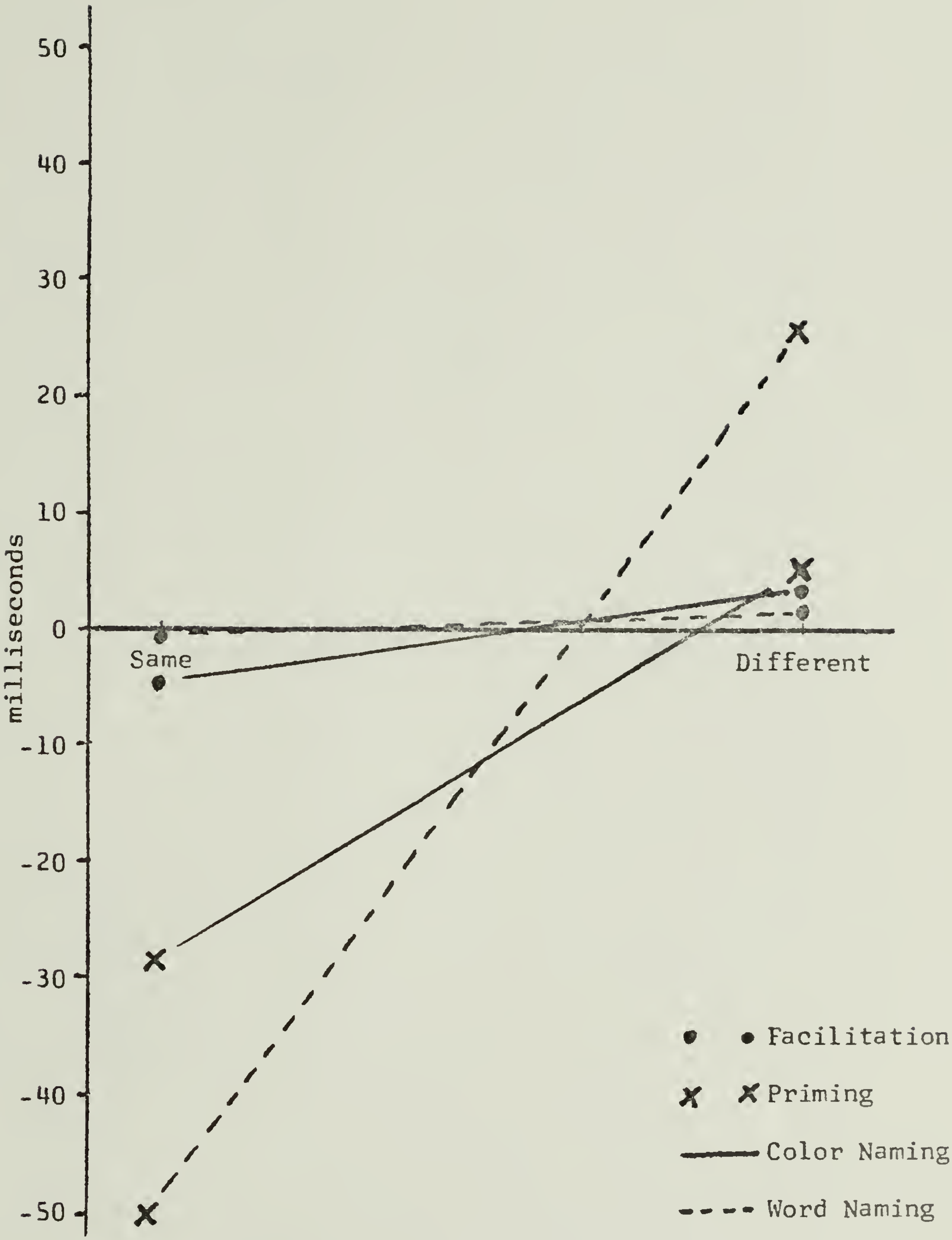


Figure 2. Difference scores relative to the control.

