Active versus passive expectancy for words
by Leo Henry Nickol

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Psychology
Montana State University
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Abstract:
The Posner-Snyder (1975) cost-benefit theory predicts that the more an event is actively expected, the greater the inhibition to respond to other nonassociated events will be. This prediction was investigated by varying the relative proportion of two different types of events, words and nonwords, presented to subjects in three conditions—75% words, 50% words, and 25% words. Reicher's (1969) forced-choice design was used to present the stimuli, and both response choice and reaction time were recorded. Significantly greater differences between word and nonword reaction times were observed when the relative proportion of words to nonwords was increased. These results support the theory. No trend toward word-nonword differences was found for the response choice results. This might be due to the resource-limited nature of the task, instructions which emphasized accuracy or both.
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Leo Henry Nickol

A thesis submitted in partial fulfillment of the requirements for the degree of

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in

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APPROVAL

of a thesis submitted by

Leo Henry Nickol

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPROVAL</td>
<td>ii</td>
</tr>
<tr>
<td>STATEMENT OF PERMISSION TO USE</td>
<td>iii</td>
</tr>
<tr>
<td>VITA</td>
<td>iv</td>
</tr>
<tr>
<td>ACKNOWLEDGMENT</td>
<td>v</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>viii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>ix</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>METHOD</td>
<td>6</td>
</tr>
<tr>
<td>Subjects</td>
<td>6</td>
</tr>
<tr>
<td>Apparatus</td>
<td>6</td>
</tr>
<tr>
<td>Stimulus Presentation</td>
<td>6</td>
</tr>
<tr>
<td>Materials</td>
<td>8</td>
</tr>
<tr>
<td>RESULTS</td>
<td>11</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>15</td>
</tr>
<tr>
<td>REFERENCES CITED</td>
<td>19</td>
</tr>
<tr>
<td>APPENDIX: STIMULI USED</td>
<td>21</td>
</tr>
<tr>
<td>TABLE</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>I</td>
<td>12</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

FIGURE 1 .................................. 13
ABSTRACT

The Posner-Snyder (1975) cost-benefit theory predicts that the more an event is actively expected, the greater the inhibition to respond to other nonassociated events will be. This prediction was investigated by varying the relative proportion of two different types of events—words and nonwords, presented to subjects in three conditions—75% words, 50% words, and 25% words. Reicher's (1969) forced-choice design was used to present the stimuli, and both response choice and reaction time were recorded. Significantly greater differences between word and nonword reaction times were observed when the relative proportion of words to nonwords was increased. These results support the theory. No trend toward word-nonword differences was found for the response choice results. This might be due to the resource-limited nature of the task, instructions which emphasized accuracy or both.
The role that a subject's expectancies play in determining how rapidly and accurately he or she can process a visual stimulus has been investigated in a number of ways (e.g., Auerbach & Leventhal, 1973; Haber, 1966; Neely, 1977; Posner, 1979). It is now clear that expectancy is a highly complex phenomenon. Kahneman and Tversky (1982) point out that "in contrast to formal theories of judgment and decision, which employ a single notion of probability, psychological analyses of responses to uncertainty reveal a wide variety of processes and experiences, which may follow different rules" (p. 143).

Empirical data strongly suggest that differing types of expectancy may produce dissimilar results. Two general types of expectancy which have been experimentally distinguished are passive and active. Posner and Snyder (1975) utilized a matching task in which subjects were presented with a priming item prior to the appearance of a stimulus requiring a response. The stimulus consisted of a pair of letters (e.g., AA), and a subject was required to press either a yes key if the letter pair matched or a no key if it did not. The priming item was either a neutral warning signal (e.g., +) or a signal of the same type as the to-be-presented stimulus pair (e.g., A). The priming item appeared 500 ms before and remained directly over the stimulus pair (e.g., AA). The principle dependent variable analyzed was the subject's reaction time. Yes responses when the letter pair matched
and no responses when the letter pair did not match were analyzed separately. The major findings reported concerned the yes responses to matching stimulus letter pairs. Facilitation was measured by subtracting the mean reaction time when the prime and stimulus pair matched from the mean reaction time when the stimulus pair was preceded by the neutral warning signal. Inhibition was measured by subtracting the mean reaction time when the prime and stimulus pair did not match (e.g., $\text{B}_A$) from the mean reaction time when the stimulus pair was preceded by the neutral warning signal. It was reported that when the prime matched the stimulus pair on 80% of the trials, facilitation was high but inhibition was also high. On the other hand, when the prime matched the stimulus on only 20% of the trials, facilitation was still high but there was no inhibition effect. Posner (1979) interpreted these findings as support for distinction between automatically activated mental pathways and those pathways that require a subject’s conscious attention for activation. He describes these processes as follows:

Put simply, the idea is that automatic activation facilitates the passage of messages that share the same pathway; but since pathways can be active in parallel, such activation has no inhibitory consequences. This one-sided bias is quite different from the effects that occur after subjects begin to attend to the input pathway. Since attentional mechanisms are of limited capacity, facilitation of the attended pathway is accompanied by a widespread inhibition in the ability of information from any other activated pathway to reach the mechanisms that subserve attention. (p. 99)

Posner and Snyder’s (1975) study is problematic because of serious methodological difficulties. In the matching task that they employed, it was not necessary for subjects to use the priming item at
all; they could make the required matches whether or not a warning signal had been presented. This is an important point to consider if conclusions are dependent upon the occurrence of a valid prime which, subsequently, affects a subject's strategies. They reported that something perhaps even more ambiguous was happening. It appeared from their results that their subjects, instead of using the prime as a warning signal, were using the prime to make the matches. They recounted the following:

First, the most serious problem with the experiments reported in this paper is that attention to the prime often appears to be used to match the prime item against the array. This serves to facilitate the "yes" responses to matching pairs when the prime also matches the array and "no" responses to mismatching prime-array pairs. This strategy alone can account for many of our results without invoking any effect of attentional capacity per se. (p. 680)

Although the authors felt that their findings were strong enough to overshadow these difficulties, they suggested that more tests of the hypothesis using nonmatching designs need to be made.

The present research is an attempt to address directly some of the problems. It is proposed that the more an event is actively, consciously expected, the greater will be the time required to respond to an unexpected event. The relative proportion of two qualitatively different types of stimuli, words and nonwords, was varied over separate, blocked conditions. Subjects, in a particular condition, were required to respond sequentially and individually to all of the events, words and nonwords, in that condition. Expectancies are assumed to develop solely by the interaction of the subjects with the series of stimuli. They were not told, in any case, about the
probability of occurrence of either of the stimulus types.

This study utilized Reicher's (1969) forced-choice design for stimulus presentation. In this procedure, subjects are presented with a brief letter stimulus (e.g., WORD), which is immediately replaced by a visual noise mask to prevent further processing of the stimulus. Above the mask, there appears a horizontally oriented series of dashes; each dash corresponds to a letter position in the previously presented stimulus. Above and below one of the dashes appears a letter. The alternative choices and the masking field would appear as indicated below:

```
- - - D
 K
```

The participant responds by pressing a key to indicate whether the appropriate letter from the now-masked stimulus is in the top or bottom position of the two presented alternatives. One of the alternatives is always correct. In this case, the correct alternative response is top because the fourth position of the stimulus, WORD, is D and D is in the top position of the presented alternatives. The alternatives were presented above and below any one of the possible positions in the stimulus, and in the case of words, such as illustrated, either of the alternatives would make a word.

The purpose of the present experiment is to examine the effects that an increasing expectancy for one type of event (words) will have on an individual's ability to respond to another event (nonwords). The specific hypothesis is that as the proportion of words presented to a subject increases, his or her active, conscious expectancy to see words
will increase, and this increasing active expectancy for words will inhibit responding to nonwords. Because this is a between-subjects design, this change should be exhibited by an increased difference between the times taken to respond to words and the times taken to respond to nonwords in the condition where most words were presented compared to those time differences in the condition where the least words were presented. It is not anticipated that any strong trends will be apparent for the nonwords. Aderman and Smith (1971), using five-letter stimuli and a forced-choice design, were unable to get their subjects to perform much above chance for correct recognition on nonwords even after explicit directions concerning what they would receive and following fifteen expectancy-confirming trials.
METHOD

Subjects

The subjects were 100 right-handed male and female college students enrolled in an introductory psychology course. They received some course credit for participating in the experiment. All subjects had 20/20 or corrected to 20/20 vision.