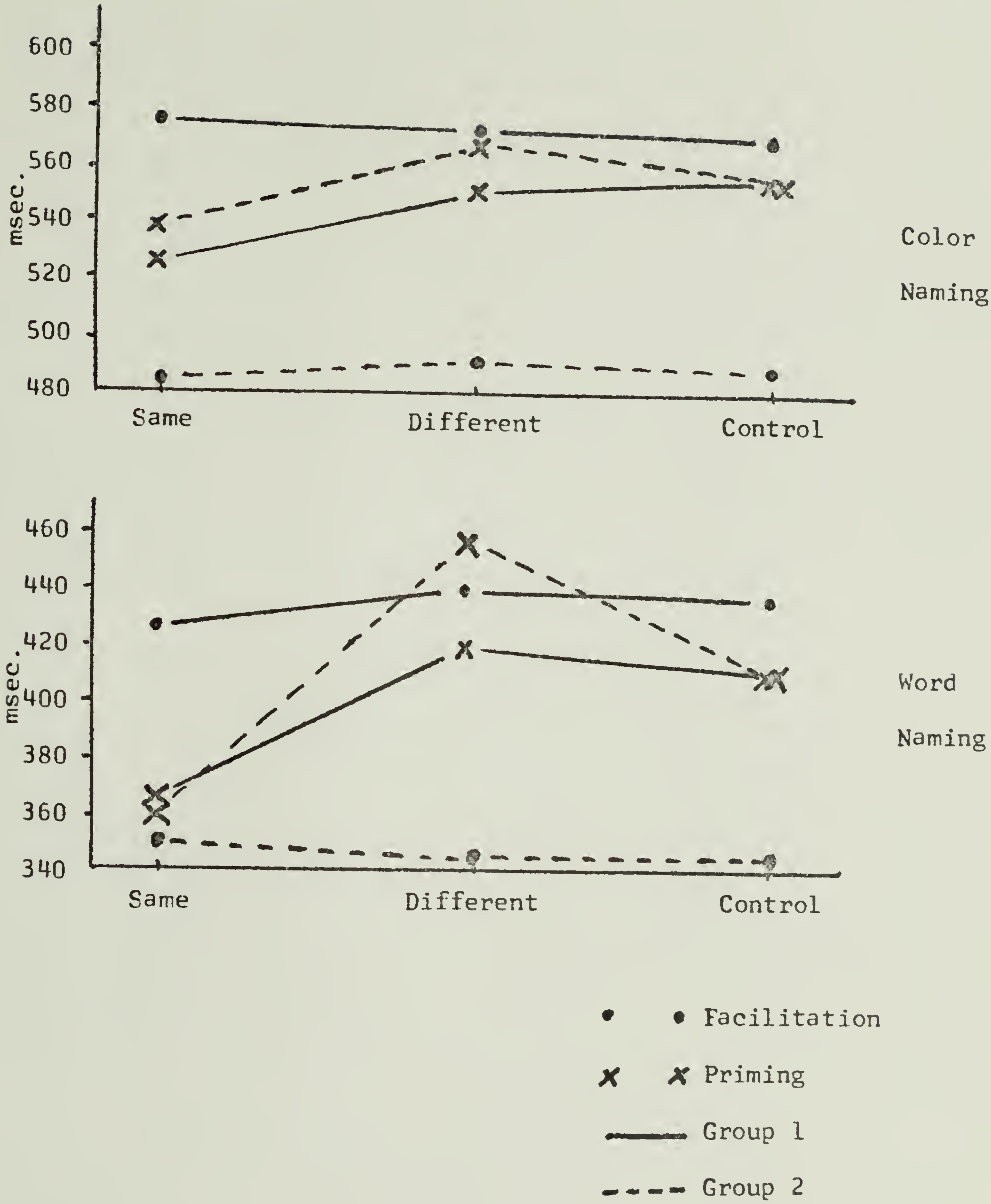


Figure 3. Mean reaction times showing effect of groups. Group 1 indicates facilitation first, then priming; Group 2 indicates priming first, then facilitation.

and $F(1,4) = 26.45$, $p<.05$ for word naming). This is due to a marginally significant difference between the counterbalance groups when only the facilitation data is considered. This pattern is true both for color naming data ($F(1,4) = 4.74$, $p<.10$) and for word naming data ($F(1,4) = 4.47$, $p<.10$). In counterbalance group two, where the priming phase of the experiment preceeded the facilitation phase, overall RT improved during the facilitation phase by 90 msec. for color naming and 70 msec. for word naming. This brought down all points in the Group 2 facilitation data equally, not interacting with other factors.

Table 2 presents the data in a complete breakdown. Two clearly deviant points are the counterbalance Group 2, Block 1 priming data. Both word and color naming RTs were abnormally slowed by an unfulfilled expectancy. These are the first and second days of the experiment for this group of Ss, so a surprise effect is the most likely cause. Ss developed a very strong expectation for a particular word which, when contradicted, surprised them for the first day or two of the experiment.

Notice the interactions of group and predictability with other factors in the overall analyses (Appendix 1). These appear to be mainly due to the interactions of group with block and agreement in the priming phase of the experiment. For instance, the two deviant points noted above contributed to the group by agreement and group by block by agreement interactions. In

TABLE 2

Mean RTs in msec. for all experimental conditions

		Same	Different	Control
Color Naming				
Facilitation	G1 B1	594	592	585
	G1 B2	559	571	576
	G2 B1	487	495	494
	G2 B2	486	497	489
Priming	G1 B1	527	554	556
	G1 B2	532	569	569
	G2 B1	554	602	578
	G2 B2	527	551	547
Word Naming				
Facilitation	G1 B1	442	450	444
	G1 B2	418	432	429
	G2 B1	354	350	347
	G2 B2	346	338	340
Priming	G1 B1	365	412	399
	G1 B2	365	434	425
	G2 B1	385	488	418
	G2 B2	339	428	409

G1 indicates facilitation, then priming; G2 is the opposite.

B1 indicates days one and two; B2 indicates days three and four.

addition, the mean RT dropped from Block 1 to Block 2 for the Group 2 subjects (37 msec. in color naming; 38 msec. in word naming), but increased slightly for the Group 1 subjects (11 msec. in color naming; 16 msec. in word naming), adding further noise to the data.

DISCUSSION

The fact that no trace of Warren's effect (1972) can be found in the data is only mildly disturbing. Recall that Warren found an increase in color naming time when the test word was pre-cued, presumeably due to an increased activation level for the word causing it to reach threshold (Morton, 1969) sooner. Consider that in the present experiment each S went through a total of 3456 actual test trials, all using a pool of only six possible words. It seems likely that the full activation level was reached almost immediately for each word. Since a full day of practice with the same stimuli preceeded each phase of the experiment, day by day data analysis will still not reveal at what point the effect faded, if in fact it was ever present. This might be one area for further investigation, since a look at how activation levels reach an asymptote could help to flesh out the spreading activation (Meyer, Schvaneveldt, and Ruddy, 1972, 1973; Collins and Quillian, 1970, 1972; Schvaneveldt and Meyer, 1973) or logogen (Morton, 1969) models. There were also many important differences between Warren's experiment and the present experiment. For instance, Warren used associates to precue the test word, while the present procedure uses either the test word itself as the precue or a completely different word.

The major results show that correct priming produces, not only a drop in word naming times, but also a drop in color naming RTs. This would appear to support a theory such as that proposed earlier; knowledge of the upcoming word allows the S to advance processing of that word past a bottleneck near the start of the limited capacity channel. The effect of a correct expectancy is to speed the flow of the expected information through that bottleneck. As mentioned earlier, Dyer obtained a similar effect (Dyer, 1971) by varying the preexposure of the word prior to coloration, thereby advancing the processing of the word and reducing the Stroop interference to color naming.