Apparatus

A Hewlett-Packard 9845B computer was used to record subjects' response choices and reaction times. The stimuli were presented on the computer monitor. The computer keys were covered with a piece of plywood. In the upper right-hand corner of the plywood, holes were drilled and buttons installed to provide access to three essential operation keys. These keys consisted of T for choice of a top alternative, B for choice of a bottom alternative, and C to continue with the next stimulus in the series. The T key and the B key were oriented horizontally 4 cm apart. The C key was 2 cm below and centered between the T and B choice keys.

Stimulus Presentation

The subject was seated in front of the computer monitor, and then received instructions by the computer program concerning his or her task. Each was given nine practice trials to ensure that he or she had the necessary operational knowledge to perform the task. The practice trials consisted of number stimuli only. The subject was
instructed to use only the index finger of the right hand for all responses. During this period, communication with the experimenter was encouraged, and it was explained that other than the actual trials consisting of letters rather than numbers, the operations required of a subject would be identical. When the subject confirmed that he or she knew exactly what was required, the experimenter left the room and the experimental trials were initiated.

The method of stimulus presentation generally followed that of Reicher (1969). First, a small fixation cross appeared in the center of the screen. The subject focused on the cross. When he or she was ready to receive a stimulus, the subject pressed the C key. The fixation cross was then replaced by a four-letter stimulus, either a word or a nonword, presented on the monitor for 100 ms. The stimulus covered approximately 0.5° visual angle vertically and 1.5° visual angle horizontally at an average viewing distance of 40 cm. After 100 ms the stimulus was masked by four light-on-dark rectangles. Each rectangle corresponded to and covered one of the letter positions in the stimulus. Directly above this mask was a dashed line, with each one of the dashes corresponding to a letter position in the stimulus. On top of and below one of the dashes was a letter. The subject was asked to press quickly the T key if he or she felt that the top alternative letter had been correct in that position in the stimulus or to press quickly the B key if he or she felt that it was the correct response. One of the alternatives was always correct for the requested position. Both alternative choice—correct or incorrect—and reaction time was recorded for each response. Subjects were not informed
whether or not their choices had been correct until the completion of the trials.

Both the selection of 100 ms for the stimulus presentation time and the choice of the visual noise mask resulted from pretrial pilot studies. It was determined at that time that this time-and-mask combination yielded a consistent middle range performance for percentage correct of between 70% to 90% correct for both words and for nonwords. The visual noise mask used was made up by repeating a computer character. The Hewlett-Packard 9845B character (ASCII-#255) consisted of a vertically oriented rectangle containing a symmetrical distribution of dots. The size of the character was equivalent to the size of a stimulus letter, and four of these characters presented horizontally effectively masked the four-letter stimulus.

Materials

A total of 64 four-letter words were chosen from Kucera and Francis' (1967) corpus of one million English words as word stimuli for the experiment. These words were selected so that even though each was unique, it was closely equivalent to the other chosen words in terms of those parameters that may differentially influence the response measures recorded in the study. Four-letter words were chosen because they have been found to show superior performance over nonwords in forced-choice tasks (Reicher, 1969; Wheeler, 1970), and, in the case of matching experiments, shorter reaction times (Eichelman, 1970; Kroll, 1977). The frequency of occurrence of a word in the English language has been found to strongly affect performance (Bruder, 1978; Krueger, 1975), and this frequency was made as equivalent as possible.
The words selected had an overall mean frequency of 57.8 occurrences per million, \( \text{SD} = 17.4 \). The means for the individual alternative frequencies were 56.1, 58.2, 58.9, and 58.1 occurrences per million for positions 1 through 4, respectively. None of the words appeared to have strong emotive content (Broadbent, 1973). Finally, none of the words had more than one syllable, had a repeating letter, or were obvious proper nouns. After the list of words was obtained, it was placed randomly in a 64-item, 8 x 8 array.

Each nonword was made up from a word so as to control both for overall letter frequency and alternative letter frequency. If, for example, a word was KING, followed by the first letter alternatives, \( \frac{R}{K} ----- \), then the nonword would be KGNI, followed by \( \frac{R}{K} ----- \). In addition, the alternatives were reversed for one-half of the subjects in each condition (e.g., KING would be \( \frac{K}{R} ----- \) for one half of the subjects, and similarly for KGNI. After the alternative choices were determined for the appropriate conditions, the remaining letters were scrambled so as to be as unwordlike as possible (Gibson & Levin, 1975). Appendix A contains the list of words and nonwords used in the study.