Also of interest here is the rather negligible effect of an incorrect expectancy upon color naming. While an incorrect expectancy slowed word naming by about 28 msec. relative to the control, it had a very small effect (6.8 msec.) upon color naming. This small effect is entirely consistent with the proposed theory. Though an incorrect cue word has been primed, the primed word is now past the point where it will affect the processing of the <u>test</u> word and its color. The incorrectly primed word is already past what bottlenecks might exist to hold up the color name, so there is no essential difference between the conflict of color and test word following an incorrect expectancy and that same conflict following no expectancy at all. It appears, then, that expectation does not act by filtering out or inhibiting unexpected information, but solely by passing expected information more quickly. One possible problem with this interpretation is that error rates rise by 1.2% for incorrectly primed color naming trials, relative to the control. This may indicate the presence of a speed-accuracy tradeoff such that the RT for that point is artificially lowered. However, this rise in error rate is insignificant by a T test ($T = 1.44$ on 10 d.f., $p > .10$ two-tailed) and appears to have been caused primarily by only two subjects.

Since there was no significant effect of incorrect priming on color naming, why is _word_ naming slowed? The easiest explanation would be than an incorrect expectancy _did_ slow the word's progress, allowing the color name into the limited capacity channel first. However, then the color naming time should have been _faster_ under incorrect priming conditions than under control conditions, when the word is still competing with the color name. Another possible explanation is that the word has been loaded into a response buffer after it exits from the limited capacity channel. A tone indicating that the correct response was to be the _color_ name would cause the information to be dropped immediately. A signal to respond with a word name, however, would only cause the word to be prepared further for output, _ie_. the actual information might be readied. When the test word appears, different from the expected word, the prepared information must all be dumped before another word can be readied for output. Of course, if the expected word appears, a correct response is ready to be released.

The slight but significant ($F(1,4) = 7.64$, $p<.05$) reversal of Warren's effect for color naming may indicate that, even in the facilitation phase of the experiment, information is gained to help predict the test word. While the cue word predicts the test word on only one-seventh of the facilitation trials (excluding control trials), there seems to be no major drawback to color naming RT when an incorrect expectancy is produced based on the small amount of information available. In other words, evan an incorrect expectation may be better than no expectation at all. One piece of conflicting evidence is that there is no change between "same" and "different" difference scores for word naming data during the facilitation phase; when dealing with the priming phase, there is a larger effect on word naming data than on color naming data. It is possible that the difference shown in the facilitation - color naming conditions is just a chance occurrence.

If it is not chance, however, then either the strategy of trying to use the minimal expectancy is employed for only a small proportion of facilitation trials or there is a continuum of expectancy effects ranging at least from that found in the facilitation phase to that present in the priming phase of the experiment. This raises the possibility that there is essentially no difference in mechanisms between facilitation and priming other than the magnitude of the effect, _ie_. the degree of expectancy involved. However, this explanation is hard to accept in light of the Warren data. Facilitation in Warren's experiments (Warren, 1972) caused an _increase_ in color naming time, while expectancy led to a _decrease_ in color and word naming time in the present experiment.

So far, only models which propose a separation between memory areas and limited capacity or conscious processing areas have been considered. This excludes many other types of models of processing. I would like to choose just one representative model which proposes no separable stages and deal with it briefly.

One very simple yet powerful way of looking at processing is to see how much can be gotten out of a relatively clutterless model, such as one relying almost exclusively on associations between the elements in memory and associations of these elements with temporal cues. In the context of the present experiment, the possible response colors might form one set of responses while the possible response word names might form another, where these two sets are not highly discriminable. When a word is precued, the representation for that word would be tagged with a cue indicating that it had just occurred. Looking at word naming trials, this means that the word with the latest temporal cue will be most discriminable from the other possible responses.