Five different conditions were developed from the word and nonword arrays. Three experimental conditions—75% words, 50% words, and 25% words—were developed by proportionately changing the words to nonwords in each condition. This proportioning constraint was continued over eight trial blocks within each condition. That is, if the 50% condition was being prepared, one-half of the eight stimuli presented would be words and one-half would be nonwords.

The computer program to present the stimuli operated by first
randomly selecting a row of stimuli from an array for presentation and then randomly selecting and presenting each of the eight stimulus items within that row. It then randomly chose another row that had not been selected before and performed the same random presentation of items. It continued in this manner until it had exhausted the sixty-four stimuli to be presented to a particular subject. There were ten sets of data in all. Two sets of data for each of the five conditions encompassed the alternative changes described above. These ten data sets were distributed randomly to the 100 subjects. At the end of a subject's trials, the computer printed out the response choices and reaction times.
RESULTS

One-way analysis-of-variance models were used to analyze the data. In addition, t-tests were used to test for hypothesized differences. Response choice (i.e., percentage correct) data and reaction time data were analyzed separately. The two control conditions—100% words and 100% nonwords—were distinguished from the three central conditions—75% words, 50% words, and 25% words—during the analysis. Table 1 contains the means for the two dependent variables in each of the five conditions, and the differences between nonword and word performance for those conditions.

In the three central conditions, containing both words and nonwords, significantly better performance was found for the words, both for percentage correct, $F(1, 57) = 51.7$, $p<.001$, and for reaction time, $F(1, 57) = 68.2$, $p<.001$. These results support similar findings (e.g., Reicher, 1969; Wheeler, 1970).

Linear trend analyses were used to test for expectancy effects across the eight trial blocks (Grant, 1956). The means for each of the blocks on both dependent variables in the central and control conditions are shown in Figure 1. A significant linearly increasing trend for percentage correct with words was found when the data from all of the conditions containing words were combined, $F(1, 76) = 11.6$, $p<.005$. Conversely, combining all of the conditions containing nonwords, nonwords showed no significant trend, $F(1, 76) = 1.82$. These results were
Table 1. Nonword and word condition means and differences for percentage correct and reaction time.

<table>
<thead>
<tr>
<th>Percentage Words/Percentage Nonwords</th>
<th>0/100</th>
<th>25/75</th>
<th>50/50</th>
<th>75/25</th>
<th>100/0</th>
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<tr>
<td><strong>Percentage Correct</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonword</td>
<td>75</td>
<td>78</td>
<td>78</td>
<td>77</td>
<td>--</td>
</tr>
<tr>
<td>Word</td>
<td>--</td>
<td>88</td>
<td>90</td>
<td>87</td>
<td>79</td>
</tr>
<tr>
<td>Difference</td>
<td>--</td>
<td>-10</td>
<td>-12</td>
<td>-10</td>
<td>--</td>
</tr>
<tr>
<td><strong>Reaction Time (ms)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonword</td>
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<td>1698</td>
<td>1676</td>
<td>1781</td>
<td>---</td>
</tr>
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<td>Word</td>
<td>-----</td>
<td>1504</td>
<td>1408</td>
<td>1396</td>
<td>1325</td>
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<tr>
<td>Difference</td>
<td>-----</td>
<td>194</td>
<td>268</td>
<td>385</td>
<td>-----</td>
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Figure 1. Mean percentage correct (upper panel) and reaction time (lower panel) for nonwords and words in each condition across the eight trial blocks. The 25%, 50%, and 75% (central) conditions have been combined and are compared with the 100% word and 100% nonword (control) conditions.
congruent with those obtained from the three central conditions in responding to words, \( F(1, 57) = 11.8, p < .005 \), and to nonwords, \( F(1, 57) = 1.87, p > .05 \). The reaction time results showed decreasing linear trends across the eight trial blocks for both words, \( F(1, 76) = 42.9, p < .001 \), and for nonwords, \( F(1, 76) = 4.79, p < .05 \).

In the three central conditions the trends were similar; for words, \( F(1, 57) = 63.1, p < .001 \), and for nonwords, \( F(1, 57) = 5.52, p < .05 \).

One apparent inconsistency concerning the trend data occurred in the 100% nonword condition, in which there was no significant trend across trial blocks, \( t(19) = .32 \).