On color naming trials, the subject "knows" that he is to respond with the color name rather than the word name. When a test word occurs which is the same as a recently tagged word, the discriminability of all word responses from all color name responses is increased, thereby reducing the reaction time to choose the proper color name response. In this conceptualization, the major difference between facilitation and priming trials is that the priming trials, due to their high predictive ability, increase the salience of the temporal cue.

The major problem with this model comes again in attempting to explain the results of the Warren (1970) study. In that experiment, facilitation of the word name increased the reaction time to respond with the proper color name. While the precue provides no <u>additional</u> information, since the subject knows he is always to respond first with the color name, there appears to be no simple explanation for an increase in reaction time when precued with an associate of the test word without resorting to activation levels in memory once again. A lot of weight in interpreting the present experiment is being put upon the accuracy of the Warren results. Before any of these interpretations are accepted, that experiment should be replicated and expanded upon for further confirmation.

One difficulty with the present study which is extremely difficult to explain is the apparent counterbalance effect upon the facilitation data (Figure 2). This did not interact with the

Agreement variable, causing only a 90 msec. drop for word naming and a 70 msec. drop for color naming when the priming phase of the experiment was first. Since this drop was equal for same, different, and control conditions, it must be attributed to some general strategy shift which caused a more or less non-specific decrease in reaction time.

Since it is presumed that the word name is capturing the limited capacity channel before the color name, and speeding the flow of the word through priming appears to have resulted in more rapid color naming, one obvious conclusion is that there must be an effect of the flow of previous information upon the time course of subsequent information.

Another, more tentative, conclusion is that the primary effect of expectation is to pass the expected information more quickly through the limited capacity channel, with little detrimental effect upon unexpected information. This would also seem to contradict one hypothesis proposed earlier; that the mechanism of priming might be in sequencing the operations through which a stimulus must travel in the limited capacity channel. If this were the case, some negative effects from improper expectation would be predicted.

Since the priming in the present experiment was advantageous to both color and word naming RTs, nothing can be said as to whether priming could be voluntarily inhibited if it were not advantageous. In addition, very little can be inferred as to exactly how priming is effected, other than to eliminate hypotheses which imply an inhibition or filtering of unexpected information in one way or another. Future research might be directed at these and related questions.

REFERENCES

Collins, A.M. and Quillian, M.R. Facilitating retrieval from semantic memory: The effect of repeating part of an inference. In Attention and Performance III, A.F. Sanders (ed.), Amsterdam: North Holland Publishing Co., 1970, 304-314.

Collins, A.M. and Quillian, M.R. Experiments on semantic memory and language comprehension. In Cognition in Learning and Memory, L.W. Gregg, (ed.), New York: John Wiley and Sons, 1972, 117-137.

Dalrymple-Alford, E.C. and Azkoul, J. The locus of interference in the Stroop and related tasks. Perception and Psychophysics, 1972, 11, 385-388.

Dyer, F.N. The duration of word meaning responses: Stroop interference for different pre-exposures of the word. Psychonomic Science, 1971, 25, 229-231.

Dyer, F.N. The Stroop phenomenon and its use in the study of perceptual, cognitive, and response processes. Memory and Cognition, 1973, 1, 106-120.

Jensen, A.R. and Rohwer, W.D. Jr. The Stroop color-word test: a review. Acta Psychologica, 1966, 25, 36-93.

Keele, S.W. Attention and Human Performance, Pacific Palisades: Goodyear, 1973.

Klein, G.S. Semantic power measured through the interference of words with color-naming. American Journal of Psychology, 1964, 77, 576-588.

Kucera, H. and Francis, W.N. Computational Analysis of Present-Day American English. Providence: Brown University Press, 1967.

Meyer, D.E., Schvaneveldt, R.W., and Ruddy, M.G. Activation of lexical memory. Paper presented at Psychonomic Society, St. Louis, Missouri, 1972.

Meyer, D.E., Schvaneveldt, R.W., and Ruddy, M.G. Locii of contextual effects on visual word-recognition. In Attention and Performance V, P. Rabbit (ed.), New York: Academic Press, 1974.

Morton, J. Interaction of information in word recognition. Psychological Review, 1969, 76, 165-178.

Pavlov, I.P. Condition Reflexes, 1927, translated by G.V. Anrep. London: Oxford University Press.

Posner, M.I. and Boies, S. Components of attention. Psychological Review, 1971, 78, 391-408.

Posner, M.I. and Klein, R.M. On the function of consciousness. In Attention and Performance IV, S. Kornblum (ed.), New York: Academic Press, 1973.

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

Scheibe, K.E., Shaver, P.R., and Carrier, S.C. Color association values and response interference on variants of the Stroop test. Acta Psychologica, 1967, 26, 286-295.

Schvaneveldt, R.W. and Meyer, D.E. Retrieval and comparison processes in semantic memory. In Attention and Performance IV, S. Kornblum (ed.), 1973, New York: Academic Press.

Seymour, P.H. Stroop interference with response, comparison, and encoding stages in a sentence-picture comparison task. Memory and Cognition, 1974, 2, 19-26.

Stroop, J.R. Studies of interference in serial verbal reactions. Journal of Experimental Psychology, 1935, 18, 643-662.

Warren, R.E. Stimulus encoding and memory. Journal of Experimental Psychology, 1972, 94, 90-100.

APPENDIX

Significant results. All probabilities less than .05 unless indicated (*), then probability less than .10

Mean Reaction Times

	F	d.f.	M.S. Error
Overall - Color Naming			
Agreement	33.04	2,8	84.03
Group X Predictability	16.68	1,4	1443.06
Predictability X Agreement	11.99	2,8	61.43
Group X Predictability X Block	11.77	1,4	439.97
*Group X Block X Agreement	3.26	2,8	72.53
Group X Block X Predict. X Agreement	4.74	2,8	34.99
Overall - Word Naming			
Agreement	42.32	2,8	231.72
Group X Predictability	26.45	1,4	1739.53
Predictability X Agreement	76.37	2,8	113.42
Group X Block X Predictability	11.78	1,4	394.56
Group X Predictability X Agreement	10.78	2,8	113.42
Facilitation - Color Naming			
*Group	4.74	1,4	15659.39
Facilitation - Word Naming			
*Group	4.47	1,4	15359.89
Priming - Color Naming			
Agreement	30.40	2,8	129.28
*Group X Block	5.86	1,4	872.47

	F	d.f.	M.S. Error
Priming - Color Naming (continued)			
Group X Block X Agreement	5.51	2,8	41.64
Priming - Word Naming			
Agreement	116.30	2,8	1314.75
*Group X Block	6.22	1,4	1067.08
Group X Block X Agreement	8.32	2,8	316.25

Difference Scores

	F	d.f.	M.S. Error
Overall - Color Naming			
Agreement	39.12	1,4	131.46
Predictability X Agreement	27.67	1,4	.33
*Group	5.45	1,4	113.33
Group X Predictability X Block	8.32	1,4	74.83
Group X Block X Agreement	16.04	1,4	24.33
Overall - Word Naming			
Agreement	55.93	1,4	339.92
*Block	5.25	1,4	444.08
*Block X Predictability	4.30	1,4	419.88
Predictability X Agreement	634.69	1,4	26.17
Group X Predictability X Agreement	87.23	1,4	26.17
Facilitation - Color Naming			
Agreement	7.64	1,4	38.50
Facilitation - Word Naming			
None			

	F	d.f.	M.S. Error
Priming - Color Naming			
Agreement	40.64	1,4	174.29
*Group	4.10	1,4	241.54
Group X Block X Agreement	27.53	1,4	17.54
Priming - Word Naming			
Agreement	221.38	1,4	160.42
Block	10.35	1,4	482.67
Group X Agreement	13.30	1,4	160.42