Finally, it was hypothesized that the differences found by subtracting the reaction times to the nonwords from the reaction times to the words would become greater as the relative proportion of words to nonwords was increased. The mean differences in reaction time are displayed in Table 1. A comparison of these differences across the three central conditions was significant, \( F(2, 21) = 4.42, p < .05 \). A \( t \)-test comparing the 25% word with the 75% word condition showed that the difference between words and nonwords in the 75% word condition was significantly greater than the difference between words and nonwords in the 25% word condition, \( t(14) = 3.17, p < .01 \). For the response choice results, however, no significant differences between word and nonword reaction times were found.
DISCUSSION

The differences found between the reaction time to words and the reaction time to nonwords support the Posner-Snyder (1975) theory that active expectancies for an event interfere with an individual's ability to process other events. The theory was supported in this study in terms of the latency to respond to less expected events. Whether or not active expectancy for an event affects the recognition of other events was not clear in this experiment.

One possible explanation for the discrepancies observed between the reaction time and the response choice results is that each was measuring a different aspect of mental processing. Norman and Bobrow (1975) differentiate between data-limited and resource-limited tasks. A distinctive characteristic of a data-limited task concerns stimulus quality. If a stimulus is not of sufficient magnitude or clarity to be recognized, or if a subject does not have the capacity to process the stimulus, then the task may be regarded as being data-limited. On the other hand, a resource-limited task may be performed more easily simply by giving a greater amount of attention to the task. Santee and Egeth (1982) suggest that "under data-limited viewing conditions . . . , response accuracy is sensitive to early perceptual interference between target and noise items, whereas reaction time is more sensitive to later processes involved in response interference" (p. 489). It
appears from the results of the present research that the effects of early perceptual interference were minimal. Indeed, with practice this author was repeatedly able to achieve 100% accuracy both for words and for nonwords, but shorter reaction times could not be produced. It should be made clear that the instructions to the subjects required them first to make a selection, and reaction times were measured after that choice. This might have demanded that response choice be given priority over reaction time. Further study varying the time that the stimulus remains on the screen or the quality of the stimulus may clarify this ambiguity.

A major dilemma with this study concerns the relative manner in which comparisons had to be made. It was not possible directly to attribute the increasing nonword-word differences in reaction time to either increasing facilitation for expected events—words—or to increasing inhibition for nonexpected events—nonwords—although both probably contributed. This is because it was impractical to use a neutral stimulus. What would it be? The results obtained in this experiment are therefore relative, and depend for their interpretation upon the predictions made by the Posner-Snyder theory. That is, if increasing expectancies for one type of event inhibit responding to other events then the results found for reaction time data in this study are consistent with that prediction.

One rather surprising finding was the practice effect for the nonwords in the central conditions where they were presented in the context of some words. No such trend was observed in the 100% nonword control condition. A possible suggestion for this inconsistency may be
made after comparing both the word and the nonword differences and trends. It can be seen that the differences between the reaction times to the nonwords and the reaction times to the words were highly significant in the conditions in which they were compared, and it can be noted that the trends for words were much stronger than those for nonwords. It appears from these findings that words are more easily processed and that this facility in processing for words becomes stronger through the course of the trials. Since subjects were given only the two types of stimuli with instructions to respond as quickly as possible, they tended to predicate their responses upon the type of stimulus that was most easily processed. It was not practical when presented with both words and nonwords for subjects to speed up when they saw a word nor to slow down when they saw a nonword. Instead, they might have adopted a strategy that produced both faster reaction time to words than to nonwords and a progressively decreasing linear trend through the course of the trials for both stimulus types. An inconsistency in this argument is that this general speeding up of responses to the nonwords over the course of the trials was not reflected by poorer performance for response choices to nonwords. It was pointed out earlier, however, that the nature of this task appears to be a resource-limited one, and simply giving a greater deal of attention to the task might alter the reaction times without affecting the percentage correct results.

In conclusion, it can be stated that this design, even though not subject to the problems with matching strategies, introduced its own set of difficulties. Taken together, however, all results provide
support for a distinction between active and passive expectancies, with accompanying facilitation or inhibition. More work needs to be done with various stimulus types, different stimulus presentation times, and good versus poor readers. This last distinction was not explored in this experiment, but it was observed that the variance in reaction times was substantial. Some of the subjects responded in 500 ms while others took more than 4000 ms. This was true even though it was made clear to all subjects that they should respond as quickly as possible.
REFERENCES CITED


<table>
<thead>
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Nickol, L. H.  
Active versus passive expectancy for words

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